

Advancing the Use of Streaming Media
And Digital Media Technologies at the Connecticut Department of
Transportation

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Division of Design Services

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16. Abstract This final research report culminates a decade-long initiative to demonstrate and implement streaming media technologies at CONNDOT. This effort began in 2001 during an earlier related-study (SPR-2231) that concluded in 2006. This study (SPR-2254) resumed from where the earlier one left-off. By project-end, the infrastructure was in place to support the production and the delivery of higher-quality video presentations and webcasts. These are being routinely used for in-house training and for better-informing the motoring public. In addition, a state-of-the-art broadcasting studio continues to be available for disseminating live-meetings and workshops via the Web.				
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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ABOUT THE ELECTRONIC VERSION OF THIS REPORT

The electronic version of this final research report contains hyperlinks that provide convenient access to all streaming video content referenced therein. Most of these links are accompanied by their corresponding URLs, which appear in the endnotes section which is the last page of the report. Free Microsoft® software is required to view the media; [Windows Media Player® 9 Seriesⁱ](#) or better and [Internet Explorer® 6.0ⁱⁱ](#) or better.

An earlier related study (*SPR-2231*) determined that the Connecticut Department of Transportation (CONNDOT) should adopt Microsoft's streaming media platform because agency servers and workstations already have licenses to run Microsoft's operating systems (OS). Additionally, most if not all of its network-based PC users already have the required *Windows Media Player®* software pre-loaded. The player is based on the Windows Media video format (WMV) which uses Microsoft's proprietary compressor/decompressor (CODEC). While the WMV format was considered to be very popular at that time, other companies like Apple and Adobe have their own flavors of streaming video; that being QuickTime® and Flash®. These are extremely popular, as well. However, it was beyond the scope of this research project to simultaneously produce and support more than one video format. Therefore while regrettable, some individuals outside of CONNDOT may be unable to view the media referenced in this document unless their network administrator installs the required free software.

At the time of this writing, CONNDOT's Web-based streaming media server remains operational on the State Data Center's robust Internet backbone, located in East Hartford CT. The Bureau of Enterprise Systems and Technology (BEST) provide software updates and ensure that it remains up and running within established limits. A second media server is also operational on CONNDOT's internal wide-area-network (WAN) from the Department's Data Center, located in Newington CT. The status of both these servers may change over time due to ongoing budgetary constraints but at present, all of this final research report's referenced videos remain accessible via the hyperlinks provided throughout this document. Alternatively, some content may be located directly in the web-based streaming media library from the shortcut <http://www.ct.gov/dot/video>.

EXECUTIVE SUMMARY

CONNDOT's Division of Research conducted an informal on-line survey of company websites in 2000 to determine if and how video was being used by the private sector. Many examples of AVI and MPEG videos were located but both formats needed to be downloaded before they could be watched. The use of dial-up modems and phone-lines for connectivity made this a tedious process and delayed viewing by minutes if not hours. Perusing this CONNDOT's own website showed it to be devoid of any video content during this same time period.

The on-line survey also illuminated the presence of a new type of video format called *streaming media* that didn't require any downloading at all. Instead, a dedicated media server is used to deliver packets of video-based information to Web-based customers 24/7. It was also being used internally on corporate LANS for employee training. Encouraged by what had been discovered, the Division of Research submitted a new research proposal to the Federal Highway Administration (FHWA) in 2001 in order to formally investigate this new technology. It was the right time to undertake this effort because of other recent related-advances like high-speed Internet access (broadband) and faster computers. The research study was titled "*Feasibility of Streaming Media for Transportation Research and Implementation*" (SPR-2231). It started-out by evaluating four of the most popular streaming media platforms available at that time. It was quickly concluded that Microsoft's streaming media solution was the best fit for CONNDOT to adopt because of the prevalence of existing Microsoft software licenses for both agency workstations and servers.

The next objective was to establish two dedicated streaming media servers for delivering video directly to the PC-desktop; one via the Web and the other via the wide-area-network (WAN). Then, a video production and webcasting studio was engineered within the confines of an existing conference room at the ConnDOT Central Laboratory in Rocky Hill, CT, for creating CONNDOT's new media. Best practices were developed and refined for producing informational videos and for conducting live webcasts. As the study progressed, a streaming media library was populated over time with a variety of transportation-related topics. Research Managers began endorsing video-on-demand (Vod) and webcasting as powerful tools for enhancing ConnDOT's presence among national transportation research colleagues. Federal Highway administrators familiar with CONNDOT's new capabilities were echoing this sentiment with accolades of their own because of ConnDOT's success with hosting [FHWA-sponsored Pavement Workshops](#)ⁱⁱⁱ.

The research project concluded late in 2005 with all study objectives being attained. However, it still appeared very doubtful that streaming media would become a supported service at CONNDOT. Many key operational areas of the Department still remained unfamiliar with the technology or hadn't taken advantage of the free media services that had been available throughout the research project's duration. Implementing new services and technologies, like streaming media, ultimately require the highest-level of administrative support. In order to reach that goal, Research Managers gave approval for continuing this initiative, but under a new research project.

In 2006, the new research study titled "*Advancing the Use of Streaming Media and Digital Media Technologies at ConnDOT*" (SPR-2254) commenced. It targeted problems and issues that had arisen during the previous research project (SPR-2231). The work tasks also focused on improving audio and video quality as well as video-production workflow in order to provide end-users with timely access to a higher-quality product. In addition to the Web-based video library, an intranet-based media library was developed for CONNDOT staff to use for important in-house training initiatives. As the quantity of new videos grew, so did interest from other operational areas that were becoming more willing to employ it. However, most of these entities are located at the Administration building in Newington CT. For this reason its two main conference rooms (A and B) were similarly outfitted with video cameras and webcasting equipment in order to record and broadcast meetings and workshops from these well-utilized meeting rooms.

Late in 2011, several State of CT agencies were being consolidated and reorganized in order to streamline state government and reduce operating costs. This provided an avenue for Division of Research engineers to explore and branch-out into other areas and work assignments within the agency. This PI was presented with the opportunity to implement streaming media technologies outside of the Division of Research early in 2012 when it was formally adopted by the Office of Information Systems (OIS) as a supported new service.

The research project concluded in 2012. By this time, the agency was enlisting streaming videos for keeping the public informed about important construction projects such as the new [Pearl Harbor Memorial Bridge](#)^{iv}. A number of close partnerships had been forged outside the agency with the [Connecticut Transportation Institute](#)^v (CTI), the [Connecticut Academy of Science and Engineering](#)^{vi} (CASE) and the [Northeast Asphalt User Producer Group](#)^{vii} (NEAUPG). All continue to value and rely on CONNDOT's streaming media capabilities for furthering their own unique mission.

1. INTRODUCTION

Microsoft®, RealNetworks®, Apple® and Macromedia® laid the groundwork around 1999 for a web-based video revolution with the introduction of their proprietary streaming media platforms. Shortly thereafter, CONNDOT's Division of Research began to envision how this same technology, if adopted, could benefit CONNDOT, as well as the national transportation research community. Further exploration was warranted so a preliminary research project was proposed. It commenced in 2001 and was titled "Feasibility of Streaming Media for Transportation Research and Implementation" (SPR-2231).

It was learned early-on that dedicated *streaming media servers* were integral to any large organizations' IT-infrastructure. When these servers are properly deployed and configured, streaming videos can be efficiently viewed via the PC-desktop without impacting the wide-area-network (WAN). Without them, employees will struggle to view their work-related videos via alternate mechanisms such as network file servers and as email attachments which will only degrade network performance.

Two streaming media servers were deployed by 2004; one for the Internet and one for the Intranet. With this crucial infrastructure in place, various operational areas at CONNDOT were engaged in order to identify potential new uses for streaming media. Then the Research unit developed and produced their videos using prosumer-level video cameras and equipment based on the NTSC digital video standard. Looking back, these initial videos only had marginal image quality. However, they were appropriately formatted for that time-period due to the meager PC-performance that results from playing high bitrate videos. It quickly became evident that the agencies' network wasn't robust enough to deliver better video quality without impacting other WAN-based applications. For this and other reasons video quality was constrained for the time being.

As the research project was concluding late in 2005, high definition (HD) video cameras and production equipment was becoming the preferred industry standard. Computer processing power had greatly-increased over the previous few years, as well. CONNDOT's WAN had recently been upgraded in preparation for the state's roll-out of the new payroll accounting system called CORE-CT.

All of the aforementioned improvements set the stage for undertaking an additional four-year research project (SPR-2254) that addressed unresolved problems and issues, developed and showcased new uses for streaming video within the research realm, while helping to

advance the use of webcasting and video-on-demand at CONNDOT as a whole.

2. BACKGROUND AND SIGNIFICANCE

Prior to 1999, telephone lines and dial-up modems were the primary means used to access the web. While suitable for emailing and browsing, this method was inadequate for viewing web-based videos, if they could even be located at all. The larger the video file, the longer it took to download before it could be watched on a PC. This very inconvenient process required patience and discouraged people from viewing videos. As time progressed, these limitations were beginning to fade away since broadband Internet connectivity was becoming readily available and computer processing power had improved, as well. These technologically-related advancements provided CONNDOT's Division of Research with the impetus for investigating whether Web-based video could peaceably co-exist here with other computer-based applications that were also vying for valuable network bandwidth.

Initially two different issues were to be addressed; the first one attempted to answer the question "why aren't video cameras used more often by engineers and inspectors in-the-field?" since the devices appeared to be well-suited for accurately documenting roadway construction and research projects. The second issue was related to the final electronically-published research report. There simply wasn't any practical way to convey project-related videos along with the PDF-formatted document. In retrospect, both issues appear to be minor ones now but they did serve to illuminate the underlying issue, which was an inability to easily share work-related videos with colleagues.

To begin, what happens after an engineer takes a video camera into-the-field was investigated. Once they return to the office, how does the recorded information become available for others to view? While the videotapes could be watched directly from the camera or played-back on a VCR and TV monitor, they couldn't be transmitted between CONNDOT Headquarters and District Offices and Garages. As a workaround, some "resourceful" staff figured out how to digitally convert the videotapes into AVI or MPEG video clips. These humongous files would then be uploaded to network servers or emailed en masse to others via the Outlook® Exchange mail server. This practice had the potential to severely impact email service and slow down network performance so IT-administrators had little choice but to "discourage" it, and the use of video cameras by staff continued to languish here.

The second problem area related to the Division of Research and the way it disseminates its final research reports. In 2000, the documents were being formatted as Adobe® PDFs® and this practice continues to this day because it is an efficient way to convey research project findings. However, there wasn't any mechanism for bundling project-related videos with the digital PDF file. To address this and other issues, a research project was initiated in 2001 titled "[Feasibility of Streaming Media for Transportation Research and Implementation](#)"^{viii}. CONNDOT Research began to solicit interest from operational areas shortly thereafter for developing new uses for streaming video from within an on-line [Streaming Media Library](#). In retrospect, this required a significant leap-of-faith by those particular offices or presenters because of their unfamiliarity with using this new technology. However, by project-end, the four-year study had yielded an agency-wide solution for sharing and viewing work-related videos via the Internet and the WAN. The research project concluded in 2005 with all proposed project goals being attained. However, there were a number of problem areas remaining and implementation had not yet been administratively addressed.

In order to help streaming media technologies reach critical mass at CONNDOT, a companion study was launched in 2006 titled "*Advancing the Use of Streaming Media and Digital Media Technologies at ConnDOT*" SPR-2254. It afforded the opportunity to improve video quality by employing equipment based on the new HD-standard. Throughout the study, a free service was made available to Research staff for developing their own streaming video presentations, for conducting webcasts and for hosting content on-line. The resulting videos were showcased on both an in-house and an Internet-based streaming media server and this effort appeared to stimulate interest from previously unexplored offices at CONNDOT such as the Safety Division, the Office of Property and Facilities, the Diversity Council and CONNDOT's Legal Office.

This final research report both demonstrates and documents the evolution of streaming video at CONNDOT while helping to ensure its continuation into the future.

3. PROBLEM STATEMENT

This research project addressed a number of problems that were identified during the previous study and were included in the research project proposal. They are described as follows:

3.1 Need to clearly convey the Presenters' PC-Desktop during live webcasts and when recording workshops and meetings

When a live webcast or a pre-recorded video (Vod) is being watched from a PC and monitor, finely-detailed information may be difficult to discern by the remote viewing audience. However, workshop attendees in the classroom are viewing the very same information on a large projection screen and it appears clearly legible. This problem can be avoided if presenters keep in mind that their visual-aids are also being viewed by a web-based audience. To that end, a procedure was put in place whereby guest-speakers would be contacted well in advance of the event in order to provide them with guidance and best practices for optimizing their presentations. Inevitably, many presenters show up just minutes from the start of an event with their hard-to-read PowerPoint slideshows in hand. The reality is that most guest speakers don't want to be constrained by "suggestions" so some different techniques were attempted for enhancing difficult-to-read slides. This consisted of locking a video camera onto either the projection screen or a standalone PC-monitor. Another method consisted of using an analog scan converter (VGA-to-Svideo). Unfortunately both methods produced only marginal results. An adequate solution would provide the ability to record, broadcast, and convey even finely-detailed graphics and text.

Solutions to Problem 3.1 are presented in Work Tasks Section 5.1

3.2 Need to reduce both the manpower and effort required to conduct webcasts and record meetings and workshops

Webcasts that were conducted during the earlier related study (2001-2005) were labor-intensive and required the services of six people. This level of staffing was costly, especially for a day-long event. The video production equipment occupied a fairly large footprint in the room and the three floor-mounted video cameras with operators were intrusive and intimidating to classroom participants (see [video-link^{ix}](#)). These issues left managers wondering whether the benefits of webcasting outweighed the cost and effort to conduct them. If webcasting is to advance within CONNDOT, it must be cost-effective and less visible to those in attendance. Both goals can be

attained by employing remotely-controllable video cameras and an automated microphone (mic) mixer. These will significantly reduce the labor and complexity required to conduct webcasts in the future.

Solutions to Problem 3.2 are presented in Work Tasks Section 5.2

3.3. Need to improve efficiency during video post-production

Two problem areas were identified during the previous related study that can slow-down the video post-production process. Post-production is the process that commences once a video recording session has ended.

The first problem requires that alternatives be found for using videotape recorder and playback decks. These have been used for decades to record and archive presentations until it is needed later for editing during video-post production. Both analog and digital videotape recorders are linear-access devices that lay-down video-based information sequentially from one end of the tape to the other. To retrieve this information, it must be offloaded in a similar manner using a playback tape deck that is connected to a computer-based, software-driven system, better known as a non-linear-editing-workstation (NLE). Because this is a real-time process, a two hour videotape (LP) can take as much as two hours to be captured and digitized by the NLE. Then the resulting digitized-video can be randomly-accessed, quickly scanned, reviewed and edited. All that remains is finalizing of the edited video. This leads us to the second issue.

The next issue has to do with finalizing the edited video. It still resides on the NLE and must be rendered and encoded into the required/desired video format before it can be published and viewed by an audience. For example, this research project encodes every video as Microsoft' Windows Media Video (WMV). The problem with rendering and encoding is that they are both CPU-intensive and can take a considerable amount of time to accomplish, depending on the complexity of the transitions and special effects that may comprise each project. All things being equal, the longer a presentation is (in minutes), the longer the rendering and encoding will take.

Solutions to problem 3.3 can be found in Work Tasks Section 5.3

3.4 Need to investigate Internet Protocol (IP)-multicast for in-house use

This research study continues to utilize a dedicated streaming media server on the WAN at its Newington, CT Data Center. However, the server isn't currently used for live broadcasting but instead is used exclusively for video-on-demand (Vod). The Vod-process uses an Internet Protocol (IP) broadcasting technique called Unicast. This term basically describes the mechanism by which each employee's PC-connection gets its own video stream when requested from the media server. As the video streams across the WAN, it uses both server resources and network bandwidth. While this method continues to provide good performance for Vod here, it is not appropriate for watching live broadcasts that are meant to be viewed throughout CONNDOT. Intentionally "inviting" dozens of workstations to simultaneously view the same video at the same time would most definitely degrade or overwhelm other network-based applications and resources.

Previous research indicated that multicasting over the WAN is the appropriate method to address simultaneous, live-broadcasting on CONNDOT's WAN for use by Administration building staff. It is envisioned that it could be utilized by all CONNDOT facilities for simultaneously viewing live messages, executive directives and training workshops using existing connectivity such as T1, OC3, and DSL lines. However, this will require procuring new media servers for each of the facilities prior to having any agency-wide solution. *Please note that Work Task 5.4 had provisions for procuring one dedicated media server to be deployed at a remote District office.*

Solutions to Problem 3.4 can be found in Work Tasks Section 5.4

3.5 Need to track, analyze and report media server usage

The quantity of on-line videos grew over time and it became crucial to ascertain what the public and CONNDOT were viewing, as well as how often. Log-files that record this client/server usage can be generated by the Windows Media Services® (WMS) plug-in which runs under the *Windows Server 2003*® operating system. When enabled, it documents very detailed information about each client's individual viewing session and experience. However, it is difficult to glean any useful information from these text-based log-files in its raw form. During the earlier research study, the data was manually tabulated from these log-files using Excel®. However, it is important to identify off-the-shelf software in order to save time and simplify the analysis and reporting process.

Solutions to Problem 3.5 are presented in Work Task Section 5.8

3.6 Need to evaluate high-definition (HD) video equipment

All of the video cameras, video mixers and video capture cards used during the earlier research project were based on a NTSC standard definition (SD) specification. Over the last several years, high definition (HD) video equipment has become more affordable and this has the potential to make SD-based video equipment obsolete soon. There would be advantages gained from moving into the HD-realm such as improved streaming video quality for Vod and webcasts but it would come at a cost. Recording and editing HD-content requires more robust video post-production equipment. The on-line videos will require that higher-bitrates are used during the encoding process and the same is true when viewing them on a PC. This will translate into more network bandwidth being consumed, and this remains of paramount concern.

Solutions to Problem 3.6 are presented in Work Task Section 5.9

3.7 Need to address audio issues in the recording studio

During the earlier research study (SPR-2231), two audio-related issues had been identified, but were not resolved. Both problems only occur when using the large conference room's video production studio for digital encoding and recording. The first issue becomes apparent when reviewing digital video recordings that provide a close-up shot of someone who is speaking. Their narrative appears slightly out-of-sync from their mouth movements. This is referred to as "lip sync" and it is annoying to watch when it presents itself in the recorded video. The problem is related to the audio (narrative component) not being in-step with the video (image component) and only occurs within digitally encoded WMV files created using Windows Media Encoder software. The second audio problem can best be described as over-modulation and also occurs when videos are recorded in the studio. It doesn't happen all the time and seems to only happen when the audio input level to the video capture card is too high or "hot".

Solutions to Problem 3.7 are presented in Work Task Section 5.10

4. STUDY OBJECTIVES

There are nine stated objectives. They are to:

- 1) Reduce the manpower required to conduct webcasts as well as during studio recording sessions and training workshops.
- 2) Improve the readability of images, graphs, data, and PowerPoint presentations captured from the presenter's PC desktop during live webcasts and studio recording sessions.
- 3) Document all the steps required to conduct a live Webcast, to be used later as a guideline for its best use.
- 4) Reduce time spent during video post-production, thereby improving product turn-around and its availability on-line.
- 5) Create technical streaming media presentations for the Division of Research and other operational areas as opportunities arise.
- 6) Evaluate software that can analyze, tabulate and report on media server usage from log-files generated by Windows Media Services®.
- 7) Evaluate video equipment based on the HD-video standard that can improve the quality of Webcasts and streaming video presentations.
- 8) Determine whether there are third party services available that could reduce the cost of streaming media hosting. This item was flagged as optional in the research proposal and depended on whether adequate time was available during the research project.
- 9) Test and assess multicasting via the WAN in order to conserve bandwidth during agency-wide live or pre-recorded broadcasts.

5. WORK PLAN

The proposed work is comprised of a number of tasks including this final research report. They are describes as follows:

5.1 Develop procedures that improve the readability of the presenter's PC-desktop for the remote viewing audience

As described earlier in *Problem Statement (Section 3.1)*, all of the informational content shown during the typical webcast or workshop resides on the presenters' PC-desktop. Training materials like PowerPoint presentations are usually formatted for viewing on the classroom's large projection screen. Unfortunately those viewing remotely via the Internet and watching on a small computer monitor may struggle to clearly see any finely-detailed objects like text or graphics. Some examples of these are:

- the presentation PC mouse cursor (this can and should be used in lieu of a laser pointer since it can be recorded as well)
- undersized fonts and poor-resolution graphics
- the act of scrolling up and down a Web page
- displaying EXCEL spreadsheets, charts and graphs
- Microsoft® WORD® documents with very small fonts (< size 14)

Two solutions were developed to address this task. The first one (5.1.1) is a real-time process that uses a Barco® ImagePRO-HD® video scan converter and the second method (5.1.2) is initiated in the recording studio and finalized later during the video post-production process.

5.1.1 Video Scan converter

Using a video scan converter in the studio has proven to be crucial during webcasts and meetings. It is primarily used for producing clearly-legible videos of presentations that incorporate PowerPoint slideshows or other types of text and graphics. Without a scan converter, one must shoot either the PC-screen or projection-screen with a video camera. This technique doesn't yield good results for many reasons including screen reflection and glare and is complicated by the ambient room lighting. The scan converter is used to electronically transform the PC-desktop into a HD-SDI digital video signal that in turn connects to a video mixer.

PCs typically output video via a VGA, DVI, or HDMI graphics adapter that connects to a display monitor and or projector. (*Please*

note that the HDMI video level is comparable to that of DVI, minus the audio signal. The DVI signal over VGA was chosen as it results in a sharper image). The scan converter can also be used to zoom-in to whatever is being displayed on the PC-desktop via a control knob located on the converter's front panel or remotely via an rs232 interface. The scan converter was housed in the lectern at the front of the room but controlled from the back of the room. A local vendor provided the engineering, systems integration and software-programming for controlling the scan converter using a Crestron® touch-panel display. (Refer to Appendix-A1.1 for the wiring diagram). The following [video](#)^{*} link illustrates how this equipment works. The scan converter (~\$8,000), Crestron hardware, engineering and integration (~\$9,500) were costly but have proven to be reliable and effective when needed. At the time of this writing, there are now more affordable choices available for scan converters.

Figure 1 provides a simplified overview of how the hardware is interconnected. The presentation PC utilizes a dual graphics card whereby one output connects to the scan converter's **DVI** loop-thru input. The converter's **SDI**-output was connected to an SDI-HD level input (#4) of the video mixer. The dual graphics card's other output connects to a video projector located in the studio.

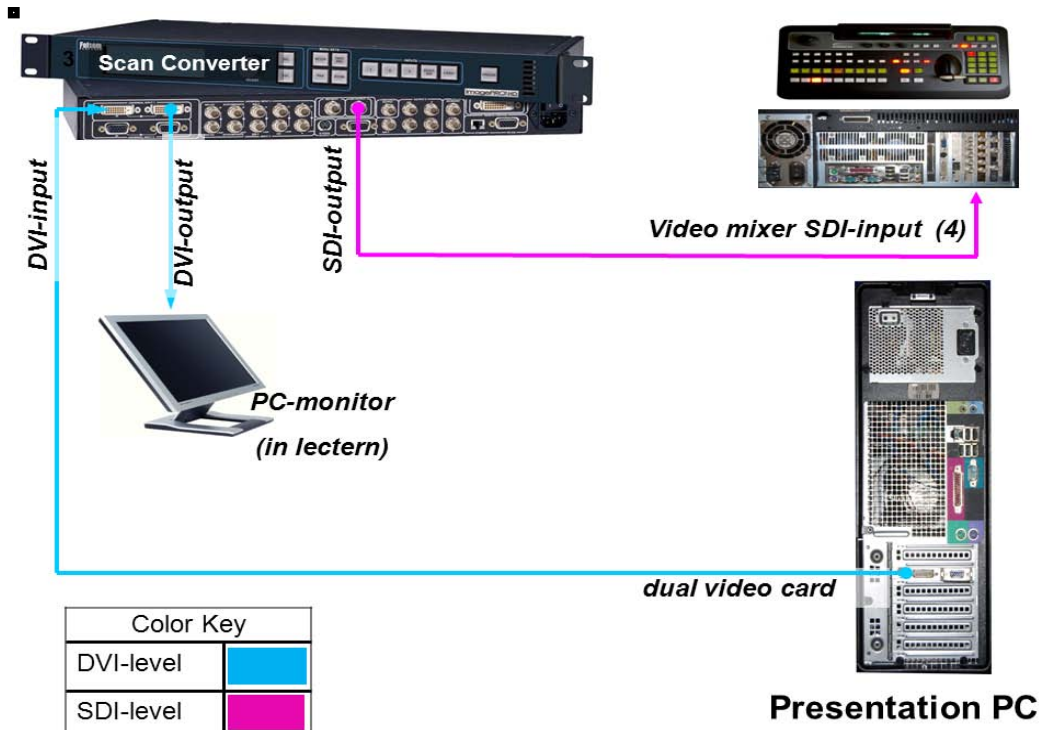


FIGURE 1 Scan Converter used for Acquiring the PC-Desktop as Video

5.1.2 Screen capture recording software

The second solution that was developed in order to improve the readability of PowerPoint presentations utilizes screen capture and recording software such as TechSmith's® Camtasia Studio®. This was installed on the PC located in the lectern. Before the recording session actually begins, the attached mic level would be checked and adjusted. Then the "record button" can be pushed. The application will record everything that is displayed on the PC-desktop such as PowerPoint® slideshows, Web pages, and Word® documents along with the presenters' narrative. Even the mouse cursor can be recorded, especially if it is being used like a laser pointer. Once the presentation concludes, Camtasia can export the recording as a digital file in any number of video/audio formats. This can take several hours to accomplish but yields an excellent quality product that can be merged in post-production along with a videotaped "talking head" of the speaker. Adobe® Premiere Pro® can be used to layer one video track over the other using a chroma-key effect. Here is an example of what this type of [video](#)^{xi} looks like.

5.2. Evaluate technologies and develop procedures that reduce labor-costs associated with webcasting

As described earlier in Problem Statement (*Section 3.2*), webcasts started-out being a labor intensive endeavor because they required the services of six people to "cover" a meeting. Both cameras and mics needed to be setup and then interconnected to recording equipment. Then there was breakdown of the equipment afterwards.

The webcasting team had been comprised of the following functions and duties:

- Director-coordinates with cameramen and mixes video program
- Sound Engineer-maintains volume levels for Webcast audience
- Podium Cameraman-focuses on presenter at lectern
- Front Audience Cameraman-focuses on audience participants
- Rear-View Cameraman- wide view of room from back
- Streaming Media Specialist-establishes upstream media server connection and monitors actual downstream Webcast

Work Task Section 5.2.1 and 5.2.2 provides additional details about the robotic cameras and the microphone Automixer.

5.2.1 Wall-mounted robotic HD-video cameras

Early-on in the research project, three tripod-mounted cameras were utilized for recording presentations and conducting webcasts. One camera would be locked onto the lectern up-front while another provided a wide-angle view from the back of the room as it pointed forward. The third camera was situated at the front of the room and pointed back towards the audience. Figure 2 shows where these video cameras and their respective operators were deployed.



FIGURE 2 Tripod-mounted Cameras with their Respective Operators

Figure 3 shows the HD-robotic cameras that replaced the three tripod-mounted cameras and their operators. Only one person is required to control them now. In addition to being more efficient, the wall-mounted cameras are far-less imposing on classroom attendees who are barely aware of their presence.



FIGURE 3 Robotic HD-cameras Shown Mounted on the Wall

Each of the three robotic cameras can be assigned 16 individual preset positions, providing seamless room coverage when used during even well-attended meetings. The joystick can control up to 7 individual cameras and is shown in Figure 4.



FIGURE 4 Remote Video Camera Joystick Controller

5.2.2 Automate the microphone selection process

When workshops are held in the Rocky Hill Central Lab's large conference room, seating is limited to 40 people "classroom style" or about 30 when configured in a "U" shape for larger meetings. Microphones (mics) need to be strategically placed so that every word uttered is clearly recorded and or broadcast. During the earlier research project, a more traditional audio mixer/equalizer was used to select or mute whoever was or wasn't speaking. It had dozens of controls and switches which required the finesse of a disc jockey to successfully operate it (Figure 5A). This unit was subsequently replaced with two Shure® SCM810® eight-input Automixers (Figure 5B). Once the initial sound levels are preset, it can function somewhat autonomously but may require adjusting for each new presenter, depending on their individual speaking styles.



FIGURE 5 Audio Mixer Comparison

Each Automixer can control up to eight mics and one auxiliary (AUX) input. Each mic input level is switch-configurable as mic, line, or phantom powered. The AUX is an unbalanced input that can provide background music from DVD decks etc. The Automixer works by always selecting the loudest mic signal while muting all the others. Four hanging mics are suspended from the ceiling and can serve as backup, should they be needed during the session. A hardwired mic is also located in the lectern up-front so that presenters don't always have to wear a wireless lavalier mic. This works well unless they walk around and stray from the lectern but the hanging mics cover any gaps in audio coverage. Refer to Appendix 10.4 for wiring diagrams.

5.3 Evaluate hardware and develop procedures that improve productivity when undertaking video post-production

Section 5.3.1 addresses the first of two issues that were identified in Problem Statement *Section 3.3* by providing some alternatives for using videotapes to archive meetings and workshops. *Section 5.3.2* addresses the second issue which is to improve the performance of the non-linear-editing workstation (NLE).

5.3.1 Identify alternate device to replace videotape deck

Throughout the earlier related research study (SPR-2231), an S-VHS tapedeck had been used for recording video of meetings and webcasts. The resulting source tapes served as the archive and are utilized later with the NLE; the workhorse used to capture and digitize from the videotapes. A sixty minute videotape requires one full hour to be ingested and the actual editing process can't begin until this occurs. *Section 5.3.1.1 through 5.3.1.3* describe three ways to encode video/audio in real-time without using videotapes.

5.3.1.1 Portable digital video recorder

The first device tested for supplanting videotape was the Focus Enhancements© FS-4¹. It is a firewire-compatible device that connects to any compatible video camera. It captures and stores the video on its internal hard-drive, providing a direct-to-edit (DTE®) capability later when connected to the NLE. It simultaneously encodes the video into one of the more commonly-used digital video formats while recording. The encoded video file can be transferred over later to the editing workstation via firewire. This provides almost instant access to the information instead of having to replay it from the device in real-time and recapture it into the NLE.



FIGURE 6 Focus Enhancements© FS-4®

¹ The company discontinued the FS-4 product line and replaced it with a new line of related products

5.3.1.2 PC-based digital video capture card

A PC with an HD-SDI video capture card was employed as the second solution for replacing videotape recorders. A Viewcast© Osprey 700© HD video capture card was installed into a fairly robust computer running Microsoft Windows Media Encoder² (WME) 9 Series software. This application is used to control the Osprey card's various encoding parameters such as video and audio source, output file, compression and video size. Figure 7 has been simplified to show only the SDI video signal (no audio) exiting the PC-based video mixer and feeding into the encoding-PCs' Osprey video capture card.

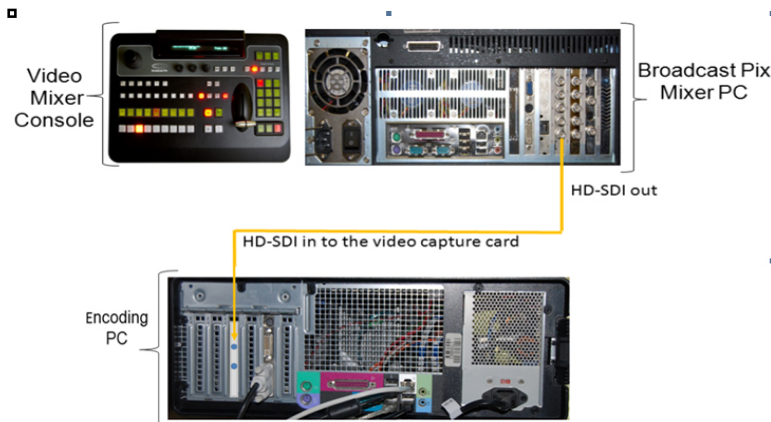


FIGURE 7 PC and Video Capture Card used as a Digital Video Encoder

5.3.1.3 Portable video encoding/webcasting appliance

Another device that was evaluated for replacing videotape was a video encoding/broadcasting appliance. The DigitalRapids© Touchstream® encoder shown in Figure 8 has an integrated video monitor with touch-screen panel and video capture card/internal hard-drive for storage. It is available in both SD and HD models and can be used for webcasts as well as for recording.



FIGURE 8 DigitalRapids© Touchstream® Encoder

² Microsoft no longer supports WME. It was replaced with a new product called Microsoft Expression® Encoder

5.3.2 Non-linear editing workstation

This Work Task identifies PC-hardware, application and operating system (OS) software that can be used to improve efficiency during *video editing, rendering and encoding*. The aforementioned procedures are accomplished on a non-linear editing workstation during video post-production.

Two of the most popular software applications used for video-editing are Apple© Final Cut Pro® and Adobe© Premiere Pro CS5.5® but this project primarily used Premiere because it is relatively easy to learn. Once editing of the presentation has concluded, video transitions and other effects must be applied to each frame of video in a process called rendering. Full-motion video is typically comprised of thirty individual images per second of content but this research project uses a 15 frame per second (fps) setting in order to conserve network bandwidth and to reduce the media servers' data storage requirements.

Back in 2001 during the earlier related research project (SPR-2231), standard definition video cameras were used. The streaming videos that were produced on the NLE were initially formatted at 352 x 240 pixels but as network performance and PC-hardware improved, this was increased to 640 x 480 and then 720 x 480 pixels by project end in 2005. We presently use three wall-mounted HD-cameras that are providing a 1920 X 1080 native pixel size so a more robust operating system was installed in the NLE workstation along with faster CPUs and more memory as listed in Table 1.

TABLE 1 Minimum specification for non-linear editing workstation

Operating System(OS)	Windows 7 (64-bit OS)
CPU	Two Dual-core Intel Xeon, 5160 @ 3 GHz
RAM	32 GB DDR3 Memory (<i>depending on motherboard</i>)
Primary Hard drive (hd) SATA	250 GB Primary hd, 250 GB secondary hd.
Secondary Hard drive	One Terabyte (need not be RAID if backed up)
Dual-Display Video Graphic Adapter	CUDA®-compatible (>2 GB graphic memory DDR-3) (requires Adobe Premiere 5.5 or better)
Blu-ray drive	25-50 GB capacity (for archiving projects)

5.4 Evaluate multicasting on WAN-based Windows media server located at ConnDOT's Data Center in Newington, CT

Execution of this work task provided the means to test and evaluate multicasting which was described earlier in Problem Statement 3.4. Preliminary research determined that the Internet is NOT multicast-capable so this section only pertains to the WAN-based media server.

Two staff members from the Office of Information Systems were invited and accepted an opportunity to attend a 1/2 day training session which was given by ADNET; a local IT-training company on July 8th, 2010. It was held at the DOT Training Center's computer lab in Newington, CT. The next two paragraphs describe the test as follows:

A virtual machine was used as the server and ran the *Windows Server 2008 Enterprise* OS. A new multicast publishing-point was configured on the server using HTTP protocol. The goal of this test was to determine whether streaming video bandwidth consumption on the WAN could be effectively reduced whenever a broadcast is being simultaneously accessed and viewed by multiple viewers/workstations.

The computer lab's local router switch was assigned a multicast IP-address. A pre-recorded WMV-file was then placed on another computer lab PC and this video served as the source for the test. The WMV-file was then referenced by and then *pulled* into the server. Then the video was simultaneously accessed and viewed via a hyperlink by two other lab PCs using Windows Media Player. The media server's status-screen reported zero (0) users/bandwidth. According to ADNET's trainer Mark Thompson, "this confirms that multicasting was both enabled and functioning properly". As a side note, if unicasting was still being used, the server's status-screen would have reported that two-users were connected and viewing the same video and not zero users.

5.5 Install a Windows Media server at a remote District Office and evaluate multicasting via the wide-area-network

This work task was included in the initial research proposal whereby a new Windows Media server was to be procured and deployed at one of CONNDOT's more remote District offices. The OS was to be the Enterprise version of Microsoft© Windows Server 2008®. Extensive load testing was to have been undertaken once it was up and running. Unfortunately, ongoing budgetary constraints in Connecticut government prohibited CONNDOT's purchasing authority from procuring the required server. As a consequence, this task could not be acted

upon. At the time of this writing however, there is more than sufficient need and justification for CONNDOT's IT-office to move forward with this effort.

5.6 Conduct Webcasts for FHWA and others as required while documenting hardware and procedures used to accomplish it

Towards the middle of an earlier related study (SPR-2231), CONNDOT conducted its first webcast; a 4 1/2 day event that was held off-site. While remote-user satisfaction was generally seen as positive, it was anticipated that employing new cameras and equipment based on the emerging HD-video standard would only improve the quality of future webcasts. To that end, this study (SPR-2254) provided the means to replace the older (SD) video equipment with that of HD. After the new HD equipment was integrated into the studio, *Work Task 5.6* provided the opportunity for CONNDOT to assist FHWA with hosting webcasts, workshops and recording presentations for FHWA-sponsored events. The webcasts were well-attended on-line by a remote-viewing audience from across the country. Most of these were conducted from the Rocky Hill Central Lab's studio and a video link to each one is provided in Table 2.

TABLE 2 FHWA-sponsored workshops that were hosted by CONNDOT

Event title and video-link	Event date
1) FHWA - 2006 Traffic Data Workshop/Webcast ^{xii}	09-18-2006
2) FHWA - 2006 Climatic Inputs Workshop/Webcast ^{xiii}	09-19-2006
3) FHWA - 2006 Use of PMS Data Workshop and Webcast ^{xiv}	09-20-2006
4) Workshop on Best Practices for Concrete Pavements ^{xv}	04-29 & 04-30, 2009
5) Special Mixture Design Considerations and Methods for Warm Mix Asphalt ^{xvi}	07-26-2011
6) FHWA Northeastern U.S. Roundabout Peer Exchange ^{xvii}	07-7 & 07-8, 2010
7) Best Practices Workshop/Webcast for Constructing and Specifying HMA Longitudinal Joints ^{xviii}	03-21-2012

In addition to the aforementioned FHWA-sponsored events, CONNDOT hosted a number of workshops and meetings for the Northeast Asphalt User Producer Group (NEAUPG). Most of these were broadcast live and viewed by interested parties located throughout New England. Video links for each are listed in Table 3.

TABLE 3 NEAUPG-sponsored workshops that were hosted by CONNDOT

Event title and video-link	Event date
1) 2009 Steering Committee Meeting and Webcast ^{xxix}	03-31-2009
2) Understanding and Implementing the Multi Stress Creep Recovery Test Workshop and Webcast ^{xxx}	09-22-2009
3) 2010 Steering Committee Meeting and Webcast ^{xxxi}	03-23-2010
4) A Webcast on Warm Mix Asphalt ^{xxxi}	09-01-2010
5) 2011 Steering Committee Meeting and Webcast ^{xxiii}	04-19-2011
8) Manual for Design of Hot Mix Asphalt ^{xxiv}	10-25-2011
9) 2012 NEAUPG Steering Committee Meeting ^{xxv}	03-26-2012

The Connecticut Academy of Science and Engineering (CASE) initially used the Research studio for only recording their meetings. At their request, CONNDOT also provided a call-in capability (teleconference) for those unable to attend in person so they could follow along on the phone as best they could. Currently, CASE relies heavily on webcasting with integrated videoconferencing capabilities and the recorded videos become part of the permanent on-line record. Video links for some of these are shown in Table 4 and this [link](#)^{xxvi} lists every event held.

TABLE 4 CASE-sponsored webcasts/meetings that were hosted by CONNDOT

Event title and video-link	Event date
1) CASE CT Workforce Study Committee Meeting ^{xxvii}	02-08-2012
2) CASE CT Workforce Study Committee Meeting ^{xxviii}	03-14-2012
3) CASE CT Workforce Study Committee Meeting ^{xxix}	04-20-2012
4) CASE CT Workforce Study Committee Meeting ^{xxx}	05-10-2012
5) CASE CT Workforce Study Committee Meeting ^{xxxi}	06-13-2012
6) CASE Workforce Study Committee Meeting ^{xxxii}	07-18-2012
7) CASE Workforce Study Committee Meeting ^{xxxiii}	08-08-2012
8) Benchmarking CT's Transportation Infrastructure Capital Program with Other States ^{xxxiv}	09-19-2012
9) Economic Impact of Transportation Projects ^{xxxv}	10-11-2012
10) Connecticut Disparity Study ^{xxxvi}	10-17-2012
11) CASE Workforce Study Committee Meeting ^{xxxvii}	10-23-2012

5.7 Produce and publish technical streaming-videos for both ongoing and completed research projects

At the start of this research project Manager Mr. James Sime (now retired), suggested that his engineering staff supplement their written final research reports with technical streaming videos and that they budget monies for this in their projects. Their final research report's *executive summary section* can serve as the script for this production effort and the resulting product can be effective for gaining insight into CONNDOT's research program. Table 5 has a few examples of these which can be viewed from the video links provided within. This [link^{xxxviii}](#) will bring up the index for every Research-related video.

TABLE 5 CONNDOT Research Program videos

Subject title and video-link	Event date
1) Investigation of Low Strength Concrete Test Results^{xxxix}	2007
2) About ConnDOT's Pavement Friction Testing and Safety Evaluation Program^{xl}	2008
3) Automated Stop Sign Identification System^{xli}	2008
4) Field Evaluation of Concrete Containing DSS^{xlii}	2008
5) About New Product Evaluation Procedures^{xliii}	2008
6) Traffic Data Research Considerations from a State Researcher's Perspective^{xliiv}	2010

The following example illustrates how streaming videos are now being used by some of ConnDOT's Research Engineers to complement their final research reports:

A colleague by the name of Mr. John Henault published a research paper in 2011 titled "[Enhancements to ConnDOT's Pavement Friction Testing Program](#)". Mr. Henault made a presentation which was subsequently recorded and listed in his final research report as a research project deliverable.

5.8 Identify software for tabulating media server usage

This work task addresses *Problem Statement 3.5* by identifying off-the-shelf logfile analysis software. It was needed in order to quantify how often the two media servers were being accessed as well

as for determining what was being viewed. Flowerfire's© Sawmill-8® was installed on the Web-based server which runs the *Windows Server 2003* operating system. *Windows Media Services client logging* must be enabled in order to generate the requisite log-files. This [video-link^{xlv}](#) illustrates the steps required to access the server log-files and also shows how to configure the Sawmill software for making queries and generating reports. It discusses drive letter assignment, folder structure, video location, and also describes the log-file structure with its various data-fields. This [video-link^{xlvi}](#) shows the server desktop. It illustrates how to log into the Sawmill application and explains how to create a new profile via the *administrator tab*. Log-files are currently being archived to the server's data drive which has **E:\video\logfiles\wms\mediapoint** as its path. The two aforementioned videos also provide an overview of the configuration and report tabs which are briefly touched upon.

The Sawmill software proved to be very reliable and was also easy to use. Here is a breakdown of the types of data that is being tabulated in the following three tables.

- **VISITORS** - The first time an individual requests a video from the server; their unique IP-address is recorded as a visitor.
- **TITLES** - There is large quantity of video clips contained within the media libraries. These can be tabulated by querying on unique URLs viewed.
- **GIGABYTES SERVED** - This represents how much data is being delivered from the server to the client and is referred to as "traffic" and relates to how much time was spent viewing any one video.
- **EVENTS** - An event is generated when a video is accessed. Events are also triggered by navigating within a given video such as via bookmarks or by dragging the Windows Media Player's scrolling play-head.

The following table was generated from actual log-file data and is being used to summarize Internet-based streaming media server activity for videos that were accessed and viewed by the public between 2006 and 2012.

TABLE 6 Internet-based media server usage generated by the Public

Type of Information Tabulated	2006	2007	2008	2009	2010	2011	2012
Total Public Visitors (Unique IP address)	3227	3303	5980	9589	2608	2191	1926
Total Amount of Unique Titles Watched	304	333	424	557	509	476	547
Total Gigabytes Served	95.59	130.58	146.11	211.53	159.52	238.92	213.75
Total Events Generated for All Videos	13,021	15,161	19,035	22,913	12,094	9,884	10,473

Please note the large increase in usage that occurred during 2008 and 2009, which came as a result of widespread public interest for watching a CT State Police recruitment video that ConnDOT hosted on the media server. This one video received 9,302 events and 6,622 visitors in 2009. Any "hits" from CONNDOT staff were filtered-out when this report was run, as indicated by "Client IP is NOT 159.247.0.209."

The next screenshot (Figure 9) is for the same police video. The left hand column shows that the query was run for [Content] and then [URLs]. The query shows the top-ten most popular videos watched that calendar year. The green line and arrow shows the URL for the aforementioned police video which is on the uppermost line (one).

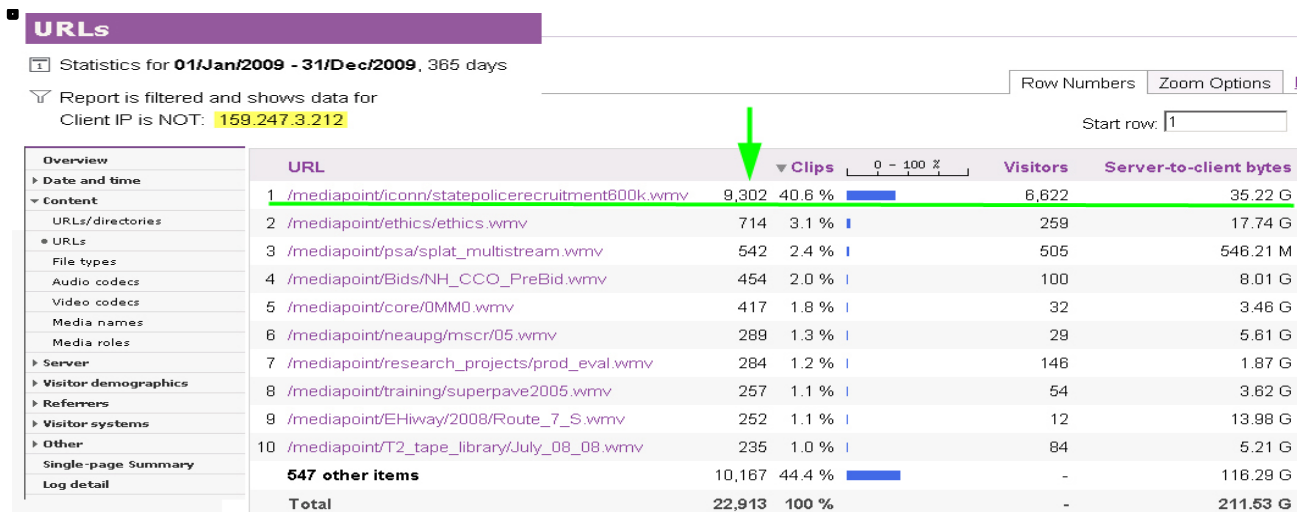


FIGURE 9 Sawmill Report for Determining Most Popular video

The following table provides media server usage summaries for videos that were accessed and viewed by CONNDOT staff from 2006-2012. All CONNDOT network-based PCs access the Internet through a proxy server so queries always return the same IP-address for everyone, regardless of a workstations' actual IP. Please note that the intranet-based media server can track individual workstation IP-addresses.

TABLE 7 Internet-based media server usage generated by CONNDOT Staff

Type of Information Tabulated	2006	2007	2008	2009	2010	2011	2012
CONNDOT Proxy server (same IP address)	1	1	1	1	1	1	1
Total Amount of Unique Titles Watched	279	312	276	716	643	423	511
Total Gigabytes Served	21.39	26.68	71.87	161.36	201.94	137.58	66.63
Total Events generated for All Videos	7,029	11,157	11,804	22,104	26,148	10,086	7,114

The next table contains media server usage summaries for videos that were accessed and viewed by CONNDOT staff from the in-house media server. It became operational in 2004 but CONNDOT Research didn't begin to document the usage on this server until shortly before 2010. The reason this machine was established was to reduce the incidence of video-based traffic coming into CONNDOT from outside, i.e. from the Web-based streaming media server located at Department of Administrative Services (DAS) Bureau of Enterprise Systems and Technology (BEST).

TABLE 8 Intranet-based media server usage generated by CONNDOT Staff

Type of Information Tabulated	2010	2011	2012
Total CONNDOT Visitors (Unique Workstation IP address)	574	585	1382
Total Amount of Unique Titles Watched	227	292	436
Total Gigabytes Served	47.85	69.06	181.21
Total Events Generated for All Videos	3431	5603	10,561

5.9 Evaluate high definition (HD) video and related equipment

It was anticipated that using HD video cameras in-the-field and in the studio would improve the overall quality of the resulting streaming video presentations. A "true" or full HD image is based on 1920 X 1080 pixels. The three wall-mounted robotic HD-cameras in the studio output this 1920 X 1080 pixel signal. This is significantly larger than standard definition (SD) video cameras which have a 720 X 480 pixel count. It was determined that shooting footage with HD-cameras improves the overall video quality (when compared to SD) but encoding and publishing the final videos in full HD resolution was simply not practical because the resulting videos would have to be encoded at much higher bit-rates than was currently being used. If full-HD videos were viewed via the network, their use could impact both the WAN and local PC performance as well. That is why videos continue to be produced at either a 960 X 540 or a 1024 X 768 pixel size and to be encoded at less than one mbps for the majority of CONNDOT's productions and webcasts. The following graphic helps visualize how HD-video relates to other formats that have been used in this research study.

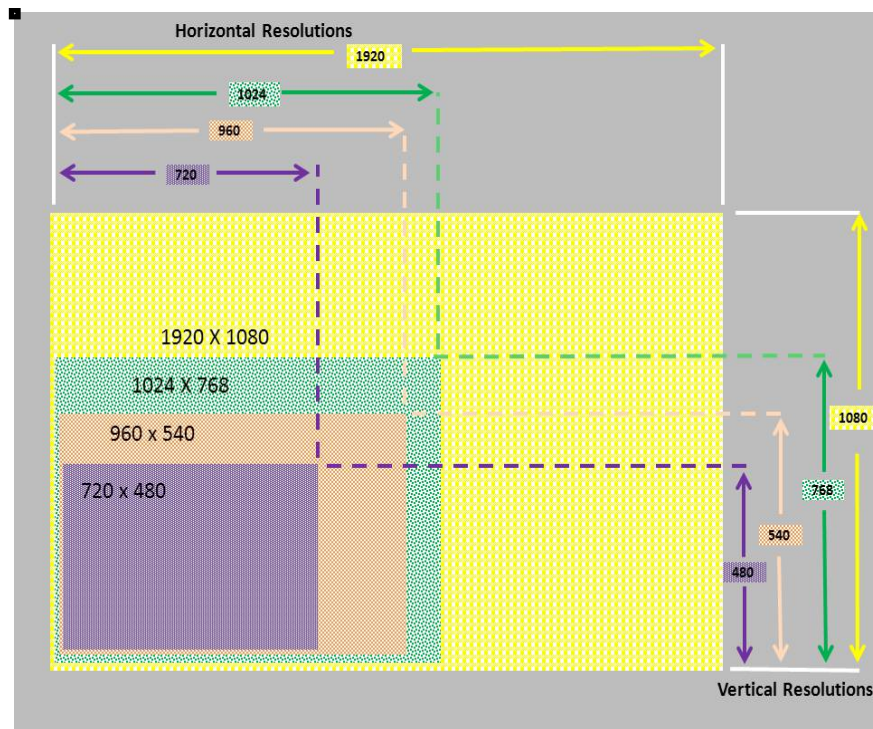


FIGURE 10 Comparison of Various Pixel Sizes used in this Project

The following table provides video links to some examples that show the incremental improvements in video quality that resulted when

SD video was transitioned to HD video cameras and production equipment. Video examples #1 and #2 were produced using SD-compatible equipment and examples #3 and #4 were created using HD-compatible equipment. As previously mentioned, the final video is not encoded at full HD resolutions in order to minimize bandwidth-usage when viewed and delivered across the WAN. The research project adopted a 15 fps rate over that of 29.97 because there is no appreciable loss in image quality. By omitting half of the total video frames, the overall image quality is improved for the remaining frames and the video files size (in megabytes) is cut in half. A videos' file-size (in MB) only becomes important when determining server hard-drive data-storage.

TABLE 9 Comparing quality between SD and HD content

Video Examples	Aspect-ratio	Pixel-size	Bit-rate	Frame-rate
1) Video-link ^{xlvii}	4:3	320 X 540	273 kbps	15 fps
2) Video-link ^{xlviii}	3:2	720 X 480	848 kbps	15 fps
3) video link ^{xlix}	1.24:1	1024 X 768	848 kbps	15 fps
4) video link ¹	16:9	960 X 540	964 kbps	29.97 fps

5.10 Resolve audio encoding issues originating in the studio.

As described in Problem Statement 3.7, there were two audio-related issues that arose in the studio of conference room 122 during the earlier research study (*SPR-2231*). The video mixer used there that can select between three different video cameras during meetings, webcasts, and workshops. Each wall-mounted unit can acquire a variety of different shots and for this reason, cannot be associated with just one stationary microphone. The video mixer, also known as a video switcher, has the added-capability to switch microphones along with a video image as well. However, audio and video inputs are connected to the device and once associated, cannot be easily reassigned on-the-fly. For this reason a separate audio switching device, described in Section 5.2.2 was initially used. This audio mixer-board (Figure 5-A) was replaced later with the Shure Automixer (Figure 5-B) in order to simplify the microphone selection process. Sections 5.10.1 and 5.10.2 describe these audio-issues in more detail and provide solutions for both.

5.10.1 Investigate audio over-modulation/clipping issue.

The following [video](#)¹¹ illustrates the over-modulation or clipping issue that apparently resulted from using an analog PC soundcard in the studio. Once the video begins to play the problem will become apparent at about the four (4) second mark when the presenter says "the topics we will cover". This noise occurred whenever the Windows Media Encoder's *Audio Monitoring Panel* registers an excessive input level on its audio-input sound-level meter, located on the left side of Figure 12 below (see red arrow).

□

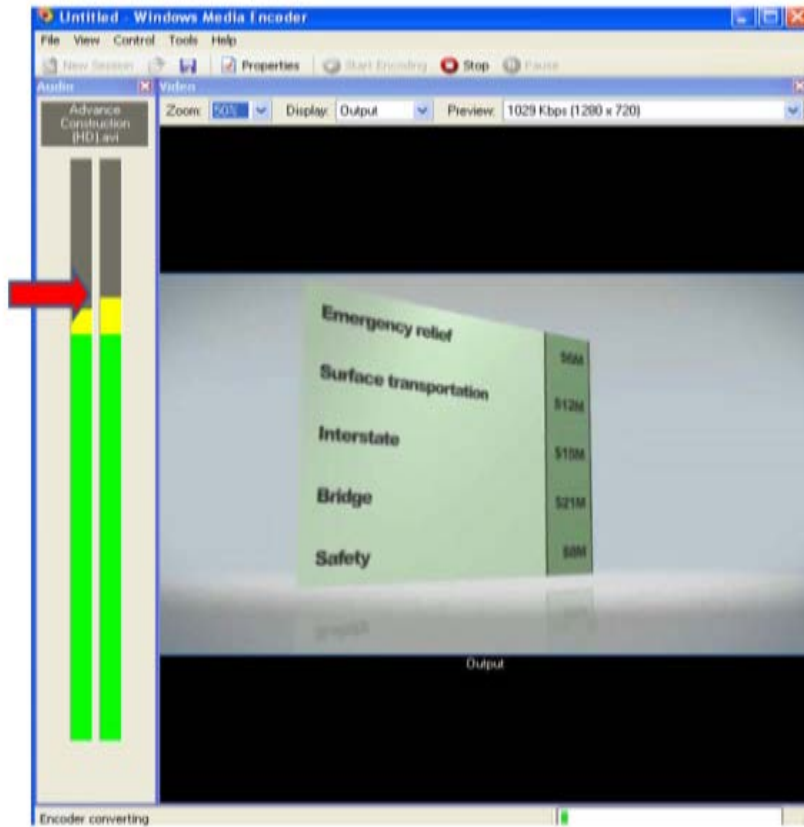


FIGURE 12 Windows Media Encoder Audio Monitor Panel

Even when the audio-input sound-level was kept well-below the yellow region, the noise issue would sometimes occur in the digitally-encoded videos that were recorded in the studio. In order to ensure better audio quality in the future, use of the analog-audio PC soundcard was discontinued and in its place was used an *AJA HD10AMA Audio Embedder*.

Referring to Figure 13 below, the AJA-device takes the **analog audio signal** coming from the Shure Automixer and embeds it digitally as SMPTE 272M (SD) or SMPTE 299M (HD) within the **SDI video signal** **once** it exits the Broadcast Pix video-mixer. The **embedded audio within the video** signal then exits the AJA-device and enters the encoding PC's Viewcast Osprey-700 video capture card via its bnc input connector.

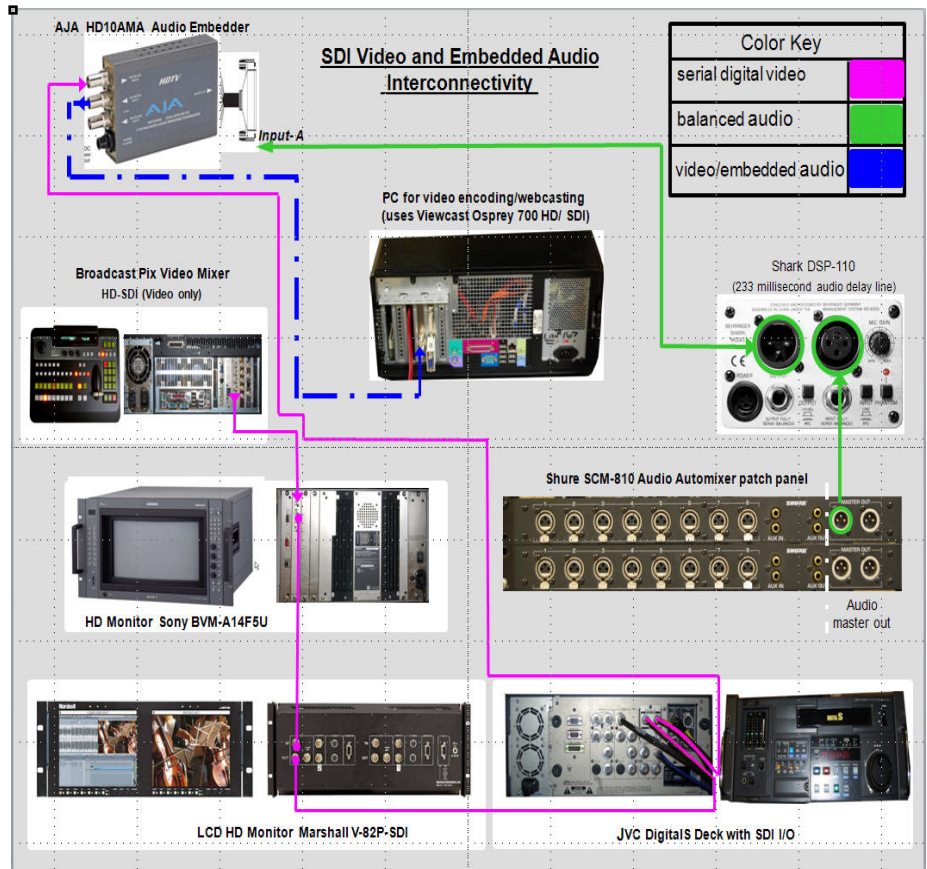


FIGURE 13 Embedding Audio within a SDI-Video Signal

5.10.2 Investigate lip synchronization issue.

This task addressed the lip sync issue described in Problem Statement 3.7. In order to analyze this further, the WMV-files in

question were imported into Adobe Premiere Pro and placed on the non-linear editor's timeline. Then the audio track was unlinked from the video track. Doing this provides the ability to offset the video (image) from the audio (voice) using arbitrary values based on video frames. Each frame represents about 1/30th of a second. It was subsequently determined that the video image was lagging behind the voice by about seven (7) video-frames. This turned out to be about a 233 milliseconds (ms) difference (see Figure 13). A search of the Internet revealed that this type of problem is a common one because there are a number of off-the-shelf devices specifically made to address this problem. They are referred to as *audio delay-lines* and they run the gamut from \$100 to more than \$1000.

The research project procured the \$100 unit which was then installed in the studio where it was connected between the Automixer's **audio output** (see Figure 13) and the AJA Audio Embedder. The audio delay line which is manufactured by Behringer© provides a few other features as well but it was only used for retarding the audio signal in this study. This device proved to be a viable and economical solution to the lip-sync problem and all subsequent recordings now have proper audio/video synchronization.



FIGURE 14 Audio delay line

5.11 Conduct presentations for Federal/State personnel

As this research project's title implies, it was of paramount importance to advance the use of streaming video here at the agency. It was initially envisioned that the best way to accomplish this aim was through formal presentations given in front of large groups. However, the most effective way to garner new interest was obtained

from working one-on-one when approached by interested parties. In 2006, 2007, and 2009, an overview of the ongoing research was presented to each of the *Transportation Research Board's* Annual Correlation Visitors. During the execution of *Work Task 5.11*, there was one formal presentation made and recorded at CONNDOT's Newington Administration building (HQ) in 2010 for the State Design Section. It can be viewed from the following [video link](#)^{lii}.

6. CONCLUSIONS

Prior to 2001 CONNDOT's website was devoid of any video-based content. Back then, even sharing videotaped information with colleagues was an annoyance as it required setting-up and then sitting down in front of a TV-monitor and VCR. Today, as a result of this successful streaming video initiative, CONNDOT staff now have quick and easy-access to video-based information from any PC on the network. The following paragraph is one small example of what can be done now and how convenient and economical this service can be when pressed into service.

Early in 2011, CONNDOT Research was asked to collect video out on the Baldwin Bridge (I-95) in Old Saybrook because District 2 engineers were being told that the snow plows on their trucks were catching on the pavement expansion bridge-joints. This was causing the plow to jump fairly-high into the air. In addition, joint material was being sheared-off, creating a potential roadway hazard. With this information in hand, video cameras were set up to capture the plow trucks as they simulated their passes across the bridge deck. Here is the [video-link](#)^{liii} to that same footage. Afterwards, it was easy to slow-down the video in post-production and to put it up on the media servers for sharing with the engineers. All that was needed then was to email them the aforementioned link which they could then forward on to others for review and comment. Clearly this is a much better mechanism than manually distributing videotapes or even CDs and DVDs.

At the time of this writing, two dedicated streaming media servers continue to provide hundreds of hours-worth of transportation-related topics and the usage is expanding. In addition, the Web-based media server continues to be routinely used to broadcast videos of live meetings, workshops and study committees and these are being viewed from all across the country. While there are operational costs associated with conducting webcasts and hosting of the Web-based media server, these are easily offset by the many benefits that are derived from having it readily-available.

One well-trained individual can master ALL of the studio equipment during a webcast event, but this really depends on the type of venue being covered. One person can manage the studio for closed-door training/recording sessions. They can also manage doing small workshops and meetings alone as well. For larger meetings, two people are required because the remote controlled cameras constantly need to be repositioned, depending on who is speaking at the moment and microphone levels may need small adjustments as this occurs as well. Three people are required when very large meetings are being broadcast along with videoconferencing and teleconferencing activities. One might argue whether it is really cost-effective to invest this much labor for one event but keep in mind that if properly leveraged in the future, streaming video technologies such as multicasting and video-on-demand will save thousands of dollars by reducing travel-time, vehicle maintenance and fuel costs. This is only the "tip-of-the iceberg" as far as savings are concerned.

Over the years, other Connecticut State Agencies have expressed their interest for acquiring and using streaming video in order to develop better services for its constituent base. One of these was the *Department of Developmental Services, Director of Communications*, Ms. Joan Barnish in 2011. She wanted to develop her agencies' own streaming video production capabilities. To that end, she recorded a presentation in the Rocky Hill studio after giving it earlier at the State Capitol in front of the *Health and Human Services Commissioners*. In the [video](#)^{liv} she refers to CONNDOT's Division of Research and many successes in this specialized area. Later in 2012, Ms. Barnish was provided with a wish-list of video production equipment, as well as providing her with contact information on how to qualify for grant money that was available from the Department of Public Utility Control (DPUC).

Now that this federally-funded research project has concluded, it is important to recognize that the vast majority of capital expenditures required to support streaming video here have already been addressed. Well over a million dollars has been invested in both its research and development. Because this was initiated over a decade ago, much of the video-equipment is now reaching the end of its service life-span, though it continues to perform reliably and could be replaced a little at a time in future budgets. While streaming video has been officially adopted and implemented, its continuation now rests in the capable hands of IT-administrators who will decide what role it will play at CONNDOT in the future. In the interim, entities like the *Connecticut Academy of Science and Engineering* and others will continue to rely on this agency for doing what it does so well. Please peruse the following two pages that provide letters submitted from Mr. Richard Strauss, the Executive

Director of CASE and from Ms. Donna Shea, the Program Director of the Connecticut Transportation Institute.



CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

December 12, 2012

To: Drew Coleman
Division of Research, ConnDOT

The Connecticut Academy of Science and Engineering (CASE) is a non-profit institution patterned after the National Academy of Sciences to identify and study issues and technological advancements that are or should be of concern to the state of Connecticut. It was founded in 1976 by a Special Act of the Connecticut General Assembly.

As Executive Director of the Academy, I would like to acknowledge the Connecticut Department of Transportation's (ConnDOT) Division of Research for its undertaking of SPR-2254 titled "Advancing the Use of Streaming Media and Digital Media Technologies at ConnDOT". Newly-supported by ConnDOT's Office of Information Systems (OIS) in 2012, this has become an invaluable service that continues to augment our various studies, conducted on behalf of the Connecticut General Assembly and state agencies such as ConnDOT. Webcasting extends the Academy's mission by allowing for the active involvement of state and nationally-recognized study committee members and presenters. The streaming video version of these meetings provides for live viewing, as well as being available 24/7 as a permanent on-line resource accessed through links that appear in our official publications for the General Assembly and state agencies.

Between 2011 and 2012, CASE Committee Meetings served as a test-bed while OIS strived to merge complimentary technologies like teleconferencing, videoconferencing and webcasting into a world-class broadcasting service. This has paid big dividends as it now allows the Academy to attract and enlist prominent guest speakers from any location in the world.

Studies conducted this year included speakers/presenters from California, Canada, Colorado, Georgia, Hawaii, Illinois, Maine, Massachusetts, Minnesota, Missouri, New Jersey, New York, Pennsylvania, Texas, Vermont, Washington, Washington D.C., and West Virginia. Agency leadership from the Departments of Economic and Community Development, Education, Labor, Transportation, the Office of Workforce Competitiveness, and the Board of Regents for Higher Education also provided presentations to CASE study committees.

The webcasting services supported the following studies conducted in 2012:

- CT Academy – Capital Benchmarking (ConnDOT)
- CT Academy – Truck Safety (ConnDOT)
- CT Academy - Economic Value of Transportation Projects (ConnDOT)
- CT Academy – Health Impact Assessments (CT General Assembly)
- CT Academy – CT Disparity Study (CT General Assembly)
- CT Academy – Workforce Alignment (CT General Assembly)

Best regards,

Richard H. Strauss
Executive Director

805 Brook Street, Building 4-CERC, Rocky Hill, Connecticut 06067-3405 • 860-571-7143 • email: acad@ctcase.org





January 2, 2013

Mr. Drew Coleman
Connecticut Department of Transportation

Dear Mr. Coleman:

CTDOT's streaming video initiative has gone a long way in helping the CT Technology Transfer Center reach those across the state who cannot attend live training sessions with important information on transportation issues. We regularly point to these resources when asked by towns and cities for educational resources on road safety and legal traffic authority issues. Busy first selectmen can use the bookmarked videos we produce to break a full day course into a series of lunch and learn sessions in their offices; getting the information they need without having to block out an entire day for training. They are also helpful as a refresher training tool that municipalities can use to reinforce lessons learned during face-to-face training opportunities. They can access them prior to starting new projects or seasonal projects to remind their staff of important safety or operational messages. We are developing resources that are very helpful tools the CTDOT and the T2 Center can use to reach local transportation professionals with important, up-to-date information on safety and regulatory information.

The Technology Transfer Center is one of 58 Local and Tribal Technical Assistance Programs across the United States and Puerto Rico, we have been able to share links to these videos with colleagues in other centers providing a multiplier effect to the benefit of our collaboration.

Without the support of the CTDOT streaming video project, the Technology Transfer Center would never have had the resources available to undertake these important projects. We are very excited about the prospect of continuing this partnership and expanding our streaming video library.

Sincerely yours,

A handwritten signature in black ink, appearing to read 'Donna M. Shea'.

Donna M. Shea
Director
Technology Transfer Center
University of Connecticut

7. RECOMMENDATIONS

A) Retain the use of both dedicated streaming media servers

At the time of this writing, billions of video clips can be viewed from across the Internet. Millions of these reside on and stream from relatively new (*circa 2005*) video sharing websites like YouTube© and Vimeo©. In order to avoid costs associated with media hosting, some state have elected to post their agencies' valuable videos up on these free sites. Not surprisingly though, the vast majority of the content found there is not related to Transportation or even work-related but instead, is there solely for entertainment value. As a consequence, Information Technology (IT) departments will often block access to these types of sites, making them unavailable to the majority of their employees. For this and other reasons, it remains paramount today that CONNDOT retains its current streaming video-on-demand (Vod) capabilities for both WAN and Internet. The project PI was the designated "gatekeeper" for all streaming media activity for over a decade. This was made possible through a Memorandum of Understanding with the *Department of Information Technologies* (now BEST). Because this was groundbreaking work, full administrative privileges were granted for configuring the Web-based media server located at BEST. It is important that future gatekeepers be provided with these same autonomous privileges.

B) Continue to conduct live webcasts in Materials Division conference room 122

CONNDOT began utilizing the Internet-based media server when the *Division of Research* conducted their first-ever webcast in 2004. This was held off-site in Mystic during a [4½ day-long event](#)^{lv}. There were two other webcasts held later that same year from the Rocky Hill Central Lab's Studio. Now fast forward to 2012 when twenty (20) of these events were broadcast live during this same year. It is anticipated that this number will continue to grow due to the travel restrictions and budgetary constraints being imposed on employees and colleagues.

CONNDOT has amassed many years of experience with webcasting during the two related research projects. Much of the improvements that were made over the years came from suggestions from remote viewers located all across the country. The following [video link](#)^{lvi} is from a webcast conducted back in 2005. In the video, then Director of *Research and Materials Testing* Mr. Keith Lane mentions eleven other states that watched remotely via their PC. Having the ability to host webcasts locally was attractive to FHWA, who then sponsored many of the workshops here in Rocky Hill. This meant that

ConnDOT Civil Engineers could have front-row classroom seating, negating their need to travel to another state.

Even today, there are only a very limited number of state agencies locally or nationally with CONNDOT's webcasting expertise. Therefore, it came as no surprise when CONNDOT Research was asked to conduct an upcoming venue for the Department of Administrative Services on January 23rd, 2013. The Office of Information Systems is providing this service at no cost in order to advance the use of this technology in Connecticut state government.

NY was one of the first states to mandate that public meetings be both recorded and broadcast live. Here is the [link](#)^{lvii} to their official website. Then Governor Elliot Spitzer enacted [Executive Order #3](#)^{lviii} which details what criteria must be met by their various agencies, beginning in 2007. If this same mandate was ever enacted in Connecticut, CONNDOT would be one of the few agencies here that could immediately meet this challenge.

C) Begin broadcasting executive messages and directives in-house

Multicasting was investigated during this research study under *Work task 5.4*. It was envisioned that the Newington Data Center's media server could be used for broadcasting executive messages in-house from the Commissioner's office. These could be simultaneously viewed from every network-based PC-desktop in the agency. Another idea was to broadcast from conference rooms A and B whenever they are filled to capacity. Apparently this situation occurs often. If broadcasting was undertaken for these *standing-room only* events, the proceedings could be viewable from any CONNDOT PC via the WAN. .

In 2010, a qualified vendor was brought in to provide multicast training to some of CONNDOT OIS staff. This experiment concluded on a positive note during computer-lab simulations at CONNDOT's Training Center. *Work Task 5.5* then called for purchasing some of the required server hardware using this studies' allocated federal funding. Unfortunately, state matching funds were unable to secured from CONNDOT's purchasing authority. It is strongly recommended that this capability be revisited and developed for the agency to use in the future.

In 2012, Research staff began assisting the Office of Policy and Planning with their Regional Planning Organization (RPO) Coordination meetings. These are typically viewed outside the agency using *Citrix® Goto Meetings®* and by keeping a phone line open in the room. This didn't provide very good audio quality to those on the phone so OIS and the Office of Communications were asked to come-in and improve the audio quality and also record the proceedings as Vod. A recommendation was made that these same RPO meetings could be

broadcast live from now on using the existing video production equipment that is present in conference room A/B and provide the use of the Citrix product for those that still want it.

D) Staff Development trainings

There will be many opportunities in the future for CONNDOT's *Staff Development* to utilize Vod and webcasting if only guest presenters would consent to being recorded. Unfortunately, many speakers are hired from private companies that don't see recording as a good thing since the resulting video could be perceived as diminishing the need for them to come back again in the future. To address this, CONNDOT could optionally provide a dollar amount that would make this more attractive when soliciting guest speakers in the future, thereby permitting us to record their training sessions which would then be placed on the in-house media server for reviewing later by staff.

The Newington Training Center and Training staff provide many hours of classroom instruction to CONNDOT employees and much of this could be recorded for the purpose of review or for absent employees. While there are many good reasons why these events should be attended in person, there are equally good reasons why certain events couldn't be viewable via a live video stream or as Vod at a date and time of one's own choosing. In this day and age, even college credits and degree programs are available via the PC-desktop and this same mechanism could be equally valuable for minimizing in-state travel for this agency. It is recommended that one of the three Training classrooms be equipped with a wall-mounted video camera, a video scan converter, video mixer, microphones and a digital-video encoder. This setup would be permanently installed and used to record training sessions as required. It could be operated by training staff if the "studio" is simply designed and configured. There is some first-generation SD-video equipment leftover from the earlier research project (SPR-2231) that could be pressed into service for this very purpose now.

E) Continue providing staff with free video production and webcasting services in conference rooms A and B and in room 122

Free video production and webcasting services were offered to staff throughout the research project's lifespan. The following screenshot on the next page shows how this was worded on the in-house streaming video library homepage. The Office of Communication's Visual Media Designer *Robert C. Moore*, directed many of the webcasts at the Central Lab's studio room 122 and also recorded a number of Diversity Council and other presentations in conference rooms A/B at CONNDOT's Administration Building (HQ). No webcasts have been conducted thus far from HQ, but rooms A and B have the required WAN

drops for the PC-encoder that would be used to push video out to either media server. It is important to note that other than the author and Mr. Moore, there isn't anyone else at CONNDOT that can provide video-production and webcasting expertise at present.

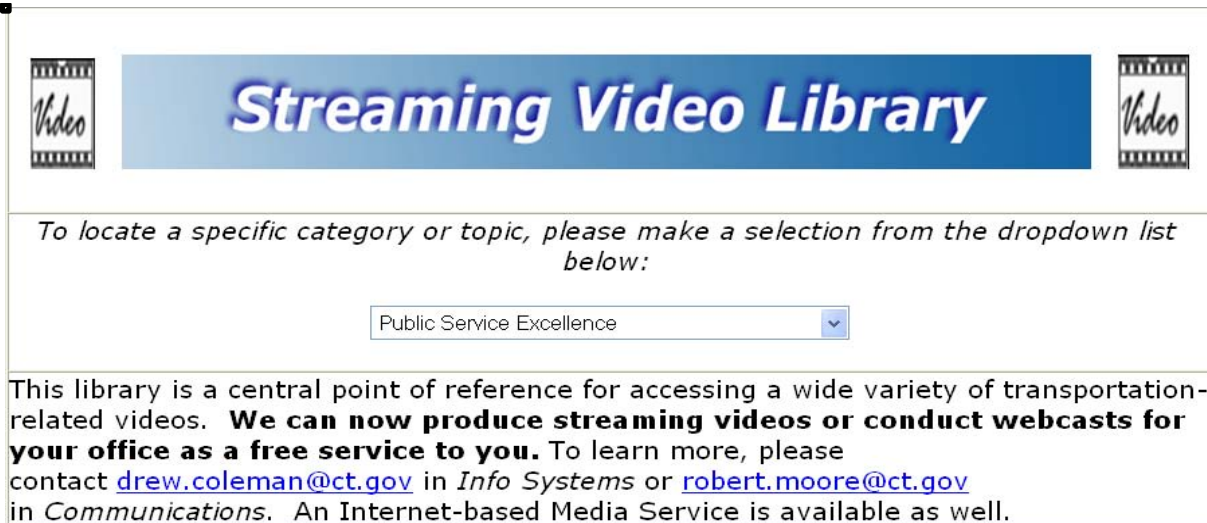


FIGURE 15 Promoting free video production services

It is further recommended that this same level of video-production support be continued or even expanded upon in the near-future. In addition to the Streaming Media Administrator, CONNDOT would benefit from having one full-time video-production specialist specifically for video-editing and webcasting. A relevant class and job-title does exist for this and can be found on the *Department of Administrative Services* (DAS) website. Either the [Media Production Technician](#)^{lix} or the [Visual Media Designer](#)^{lix} series would be appropriate for this type of work.

F) Upgrade video-encoding software and improve webpage design

As previously mentioned, the Windows Media Encoder software is no longer supported by Microsoft. The Expressions Encoder has replaced it and should be utilized in the future for capturing, transcoding and broadcasting of video. At the time of this writing there are known compatibility issues between Expressions (version four) and the Viewcast Osprey 700-HD video capture card but this will most likely be resolved in subsequent driver revisions.

It is recommended that Microsoft Silverlight be investigated for designing new webpage applications that incorporate streaming video. It appears to offer enhanced capabilities as compared to what is being used now but its adoption would require that Silverlight software be installed on every PC in the Department. This may sound

like a difficult task for OIS but similar updates are being routinely done for Adobe Flash.

G) Expand video service to support mobile devices such as smartphones

At the time of this writing it is not clear whether tablets, smartphones, or other cellular devices are able to view ConnDOT's on-line videos. Since they are so widely used, this is an important area in which to expand upon in the future. However, it has been demonstrated that CONNDOT's Windows Media Videos (WMV) can be viewed using a variety of browsers such as Internet Explorer®, Google®-Chrome®, Firefox®, and Safari®. This is accomplished by providing the end-user with a link to the required video plug-in and by "coding" the webpage with the appropriate required HTML-tags. It has also been shown that these same videos can be played on MAC-based Apple computers when their owners install the Flip4MAC [Windows Media® for QuickTime](#)^{lxi} plug-in. In the not-to-distant future, the *World Wide Web Consortium's* (W3C) HTML5 specification should make using and playing video much easier for everyone by eliminating the need for video plug-ins and proprietary video formats.

H) Upgrade both media servers and increase their storage capacity

There is only about 30 GB of space left on the Web-based media server's data-drive out at BEST. This on-line video repository currently contains videos dating back to 2004 to the present. From its conception, the video library was envisioned to provide this agency and colleagues with a historical record from past workshops and meetings. Unfortunately, the server is quickly running out of storage space so some corrective action will be required shortly.

It is of outmost importance that **all video-links in this federally-funded final research report remain intact** as these are integral to this on-line document and the potential benefit it can provide.

The server itself is almost ten-years old so it makes sense to replace it with a newer unit with even greater storage capacity. It has not been feasible to use other than RAID-0 because of the tradeoffs that result in redundancy such as dramatically-reduced data storage. In the future, it is recommended to move towards a terabyte (TB) of data storage at RAID-0. The media server located at the Newington Data Center has over 200 GB of data storage remaining so the urgency for replacing it isn't as great.

8. DELIVERABLES

There were a number of deliverables that resulted from this research project that are listed in the following table:

TABLE 10 Research Project SPR-2254 Deliverables

Two facilities available for webcasting and video recording
▪ Rocky Hill Central Lab's Conference room 122
▪ Newington Administration Buildings Conference rooms A/B
Two on-line streaming video servers and libraries
▪ Intranet (WAN)
▪ Internet (Web)
Independent portal webpage management and publishing rights
Autonomous Vod publication services
Video post-production and presentation development
e-HIWAY: a browser-based Photolog viewing application

8.1 Live webcasting, video production and recording studios

This research project provided the means to transform a large common meeting room into a *state-of-the-art* webcasting and HD-video production studio at CONNDOT's Central Lab in Rocky Hill. The studio served as a test bed throughout the study and "lessons-learned" were applied to the Administration Building's Conference Rooms' A & B. Sections 8.1.1 and 8.1.2 provide additional details about how each facility is currently being used.

8.1.1 Central Lab Studio in Rocky Hill CT

The Central Lab's *large conference room 122* continues to be the Department's primary video production and webcasting studio for a number of reasons. It is centrally-located within the State and is usually available for impromptu recording opportunities. The video equipment is permanently installed in the room and only needs to be powered-up to be used. There are wire raceways that go around the

room perimeter and these are used for feeding power and sourcing video from the three wall-mounted remote-controlled HD-video cameras. Four microphones hang from the ceiling and dimmable spotlights and a lectern in the blue-screen presentation area provide the ability to combine both presenter and slideshows using real-time chroma-keying during live webcasts or video recording sessions. The lectern houses a PC (a) and computer monitor (f) that is used with an LCD projector for displaying presentations for the benefit of classroom attendees. This same PC has *Camtasia Studio* installed on it and a microphone (c) always connected to it. This provides the ability to record and annotate their narrative to the Camtasia recording taking place on the PC. This requires minimal staff and no other video equipment is required either. The lectern has a second microphone installed (d) for picking up the presenter's voice and sending the audio to amplifiers in the house sound system. There is a video scan converter (e) that feeds the video-mixer located in the back of the room with a high-quality SDI video-signal of the PC-desktop. The following photo shows where the equipment is located.



FIGURE 16 Lectern hardware

One of the primary reasons that the Rocky Hill facility is ideally suited for webcasting is its robust OC3-connectivity to the Newington Data Center. It is currently rated at about 15 mbps but much of this is consumed by emailing and web-browsing. It still provides reliable service for webcasting since we only generate one single-stream for video that is encoded just under one (1) mbps. A successful broadcast is one where the video packets reach the streaming media server at BEST intact and uninterrupted. Otherwise the remote-users experience re-buffering and this creates blackouts during a meeting. For this reason a separate network jack and standalone PC/monitor are used within the studio for surveillance of the downstream video. Problems of this nature have been rare but can occasionally be addressed by ConnDOT's network-communications staff who can balance the network load.

It is important to note that Microsoft's webcasting solution has inherent latency that is related to the PC-encoder, WAN and remote server hardware and software. This results in a twenty (20) second delay between what is being viewed on-line and what is actually occurring in real-time in the meeting room/studio. This delay in itself isn't a problem because it isn't apparent to someone watching remotely via their PC. However, a teleconferencing-line is often used during some meetings that are being webcast. This is done for the benefit of committee members who are verbally participating from other states during the meeting and live webcast. This requires some juggling when remote viewers are prompted to switch from "webcast-mode" to the "teleconference-mode". This has worked very well but only when the meeting's moderator understands the timing-issues. This [video-link](#)^{lxii} provides an inside-look as the moderator explains this same scenario to both classroom attendees and those listening via teleconference. All remote participants are asked to check into the meeting via phone prior to there watching via the webcast.

There are obvious advantages to attending meetings in person versus via the phone or by webcast. However, the webcast does provide a more engaging experience when compared to those who teleconference into the meeting. The later must listen, view and advance their copy of the PowerPoint presentation. The webcast is a one-way passive process, but provides a view of the presenter, the presentation, the moderator and other committee members interacting. Over the years, many distant committee members have viewed the webcasts without sacrificing the need to verbally participate because they are given this opportunity later when the presentation concludes. This is their opportunity when they are prompted to return to the teleconferencing line for exactly that purpose. This [video-link](#)^{lxiii} exemplifies that procedure being followed.

The following image shows one of the well-attended CASE meetings being held in conference room 122. As previously noted, the room is outfitted with specialized equipment that facilitates recording and webcasting. Table 11 lists each delineated item and what it is.



FIGURE 17 Webcast being conducted in conference room 122

TABLE 11 Equipment used to facilitate recording and webcasting

A	Front wall-mounted loud-speakers (<i>rear speakers not shown</i>)
B	Rear-pointing video camera (<i>two forward-pointing cameras not shown</i>)
C	Motorized widescreen format projection screen (<i>projector not shown</i>)
D	Downward-pointing spotlight for blue-screen illumination
E	Forward-pointing spotlights for lectern-area illumination
F	Wiremold® electrical raceway encompassing the room perimeter
Note* The four red circles/lines are four hanging microphones	

The next photo shows two of the three staff members needed to conduct webcasts during larger, more complex meetings or workshops. The person on the left controls the three wall-mounted video cameras using a remote keypad (A). The man on the right is the "Director" whose job is to select from the various video feeds that have been provided to the Slate 1000 video switcher. Table 12 provides a brief

description for each of the devices that comprise this suite of video componentry.



FIGURE 18 HD-Video Control Booth located in the Studio

TABLE 12 Video control booth equipment description

A	Remote camera keypad with joystick controller (<i>see Figure 4</i>)
B	Video monitor used for previewing from the video mixer
C	Video monitor used for live-output from the video mixer
D	Camera number 1 video monitor (forward facing-located in rear)
E	Camera number 2 video monitor (forward facing-located in rear)
F	Camera number 3 video monitor (rear facing-located in front)
G	Video monitor used for displaying PC-desktop from scan converter
H	User interface for the Broadcast Pix SLATE-1000 video mixer
I	PC-monitor used with the Slate-1000 as the primary display
J	Analog black-burst reference signal for the Slate-1000 mixer
K	Composite video monitor used for previewing video from mixer
L	Non-network PC dedicated to the Slate-1000 application
M	PC-monitor for displaying the Inscribe-CG captioning & graphics
N	Shark DSP-110 audio delay-line (<i>see figure 14</i>)

The third team member (not shown) operates the equipment that is delineated in the next photo. Once the encoding/webcasting session is initiated on the PC-workstation (E) quality assurance is accomplished via another PC and monitor (G) and (H). This is done by observing the video and audio as it returns downstream via the Web. The individual manning this equipment also functions as a sound engineer by establishing and adjusting Automixer (C) audio levels for all room microphones and also for the room's house sound system (K)-(O).

Another duty is staying logged-in to the remote server in order to ascertain how many people are connected. Email is used for alerting us of any technical problems and for submitting any questions that are generated by the remote-viewing audience. Table 13 below provides a description of each delineated item

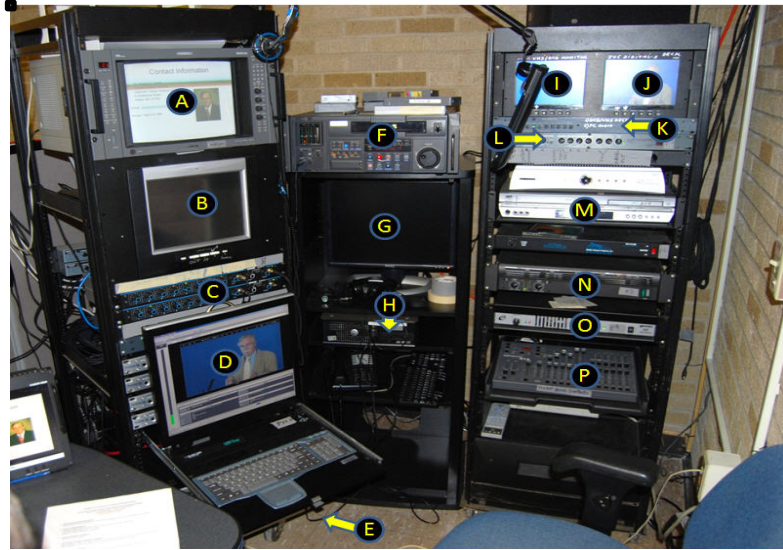


FIGURE 19 Additional audio/video componentry

TABLE 13 Additional audio and video equipment descriptions

A	SDI video monitor used to visualize Crestron touch-panel output
B	Crestron panel used to zoom-in on VGA from PC-desktop in lectern
C	Two-Shure SCM-810 audio Automixers used for microphone levels
D	PC-monitor/keyboard used for PC-encoding Workstation - (see E)
E	PC-encoding workstation with Osprey 700 HD video capture card
F	JVC DigitalS recording deck/SDI used as a tape backup
G	PC-display used with (H) for monitoring the downstream broadcast
H	PC-workstation used for watching the downstream broadcast
I	LCD display that monitors VHS tapes or DVDs in the player (see M)
J	LCD display that monitors the output of the DigitalS deck (see F)
K	Multiple-input audio/video switcher used with house-sound
L	Microphone audio-mixer used with the various audio devices
M	DVD/S-VHS deck used for playing movies and music (see I)
N	Audio amplifier used with the rear-mounted room loud-speakers
O	Audio amplifier used with the front-mounted room loud-speakers
P	Overhead spotlight intensity controller used with Lectern area

8.1.2 Administration Building Conference Rooms A and B

It is an understatement to say that rooms A/B are well-utilized because they must be reserved months in advance. There have been fewer requests than expected for video recording or for webcasting

from this facility other than some vendor demos and Diversity Council presentations. However, the room has been adequately-outfitted with wall-mounted video cameras, and microphones. It has multimedia capabilities such as projector/screen and house sound system. Figure 20B shows the "Director" with the room's video cart which must be pulled-out of a rear closet when needed. It utilizes a *Broadcast Pix Slate 1000* video mixer, a PC-encoder/*Viewcast Osprey 500 DV* video capture card, a *Shark DSP110* audio delay line and videotape deck.



FIGURE 20 Regional Planning Organization Coordination Meeting

Figure 20A shows the ancillary audio equipment that must be brought in for certain types of meetings in order to ensure adequate audio recording levels of the audience in attendance and on the telephone.

A	Wireless microphone receivers/lavaliere & handheld mics.
B	Shure SCM810 Automixer and a Rolls microphone mixer
C	Polycom VTX-1000 teleconference phone
D	PC monitor LCD HD-SDI inputs for use with HD-Camera (E)
E	Tripod-mounted robotic HD-camera
F	Stand mounted loud-speakers with amplifier (<i>not shown</i>)

8.2 Integrating teleconferencing and videoconferencing with webcasts

Teleconferencing

As previously mentioned, teleconferencing is frequently utilized during webcasts for people not able to attend in person. The Polycom VTX-1000 is used for this purpose. The device has internal speakers and microphone but neither provides adequate performance in a large room so it is interconnected to the house sound system and room microphones. This is done via its auxiliary audio-interface. Figure 21A shows how the unit is connected to amplified loud-speakers via its [aux-out] plug and also to the room microphones via its [aux-in] plug. The VTX-1000 must be optimized and configured for this to work properly and this is accomplished by enabling or disabling certain options as shown in Figure 21B.

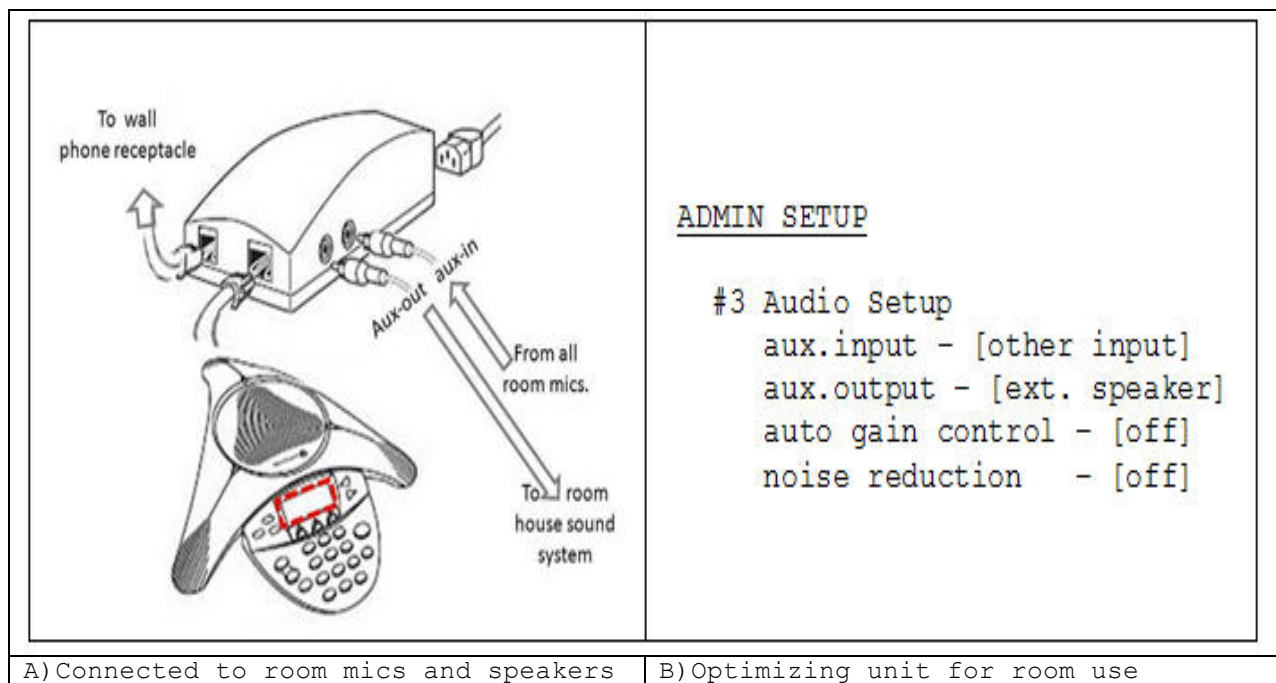


FIGURE 21 Teleconferencing connectivity and menu configuration

First, the internal console microphones are disabled because they will pick up ambient room sound and this will interfere with the units overall performance. The internal console speakers are disabled as well as they are not being utilized. Next, the auxiliary input is configured for [other input] and the auxiliary output for

[external speaker]. Auto gain control is turned [off] along with noise reduction.



FIGURE 22 Graphic displayed during a webcast of a teleconference

Occasionally, a guest presenter asks to only use the teleconference line/phone for giving their presentation remotely. They verbally prompt us to advance to the next slide of their PowerPoint presentation which is being projected on the conference room's projection screen before a live classroom audience. This is simultaneously broadcast to the Internet. Figure 22 shows how a 720 X 480 pixel BMP-graphic is created and used for displaying on the *Broadcast Pix* video mixer. This is done on behalf of the webcast audience and becomes part of the resulting final video product. Here is the [video-link](#)^{lxiv} to the teleconferencing-portion of the *CASE Health Impact Assessments Study* recorded on 11/15/12.

Videoconferencing

Videoconferencing is a new service that was collaboratively undertaken by the Office of Policy and Planning and the Office of information Systems. The following [video-link](#)^{lxv} shows how it was marketed here when introduced in 2011. There are many different methods and technologies that can be used for videoconferencing. The cost and complexity to conduct them depends on how many locations are participating. Multipoint videoconferences appear to be the most complicated and costly scenario but in CONNDOT's case, it appears to be practical for supporting only about twelve simultaneous locations. Throughout this project it was never completely understood what was limiting participants, but this may improve in the future. A Multipoint Control unit (MCU) bridge is employed for this process and depending on vendor, can be software or hardware-based. Some companies provide IP-based solutions and some ISDN. CONNDOT has

purchased a number of licenses for Cisco's® Telepresence® videoconferencing solution and this entitles CONNDOT to distribute their free client application called Jabber®. It has been provided to guest speakers during this research project over the last year via an email link. Once installed on their PC, guest speakers and subject-matter-experts can remotely participate from the convenience of their home state without traveling halfway across the country to appear during important meetings. This has played a major role during Study committee meetings that are broadcasted for the Connecticut Academy of Science and Engineering (CASE).

Sometimes even scheduling a guest presenter for their remote participation via a videoconference can be problematic due to prior commitments they may have made. This would prevent them from participating at all. This situation occurred during 2012 when CONNDOT's Research studio/equipment was employed to pre-record a videoconference one week in advance of the actual committee meeting. It was then shown later to the study committee group. A screenshot of this being viewed by the group is shown in Figure 22 and the actual [video-link](#)^{lxvi} of that pre-recorded presentation has been provided.



FIGURE 22 Pre-recorded video-conference shown during a Webcast

The photo above shows a green arrow where the Polycom VTX-1000 teleconferencing unit sits during meetings. Please note that the unit's console speaker and microphone are disabled via the front panel display in order to improve performance. Instead, all room microphones feed into the auxiliary audio interface and the auxiliary output connects to the room's house sound system.

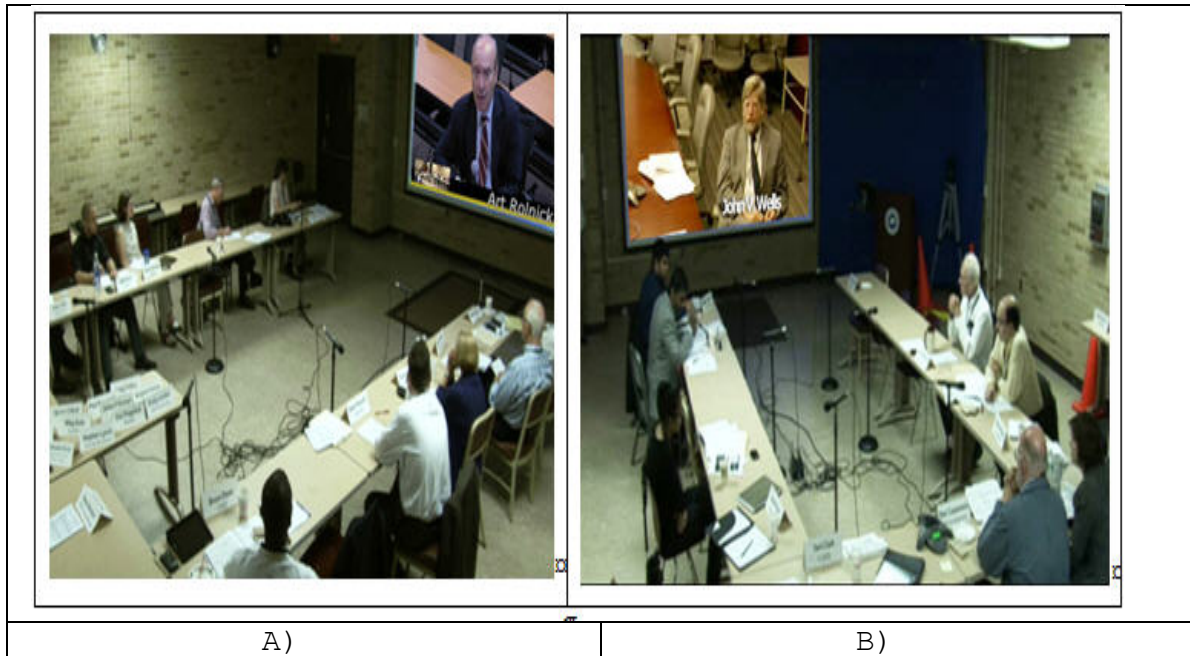


FIGURE 23 Video-conferencing being used during webcasts

Figure 23A above shows how a videoconference was used during a CASE Workforce Study Committee Meeting broadcast on July 18, 2012. Here is the [video-link](#)^{lxvii} from the actual session as it was being simultaneously webcast to the remote audience. Figure 23B shows how a videoconference was used during a CASE Economic Impact Study Committee meeting broadcast on 11/09/12. Here is the [video-link](#)^{lxviii} from the actual session as it was being simultaneously webcast to the remote viewing audience.

8.3 Two Streaming Video Libraries and Media Servers

Two very-similar streaming video libraries were developed. The in-house video library (intranet) contains everything the Web-based library does but in addition, provides videos created for the following uses: Ethics training, Employee safety, Diversity and other video topics that were deemed to be of limited interest to anyone other than DOT staff. Each Library utilizes its own dedicated streaming media server which has the videos stored on a hard drive dedicated to data storage. Please keep in mind that the primary

reason for employing an in-house media server was to minimize any impact to bandwidth consumption by videos coming across the “big pipe” from the media server at BEST.

At the time of this writing, both media servers have used-up about 175 GB of data storage. There isn’t any RAID configuration being employed on either machine but the data lives in two places so there is duplication of content between both the servers. Should a catastrophic failure occur in one server, its videos could be restored across the WAN from the remaining machine during off-peak hours. Blu-ray media is also used as an additional backup mechanism.

The following diagram (Figure 24) provides a general idea of how network pathways and facilities-connectivity were used during this project to populate both media servers with newly-created videos. Starting from the lower-left corner, new videos created here at CONNDOT’s Central Lab will take one of two routes, depending on who the intended audience will be.

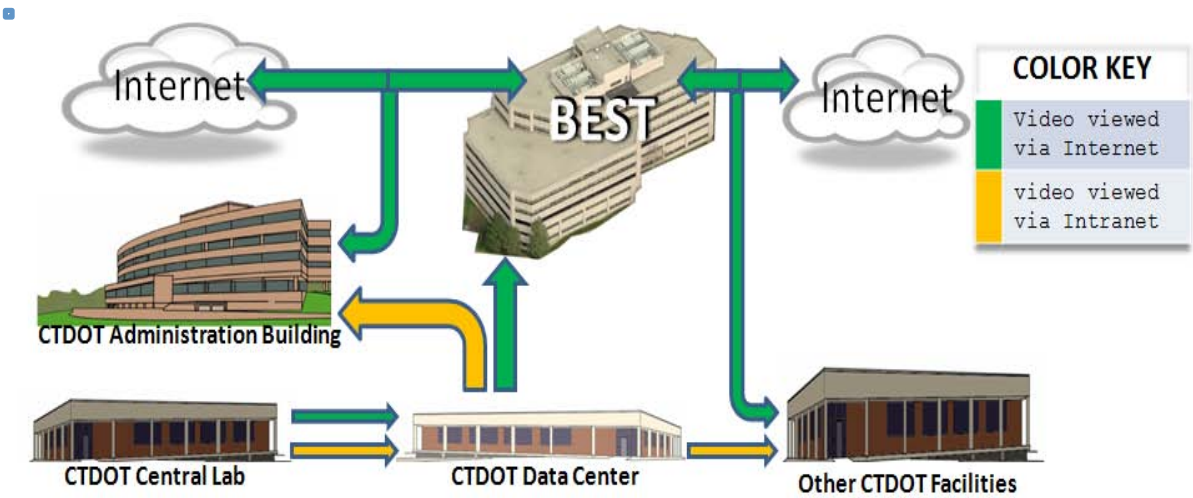


FIGURE 24 Connectivity used for publishing videos

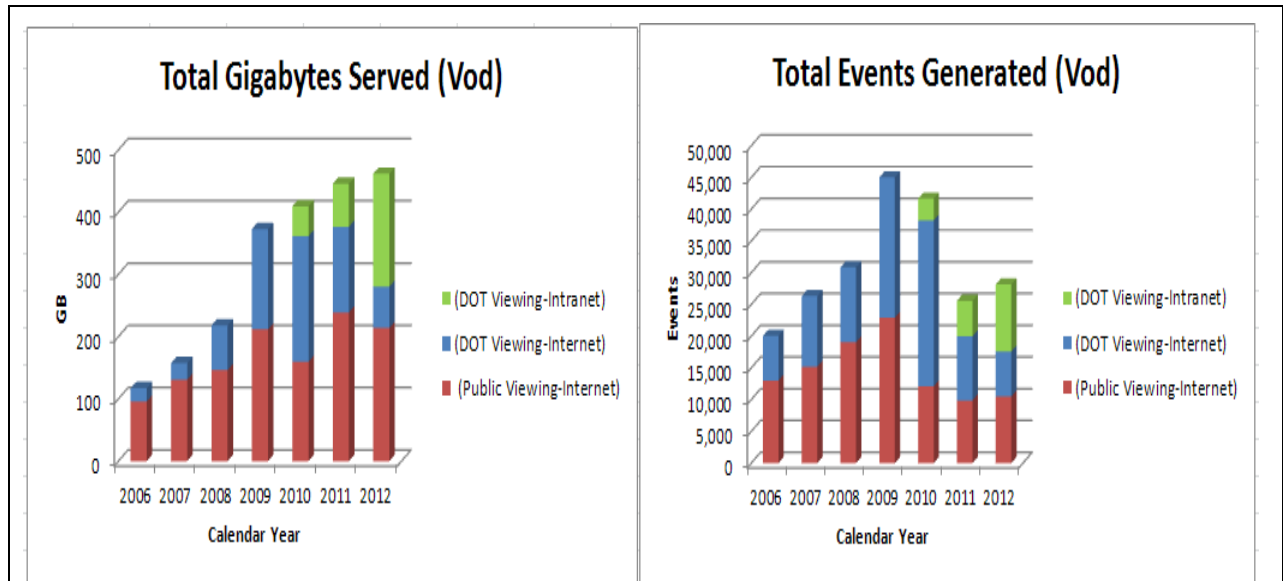
If the video is intended for general viewing by the public, then follow the **green arrow** route which is used to populate the media server at BEST. If the videos are for exclusive viewing by CONNDOT staff, then follow the **yellow arrow** route which is also used to populate the CONNDOT Data Center’s media server.

As previously noted in *Section 5.8*, user-data taken from the Internet-based media server was tabulated using Sawmill software for the period 2006-2012. User-data taken from the Newington Data Center

media server was only tabulated for three years; 2010-2012 because prior to 2010, there wasn't a second streaming media library homepage available like there is now. Therefore, there wasn't any logical reason for posting videos on the in-house server because there wasn't a separate index available from which to access the videos from. That rationale changed around 2010 when the project lead was provided with the ability to create intranet-portal webpages. This led to a second media library homepage (index) being created for the intranet.

Referring to Figure 25 below, please note the three colors used in the bar chart. Both charts combine the user log-data in an additive fashion from the in-house media server as well as the web-based media server. Figure 25A clearly indicates an increasing trend in user activity. Gigabytes-served directly correlates to the amount of time (in minutes or hours) that someone is watching a given video.

The **green** bar delineates activity generated by DOT-staff as they viewed videos from the Newington Data Center's in-house server. The **blue** bar is used to delineate requests from DOT-staff to view videos on the Internet-based media server located at Best. The **red** bar also delineates Internet-based media server activity but these requests originate from the outside world and not from DOT staff.



A) server-to-client bytes (GB) B) annual server hits (events)

FIGURE 25 Comparing streaming video usage from 2006 through 2012

Referring to Figure 25B, at first glance it might appear that overall interest in viewing videos is reduced during 2011 and 2012 but this chart only tracks "hits" which are generated when someone

clicks on a video link. The more significant value is the amount of data that traverses between server and client, as shown in Figure 25A. Tables 6, 7 and 8 provide more usage-details.

Work Sections 8.3.1 and 8.3.2 provide screenshots that illustrate what each media library has to offer.

8.3.1 Intranet-based Streaming Video Library

Referring to Figure 26 below, at the time of this writing the Newington Data Center's media server had 233 GB of data storage on drive D remaining. It would have been beneficial if OIS had provided the project lead with administrative privileges on this server but did provide a video publishing point and also "shared-out" a folder so that media server user logfiles could be retrieved and tabulated for the benefit of this research project.




Hard Disk Drives			
 Local Disk (C:)	Local Disk	20.4 GB	13.3 GB
 Local Disk (D:)	Local Disk	408 GB	175 GB
 Partition (E:)	Local Disk	47.2 GB	42.7 GB

FIGURE 26 Intranet-based media server and hard-drive capacities



FIGURE 27 Location of the Vod Link for the Intranet

Figure 27 above is a screenshot of the department's intranet homepage. This page loads by default on the majority of network-based PC here. Please note the prominent location of the video library link, delineated by the red arrow.

The screenshot displays the intranet homepage with several sections:

- Presentations for In-house Communication:** A list of video presentations including:
 - [Ethics Training for ConnDOT Employees](#) (Presented by Alice Sexton, CTDOT Legal Services Unit, Recorded July 11, 2012)
 - [Underground Storage Tank Operator Training](#) (Presented by Steve P. Farrick, TRC Environmental, Recorded July 2012)
 - [Fuel Control Basic Training-101](#) (Presented by Janice Snyder, Assistant Director of Purchasing and Materials Management - CTDOT, Recorded July 2012)
 - [Safety Section Videos](#) (A Collection of Topics that Help Keep our Staff Safe)
 - [Diversity Council Videos](#) (A Collection of Topics that Celebrate our Workforce Diversity)
 - [Instituform: Cured-in-Place Pipe](#) (Presented by Michael Cronin, Insituform Technologies, Hosted by CTDOT Highway Design, February 22, 2012)
 - [Announcing Video Conferencing at ConnDOT](#) (A Collaborative Effort between the Bureau of Policy and Planning and the Office of Information Systems, October 11, 2011)
 - [About High Tension Cable Barrier](#) (Presented by Mr. Richard Butler of Brifen - Sept 01, 2010)
 - [Concrete Testing Training](#) (Provided by Central Lab/Materials Testing - May 18, 2010)
 - [Benefits and Pitfalls of Designing with Architectural Concrete](#) (Presented by Mr John Glover - LM Scofield Company, Hosted by CTDOT State Design - April 2010)
 - [H1N1/Seasonal Flu Awareness and Prevention](#) (Cheryl Mareick, DOT Occupational Health Nurse - January 2010)
 - [Performance Measures-2009](#) (Presented by Donald Larsen on 04/21/2009)
- Safety Division Videos:** A table listing safety-related videos:

About High Visibility Apparel	Presented by Amy Shopey in December 2010
2010 Annual Hazardous Materials Training for the Central Lab	Developed for Materials Testing Personnel in Rocky Hill (2010)
Lead Awareness Training	Presented by Martin Lewis from TRC Environmental in July 2009
Asbestos Awareness Training	Presented by Martin Lewis from TRC Environmental in July 2009
- Diversity Council Videos:** A list of diversity-related videos:
 - [Celebrating Hispanic Heritage](#) (Master of Ceremonies - Ricardo Almeida, Sponsored by the Diversity Council, Recorded on October 12, 2011)
 - [Health Disparities](#) (Cheryl Mareick, DOT Occupational Health Nurse, Sponsored by the Diversity Council, Recorded on August 1, 2011)
 - [Celebrating Black History Month 2011](#) (Presented by Robert W. Ike, Sponsored by the Diversity Council, Recorded on February 18, 2011)
 - [Generational Communications](#) (Presented by Dr. Glynis Fitzgerald - C.C.S.U., Sponsored by the Diversity Council, Recorded on April 29, 2010)
 - [Transportation, Economic Development, and the Black Community](#) (Presented by Deputy Commissioner Albert Martin, Sponsored by the Diversity Council, Recorded on February 16, 2010)
 - [Interacting with Persons with Disabilities](#) (Presented by Brian Dunphy-D.M.H.A.S., Sponsored by the Diversity Council, Recorded on Nov 25, 2009)
 - [Celebrating Black History Month 2009](#) (Presenting Clifton E. Graves Jr. - Amistad America, Sponsored by the Diversity Council, Recorded on February 19, 2008)

FIGURE 28 In-house Communications Webpage

Figure 28 above is a screenshot of the first video category that can be found on the intranet-based media library. This category called "Presentations for In-house Communications" can only be accessed via WAN-based computer users and is the sole difference between the in-house and the web-based libraries.

8.3.2 Internet-based streaming video library

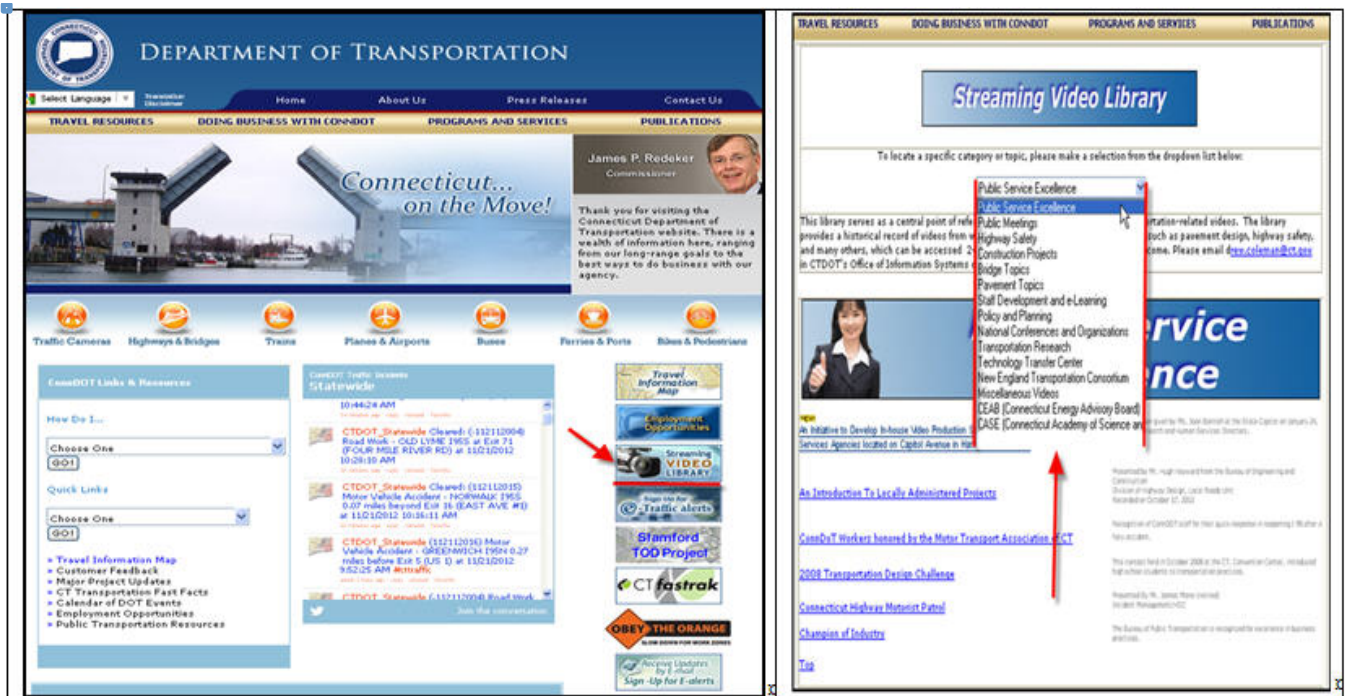


FIGURE 29 Internet-based Streaming Media Library

Figure 29 (left side) shows the department's Internet homepage and the red arrow of delineates the location of the link for accessing the Web-based streaming video library. Figure 29 (right side) shows the pull-down menu on the Video Library homepage that can be used to jump to a specific category contained within. This feature exists in both libraries.

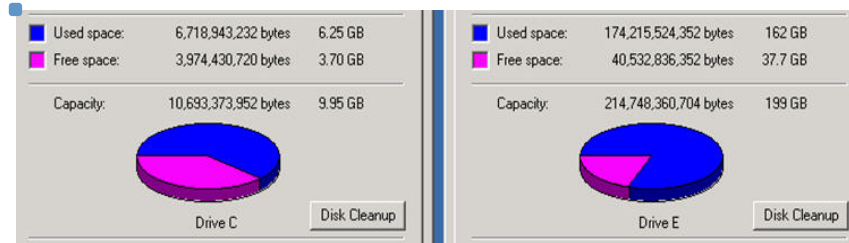


FIGURE 30 Internet Media Server Hard Drive Resources

Figure 30 is a screenshot from the web-based media server. The right hand panel shows Drive E: used for video data storage. There is only 38 GB of data storage remaining at the time of this writing.

8.4 Portal webpage management and Vod publication services

In order to publish videos in a timely fashion for the benefit of end-users, it was necessary to obtain permission and some rudimentary training for using the State's Web Portal Management tool which requires a log-in and password to use it. The photo below shows the [Display Settings] tab for generating web pages for in-house [DOT-SI] use. The green arrows delineate those check boxes that must be selected when initially setting-up a new webpage. The [end date] must be extended-out as well.

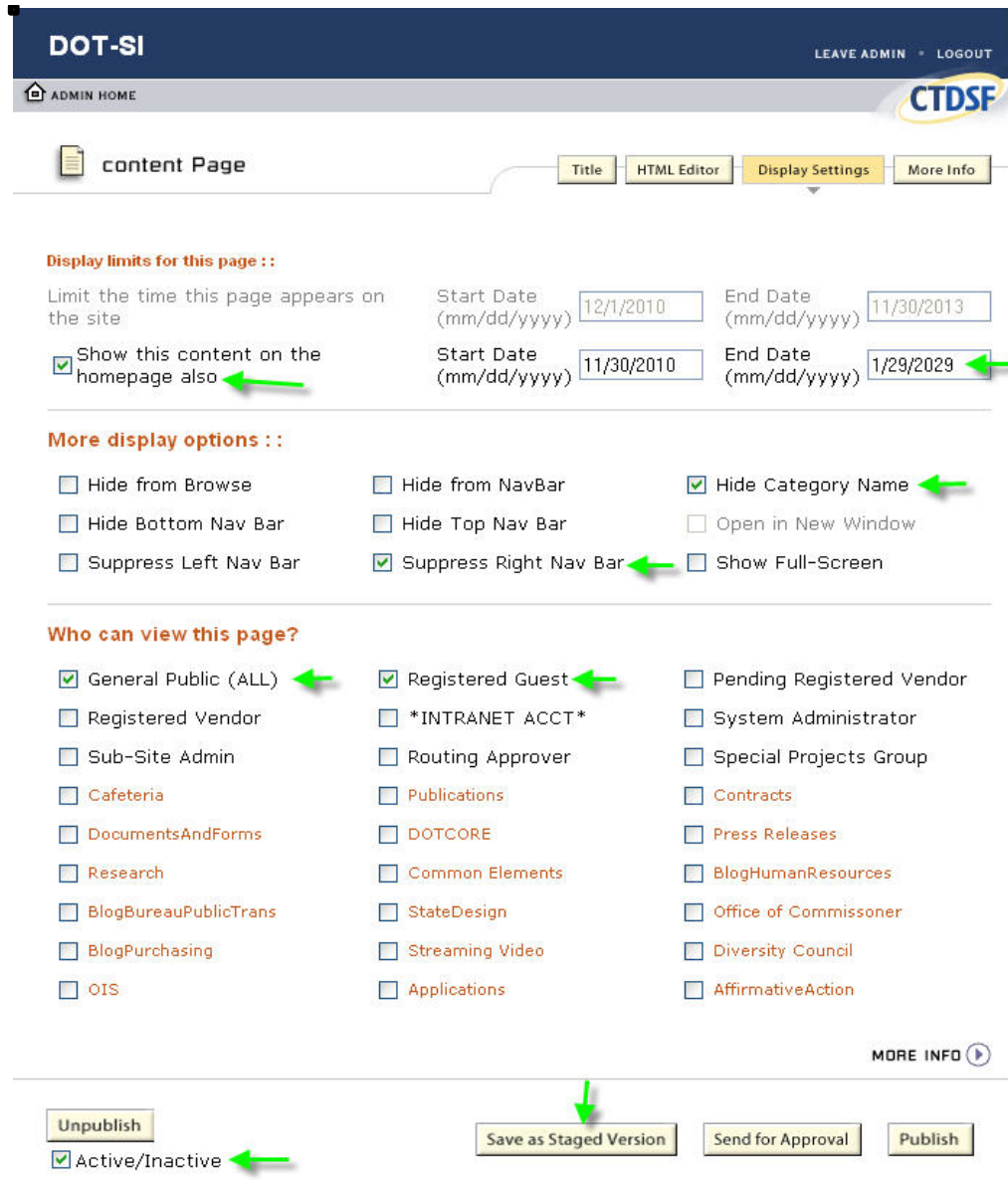


FIGURE 31 Intranet Portal [Display Settings] Screen

The following photo below provides a list of webpages that have been developed during the course of this research project. This is a fairly-easy task to accomplish and while time-consuming, does not require outside assistance. The green arrow delineates the Streaming Media Library homepage. This page provides video links to each and every one of the webpages that are listed in the photo.

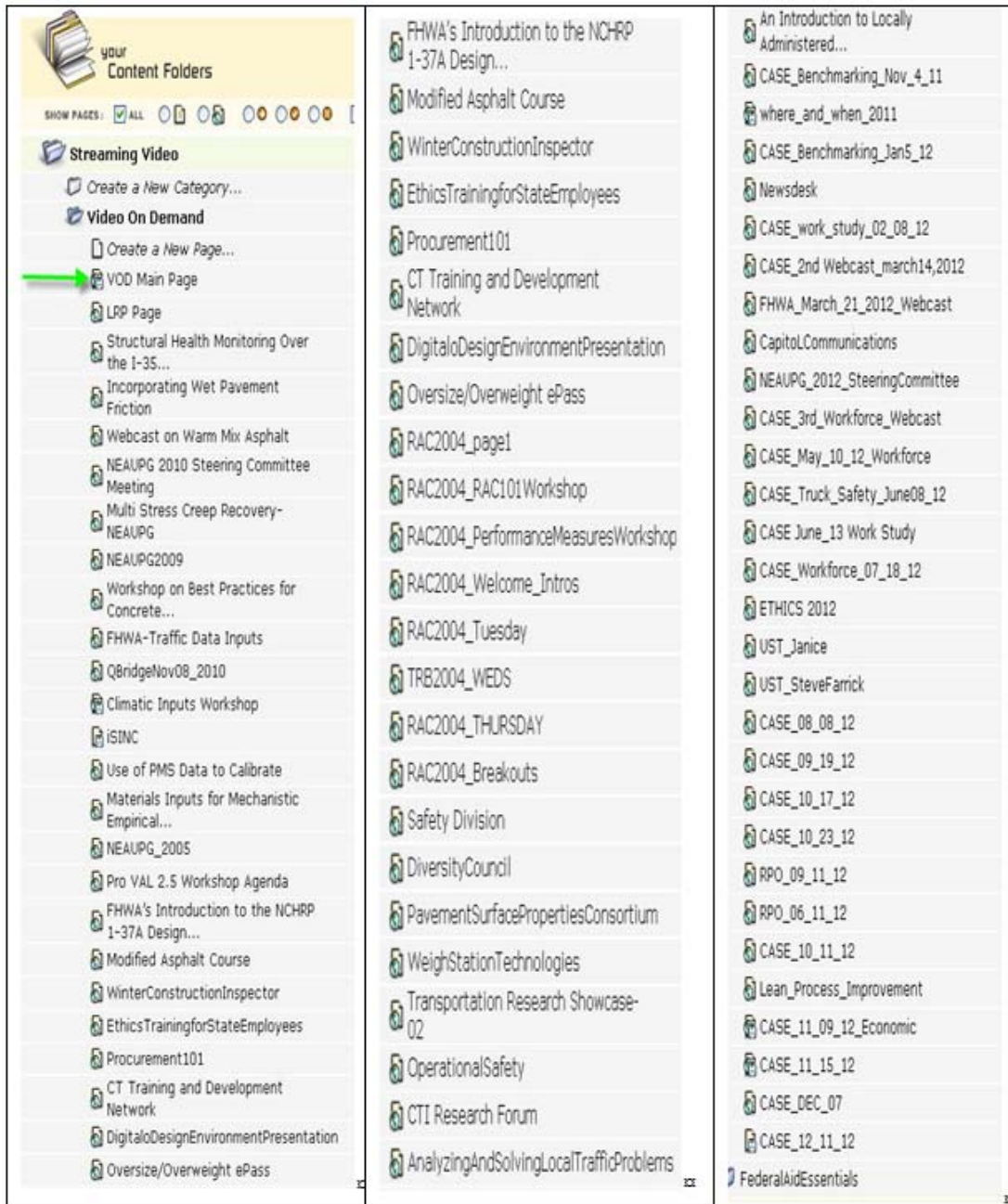


FIGURE 32 Intranet Portal Content Folders [Video on Demand] Screen

The following screenshot lists all of the folders that were created on both media servers for organizing video content by either office or operational-use. Having duplicate media in two different locations provides the ability to back-up content and restore from across the WAN. These abbreviations and acronyms aren't intuitive but what they stand for wouldn't be of much interest to anyone outside of CONNDOT. They are simply being provided as a time capsule from 2012

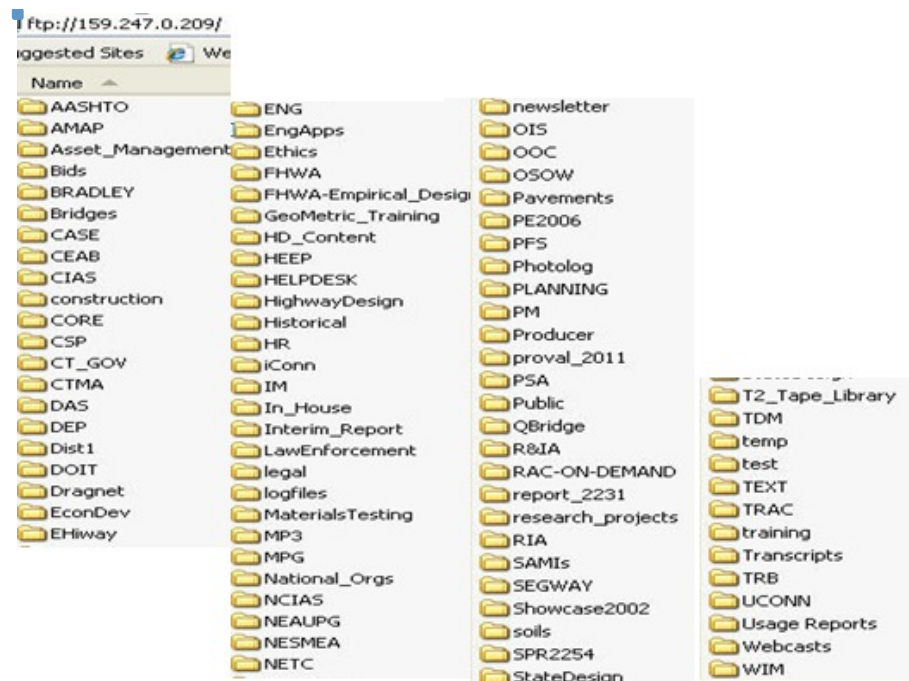


FIGURE 33 Media Server Folders used to Organize Video

8.5. Video post-production suite and presentation development

During the earlier-related research project (*SPR-2231*), the project had the benefit of working with local college students that were hired as temporary Interns. Some came here with video-editing skills while others learned hands-on. They performed the brunt of the video editing and publication effort. Unfortunately, during this research project (*SPR-2254*), the CONNDOT chose not to participate in the *Cooperative Education Intern Program*.

Continuing to have a *qualified* video-production person in-house is a critical element to ensure the continuation of a successful video service..

8.6. e-HIWAY a browser-based Photolog viewing application

For many years CONNDOT's Division of Research had administered a Photolog program whose primary mission was to annually collect roadway pictures and associated data for all state-maintained highways using a vehicular-based platform. The digital images were acquired at a five-meter sampling interval, and these became part of the permanent record. Once processed, the images could be accessed by staff from any network-based PC. However, this wasn't the case

for those outside the agencies' firewall. Entities like legal firms, accident investigators and regional *Council of Governments* in Connecticut were provided with images stored on DVD-9 media, which could only be mastered at the very end of each Photolog collection season. It was envisioned that a free, on-line, browser-based Photolog-viewing application would meet all of the needs as long as the discrete five meter images could be consolidated within a streamable video product.

It was learned during this streaming media project (SPR-2254) that the Microsoft WMV format can be used for the abovementioned purpose as long as an image sequence for each individual Photolog route/direction is created. It was fortunate that CONNDOT Research already possessed a Digital Rapids© StreamZ-HD® encoder as it comes with Stream® software, which has an image sequence plug-in. The plug-in takes each discrete five-meter sampled roadway image and can be used to replicate it thirty times. This process yields one video file which is created from each static image-sequence for a given route/direction.

Having successfully tested this methodology, a research proposal (P-09-5) was developed in September 2010. Unfortunately, due to ongoing budgetary constraints in Connecticut, the proposal was never submitted for FHWA's approval. However, the project continued to provide support and assistance to the Photolog Unit, who then continued this effort on their own. At the present time, their plan is to only provide the three most current years' worth of primary Interstate routes; that being 2010, 2011 and 2012. The aforementioned research proposal has been included within Appendix A of this research report because it was being developed using this research project's allocated resources such as time, hardware and software. For this reason it is also being listed as a deliverable product.

Figure 34 on the next page shows the Photolog user-interface (*on left side*) that was developed by Policy and Planning's Photolog section. On-line users can select from the last three filming seasons. The photo on the right side provides the ability to choose between individual routes and direction. Here is the [video-link](#)^{lxix} to peruse this service via the Web.

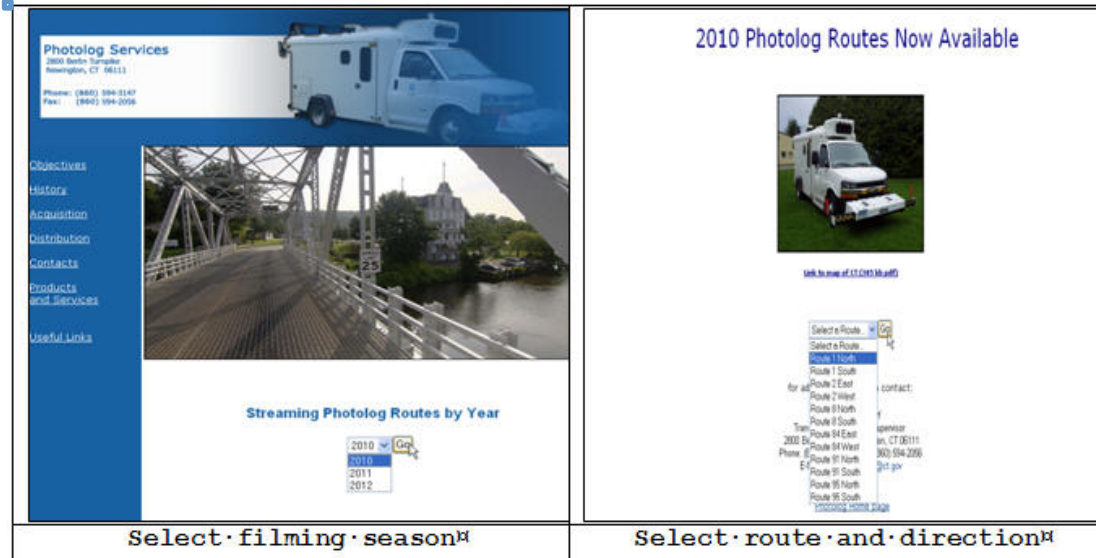


FIGURE 34 e-HIWAY Filming-season and Route/direction Index

Figure 35 shown below is a screenshot of the actual Photolog viewing tool that displays a 1920 X 1080 HD-image. A checkpoint tool provides a checkpoint referencing tool that can be clicked-on, thereby advancing to that particular Photolog image.

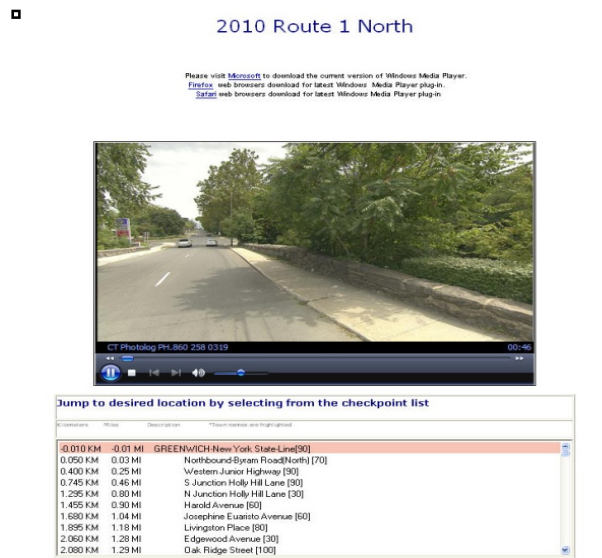


FIGURE 35 e-HIWAY Viewer with Navigable Checkpoint List

9. IMPLEMENTATION

As previously mentioned the two back-to-back related-studies have resulted in streaming media technologies being implemented

within CONNDOT's Office of Information System. The following paragraph was submitted by Mr. John Krewalk for its inclusion in this final research report.

"As Director of CONNDOT's Office of Information Systems, we decided to adopt streaming media as a supported service late in 2011. The Division of Research had spent the last decade identifying new uses for this technology here which led to the formation of a fairly significant user-base in and outside of the agency. This helped influence our decision to continue to support webcasting and video-on-demand. Certainly a major contributing factor was the department-wide restructuring that took place in 2011 whereby implementation of Research project SPR-2254 was realized when it officially came under our IT-umbrella. We strongly believe this to be an appropriate placement for the technology and will continue to develop cost-saving uses for it into the future."

APPENDIX A. SNAPSHOT OF MEDIA LIBRARY AS OF JANUARY 2013



Presentations for In-house Communication

NEW! Ethics Training for ConnDOT Employees	Presented by Alice Sexton, CTDOT Legal Services Unit Recorded July 11, 2012.
NEW! Underground Storage Tank Operator Training	Presented by Steve P. Farrick TRC Environmental Recorded July 2012
NEW! Fuel Control Basic Training-101	Presented by Janice Snyder Assistant Director of Purchasing and Materials Management - CTDOT Recorded July 2012
Safety Section Videos 	A Collection of Topics that Help Keep our Staff Safe
Diversity Council Videos 	A Collection of Topics that Celebrate our Workforce Diversity
Insituform: Cured-in-Place Pipe	Presented by Michael Cronin, Insituform Technologies Hosted by CTDOT Highway Design, February 22, 2012
Announcing Video Conferencing at ConnDOT	A Collaborative Effort between the Bureau of Policy and Planning and the Office of Information Systems October 11, 2011
About High Tension Cable Barrier	Presented by Mr. Richard Butler of Brifen - Sept 01, 2010
Concrete Testing Training	Provided by Central Lab/Materials Testing- May 18, 2010
Benefits and Pitfalls of Designing with Architectural Concrete	Presented by Mr John Glover - LM Scofield Company, Hosted by CTDOT State Design -April 2010
H1N1/Seasonal Flu Awareness and Prevention	Cheryl Marenick, DOT Occupational Health Nurse - January 2010
Performance Measures-2009	Presented by Donald Larsen on 04/21/2009



About High Visibility Apparel	Presented by Amy Shoppey in December 2010
2010 Annual Hazardous Materials Training for the Central Lab	Developed for Materials Testing Personnel in Rocky Hill (2010)
Lead Awareness Training	Presented by Martin Lewis from TRC Environmental in July 2009
Asbestos Awareness Training	Presented by Martin Lewis from TRC Environmental in July 2009



NEW! Celebrating Hispanic Heritage	Master of Ceremonies - Ricardo Almeida Sponsored by the Diversity Council Recorded on October 12, 2011
Health Disparities	Cheryl Marenick, DOT Occupational Health Nurse- Sponsored by the Diversity Council Recorded on August 1, 2011
Celebrating Black History Month 2011	Presented by Robert W. Ike Sponsored by the Diversity Council Recorded on February 18, 2011
Generational Communications	Presented by Dr. Glynis Fitzgerald - C.C.S.U. Sponsored by the Diversity Council Recorded on April 29, 2010
Transportation, Economic Development, and the Black Community	Presented by Deputy Commissioner Albert Martin Sponsored by the Diversity Council Recorded on February 16, 2010
Interacting with Persons with Disabilities	Presented by Brian Dunphy-D.M.H.A.S. Sponsored by the Diversity Council Recorded on Nov 25, 2009
Celebrating Black History Month 2008	Presenting Clifton E. Graves Jr. - Amistad America Sponsored by the Diversity Council Recorded on February 19, 2008



Public Service Excellence

NEW!

[An Initiative to Develop In-house Video Production Services for the Health and Human Services Agencies on Capitol Avenue located in Hartford Connecticut.](#)

A presentation made by Ms. Joan Barnish at the State Capitol on January 24, 2012 for the Health and Human Services Directors.

[An Introduction to Locally Administered Projects](#)

Presented by Mr. Hugh Hayward from the Bureau of Engineering and Construction, Division of Highway Design, Local Roads Unit
Recorded on October 17, 2011

[ConnDOT Workers honored by the Motor Transport Association of CT](#)

Recognition of ConnDOT staff for their quick response in reopening I-95 after a fiery accident.

[2008 Transportation Design Challenge](#)

This contest held in October 2008 at the CT. Convention Center, introduced high school students to transportation practices.

[Connecticut Highway Motorist Patrol](#)

Presented By Mr. James Mona-(retired)
Incident Management/HOC

[Champion of Industry](#)

The Bureau of Public Transportation is recognized for excellence in business practices.



Public Meetings

[Salem Four-Corners Proposed Roundabout Meeting, held at the Salem Town Hall](#)

Originally recorded on June 17, 2009

[Salem Four-Corners Proposed Roundabout Simulation](#)

Narrated by Will Britnell - State Highway Design
June 2009

[Draft Long-Range Transportation Plan](#)

Presented by Ms. Roxane M. Fromson on April 02, 2009



Highway Safety

[Don't be a Conehead](#)

27th Annual Telly Award winner



[No Zone](#)

27th Annual Telly Award winner



[At The Office](#)

Public Service Announcement

[In the Elevator](#)

Public Service Announcement

[Splat](#)

Public Service Announcement

[Work Zone Safety 1](#)

Public Service Announcement

[Work Zone Safety 2](#)

Public Service Announcement



Construction Projects

NEW! [Oyster River Roundabout Simulation](#)

Located at the Intersection of Route 162 and S.R. 705 (Ocean Avenue and Jones Hill Road).

[Call Before You Dig Video](#)

Submitted by Derek Brown
ConnDOT Utilities Section
May 2011

[Open House for the I-95 New Haven Harbor Crossing Corridor Improvement Program](#)

Presented by ConnDOT's Program Director Mr. Brian Mercure and showcased on March 14, 2010 in New Haven CT.

[Moses Wheeler Bridge Voluntary Pre-bid Conference](#)

Pre-Bid Conference for Project 138-221 Bridge Replacement I-95 over the Housatonic Rvr. Recorded January 25, 2011 in Newington CT

[Update on Pearl Harbor Memorial Bridge](#)

Presented by ConnDOT Engineers Brian Mercure, John Dunham, and Domenic LaRosa. Presented on November 8, 2010.

[Q-Bridge Voluntary Pre-Bid Conference](#)

Contract E Project 92-531/622/627
Recorded May 26, 2010

[New Haven Rail Yard Component Change Out Shop](#)

Pre-bid Conference for State Project #301-0106. Presented on June 23rd, 2009.

[DRAGNET Vehicle Arrestor System](#)

About a vehicle attenuation system, similar to the one used on Avon Mt. Proposed Improvements on Routes 62/44 in Manchester at East Catholic and Cheney Technical High Schools.

[Traffic Simulation](#)

["The Big Pick"](#)

The 1,000 ton lift of the Church St. bridge truss span in New Haven, CT. The 3 hour move is compressed here into less than 3 minutes. Recorded on May 4, 2003



Bridge Topics

<p>NEW! Maintaining Adequate Safety Margins while Extending Life Span of Problematic Bridges</p> <p>Bridge Level Condition Prediction with Artificial Neural Network</p> <p>About Accelerometers used in Bridge Monitoring</p> <p>About Strain Gauges used in Bridge Monitoring</p> <p>Structural Health Monitoring using Fiber Optic Technologies on the I-35 W Bridge over the Mississippi River</p> <p>History of Bridge Monitoring in Connecticut</p> <p>Data Qualification for the Connecticut Bridge Monitoring Network</p> <p>Structural Monitoring of the Sikorsky Bridge</p> <p>Field Strain Monitoring to Evaluate Unexpected Cracking of a Non-redundant Steel Plate Girder Bridge</p>	<p>Hosted by Ali Jamalipour on July 28, 2011</p> <p>Presented by Patrick Creary on February 10, 2011</p> <p>Presented by Ron Gusk on July 22rd, 2010</p> <p>Presented by Ron Gusk on July 22rd, 2010</p> <p>Dr. Daniele Inaudi Rocrest Group November 4th, 2009</p> <p>Professor John DeWolf - July 29, 2009</p> <p>Presented by Harinee Trivedi - May 15, 2009</p> <p>Presented by Varsha Singh September 20, 2007</p> <p>Presented by Gino Troiano March 2007</p>
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Pavement Topics

<p>NEW! 2012 New England Asphalt User Producer Group Steering Committee Meeting and Webcast</p> <p>Best Practice Workshop/Webcast for Constructing and Specifying HMA Longitudinal Joints</p> <p>Manual for Design of Hot Mix Asphalt</p> <p>Special Mixture Design Considerations and Methods for Warm Mix Asphalt</p> <p>2011 New England Asphalt User Producer Group Steering Committee Meeting and Webcast</p> <p>ProVAL 3.1 Webcast and Workshop</p> <p>Density Testing of HMA Utilizing Core Samples</p> <p>Incorporating Wet Pavement Friction into Traffic Safety Analysis</p> <p>A Webcast on Warm Mix Asphalt</p> <p>Precast Concrete Pavement- A Case Study</p> <p>MTG Pavement Design Catalog</p> <p>NEAUPG 2010 Steering Committee Meeting and Webcast</p> <p>NEAUPG-Understanding and Implementing the Multi Stress Creep Recovery Test Workshop and Webcast</p> <p>NEAUPG 2009 Steering Committee Meeting</p>	<p>Hosted by the Office of Information Systems and Webcast from the Central Lab in Rocky Hill on March 26, 2012</p> <p>Organized by Steve Cooper, FHWA Hosted by CTDOT's Office of Information Systems March 21, 2012</p> <p>Webcast on the NCHRP Report 673 from the Central Lab in Rocky Hill on October 25, 2011</p> <p>An Appendix to AASHTO R35 Presented by Dr. Ramon Bonaquist July 26, 2011</p> <p>Broadcast live from the Central Lab in Rocky Hill on April 19, 2011</p> <p>Broadcast live from ConnDOT's Computer Training Lab in Newington CT on February 17, 2011</p> <p>Presented by Mr. Dave Howley from ConnDOT's Division of Materials and Mr. Gregg Shaffer from the Office of Construction on March 22nd, 2011</p> <p>Mr. John Henault and Dr. John Ivan. CCTRP Project JHR 07-5 Final Presentation to the Technical Advisory Committee - October 6, 2010</p> <p>Sponsored by NEAUPG and hosted by ConnDOT at its Central Lab in Rocky Hill CT on September 1st, 2010.</p> <p>In Reference to a site on Rockaway Blvd in Jamaica, New York. This was presented by Edgardo Block on July 28, 2010</p> <p>Mike Derewianka-Pavement Management Presented on April 8, 2010</p> <p>Conducted in Rocky Hill CT on March 23, 2010</p> <p>A Webcast conducted on September 22, 2009</p> <p>Presented on March 31, 2009</p>
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Staff Development and e-Learning

NEW!

[DOT/DEEP Design Team Training](#)

New coordination practices resulting from the 2012 inter-agency LEAN process to promote early and continuous coordination on the acquisition of environmental permits. Presented by Hugh Hayward-Highway Design-Local Roads Section. Posted on November 14, 2012

[Federal-aid Essentials for Local Public Agencies](#)

Videos produced by the Federal Highway Administration. Transcoding and media hosting provided by OIS per the request of the Highway Design Unit. Posted on 10/23/2012

[WIM Systems and iSINC Electronics](#)

A training class about equipment used in Lebanon CT at traffic data collection/weigh-in-motion site. Presented by Dan Bonnet, International Road Dynamics. September 14, 2010 (*in-house only*)

[The History and Advancement of Streaming Media Technologies at ConnDOT](#)

Hosted by State Highway Design Section Presented by Drew Coleman/Div. of Research Newington Ct. -May 12, 2010

[The CT State Libraries Internet Search Tool](#)

About IConn.org - 2008

[Winter Construction Inspection Training Series](#)

Held in Rocky Hill - Winter 2007

[Ethics Training For State Employees](#)

Office of State Ethics-2008

[Material Stock Request for CORE-CT](#)

Presented by Tom Vaughan in November 2008
**still on DOIT server*

[DAS Procurement-101](#)

Webcast on June 8th,2005

[Site Manager Training](#)

Introduction to Site Manager
- Presented by Joe Bouchey
**still on DOIT server*

[CT Training and Development Network Meeting](#)

Held in Rocky Hill December 16, 2005



Policy and Planning

NEW!

[Regional Planning Organization Coordination Meeting](#)

Recorded in Newington at the Administration Building on December 11, 2012

[Regional Planning Organization Coordination Meeting](#)

Recorded in Newington at the Administration Building on September 11, 2012

[Regional Planning Organization Coordination Meeting](#)

Recorded in Newington at the Administration Building on June 12, 2012

 <h1>Photolog and DigitalHIWAY</h1>	
NEW! First Bear Ever to be Filmed by Photolog Crew	Recorded July 2012
Using Advanced Features of DigitalHIWAY	Presentation made at UConn's School of Engineering -February 14, 2011
State-Of-The-Art Photolog Van	ConnDOT's newest mobile Data/Image System -June 2010
DigitalHIWAY for Power Users	Hosted by State Highway Design Section Presented by Brad Overturf/Div. of Research Newington Ct. -May 12, 2010
DigitalHIWAY Training	Presented by David Burns - Software Developer About New Video Tutorials & Quicktips -May 2010
About ConnDOT's Photolog Program	Presented by Mr. Bradley Overturf in May 2008

 <h1>National Conferences and Organizations</h1>	
FHWA Northeastern U.S. Roundabout Peer Exchange	Held at ConnDOT HQ Conference Facility Newington, CT on July 7-8, 2010
TRB Annual Correlation Visit - 2009	Presented by Ms. Elaine King on July 7th, 2009
TRB Annual Correlation Visit - 2007	Presented by Ms. Christine Gerencher in May 2007
TRB Annual Correlation Visit - 2006	Presented by Kimberly Fisher in 2006
2004 National Research Advisory Committee	Held in Mystic, Connecticut, July 18 to July 22, 2004



Transportation Research

NEW! [Forensic Testing of SPS-9A Experiment](#)

Presented by Alexander K. Bernier E.I.T.
Graduate Research assistant - University of CT.
September 21, 2011

[Photolog Unit - DigitalHIWAY](#)



A Collection of Videos about the Annual Roadway Image and Data Collection Process

[Connecticut's SPS-9A Site - Harvesting for the Greatest Yield](#)

Presented by Ms. Anne-Marie McDonnell January 10, 2010. Developed for the FHWA-LTPP (Long Term Pavement Performance) 2010 State Coordinators' Meeting.

[Traffic Data Research Considerations from a State Researcher's Perspective](#)

Presented by Ms. Anne-Marie McDonnell March 11, 2010. Developed for the North American Travel Monitoring Exposition & Conference (NATMEC 2006).

[Pavement Surface Properties Consortium: A Collaborative Research Program](#)

Conducted by Gerardo Flintsch - Virginia Tech.
Live webcast from Rocky Hill CT first aired on September 24, 2009

[About New Product Evaluation Procedures](#)

Presented by Mr. Andrew Mroczkowski in 2008

[Field Evaluation of Concrete Containing DSS](#)

Presented by Mr. Richard Hanley in 2008

[Automated Stop Sign Identification System](#)

Presented by Mr. Richard Hanley in 2008

[About ConnDOT's Pavement Friction Testing and Safety Evaluation Program](#)

Presented by Mr. John Henault in 2008

[Investigation of Low Strength Concrete Test Results](#)

Presented by Mr. John Henault in 2007

[Transportation Pooled Fund Study 5-\(100\)](#)

Deicer Scaling Resistance of Concrete Pavements, Bridge Decks and Other Structures Containing Slag Cement. Presented by Dr. Scott Schlorholtz

[Executive Summary for SPR-2231](#)

Feasibility of Streaming Media for Transportation Research and Implementation
- Presented by Mr. Drew M. Coleman in 2006

[Thermal Imaging of Hot Mix Asphalt in CT](#)

Presented by Mr. John Henault in the fall of 2005
Alternate Merge Sign at Signalized Intersections
- Presented by Mr. Eric Feldblum in February 2005

[Alternate Merge Sign](#)

[Synopsis of the NCIAS](#)

A Discussion of the Narrow Connecticut Impact Attenuation System
- Presented by Ms. Erika Lindeberg in January 2004
**still on DOIT server*

[Transportation Research Showcase](#)

Held at UConn in Storrs CT on March 19, 2002

[Research and Implementation Activities](#)

In-house research projects conducted on a wide range of topics
**still on DOIT server*



CONNECTICUT TRANSPORTATION INSTITUTE *Technology Transfer Center*

NEW!

Where and When to Use Traffic Signs, Signals, and Markings	Presented by Mark M. Hood on June 22, 2011
2009 Manual on Uniform Traffic Control Devices	Presented by Mark Hood on June 22, 2011
About CT. Industrial Stormwater Permit	CT. Industrial Stormwater Permitting Presented by Chris Stone-DEP December 8, 2010
Operational Safety for Public Works Responders	Adam Drummond - Instructor - June 15, 2010
About the Technology Expo-2009	Recorded on September 16, 2009 in Storrs CT
Flagger Safety Training	Presented by Scott Zinke -December 2009
CTI Research Forum	Filmed at UConn November 5, 2009 in Storrs CT
Retroreflectivity	Presented by Mark M. Hood on August 26, 2009
Analyzing and Solving Local Traffic Problems	Presented by Mark M. Hood on August 19, 2008
Roadway Safety Fundamentals	Presented by Mark M. Hood on July 08, 2008
Infrastructure Asset Management	Presented by Mr. Paul Brown on July 11, 2007
About the Technology Transfer Center	Presented by Ms. Donna Shea - Program Director



New England Transportation Consortium

NCHRP Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features	Presented by Dean C. Alberson, Ph.D., P.E. Texas Transportation Institute Recorded February 02, 2006
NCHRP Report 350 Testing and Evaluation of NETC Bridge Rail Transitions - NETC Project 99-1 (Presentation of Results)	Presented by Dean C. Alberson 2-Bar Curb-Mounted and 4-Bar Sidewalk-Mounted Bridge Rails. February 02, 2006
Using Traffic Simulation Models to Assess the Impacts of Highway Work Zone Strategies: A Review of Eight Case Studies	An overview of NETC Project 05-8 Presented by John Collura Ph.D., P.E. Recorded on December 21, 2010.
Employing Graphic-Aided Dynamic Message Signs to Assist Elder Driver's Message Comprehension	An overview of NETC Project 05-6 Presented by Jay Wang Ph.D., Recorded September 27, 2007.

Miscellaneous Videos

[Caring for Connecticut and Beyond](#)

2010 CT State Employees Campaign for Charitable Giving
Presented by Ann Calafiore - Department Coordinator

[Reducing Fatigue in Wind-Excited Traffic Signal Support Structures using Smart Dampening Technologies](#)

NCHRP-IDEA Project 141
Presented by Dr. Richard Christenson at UConn in Storrs CT on June 17, 2010.

[Purple Loosestrife Control using Galerucella Beetles](#)

Presented by Ms. Donna Ellis - UConn 2007

[Bradley Intl Airport](#)

Go Easy Commercial-Bradley International Airport

[Segway](#)

The Segway people mover demonstration held at ConnDOT's Central Lab in Rocky Hill CT.

[History of NESMEA](#)

Presented by Mr. Philip E. McCyntire



[Air Quality-101](#)

Presented by DEP Tracy R. Babbidge, DEP, on 11/07/08

[High Electric Demand Days](#)

Presented in 2008 by Richard G. Rodrigue, DEP, on 11/07/08

[Climate and Energy Challenges and Opportunities](#)

Presented by Paul E. Farrell, DEP, on 11/07/08

[Introduction to the Electric System](#)

Presented by DPUC Chairman Donald Downes on 09/05/08

[Introduction to the Natural Gas System](#)

Presented by DPUC Commissioner Anne C. George on 09/05/08



CT Academy of Science and Engineering



NEW! [Economic Impact of Transportation Projects](#)

A Webcast about "Assessing the Economic Development Value of Transportation Projects and Systems." Recorded on November 15, 2012

NEW! [CT Workforce Study Committee Meeting](#)

Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. October 23, 2012

NEW! [CT Disparity Study](#)

Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. October 17, 2012

[Economic Impact of Transportation Projects](#)

A Webcast about "Assessing the Economic Development Value of Transportation Projects and Systems." Recorded on October 11, 2012

[Benchmarking Connecticut's Transportation Infrastructure Capital Program with Other States](#)

Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. September 19, 2012

[CT Workforce Study Committee Meeting](#)

Webcast and videoconference conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. August 12, 2012

[CT Workforce Study Committee Meeting](#)

Webcast and videoconference conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. July 18, 2012

[CT Workforce Study Committee Meeting](#)

Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. June 13, 2012

[CT Truck Safety Briefing](#)

Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. June 08, 2012

[CT Workforce Study Committee Meeting](#)

Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. May 10, 2012

[CT Workforce Study Committee Meeting](#)

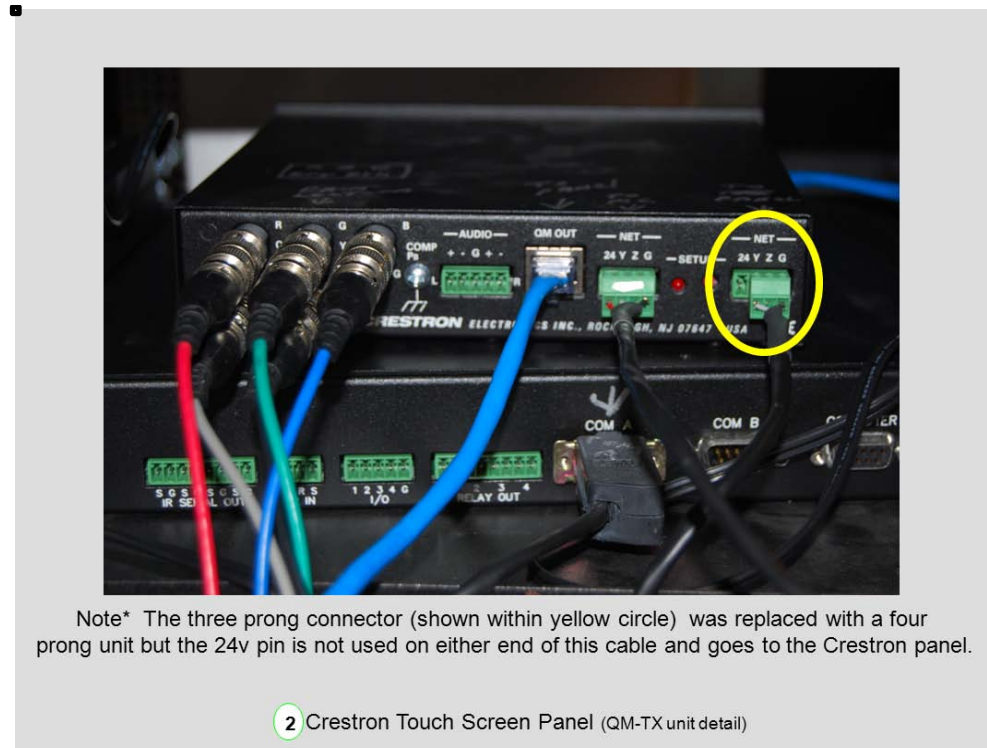
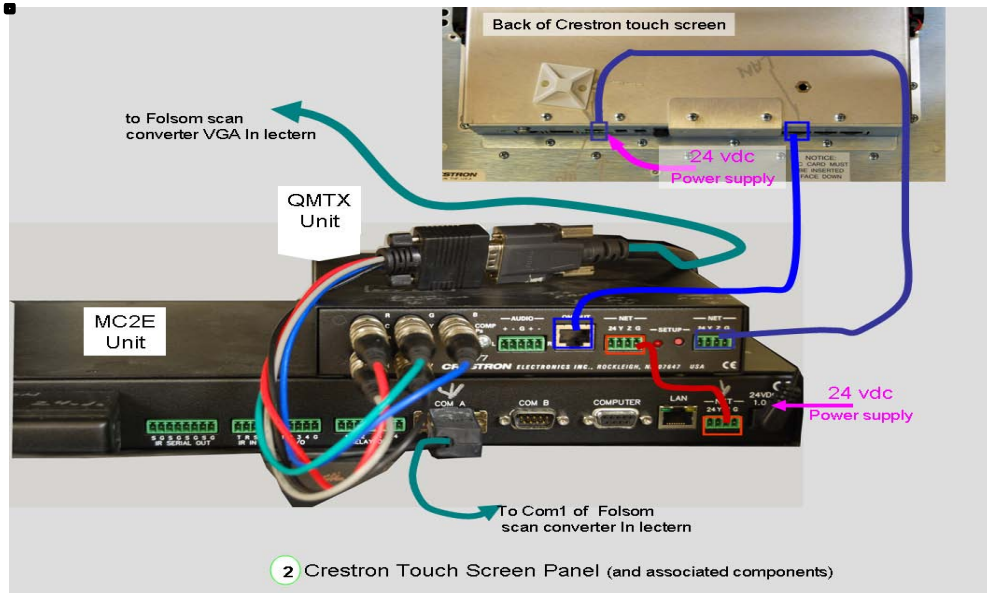
Webcast conducted at the Rocky Hill Central Lab. Hosted by Office of Info Systems. April 20, 2012

[CT Workforce Study Committee Meeting](#)

Webcast conducted at the Rocky Hill Central Lab. Hosting provided by Office of Info Systems. March 14, 2012

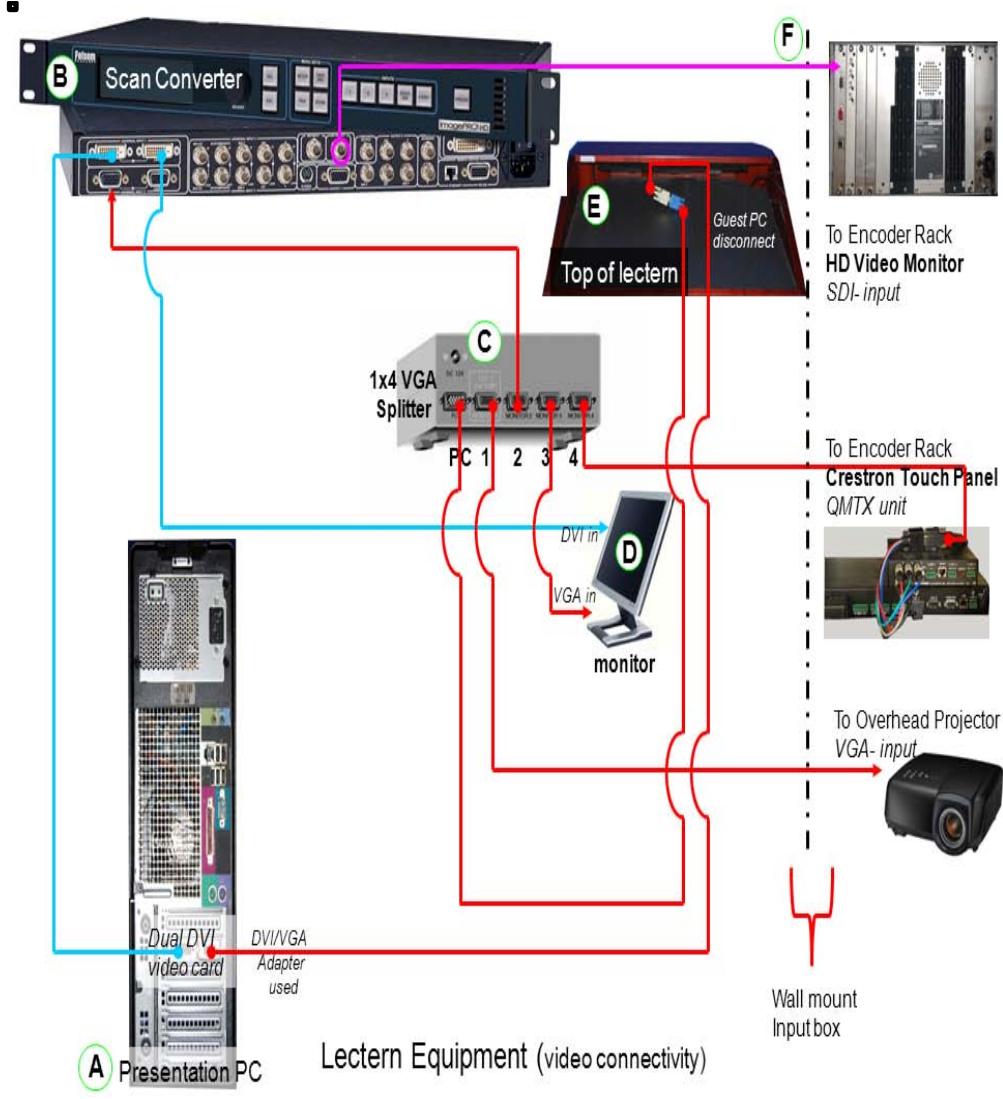
<p>CT Workforce Study Committee Meeting</p>	<p>Webcast conducted at the Rocky Hill Central Lab. Hosting provided by Office of Info Systems. March 14, 2012</p>
<p>CT Workforce Study Committee Meeting</p>	<p>Webcast conducted at the Rocky Hill Central Lab. Hosting provided by Office of Info Systems. February 08, 2012</p>
<p>Benchmarking Connecticut's Transportation Infrastructure Capital Program with Other States</p>	<p>Conducted at the Rocky Hill Central Lab on January 05, 2012</p>
<p>CASE Briefing on Nuclear Power Technology to the CT Energy Advisory Board</p>	<p>Video provided, courtesy of CT-N Recorded on December 9, 2011.</p>
<p>Benchmarking Connecticut's Transportation Infrastructure Capital Program with Other States</p>	<p>Conducted at the Rocky Hill Central Lab on November 4, 2011</p>
<p>Benchmarking Connecticut's Transportation Infrastructure Capital Program with Other States</p>	<p>Conducted at the Rocky Hill Central Lab on September 30, 2011</p>
<p>The Uncertain Future of Nuclear energy after Fukushima</p>	
<p>Advances in Nuclear Power Technologies (A study in progress)</p>	<p>Presented by Professor Frank von Hippel May 10, 2011</p>
<p>About mPower Reactor Technologies</p>	
<p>Advances in Nuclear Power Technologies (A study in progress)</p>	<p>Presented by Mr. Jeff Halfinger Babcock and Wilcox Company February 4, 2011</p>
<p>An Industry Perspective on Closing the Nuclear Fuel Cycle</p>	
<p>Advances in Nuclear Power Technologies (A study in progress)</p>	<p>Presented by Mr. Paul Murray-AREVA February 4, 2011</p>
<p>Nuclear Power in the United States</p>	
<p>Advances in Nuclear Power Technologies (A study in progress)</p>	<p>Presented by Dr. Pete Lyons, Acting Asst. Secretary for Nuclear Energy, U.S.D.O.E. Meeting held January 18, 2011</p>
<p>Advances in Nuclear Power Technologies</p>	
<p>(A study in progress)</p>	<p>A Study Committee Meeting held on October 18, 2010</p>
<p>Environmental Mitigation Alternatives for Transportation Projects - SPR-2266</p>	<p>A Briefing held on September 30, 2010 in Rocky Hill</p>
<p>A Study of the Weigh Station Technologies and Practices</p>	<p>Presented on September 21, 2008</p>

APPENDIX B. CENTRAL LAB STUDIO WIRING AND DOCUMENTATION





Crestron Touch Screen Panel (works with Folsom Scan Converter)



ENDNOTES

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- i <http://windows.microsoft.com/en-US/windows/downloads/windows-media-player>
- ii <http://windows.microsoft.com/en-US/internet-explorer/downloads/ie>
- iii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=477662>
- iv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=469182>
- v <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=441710>
- vi <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=499762>
- vii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=477642>
- viii <http://docs.trb.org/01101651.pdf>
- ix mms://159.247.0.209/mediapoint/research_projects/spr-2254/oldwayofwebcasting.wmv
- x mms://159.247.0.209/mediapoint/research_projects/spr-2254/crestron.wmv
- xi mms://159.247.0.209/mediapoint/research_projects/spr-2254/davehowley_coring4.wmv
- xii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=327664>
- xiii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=327668>
- xiv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=327670>
- xv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=439660>
- xvi mms://conndot-video.ct.gov/mediapoint/fhwa/Ramon_Bonaquist.wmv
- xvii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=479652>
- xviii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=501604>
- xix <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=445792>
- xx <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=448116>
- xxi <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=461486>
- xxii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=465402>
- xxiii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=477572>
- xxiv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=489604>
- xxv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=502256>
- xxvi <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=499762>
- xxvii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=499142>
- xxviii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=500934>
- xxix <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=503144>
- xxx <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=504362>
- xxxi <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=506930>
- xxxii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=508344>
- xxxiii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=509966>
- xxxiv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=511194>
- xxxv <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=512512>
- xxxvi <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=512718>
- xxxvii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=512876>
- xxxviii <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=441700>
- xxxix http://www.ct.gov/dot/low_strength_concrete
- xl <http://www.ct.gov/dot/frictiontesting>
- xli <http://www.ct.gov/dot/asis>
- xlii <http://www.ct.gov/dot/dss>

ENDNOTES (continued)

- xliv** mms:// 159.247.0.209/mediapoint/research_projects/prod_eval.wmv
- xliv** mms://159.247.0.209/mediapoint/research_projects/TDRC.wmv
- xlv** <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=507464>
- xlvi** <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=507464>
- xlvii** mms://159.247.0.209/mediapoint/psa/Rte_95_Bridge_Accident_multistream.wmv
- xlviii** mms://conndot-video.ct.gov/mediapoint/Construction/MosesWheelerPrebid_1-25-11.wmv
- xliv** <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=468388>
- l** <http://www.ct.gov/dot/smartdampeningtechnologies>
- li** mms://159.247.0.209/mediapoint/SPR2254/overdrive_audio.wmv
- lii** mms://conndot-video.ct.gov/mediapoint/statedesign/May_12_10_AboutStreamingMedia.wmv
- liii** mms://conndot-video.ct.gov/mediapoint/spr2254/baldwinbridgejoint.wmv
- liv** <http://www.ct.gov/dot/cwp/view.asp?a=1617&q=502152>
- lv** <http://www.ct.gov/dot/cwp/view.asp?a=1617&Q=284838&PM=1>
- lvi** mms://159.247.0.209/mediapoint/spr2254/webcast_reach.wmv
- lvii** <http://www.nysegov.com/webcast.cfm>
- lviii** http://www.governor.ny.gov/archive/spitzer/executiveorders/eo_3.html
- lix** <http://das.ct.gov/HR/JobspecNew/JobDetail.asp?FCC=1140>
- lx** <http://das.ct.gov/HR/JobspecNew/JobDetail.asp?FCC=361>
- lxi** <http://www.microsoft.com/en-us/download/details.aspx?id=9442>
- lxii** mms://159.247.0.209/mediapoint/webcast/spr2254/webcast_delay.wmv
- lxiii** mms://159.247.0.209/mediapoint/SPR2254/questions_after_presentation.wmv
- lxiv** Mms://159.247.0.209/mediapoint/case/11_15_12/part3.wmv
- lxv** mms://159.247.0.209/mediapoint/In_House/videoconferencingV8.wmv
- lxvi** mms://159.247.0.209/mediapoint/case/12_11_12/part2.wmv
- lxvii** mms://159.247.0.209/mediapoint/CASE/07_18_12/part2.wmv
- lxviii** mms://159.247.0.209/mediapoint/case/11_09_12/part4.wmv
- lxix** <http://www.ct.gov/dot/cwp/view.asp?a=2857&q=438418>