Feasibility of Streaming Media
For
Transportation Research and Implementation
Final Report

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16. Abstract This report is intended to serve as a guide for transportation personnel in the development and dissemination of streaming video-based presentations. These were created using streaming media production tools, then delivered via network and Web-based media servers, and finally, viewed from the end-users' PC-desktop. The study focuses on three popular streaming media technology platforms: RealNetworks® Microsoft® and Apple®. In-house video production was undertaken for a variety of uses within the agency. Section 508 and handicapped accessibility (ADA) was addressed by transcribing the spoken word into text and then synchronizing it to each presentation. Conservation of network bandwidth was paramount throughout the research project. Streaming media servers were established on both LAN and WAN, and demonstrated how streaming media can enhance ConnDOT's communications. Later, a Web-based media server was established on a robust Internet backbone. This valuable resource continues to be used for "live" Webcasts of national conferences and regional meetings, facilitating communications between this Agency and the national transportation research community. Video on demand (VOD), accessed through ConnDOT's Internet Website, demonstrated a wide variety of communication missions, including the dissemination of transportation research findings and implementation efforts. The streaming media library can be perused at http://www.ct.gov/dot/video				
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LIST OF ABBREVIATIONS AND ACRONYMS

ASCII text file format	TXT
Adobe Acrobat personal document file extension	PDF
Microsoft advanced streaming format	ASF
American Association of State Highway and Transp. Officials	AASHTO
Americans with Disabilities Act	ADA
audio/video	AV
audio video interleave	AVI
bit-mapped image file extension	BMP
California Department of Transportation	Caltrans
Central Connecticut State University	CCSU
charged coupled device	CCD
closed circuit television	CCTV
compressor/decompressor	Codec
cooperative education intern student	coop
compact disc recordable	CD-R
computer processing unit	CPU
Connecticut Administrative Technology Center	CATER
Connecticut Department of Transportation	ConnDOT
Connecticut Highway Motorist Patrol	CHAMP
Connecticut Management Advisory Committee	CMAC
cathode ray tube	CRT
Connecticut Television Network	CT-N
constant bit rate	CBR
Department of Administrative Services	DAS
Department of Environmental Protection	DEP
Department of Motor Vehicles	DMV
Department of Information Technology	DOIT
digital image stabilization	DIS
digital subscriber line	DSL
digital versatile disc-recordable	DVD-R
digital video	DV
digital video interface	DVI
digital video recorder	DVR
disk operating system	DOS
domain name system	DNS
E-Transcript Court Reporting file extension	PTX
Federal Highway Administration	FHWA
file transfer protocol	FTP
frames per second	fps
gigabits per second	Gbps
Gigabytes	GB
Gigahertz	GHz
graphical user interface	GUI
high definition	HD
Hypertext Markup Language	HTML
Hypertext Transfer Protocol	HTTP
Joint Photographic Experts Group	JPEG
Incident Management	IM
Institute of Electrical and Electronics Engineers Spec. 1394	IEEE-1394
Integrated Services Digital Network	ISDN
Internet Explorer	IE
kilobits per second	Kbps
local area network	LAN
Local Technical Assistance Program	LTAP
Macromedia's Shockwave file format	SWF

megabits per second	Mbps
Megabyte	MB
Megahertz	MHz
Memorandum of Understanding	MOU
Mississippi Department of Transportation	MDOT
Moving Picture Expert Group	MPEG
mp3 sound file format	MP3
National Cooperative Highway Research Program	NCHRP
National Television Standards Committee	NTSC
New Mexico Department of Transportation	NMDOT
non linear editing	NLE
Office of Communications	OOC
Office of Information Systems	OIS
Office of State Ethics	OSE
open host controller interface	OHCI
operating system	OS
personal computer memory card international association	PCMCIA
personal computer	PC
peripheral component interconnect	PCI
PowerPoint file extension	PPT
Principle Investigator	PI
Public Service Announcements	PSAs
Redundant Array of Independent Drives	RAID
random access memory	RAM
RealNetworks RealAudio file extension	RA
RealNetworks RealMedia file extension	RM
RealNetworks RealPix file extension	RP
RealNetworks RealText file extension	RT
Research and Implementation Activities	R&IA
Research and Innovative Technology Administration	RITA
Request for Information	RFI
Request for Proposal	RFP
serial digital interface	SDI
Strategic Information Communications Systems Committee	SI/CSC
streaming media	SM
Streaming Media Administrator	SMA
synchronized accessible media interchange file extension	SAMI or .SMI
super-video home system	S-VHS, VHS
synchronized multimedia integration language	SMIL
Targa image file extension	TIF
Transportation and Civil Engineering	TRAC
Transportation Research Board	TRB
uniform resource locator	URL
universal serial bus	USB
variable bitrate	VBR
video cassette recorder	VCR
video graphics adapter	VGA
video-on-demand	VoD
video production department	VPD
waveform audio file format	WAV
wide area network	WAN
Microsoft Windows Media Audio file extension	WMA
Microsoft Windows Media Encoder	WME
Microsoft Windows Media Player	WMP
Microsoft Windows Media Services	WMS
Microsoft Windows Media Video file extension	WMV
World-Wide-Web	WWW

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HOW TO USE THIS REPORT

The electronic version of this report contains hyperlinks that can provide access to all Microsoft Producer presentations and Windows Media Video (WMV) demonstration media by simply clicking on hyperlinks in the report. When viewing Microsoft'® media, use of the Windows Media Player (WMP) 9 series and Internet Explorer (IE) 5.0 Web browser is highly suggested. All hyperlinks will be accompanied by corresponding URLs, which appear within footnotes.

The Connecticut Department of Transportation's (ConnDOT's) Web Server will provide the ability to download non-Microsoft video/support-files that have been described in this report. Since WinZip[1] was used as a mechanism for compacting, organizing and packaging each non-Microsoft project/presentation into one exclusive folder, it is also required for unzipping, once downloading has been completed. A "read me" file within each folder then explains how to proceed once downloading and unzipping have occurred.

Based on statistics obtained from ConnDOT's Office of Information Systems (OIS), the majority of this Department's network-based personal-computer (PC) users already have the required hardware and software needed to play this research project's demonstration streaming media. The following table provides the minimum hardware and software requirements as well as the recommended specifications for viewing ConnDOT's new streaming media.

Table 1: Minimum and Recommended PC Hardware and Software Requirements

Item	Minimum Requirements for Playing ConnDOT's Media	Recommended PC- Workstation Configuration
CPU/memory	400 MHz PC/256k RAM.	1.5 GHz PC/512k RAM.
Monitor	SVGA, set to 800x600 pixels	SVGA, set to 1024x768 pixels
Operating System	All Microsoft Windows platforms better than Windows 3.1	Microsoft Windows XP
Soundcard Speakers	SoundBlaster compatible, with multimedia speakers	SoundBlaster compatible, with multimedia speakers
Media Player	Windows Media Player v6.4/better	Windows Media Player V9
Web Browser	Internet Explorer 5.0	Internet Explorer 6.0
Network	Ethernet 10/100 NIC	Ethernet 10/100 NIC

Please note that a full listing for all acronyms and abbreviations used in this report can be found on page VI.

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[1] http://www.winzip.com/

EXECUTIVE SUMMARY

This research project summary explains how streaming media technologies became an efficient mechanism for disseminating ConnDOT's transportation research program's findings. A streaming video version of this section of the report has been provided and can be viewed from the link *Executive Video Summary*[2].

Prior to 2000, the all-too-familiar video tape deck and TV monitor were being reluctantly pressed into service by staff, when needed. This inconvenient-to-use equipment only served to diminish videos' value here, since there wasn't any efficient means for sharing the ever-growing pile of videotapes with colleagues. What was needed was a method for electronically distributing and sharing research-project related video.

As faster computers became more affordable and available, they were providing the means to transform videotapes and video from cameras into a variety of digital video formats. When accessed from the PC-desktop, these typically-large "non-streaming" files (AVI and MPEG) quickly began to saturate ConnDOT's network and email servers, leaving IT administrators little choice but to restrict their use throughout the Department.

Negative perceptions regarding digital videos' use would persist at ConnDOT until around 2001, when Research staff observed that the Internet was being used by a growing number of individuals, universities, and corporate entities for distributing video-based information. An informal survey was conducted, and it was determined that video movies were being broadcast to an Internet audience using a relatively new technology called *streaming media*. In addition to enhancing Web-based client services, it was also being utilized internally to supplement employee training. With this information in-hand, engineers from ConnDOT's Division of Research began to envision how streaming media technologies could improve communications within the transportation research community.

A formal research project was initiated in January 2001 titled *"Feasibility of Streaming Media for Transportation Research and Implementation"*. The project evolved over the course of four-plus years. While the majority of the work tasks were pre-defined in a proposal, in actuality, supplementary research was conducted as new challenges arose. This significantly expanded on the original scope of work but also yielded additional findings and increased benefits.

At the onset of the work, the top-three leading streaming media platforms were identified: RealNetworks, Microsoft, and Apple. All were compared to determine which would be most suitable for meeting the needs of this office and the Department.

In order to effectively demonstrate streaming media's potential value, Cooperative Education Intern Students (coops) were employed for two years to create some of ConnDOT's new streaming media. The students' primary focus was video production and computer animation/graphics. In addition to creating presentations about the Division of Research and its various activities, other operational areas at ConnDOT were explored. To that end, the coops developed

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[2] http://www.ct.gov/dot/spr2231_video

presentations about the *Connecticut Highway Motorist Patrol* (CHAMP) and about the PC Support Help Desk.

After new presentations were created, they were then encoded using the three aforementioned streaming media formats. Each was evaluated for overall video and audio quality by conducting a "side-by-side" comparison. It was later concluded that from the end-users perspective, little difference in image-quality (appearance) exists between the three streaming media platforms.

Throughout the research project, streaming video presentations were freely made available to the public, via the Department's website. In order to ensure compliance with the Americans with Disabilities Act (ADA), *Department of Justice Section 508* Standards were employed as a guide. This meant that the majority of video found on ConnDOT's Media Library was accompanied by captions that were created from a text transcript of the "spoken words". The text is then synchronized to the audio-track and displayed, along with the video. While ensuring ADA compliance equates to additional effort and expense, the majority of ConnDOT's new streaming media does conform to the Section 508 Standards.

Beginning early in 2001, a Windows media server was established on the local-area-network (LAN) at the Rocky Hill CT Research and Materials Testing Laboratory (Rocky Hill Lab). One-hundred PC-users were provided with the ability to access and assess the research project's new streaming media.

Later in the fall of 2001, this research project's initial findings were presented to the ConneCT Management Advisory Committee (CMAC). CMAC manages the official State of Connecticut Website, known as ConneCT. The focus of the meeting was website accessibility issues and was attended by Webmasters from state government.

Throughout most of 2002, monitoring of the Rocky Hill Lab's LAN helped to confirm that the local media server had a negligible-impact to this facility's network-based traffic. This fact helped to justify obtaining a second Windows media server, which was strategically deployed in September 2002, at ConnDOT's Data Center. This expanded the research project's exposure to a much larger audience; that being the Administration building and its 2000-plus wide-area-network (WAN) PC-users.

Around January of 2003, the project's scope was modified to investigate whether the Department's Incident Management (IM) traffic camera infrastructure could be enhanced by using streaming video as a transmission mechanism. This effort did demonstrate through simulations that streaming video can deliver traffic camera images at increased frame rates to the PC-desktop. This was seen by this Office as an improvement, when compared to the Highway Operations Center's current method of supplying periodically-refreshed, JPEG images. However, it was determined that switching over to streaming video would be very costly to implement for approximately 200 traffic cameras in the highway corridor. No further action came out of this endeavor.

A significant project milestone was reached in February 2004, when a Web-based Windows media server was deployed at the State's Data Center (CATER) in East Hartford CT. This earned ConnDOT the distinction of being the first State of CT agency (other than DOIT) to operate and administer a Web-based streaming media server. It continues to be utilized to showcase innovative new uses for video-on-demand (VOD) at ConnDOT.

Ongoing collaboration between this office and ConnDOT's webmaster has provided the motoring public with streaming media 24/7 in the form of work zone safety videos. These are Highway Safety television commercials that have been in essence, recycled, by converting them into streaming videos.

The research project provided the impetus for developing ConnDOT's streaming media library. While only forty four research topics are currently available, these are being accessed quite often by the public, this office, and ConnDOT's national transportation research colleagues. The frequency of usage was determined by analyzing the media server's daily log files. The number of visits expected in 2007 is estimated to exceed 40,000. Based on these data, it is clear that continuing to utilize this new media server will advance the department's overall mission by providing enhanced Web-based services. This comes at a price; since DOIT charges ConnDOT about $12,000 per year for CATER to host the server.

In the summer of 2004, ConnDOT piloted Webcasting and demonstrated the role they can play for meetings and conferences. This was successfully demonstrated throughout the 4 ½ day 2004 AASHTO Research Advisory Committee Meeting, held in Mystic CT. The live webcasts of the conference were viewed by more than thirty Transportation Research professionals, from their respective states.

By the spring of 2005, Research personnel had achieved significant expertise in webcasting as a result of this office's hosting on-line technical workshops for the Federal Highway Administration (FHWA). Based on favorable comments obtained from the remote viewing audience, the Team Leader for FHWA's Pavement Design & Performance Modeling Team has indicated FHWA's interest in developing a similar capability. Additional webcasting opportunities arose in the summer of 2005. Initiated on behalf of the CT Department of Administrative Services (DAS), a webcast was undertaken as a pilot project for that agency. This collaborative endeavor was called Procurement-101 Training and not only demonstrated proof-of-concept to DAS' management, but inevitably propelled DAS onto the streaming media fast-track.

As the research project proceeded, a number of requests were received from outside agencies looking for assistance, related to streaming media. In response, this office shared both expertise and best practices with other state agencies like DAS. Furthermore, ConnDOT's media server and the researcher's acquired knowledge-base continue to be made available to others as needed, although requests must be considered on a case-by-case basis.

Late in December 2005, a presentation was conducted for the quarterly gathering of the Statewide Training Directors at the Rocky Hill Lab. The meeting started off by summarizing this research project's findings. Then, keynote speakers shared either their own streaming-media related experiences or disclosed streaming-media related services that their respective organizations can potentially provide to state of CT agencies. The link to this presentation is http://www.ct.gov/dot/tdm.

While the research project concluded around June 2006, the Division of Research continues to reap the benefits from having two powerful new tools in its repertoire: Video-on-Demand (VoD), and Webcasts. It is recommended that the Department move forward with a wider implementation based on Microsoft's Windows Media. This is the most practical platform to adopt, based on ConnDOT's existing software licenses and operating systems.

There are four key operational areas within ConnDOT that could gain the most from implementation. They are the Office of Communications, Office of Information Systems, Training Division, and Division of Research. All are well-positioned to benefit from implementation, but at present, may be inadequately staffed to support its use. At the time of this writing, implementation has not been administratively addressed.

The Division of Research began exploring additional innovative uses for this technology in an upcoming project titled "*Advancing the use of streaming media and digital media technologies at ConnDOT*", which was initiated in late October, 2006.

Chapter 1

INTRODUCTION AND BACKGROUND

ConnDOT's Division of Research undertakes an array of transportation-related studies and is charged with dissemination of those resultant findings. In this way, the research not only benefits ConnDOT but on a broader scale, other States and their respective transportation Research Departments. Prior to 2000, each principal investigator would generate a final research report upon conclusion of a federally-funded project, using the traditional printed publication method.

The distribution of documents in the Adobe Acrobat (.PDF) format was beginning to gain widespread acceptance, since it provided increased efficiency, utility, and convenience. Emailing of research reports as hyperlinks to PDF documents on Web servers greatly reduced the cost and effort to disseminate them and also diminished the paper stream. The Internet was also playing a role by providing on-line access to electronic document libraries.

The typical research report is a text-based composition that frequently contains graphs, charts, and pictures. Relevant, video-based information was occasionally distributed on CD-ROM with the report. However, disseminating video-based information along with the electronic document was not feasible, since there wasn't any efficient mechanism for doing so at the time. This was unfortunate because video cameras were occasionally used in the field by engineers for documenting important elements of research projects. As a result, potentially valuable project related video continued to be excluded from the on-line reporting process.

By 2000, video in its digital "state" was finding its way onto ConnDOT's file and email servers and was garnering the attention of IT administrators. They were becoming concerned that engineers, although well-intentioned, were sharing work-related video-based information via the network. Facilitating this process were faster computers, which were being used to capture and digitize analog video tapes. Firewire-compatible video cameras were also contributing to this evolution because they could output digital video formats like AVI and MPEG. However, these were typically, extremely large files.

Once these "*non-streaming*" files were copied onto network servers or worse, emailed as attachments, they had the potential to adversely affect other operational areas at ConnDOT that were using the same finite network resources (bandwidth). No matter how infrequently this occurred, it only served to reinforce the premise that the use of digital video via the LAN and WAN should be severely limited. As a result, more restrictive policies were put in place by ConnDOT's IT administrators.

While the Department's usage of digital video was waning, the Web's popularity was continuing to expand. By 2001, the private sector was using the Internet as a conduit to showcase both goods and services. In a similar manner, ConnDOT had amassed hundreds of documents on its Website for keeping the motoring-public better informed. However, upon closer examination, not one hyperlink to video could be located. By comparison, the private sector's Websites were bristling with engaging and informative videos. Businesses were beginning to employ a relatively new technology called *streaming media* for training their staff, marketing their products, and enhancing customer services.

Comprised of audio, video, text and graphics, streaming videos were infinitely more convenient to view (when compared to videotape) from the PC-desktop. An important distinction was that streaming movies didn't need to be downloaded before viewing and once finished, didn't require deletion from the end user's computer. Of paramount importance was that streaming media servers could be configured to protect the integrity of the WAN. This would ensure that video would peaceably-coexist with all the other applications vying for network resources at ConnDOT. All of these factors made it feasible to initiate a new research project. The primary goal would be how best to implement this new technology for improving communications between the Division of Research and the national and international transportation research community.

Chapter 2

PROBLEM STATEMENT

During this research project, solutions to a number of problems were sought. As the work progressed, additional challenges arose and were subsequently investigated as well. This significantly expanded on the original scope of work but also yielded additional benefits. A brief description of the problems follows:

2.1: Need to make analog video more convenient to view and use

Prior to 2000, video cassette tapes, tape deck, and monitor were seen as the only viable means for viewing and sharing of pre-recorded training materials and any videotaped research project-related documentation. Unfortunately, setting up the requisite audio/video (AV) hardware proved to be very inconvenient for staff, even for occasional use. If duplication of the tapes was required en-masse, it was cumbersome to manage and costly to deliver. Over time, research engineers depended less on video cameras for in-the-field documentation, since an ever-growing pile of videotapes yielded few tangible benefits to ongoing or completed projects.

Then, there were concerns regarding videotapes' longevity. It has a relatively short life expectancy due to susceptibility from strong magnetic fields, excessive humidity and temperature.

Lastly, the footprint required to physically store videotapes is substantial. Based on these issues, it came as no surprise when this facilities' videotape library was relocated to the basement.

2.2: Need to conserve network bandwidth when utilizing digital video

Over time, some of ConnDOT' engineers figured-out that their work-related videotapes could be captured and digitized using the PC. Once the digital-video files were created, they could be placed on the Department's network and file servers, for conveniently sharing with colleagues. Unfortunately, these uncompressed or high quality files are not network friendly, since they can utilize massive amounts of hard drive storage and can also consume much of the available network bandwidth when being accessed and viewed. In response, ConnDOT's IT administrators established more restrictive policies on its file servers. This action effectively limited digital videos' value and use within the agency.

2.3: Need viable way to share digital video files with colleagues

Email was also employed for the transmission of digital video files as email attachments. Regrettably, these typically-large files (AVI and MPEG) had the deleterious effect of bogging down the Department's Microsoft Exchange server, especially when multiple email recipients were copied-in. This and similar activities contributed to a 5 MB size-limit being imposed for all email attachments. This made it impractical to share digital-video files as an email attachment. On the other hand, it is permissible to email a streaming videos' URL within the body of a correspondence. This practice would not transmit the actual video file but instead, provides a path (link) to where the video could be viewed.

2.4: Need to develop infrastructure to support streaming video

Prior to 2001 and this research project's inception, there weren't any media servers on ConnDOT's intranet and the Department didn't have access to an Internet-based media server. Additionally, the Department's network interconnectivity between its outlying facilities and its Data Center was inadequate to *support* agency-wide use of streaming media/video. Coincidently, a new Web-based statewide accounting system (CoreCT) would drive the need for upgrading the network.

2.5: Need to mitigate impact from out-of-State travel restrictions

For decades, out-of-state travel has been used to facilitate state DOT's in their effort to avoid duplication in transportation research. This was accomplished by institutionalizing national and multi-state collaborations to address research needs of mutual interest. More recently, budgetary constraints had led to restrictions being imposed on Connecticut state employees for out-of-state business travel. This meant that ConnDOT research staff could no longer count on attending research conferences and meetings. It was envisioned that streaming media technologies could play a positive role through the use of Webcasts and video-on-demand. These tools could be used to help mitigate the negative impact of travel restrictions on hundreds of collaborative research projects costing millions of dollars to execute.

2.6: Need to augment in-service training using an alternate mechanism

ConnDOT's Training Center is centrally-located in Newington CT and provides in-service classroom-based training to staff. While the majority (two thousand) can quickly commute to the Training Center, over 1100 individuals are not as conveniently situated. The most distant of these require a round-trip transit time in excess of two hours. While staff development is very important, this transit time coupled with increasing fuel and vehicle maintenance costs meant that workshops continued to be both costly and inconvenient to attend. For this reason, it was envisioned that streaming media technologies could be leveraged to augment classroom training.

2.7: Need Web-based training rather than distributing CDs and DVDs

Over time, the research project provided some of ConnDOT's operational areas with the impetus to develop video-based training. It was envisioned that this training would then be readily accessible from every desktop in the

Department. However, subsequent research determined that additional media servers would be needed to support broader internal-use of streaming media at ConnDOT.

As an interim solution, CDs and DVDs were seen as a viable way to distribute digital video-based training. While this removable optical-disc media can provide excellent quality, there is no efficient way to ensure that the information is up-to-date and therefore, accurate. It was envisioned that streaming media-based training, originating from one central server, would be the best way to ensure that video-based training was both timely and correct.

2.8: Need to ensure compliance with American with Disabilities Act (ADA)

Some of ConnDOT's research projects derive funding from the federal government. Utilizing these monies comes with the obligation to follow relevant established guidelines. One in particular that pertains to this research project is the *Americans with Disabilities Act* (ADA). It would appear that streaming media falls under the multimedia category and further interpretation suggested that an alternate form of accessibility was required.

Most if not all of ConnDOT's streaming media presentations are comprised of both audio and video (images). The video stream may consist of close-up views of the presenter, the audience, or of a PowerPoint slideshow. These images provide accessibility to those persons NOT *visually-impaired*. On the other hand, the audio stream consists of the presenter's spoken word, any audience questions, music, or other sounds. The audio stream provides accessibility to those individuals NOT *hearing-impaired*.

The use of captions that are synchronized to the audio stream was seen as the most viable way to supplement this type of multimedia presentation. However, preliminary research indicated that this may be costly to outsource or time-intensive to undertake in-house. Regardless of the cost or the complexity to accomplish, it was a requirement that must be met before streaming media could have any future viability at ConnDOT.

Chapter 3

STUDY OBJECTIVES

It should be noted that some of the following study objectives expanded and evolved as the study progressed. The objectives are concisely presented as follows:

- Improve communications with our transportation research colleagues, by disseminating any video-based assets of our transportation research projects.

  o Encourage research staff to expand their use of video recording in-the-field, thereby providing relevant source materials that are subsequently encoded and published as demonstration material on-line.

  o Collaborate with key operational areas within the Department to garner interest and support for future implementation of streaming media technologies.

o   Create streaming media content and determine how it will be
    formatted. Ensure compliancy with Section 508 guidelines
    pertaining to accessibility and disabilities.

o   Obtain and administer an Internet-based streaming media
    server, to efficiently disseminate demonstration media to the
    national transportation research community, via the Web.

o   Develop a "live" Webcasting capability for use during national
    transportation research conferences and meetings, and for Web-
    based distance learning and training.

o   Investigate whether these same technologies could play an even
    greater local role by providing ConnDOT with an effective
    mechanism to enhance Web-based services for use by the
    motoring public.

Chapter 4

WORK TASKS

In order to develop the required level of proficiency to utilize streaming media technologies, this study delineated some main areas on which to focus. These have been developed into specific work tasks. One of these tasks was instructional in nature and is titled "*factors that can influence streaming media quality*". It has been provided in Section A3 of appendix A (page A-7).

4.1: Identify and Evaluate Three Most Popular Streaming-Media Platforms

It was determined early on in this research study, that only the three most popular streaming media platforms would be investigated. The technical documentation that each company provides was found to be both well-written and readily accessible from their respective Websites. Therefore, this report will not attempt to duplicate this information.

By the time this report was being published, RealNetworks had already discontinued some of the products described within this document. Because computer hardware and software development is in a constant state of flux, this report will only be capturing a brief "snapshot in time" of any given products' capabilities. This means that any deficiencies that were mentioned may have already been resolved in a subsequent hardware or software revision.

4.1.1: Compare Unicast vs. Multicast and On-demand vs. Broadcast

While there are differences between the three leading streaming media platforms, there are also many similarities. For example, all three can deliver streaming media content to the PC-desktop via a client/server mechanism. There are two primary methods for establishing a connection between the client and server: unicast and multicast. This is determined by the streaming media administrator (SMA) at the time a publishing point is first configured. A publishing point resembles a DOS folder and has a root directory that can be further divided into subdirectories. In this way, new media can be organized into various categories. A brief description of unicast and multicast follows.

> o *Unicast* refers to any one single user's controlling of an on-demand stream. In this case, the one client/server connection has exclusive control over this stream by being able to start, pause, fast-forward, and terminate it.

> o *Multicast* should be used when the intended audience is comprised of many concurrent viewers. Each person receives the same identical program but can't control it in any way. Multicast is reputed to be a much better choice than unicast in this case because its use can significantly reduce network bandwidth consumption. Please note that the Internet does not support multicasting.

There is some additional terminology that differentiates how a streaming media presentation is disseminated to the end-user; that being on-demand or broadcast.

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o *On-demand* describes how media files residing on a media server can be viewed anytime 24/7. It also refers to the way in which the client selects the desired presentation they want to see and initiate *when they want to see it*.

o *Broadcast* on the other hand is analogous to television in that a number of clients can view only what is currently being provided by the host/content provider. Media can only be accessed during the timeframe that the host determines it be made available. A broadcasts' availability is typically announced by email, Webpage or other means, prior to a live event.

A brief description of three of the most popular streaming media platforms investigated during this research study follows. This work was undertaken in three distinct phases.

4.1.2: RealNetworks

RealNetworks' streaming media platform is based on the RealMedia movie format. The company was one of the first to move towards multi-platform media players. This contradicted the commonly held premise that streaming media technologies were exclusively proprietary in nature. This had been based on the fact that most company's media must be created, streamed, and viewed using its own products. It was later confirmed that the RealOne media player also plays Microsoft's .WMV and .ASF formatted files.

While it was noted early on that RealNetworks had a number of free offerings back in 2001, at the present time, the majority of its products must be procured. A description of those products evaluated during the RealNetworks' phase-of-work can be found in the appendix.

4.1.3: Microsoft

Microsoft streaming media platform was initially based on the Advanced Streaming Format (ASF) which later became the Windows Media Video (WMV) format. ConnDOT's *Office of Information Systems* (OIS) continues to employ Microsoft operating systems and software licenses for the Department's many servers and workstations. Since Windows Media Player (WMP) typically comes bundled with most workstation OS, the majority of PCs here already have one version or another of the player. Prior to the Windows XP OS being released in 2001, WMP came in two basic flavors which were version 6.4 for use with NT 4.0 and version 7.1 for using with Windows 2000. At the time of this writing, version 10 had just been released.

One advantage to using Microsoft's streaming media-related products is that many are available at no cost. This does not apply to OS or server software. The appendix provides a detailed description of those Microsoft products that were evaluated during this research study.

4.1.4: Apple

Apples' streaming media platform is based on the QuickTime® (MOV) movie format. Unfortunately, ConnDOT's OIS does not support Apple workstations and servers. This manifested itself by not having any assistance for resolving

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problems getting Apple machines connected to the network. This continues to be an ongoing issue at ConnDOT, and appears to be due to concerns regarding network security. This is very unfortunate since Apple continues to be a leader in the digital video and computer graphics arena for both video production software and hardware. Macintosh G4, G5, and PowerMac Pro computers were successfully utilized for digital video editing. The appendix provides a detailed description of those Apple products that were evaluated during this research study.

4.2: Provide Publishing Tool Training to Office staff

As streaming media-related expertise was acquired, this principle investigator (PI) actively solicited interest and provided assistance to research staff for the purpose of developing their own research project's presentations. This task's title refers to "publishing tools". This is software that is commonly used to both create and generate streaming video-based content. Once new content is created, it is published by uploading it to a media server for distribution via local network or the Web.

The first step taken in this training effort was to encourage staff to take video cameras with them into the field. These would be used for documenting various elements of research projects such as in-the-field data collection methods, site layout, instrumentation placement, and vendor-installation procedures.

Prior to 2001, this Office shared only one S-VHS video camera. Unfortunately the camera battery was often left discharged and the camera's substantial weight and size did not motivate staff to use it. To make it easier to tout around, four DV video cameras were procured. Being small and lightweight went far in motivating engineers to bring them in the field more often. As an added incentive to research staff, these cameras are available on short notice and camera batteries are always kept in a ready state of charge.

Next, to facilitate the offloading of video from the DV cameras, inexpensive PCI-bus firewire cards were procured for existing desktop PCs and PCMCIA-slot firewire cards were purchased for notebook PCs. Before 2003, most new PC purchases did not come standard with DV. Firewire is also known as IEEE-1394. It is a digital video (DV) format that uses a single-cable serial data transfer protocol and interconnection system. Staff was encouraged to offload video onto their own PCs using already-installed software such as XP's Movie Maker®. If required, engineers could rely on this PI for accomplishing this task for them.

It was necessary to obtain additional hard drive space for staff members to use while they were giving video editing a try. External firewire drives were procured, since these are easily and quickly connected to the PC and don't require any driver installation for Windows XP™. The earlier drives were based on the 400 mbps data transfer rate which was adequate for digital storage. Then in 2004, the faster 800 mbps data transfer rate became available and were better suited to more rigorous tasks like audio/video (AV) editing and rendering. These drives provided storage of 250 GB for less than $300.00 each.

For video editing, staff used both Microsoft *Movie Maker* and *Producer for PowerPoint.* Movie Maker was used for capturing video and audio to the PC and for basic video editing. Producer was used for creating streaming presentations

from existing PowerPoint slideshows. A handful of staff learned how to use these programs with very little effort.

To summarize, the following steps are enlisted for getting staff to incorporate video into their research projects. These are:

- o   Actively promote the use of video within the Office
- o   Instruct staff on proper use of video cameras in the field
- o   Provide firewire cards and external hard drives to staff
- o   Offer training to staff for using basic video editing software

It was concluded that most research engineers have neither the time nor the inclination for taking on new duties like video editing. Therefore, there is an ongoing need to provide video production services and support to staff when needed.

4.3:   Utilize and Evaluate a Media server on the Local Area Network

Watching streaming media (SM) presentations on a PC can provide a television-like viewing experience. SM is even capable of supporting "high definition" (HD) video of *1280 x 720* pixels at an encoded bitrate of 5.5 megabits per second (mbps).

 While HD streaming videos provide the highest possible quality, this research project prescribed to the tenet of *doing more with less. T*his meant that conserving network bandwidth was a primary objective throughout the study. To that end, the following smaller-size video format was arrived upon.

The project adopted a maximum video size of *640 x 480* pixels and an encoded bitrate of 300 kilobits per second (kbps). The video frame rate of 15 frames per second (fps) was adopted, deviating from the Industry-standard of 30 fps. Since these settings provided adequate image and audio quality throughout the research project, they continue to be used to this day.

Once new streaming media content has been created, it can be played locally from most PCs via hard drive, CD, DVD, or network. However, having a client/server capability was seen as infinitely more convenient. It was determined that all three streaming media companies support this capability. Of primary importance is that streaming media servers can be configured to protect network bandwidth from misuse or overuse.

The word "*misuse*" refers to someone inappropriately encoding a video presentation at excessively-high bitrates during the media creation process. This could happen by accident or even deliberately by applying the age old adage that "*bigger is better*".

The word "*overuse*" refers to an excessively high number of simultaneous connections being made on the server. This can result when using inadequate server hardware or if network throughput is marginal.

In 2000, permission was obtained to begin testing and evaluation of streaming media from the local area network (LAN). First, a RealNetworks RealSystem® Server was deployed at the Rocky Hill Lab. This provided limited access for about 100 clients at this facility. After evaluating the server's performance, the machine was reconfigured for testing and evaluation as a Microsoft Windows Media® server later in 2001. As new streaming media was

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created and evaluated via the LAN, expertise and confidence were gained. The server had posed negligible impact to the network, so it became time to increase the research project's audience size and exposure.

4.4: Manage a Streaming Media server on the Wide-Area-Network

The majority of the Department's 2000+ network-based PC users were not "invited" to view this project's new streaming media until such time that a local media server came on-line at the Newington Data Center. This would keep network traffic on the external OC3-line to a minimum. The Data Center is connected to the Administration building via eight separate fiber cables that provide a combined bandwidth capacity of 8 gigabits per second (gbps).

Before this server could become operational, permission was required from the Strategic Information and Communications Systems Committee or SI/CSC. The request was made and authorization was given to proceed, but with caution. It was mutually agreed that the server would be initially configured to limit the total streaming media bandwidth usage to one (1) mbps; a fraction of the total available capacity.

From the onset, it was anticipated that OIS would grant this PI administrative (admin) rights to the server. Learning first-hand how to configure the server's various parameters would make documenting the entire process more accurate. In addition, admin rights also convey the ability to monitor the server's performance in real-time using a *remote desktop connection*. While this issue was seen as very important by this Office, admin-rights were not granted by OIS. This initially hampered the study. Also, this PI was not given access to the *Windows Media Services* (WMS) log files. Instead, monthly requests to OIS were required for obtaining them. It was later determined that "sharing-out" the server's log-file folder as a network drive would have provided a more convenient solution.

During 2002, the server was installed onto the WAN by OIS staff and a *publishing point* was configured for this PI's exclusive-use. Once the new content is created in the WMV format, it is "moved" onto the server's "data" hard drive. Then, a hyperlink containing the required URL is used to initiate the video stream.

Over the next few years, confidence was gained from knowing that the server was providing good overall performance to the Administration building and without generating complaints or concerns from the research activities.   This fact cleared the way for OIS to incrementally authorize more bandwidth usage; first to two mbps and later to ten mbps.

Table 2 gives specifications for the project's WAN-based Windows media server, located at the Data Center, in Newington CT.

Table 2: Specifications for WAN-based Streaming Media Server

PC:	Dual Intel Pentium III, 1.4GHz CPU
Memory:	512KB L2 cache,512MB of 133MHz ECC SDRAM
Storage:	3 hot-swappable 32GB hard drives at RAID-5.
Network:	Integrated dual Gigabit Network Interface Card
Controller:	Integrated dual-channel Ultra3 (U160) SCSI
Operating System:	Microsoft Windows 2000 Advanced Server
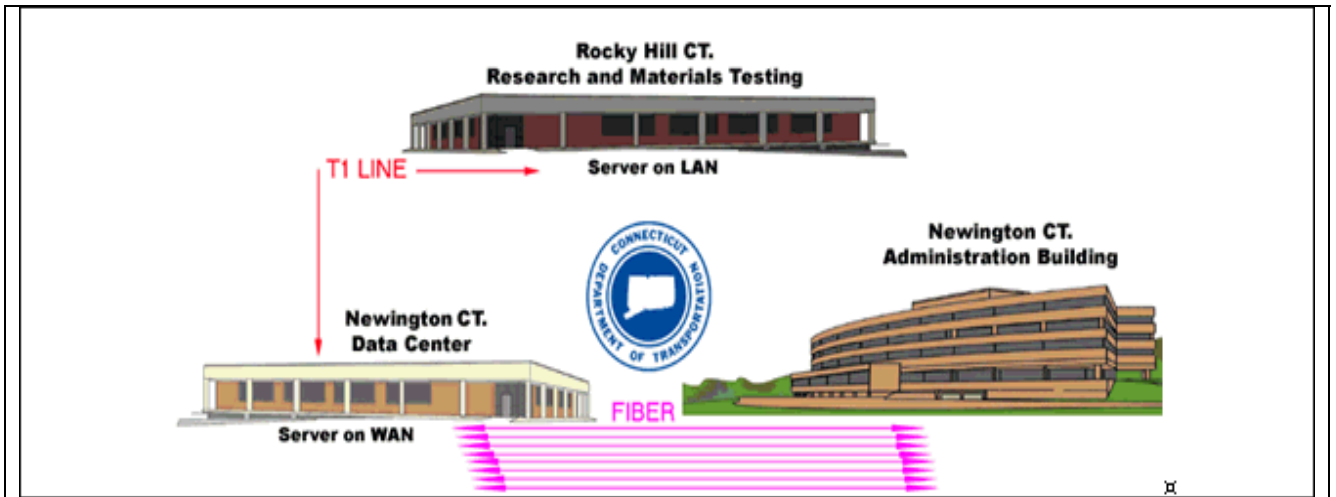
Figure 1: Location of WAN and LAN-based Media Servers (*prior to 2005*)

4.5: Evaluate and Integrate Video Production Equipment

Prosumer-quality video cameras were initially purchased for the project. These meld professional quality features with pricing that is slightly higher than that of consumer level equipment. This office employed mini-DV cameras, costing less than $800 each for creating good quality video content. In comparison, professional models can cost 10 times that amount. While it is true that high-end equipment ultimately produces better quality video, sophisticated cameras can require significant expertise to properly use them. Equally as important to image quality were camera size and weight. It was envisioned that staff were more likely to tout into the field a compact and easy-to-use video camera, rather than a bulkier, more complicated model.

Once recorded onto tape, the video may need to be edited. There are a number of ways to accomplish this but the most practical method relies on the use of the non linear editing (NLE) workstation. It is typically used to:

- o Digitize video and audio from a video camera or tape deck
- o Edit scenes, adding transitions, music tracks, etc.
- o Publish the final streaming movie format

The typical NLE is a computer-based system that can be procured for as little as $1,000 to over $50,000. This project evaluated a handful of the lower-priced systems. It was concluded that performance and efficiency was dramatically improved when the PC or MAC came with multiple-processor support and lots of memory (RAM). This equated to less time waiting around to render the video.

In order to facilitate video production, a substantial amount of time and effort went towards engineering a studio at the Rocky Hill Lab. This is where video and audio mixers, stage lighting and video cameras have been integrated to record presentations. The studio serves double-duty during Webcasts, meetings, or when training opportunities present themselves. Section A2 of the appendix provides a more detailed breakdown and description of this equipment and how it is utilized within the studio.

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4.6: Make Streaming Media ADA Compliant

In 1998 Congress amended [Section 508][3] of the Rehabilitation Act (29 U.S.C. 794d). It requires, in part, that "Federal agencies' electronic and information technology are accessible to people with disabilities, including employees and members of the public". Part 1194.24 specifically addresses video or multimedia products as shown in the following paragraph:

> *"Multimedia products involve more than one media and include, but are not limited to, video programs, narrated slide production, and computer generated presentations. Provisions address caption decoder circuitry (for any system with a screen larger than 13 inches) and secondary audio channels for television tuners, including tuner cards for use in computers. The standards also require captioning and audio description for certain training and informational multimedia productions developed or procured by Federal agencies. The standards also provide that viewers be able to turn captioning or video description features on or off."*

It can be inferred from perusing the Section 508 documentation, that any State Agency conducting projects using federal funds must provide an alternate means by which disabled people can access information when disseminated via the Internet. Synchronizing transcribed text to the streaming presentation appears to be the most viable way to accomplish this goal and this research report documents how to implement captioning. While making streaming media presentations ADA-compliant equates to additional expense and effort, not doing so would appear to present some degree of liability for ConnDOT. Figure 2 below illustrates how *open captions* are being utilized by ConnDOT (see area between arrows for illustration).

(A)Embedded video and caption region in typical Webpage	(B)Black caption box created with DIV HTML-tag in *Producer for PowerPoint 2002*
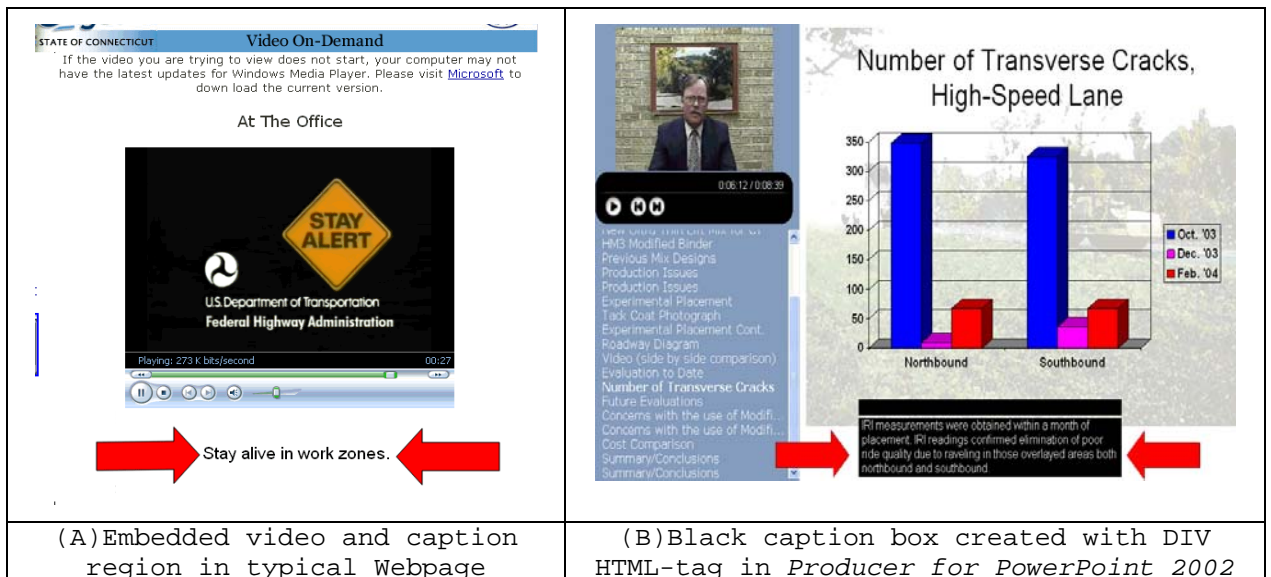
Figure 2: ConnDOT's Use of Open Captions

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[3] http://www.usdoj.gov/crt/508/508home.html

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During the research project, captions were employed with the video, but the captions were not of a closed nature. C*losed captions* require that the end-user enable this feature in the media player. Unless intentionally activated, the captions would not be discernable. People with disabilities may be more familiar with how to accomplish this, but others may not. Because this research project is for demonstration, another method for displaying captions was developed. The use of o*pen captions* ensured that the captions would always be visible.

The next three sections will focus on how to address ADA for the Microsoft *Windows Media Player*. Some of these procedures were used to make this research project's new media ADA-compliant.

4.6.1: Transcription

A text transcript is created from all of the words spoken during a presentation. If undertaken in-house, this process would require a proficient typist using a PC and text generating program like Notepad™ or WordPad™. Microsoft Word™ provides spelling and grammar checking and is a better choice for word processing. The typist must simultaneously listen to the audio portion of the presentation while typing along. If interrupted, by phone call etc., it is cumbersome to resume where leaving off in the presentation. When the transcript has been finished, the resultant document is saved as a text (TXT) file. Using these procedures to create transcripts is time consuming and tedious.

In-house transcript creation can be somewhat simplified by using a PC-based application called WavPedal™. It employs a foot-pedal to control the playback of the video/audio file within the word processor environment. This functionality is similar in nature to the now ubiquitous Dictaphone©.

Thankfully, there are court reporting and legal transcription services that can be procured to accomplish the transcription task. Court-stenographers using specialized software will typically generate 40 typewritten pages per hour of video/audio in which people are speaking. The effort typically yields a PTX output file common to the Court Reporting industry. The PTX is specially formatted and consists of 25 lines per page and approximately 50 characters per line. In addition, the left-most column contains both numerical page breaks as well as line numbers. ConnDOT has these line numbers omitted, since they are not used in captioning. A TXT file is required for the next step and this is exported from the PTX file using standalone software that is usually provided free of charge.

4.6.2: Video-to-Text Synchronization

The next step taken to make the streaming video ADA-compliant is synchronizing the TXT file to the streaming video presentation (WMV) and creating a SAMI file. SAMI is a text synchronization file that was specifically created by Microsoft for displaying captions within its Windows Media Players. The only practical way to create a SAMI in-house is to use a program specifically designed for that purpose.

One such program is called Magpie[4] and can be downloaded, free of charge. It was used throughout this research project for synchronizing videos of one-hour

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[4] http://ncam.wgbh.org/webaccess/magpie

or less in duration. This task is accomplished in real-time and is tedious.
Outsourcing of this task is preferable so queries were made and yielded at least
three companies that provide this service. They are Visionary Legal
Technologies, LiveNote, and Synchron.

4.6.3: Compilation

Before an ADA-compliant streaming video presentation is capable of being
viewed on-line, some technical issues need to be addressed. First, the new SAMI
file needs to be posted to the Department's Web server by the Webmaster. Then,
this PI transfers the new WMV video file using FTP, to the appropriate
publishing point on the Windows media server. Lastly, this PI assembles the
URL-string from the known video-file and SAMI-file paths and requests a shorter
version (shortcut) from the Webmaster.

4.6.4: Costs

During this project, it was determined that transcribing services are
currently available under existing State contract. An hour of video will
typically translate into forty typewritten pages, once transcribed. Each page
costs $4.09 to transcribe, based on a 14 day turn-around time. This equates to
about $164.00.

At present, there are no State contracts in place for video synchronization
services. However, a handful of vendors were identified that can do this. Their
prices ranged from $12.50 to $95.00 per each hour of program video. Therefore,
the total combined cost for both transcription and synchronization is about
$182.00 per each hour of program video.

Transcription creation represents the bulk of the expense when addressing
ADA. It is envisioned that voice recognition software may play a future role by
lowering these costs. However, at the present time, this is not technically
feasible. The primary problem with most if not all voice recognition software is
that it needs to become "familiar" with each speaker's unique speech patterns and
vocabulary. This requires an extensive training session, whereby the speaker is
prompted to annunciate specific phrases or words.

Some speech recognition software developed for use by the Legal and Medical
professions has libraries of commonly spoken words or terms. These have been
shown to improve the software's overall accuracy. If a library of commonly-
spoken transportation words and acronyms were added to voice recognition
software, maybe it would result in additional accuracy and increased utility.

4.7: Assist Engineers with Producing Research Project-related Media

During the execution of this task, this PI assisted research engineers by
addressing content creation and streaming media production as required. One new
product that continues to be highly valued by ConnDOT's research management is
streaming media-based executive summaries. These videos have been shown to
succinctly present research project findings. When viewed from the PC-desktop,
they are an effective way to efficiently convey information via the Web.

Creation of a video-based executive summary usually commences once the
research project has been concluded. Many written research reports already

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incorporate a text-based executive summary within that document. This can quickly serve as the nucleus for the next step which is to videotape the presenter in the studio. The presenter stands in front of a blue-screen while reading their project summaries from a teleprompter. The videotaped content is then captured and imported into a non-linear-editing (NLE) workstation. This video is then used to produce a "talking head" that will need to be synchronized to additional illustrative elements such as images, tables, and charts. Supplementary graphics like these can help clarify complex ideas and enhance the overall effectiveness of any presentation. Most PI's develop project-related PowerPoint slideshows and images that can be exported from PowerPoint by saving the slideshow as TIF images. The TIF format was selected because it provides the highest possible quality when later imported into the NLE environment. Two examples of Division of Research executive summaries that are based on presentations and technical papers prepared for the Annual Transportation Research Board meeting are http://www.ct.gov/dot/tdd and http://www.ct.gov/dot/2-500ex.

4.8: Enlist Cooperative Education Interns to Create "How to" Training

In years past, local state colleges have provided a valuable resource to state agencies with their participation in the Cooperative Education Intern Program. Students or co-ops were utilized in this research study from the beginning of 2001 to the end of 2002 to undertake tasks that included speech writing, video production and editing, digital graphics and animation, and Web page design.

In principle, the coop program provides students with valuable career-oriented training in their desired-area of expertise, while providing ConnDOT with an economical, capable, and supplemental workforce. A six month training period was typically required before most freshmen would acquire proficiency using unfamiliar software such as Macromedia® Flash™ and Authorware™. College juniors may already possess familiarity with the Media-100® non-linear editing system if they had taken related classes at their University.

The research project realized a good "return on investment" when students stayed on for an additional six month internship block. This was evident by increased productivity and more sophistication in the quality of work created. It was originally proposed that coops would be utilized for media creation throughout this project's duration, but issues concerning Connecticut's State budget and Employee Unions prevented enlisting any interns after 2002 to the conclusion of this research project. Therefore, this PI and the Department's *Visual Media Designer* took on the bulk of this project's content development after 2002.

4.9: Develop Web Pages to Showcase ConnDOT's New Streaming Media

A variety of streaming media presentations were created, categorized, and freely-made available from the Department's Website and new Streaming Media Library.   This was done to demonstrate the potential uses of streaming media, when being viewed on-demand. The categories consisted of;
- Public Service-type Announcements *(Highway safety)*
- General Information *(of interest to Public)*
- Training *(webcasts and workshops)*
- ConnDOT Research Projects
- Miscellaneous

Early on in the research project, hyperlinks were created that only provided the direct path (URL) to the video files. The following link is an example mms://conndot-video.ct.gov/mediapoint/historical/recycledrubber_05.wmv. Clicking on the link triggers Microsoft Windows Media Player (if installed). This occurs because "*mms*" (**Microsoft *Media server***) is a protocol associated with transferring unicast data. Unfortunately, proper ownership of the videos was not being conveyed to the outside world when accessed in this manner. Discussions with ConnDOT's Webmaster led to developing new procedures for making all video easily identifiable as ConnDOT's intellectual property.

ConnDOT's Web-based streaming videos are contained within a "wrapper" that displays the *State of Connecticut* Web-Portal's standard Web page design. A *Windows Media Player* (activeX control) is embedded in the wrapper along with open captions in a reserved area, located directly below the video. Many examples of this can be seen from the Streaming Media Library[5]. In order to expedite content creation and turnaround, ConnDOT's Webmaster provided this Office with the ability to dynamically create new Web page wrappers as required, using an Active Server Page™ (aspx) template.

When navigating to this project's demonstration media, a somewhat lengthy hyperlink is used to provide the URL. Each URL is a concatenation of:

   o path to the Web server for both Active Server Page and SAMI file
   o path to the media server's publishing point and the video file
   o title to display on each wrapper page for each video presentation

Because these URL contains so much information, the text string sprawls across the Webpage as shown in the following example: http://www.conndot.ct.gov/media/mainpsa.aspx?url=mms://conndot-video.ct.gov/mediapoint/historical/recycledrubber_05.wmv?sami=http://www.conndot.ct.gov/sami/recycledrubber_05.smi&name=Mr.%20Donald%20Larsen%20. The following paragraph gives a breakdown of what information is contained within the URL above.

   o [*www.conndot.ct.gov*] is the Web server's DNS. This server houses the Active Server page called [*mainpsa.aspx*].
   o [*www.conndot-video.ct.gov*] is the media server's DNS. [*Mediapoint*] is the media server's publishing point that houses the video file.
   o [*historical*] is a folder created on the media server for organizing video. [*recycledrubber_05.wmv*] is the video filename.
   o [*recycledrubber.smi*] is the SAMI Captions filename on the Web server
   o [*%20**Mr.**%20**Donald**%20**Larsen***] displays the title "Mr. Donald Larsen"

Sometimes the sprawling text strings (URLs) "fall apart" when copied to the clipboard and emailed in a message. This happens if the email application software inserts page breaks or non-printable characters into the long URL character string. To prevent this from occurring, shortcuts should be provided. This Office requests shortcuts from ConnDOT's Webmaster any time a URL is used within a report. A shortcut used for replacing the sprawling URL above is simply http://www.ct.gov/dot/recycledrubber.

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[5] http://www.ct.gov/dot/video

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4.10: Explore Streaming Media's Potential Use by Other Operational Areas

In addition to the Division of Research, other key operational areas at ConnDOT were identified and solicited to see if streaming media could provide similar benefits. This appeared to be a prudent step because staff inevitably retire or move on from state service. When this occurs, valuable knowledge resources are lost forever. Using streaming media to document specific skills while they are still available can help minimize this lose. One example is *SiteManager Training*[6]. The Department's resident expert on this system was Mr. Joseph Bouchey, who resigned in 2005.

The PC Support Group, the Office of Communications, and Highway Operations agreed to participate in this research project. Their efforts further demonstrated that streaming media technologies could be utilized Department-wide. This point will be expanded-on in the following paragraphs.

4.10.1: PC Support Help Desk

The Office of Information Systems (OIS) has a PC Support Group whose primary goal is to ensure that computer-related equipment remains operational. Since this research project relies on IT-related technologies, it was important to solicit both support and interest from OIS as early on in the project as possible. It was anticipated that collaboration would be mutually beneficial, so work was proposed to enhance OIS' *Self Help Desk*, located on the Department's Intranet.

PC Support staff were enlisted as "actors". Coop students helped develop the dialog and created customized graphics using Macromedia' Flash™. This effort yielded informative and compelling streaming videos that were effectively used to augment the OIS Website. The four streaming media presentations are:

- Greeting from Administrator of Office of Information Systems (OIS)[7]
- OIS mission statement presented by PC Support Supervisor[8]
- What happens when employees call the PC Support Help Desk?[9]
- How streaming media can begin to answer frequently asked questions[10]

In addition to providing a valuable product for OIS to use, it was anticipated that this endeavor would foster a more-productive relationship between OIS and this Office.

4.10.2: Office of Communications

Collaboration with ConnDOT's Office of Communications (OOC) provided the research project with both video-production assistance and expertise. This was

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[6] http://www.conndot.ct.gov/Site_Manager/default.htm#nopreload=1#autostart=1

[7] http://www.ct.gov/dot/greetings

[8] http://www.ct.gov/dot/pcsupport

[9] http://www.ct.gov/dot/helpdesk

[10] http://www.ct.gov/dot/afaqs

used to demonstrate that streaming media could enhance Web-based information and services that ConnDOT provides to the motoring public via its Website.

Highway-safety media campaigns have been used routinely by the Department to inform the public via television and radio. A 30 second segment can cost many thousands of dollars to air. Once produced, they are archived onto VHS-format video tape. The research project "recycled" these tapes by converting them to streaming video *Public Service Announcements* or PSA's. The past *Director of Communications,* Christopher Cooper, said:

> "*Public Service Announcements (PSAs) are just one small example of what can be economically-produced to better serve Connecticut's motoring public. In the future, this Office will continue to use streaming media to enhance the Department's presence on the Internet*".

Detailed analysis of ConnDOT's media server log-files validates that a Web-savvy public has perused these PSA's almost 37,000 times between February 2004 and November 2006. This can be seen in Figure 3 below under "Hits".
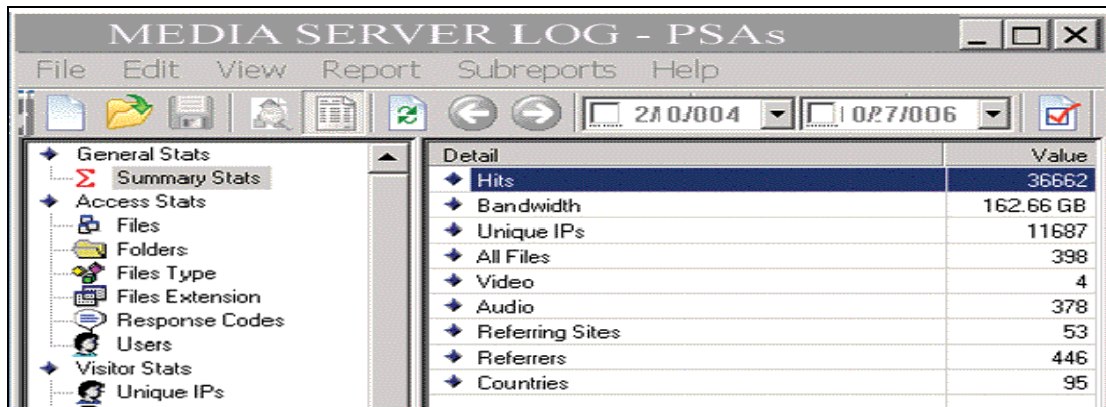
Figure 3: Summary of Media Server Usage for Highway Safety Videos

It is significant that the PSAs are being viewed as much as they are, considering there are only a handful of them on the server. Being accessible on-line and 24 hours a day/7 day's a week are two contributing factors.

4.10.3: Training Division

ConnDOT's Training Center is strategically situated, being in close proximity to the Department's Administration Building. This puts in-service training within convenient reach for a large number of employees. However, there are still four District Offices and ninety Highway Maintenance garages that are more remote. This can present some obstacles.

For example, a maintenance worker who must attend in-service training may be required to travel one or more hours. Coupled with increasing fuel and vehicle maintenance costs, employee training can be both inconvenient and costly. Streaming media can help bridge the distance gap by economically augmenting training. For example, it can be used later by past workshop attendees for review. It can also be made available for the benefit of newly-

hired employees and those individuals that were not able to attend training sessions, due to illness, etc.

There are a number of reasons why Web-based training delivered to the PC-desktop cannot totally replace training conducted in the classroom. One important one is compliance with mandatory training. Classroom attendance ensures that employees are receiving the required training, such as *Diversity Training* and *Sexual Harassment*.

In 2005, the Office of Materials Testing produced Web-based training that targeted ConnDOT's maintenance personnel. The topic is hot mix asphalt (HMA) and can be seen from the following link http://www.ct.gov/dot/superpave2005.

4.10.4:   Division of Highway Operations and Traffic Cameras

Prior to this research project's involvement with traffic cameras, ConnDOT's Division of Highway Operations was investigating Video Hosting Services like Trafficland[11]. It provides clients with the ability to offer real-time video on their Web sites. Highway Operations decided to enlist the services of this Office early in 2003, to explore whether streaming media (SM) technologies could be used for disseminating traffic camera video via the Internet. A request to modify this research project was filed with FHWA late March of 2003. Permission to proceed was granted and additional time and monies were allocated.

Highway Operations maintains and operates an expansive closed-circuit-television (CCTV) network at its Newington and Bridgeport CT facilities as shown below in Figure 4.
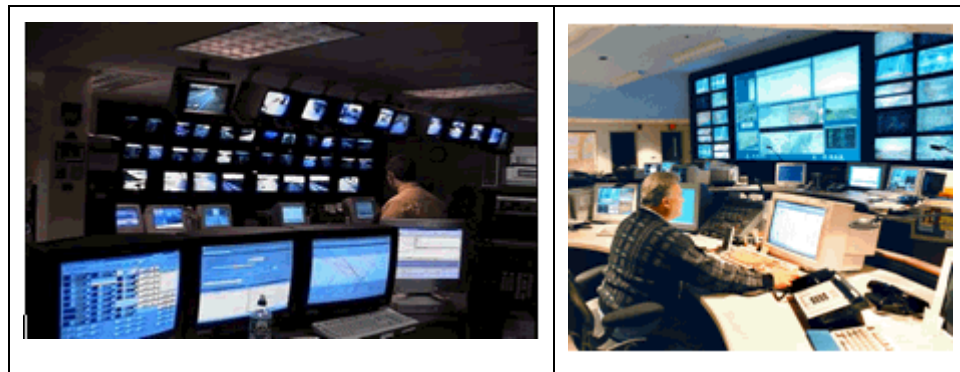
Figure 4:   Bridgeport and Newington CT. Highway Operations Centers

At the time the research was conducted, traffic camera installations were in-place at over two hundred locations at some of Connecticut's busiest highway corridors. In order to provide "real-time" traffic information to commuters traversing the interstates, still-frame JPEG images are provided as a joint service by the local television station *WTNH Channel 8 News* and the Connecticut Department of Transportation. These static pictures are typically formatted at

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[11] http://www.trafficland.com

250 X 250 pixels and uploaded to ConnDOT's traffic camera website[12] where they are refreshed every 5 minutes. This is similar to what other states provide to the public. Some websites suggest they provide live traffic video but as shown in the following example and link Washington-Baltimore-Annapolis Area Traffic Cameras, the images are actually static JPEG images that are periodically refreshed. This fact can be confirmed by right-clicking on the image and taking note of the files properties.

The California Department of Transportation (Caltrans) and Mississippi DOT (MDOT) are among a growing number of states that actually provide "live" traffic camera video for use by the public. The Caltrans site can be perused from the following link at http://video.dot.ca.gov/. It provides video that is formatted at 640 x 480 pixels and at 30 frames per second. It is encoded at 300 kbps.

This research project initiated its traffic camera phase of work during the spring of 2003. Specifications for off-the-shelf "*streaming media appliances*" were examined. These would be used to encode traffic camera video signals (NTSC) into the Windows Media Video format. Two Winnov *XstreamEngine EZ* were procured from a company called Winnov[13].

The Winnov units utilized a 1-GHz CPU running the Windows 2000 OS. Using a PCI-bus video capture card, it can accept either one s-video or two composite-video inputs. The encoding-engine of this device utilizes Microsoft' Windows Media Encoder (WME) version 7.1, and is controlled by Winnov's graphical user interface (GUI). This provides the ability to remotely configure (via network adapter) encoder parameters such as data rate, frame rate, and pixel size.

Prior to the Winnov units being purchased, a Winnov' salesperson had stated that the unit's software would be upgradeable as newer versions of the WME became available. In actuality, updating the unit to the newest Windows Media Encoder 9 Series codec could only be done at a substantial cost to the owner. Winnov said that this was necessitated by its having to re-write the "front end" (GUI) and also, update the unit's hardware. Based on this additional expense, in-house testing was done using version 7.1 of the WME. The unit was installed onto the WAN at the Highway Operations Center in Newington CT and provided with one NTSC-video traffic camera feed.

The Winnov unit's composite video signal was split and sent to two of the *XstreamEngine EZ's* composite video inputs. Then, a 33 kbps (dial-up) and a 100 kbps (broadband) stream were remotely-configured via the Winnov' GUI. Setup was straightforward and testing continued for six months. The two video streams were readily available for in-house evaluation during this period.

In order to demonstrate what effect bitrate and video frame rate have on video image quality, a variety of simulations were developed at one, five, and fifteen frames-per-second (fps), using the same video source footage for each simulation. This was subsequently encoded into streaming media at a native video resolution of 320 X 240 pixels. From perusing the links in the following Table, some conclusions were reached.

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[12] http://www.ct.gov/dot/cwp/view.asp?a=2354&Q=290242&dotNav=|
[13] http://www.winnov.com/

Table 3: Traffic Camera Simulation

	Traffic Camera Simulation Video Size is 320 x 240 Pixels		
Data Rate & Connectivity	28 kbps Dial-up	150 kbps DSL	300 kbps Cable
Video Frames/second Vs Image Quality	1 FPS[14] Good	1 FPS[15] Excellent	1 FPS[16] Excellent
	5 FPS[17] Acceptable	5 FPS[18] Good	5 FPS[19] Good
	15 fps Unacceptable	15 FPS[20] Acceptable	15 FPS[21] acceptable

The simulations showed that video frame rates in excess of 5 fps provide little tangible benefit to the end user. The three encoded bitrates demonstrate that both dial-up and broadband users can derive some utility. It would be prudent to limit each video stream to 150 kbps. If this were implemented for the entire traffic camera network, substantial bandwidth could be saved and the complexity and cost of the encoder devices could be reduced.

In order to determine what turnkey solutions were available for multiple-input streaming video appliances, keyword searches were conducted using Google™. Very few products could be found for encoding and streaming of video for 200+ traffic cameras. Winnov was asked to provide an estimate and proposed that a new system could be developed costing $1,000 per camera-stream or $200,000. This would address the encoding issue but not that of media hosting. This solution was simply deemed to be too expensive.

A more affordable solution was sought out and a local system's integrator in CT was contacted and asked to assist with identifying the required hardware. This effort did flag a potential solution that would cost half as much that of Winnov's quotation. Testing of an 8-stream "scaled-down" version was proposed to Highway Operations. Regrettably, that office was unable to provide the required video feeds to continue the proposed research at its Newington facility.

4.10.4.1: Traffic Camera Summary and Conclusions

In summary, both 100 kbps and 300 kbps connection speeds provided good results for traffic videos at one, five and 15 fps. It is suggested that using the five fps video frame rate would be the most practical approach.

A 28 kbps dial-up connection delivered good quality video at one fps and acceptable quality video at five fps. However, frame rates in excess of five

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[14] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_1fps_28k.wmv

[15] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_1fps_150k.wmv

[16] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_1fps_300k.wmv

[17] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_5fps_28k.wmv

[18] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_5fps_150k.wmv

[19] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_5fps_300k.wmv

[20] mms://conndot-video.ct.gov/mediapoint/Interim_report/trafficcam_320x240_15fps_150k.wmv

[21] mms://conndot-video.ct.gov/mediapoint/ntIerim_report/trafficcam_320x240_15fps_300k.wmv

fps yielded somewhat poor quality video and would not be recommended for dial-up use.

While some states like California encode traffic videos at 640 X 480 pixels, there appeared to be little or no appreciable advantage to using video sizes in excess of 320 x 240 pixels when the purpose is simply to assess traffic flow or general highway conditions. This smaller format helps conserve bandwidth and thereby reduces both media server and PC hardware-encoder costs, because less CPU power is required to encode and deliver it. This becomes even more important if designing a complex streaming-media system for 200+ traffic cameras.

It was concluded that redesigning or modifying the existing traffic camera infrastructure to support streaming video would be costly for the 200+ traffic cameras in the highway corridor. If hardware costs could be substantially reduced in the future, it would become more feasible to replace existing equipment and utilize streaming video technologies to provide live traffic camera video for use by the public and government agencies.

4.10.5: Engineering Applications Section

In 2005, ConnDOT's *Engineering Applications Section* enlisted assistance from this research project for creating Web-based training for use with its Design/CADD Environment. It was anticipated that this on-line resource would augment classroom training for its consultant-engineering workforce. A training video has been incorporated into the 2005 Digital Design Webpage and can been seen from the Digital Design Website link http://www.ct.gov/dot/digitaldesign or directly from the link http://www.conndot.ct.gov/media/v8.aspx. Mr. Eric Bergeron contributed the following paragraph.

  "Assisted by the Division of Research, Engineering Applications has
  successfully utilized Web-based streaming video to train ConnDOT engineers as
  well as our external consultant engineers. Expanding the use of this
  technology in the future can potentially save the Department significant
  money and time. Additionally, it will result in a more knowledgeable
  workforce who is better prepared to deliver the Department's Capital Program
  in a higher quality and cost efficient manner."

In 2007, Engineering Applications began using Camtasia™ software for capturing the PC screen and for their own presentation development, in-house. According to Eric, the quality of the resulting presentation was excellent. It is envisioned that streaming media technologies would still be employed for any subsequent delivery to the end user.

4.10.6: ConnDOT TRAC Program

The Connecticut Transportation and Civil Engineering (TRAC) Program is a hands-on educational enrichment program of the American Association of State Highway and Transportation Officials (AASHTO). Its primary mission is to interest teenage students in civil engineering careers within the transportation industry. The Division of Research has enhanced the TRAC Website by integrating on-demand streaming video for use in training new TRAC volunteers. These videos can be seen at http://www.ct.gov/dot/TRAC. A key volunteer from this office Mr. James Moffett submitted the following paragraph.

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"The use of web-based streaming video in the Connecticut TRAC Program has been an inventive way of introducing students, teachers and other TRAC volunteers to the Program. The on-demand video is equally effective for training TRAC volunteers and illustrating TRAC classroom activities via the Internet. It is an invaluable tool for enhancing the effectiveness of the Program and at the same time, heightening ConnDOT's image."

4.10.7: Local Technical Assistance Program (LTAP)

Streaming media provided benefits outside this agency as well. *Connecticut's Local Technical Assistance Program* (LTAP) is supported by FHWA and ConnDOT through a partnership with the University of Connecticut's *School of Engineering*. The program Director collaborated with this office and produced a streaming informational video. It outlines the many services offered by the *Technology Transfer Center*. Ms. Donna Shea said

"This video and [link](22) has served as a strong promotional tool, as well as a vehicle to increase awareness of local agencies for considering using this technology. Ideally and in the future, a streaming media server could be funded by the National LTAP Program sponsors at the LTAP Clearinghouse. This would greatly improve the ability of member states to leverage the benefits from using streaming media."

4.11: Establish a Streaming Media server on the Internet

By 2003, two network-based servers were showcasing innovative uses for streaming media internally via ConnDOT's network/Intranet. As new videos were produced and published, the media library grew larger. Obtaining a Web-based streaming media server became paramount for reaching out to the national transportation research community. There initially appeared to be two avenues by which to obtain this new capability. The first and easiest option was to "piggyback" onto an existing Web server, since the "box" was already serving-up HTML pages for the Department via the Web. However, Microsoft provides a number of technical reasons for not taking this "easy way out". The second and more difficult approach was to obtain a dedicated streaming media server. Appendix F contains important information that was copied from Microsoft's Website[23]. It makes a strong case for using a streaming media server over a Web server for delivering video. Based on this information, this research project set out to obtain a dedicated Web-based streaming media server.

There were a few ways to gain access to a new media server. The first avenue would be to engage the services of a m*edia hosting company* for providing a "turnkey" solution, scaleable to the customer's specific needs. In 2002, inquiries were made into what media hosting services would cost. It was determined that an "entry-level" server with a pre-determined amount of monthly bandwidth could be leased for around $4,000 annually. Table 4 lists the general specifications for the server that the vendor could provide. However, it was determined that this server would only initially meet ConnDOT's streaming media needs, because the server's CPU and overall performance would be inadequate for undertaking webcasting. Taking note of the last item in Table 4 "traffic"; it

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[22] http://www.ct.gov/dot/t2
[23] http://www.microsoft.com/windows/windowsmedia/howto/articles/IntroHosting.aspx

refers to the total amount of data in gigabytes (GB) that can be delivered from the server per month.

Table 4: Specifications for a Leased Entry-Level Media Server (2002)

PC:	PC 1GHz, Pentium III
Memory:	384 MB 133MHz SDRAM ECC
Storage	20.4 GB 7.2K ATA 100 IDE hard drive
Network:	Single Ethernet
Operating System:	Windows Server 2000
Traffic:	Limited to 60 GB monthly traffic volume

In 2005, media hosting costs were updated. This was done by searching Google™ for *media hosting.* This query returned 339,000 hits. Then, a handful of vendors were arbitrarily chosen and contacted. Costs of media hosting are illustrated in Table 5.

Table 5: Specifications for a Dedicated High-End Media Server (2005)

PC:	PC@ 3.06, GHz Pentium 4,
Memory:	2,048 MB DDR RAM
Storage	120 GB IDE hard drive
Network:	unknown
Operating System:	Windows Server 2003
Traffic:	varies from vendor to vendor from 100 to 1500 GB monthly transfer volume

When comparing Table 4 (2002) to Table 5 (2005), hardware specifications are dramatically improved as is monthly traffic. Additional monthly bandwidth can be obtained for as low as 49 cents per GB. Typical costs for turnkey packages were found to be as low as $149.00 per month.

The second avenue that was explored for media hosting was the *Department of Information Technology* (DOIT) and it's Data Center. It is called the *Connecticut Administrative Technology Center* or more commonly referred to as CATER. Prior to 2004, DOIT was not providing state agencies with media hosting, but were offering other Web-related services. In fact, State Agencies are directed to utilize CATER services as stated in its published DOIT policies[24]. While it doesn't specifically reference media hosting, further investigation would be warranted in the future.

A third avenue for media-hosting was inadvertently discovered much later in the spring of 2005. It was learned that the UConn Health Center has a *Video Production Department* (VPD) that can be enlisted by State of Connecticut agencies for video production. While not as convenient as having your own in-house video production capability, it does provide reasonably-priced services to those agencies that meet its stated mission and will also host what it produces on its Web-based media server.

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[24] http://www.ct.gov/doit/cwp/view.asp?a=1245&q=254006

4.11.1: Media Hosting and the Department of Information Technology

Around 2001, it was learned that DOIT was assisting the Connecticut Television Network (CT-N) with media hosting. It was necessary to ascertain whether DOIT would extend this same service to state agencies. To find out, a number of meetings were initiated with DOIT. The first one took place in July of 2003 and shortly thereafter, the following documentation needed to be submitted.

ConnDOT was required to fill out a Memorandum-of-Understanding (MOU) for DOIT's technical review team. The MOU delineated what each agency's obligations/responsibilities would be. Later in September of 2003, DOIT required an IT Project Plan as well. By the end of January 2004, all the documentation had been finalized by DOIT. Please note that copies of both these documents have been provided in this report's appendix, sections G and H.

This office decided to purchase the media server hardware and software outright because DOIT wouldn't supply it. DOIT would provide a robust Internet gateway and periodically conduct software updates, once it deployed the new server at its Data Center (CATER). It was agreed that the Division of Research would be allowed to administer the "box" as it saw fit, since the server is located outside of DOIT's firewall. This cleared the way for the Connecticut Department of Transportation's first Internet-based streaming-media server to go on-line by February 2004. DOIT charges ConnDOT almost $12,000 annually for this service. Please see the following table which provides ConnDOT's media server specifications in 2004.

Table 6:   Specifications for ConnDOT's Internet-based Media Server (2004)

PC:	2.8GHz/512K Cache Dual Xeon™ Processor
Memory:	2GB DDR, 200MHz,2x1GB DIMMS
Storage:	3-73GB 10K RPM Ultra 320 SCSI Hard Drives
Controller:	RAID on motherboard,PERC3-DI 128MB
Network Card:	Dual on-board NICS.
Operating System:	Windows Server™ 2003 Standard Edition
Traffic:	No imposed monthly volume limit by DOIT

4.11.2: Administer the Web-based Streaming Media Server

Once the research project had access to a Web-based media server, it needed to be carefully administered. Normally, this IT-related responsibility would be assigned to an individual possessing the appropriate title. However, *streaming media specialist* is a new title that doesn't currently exist in CT state government. Quite frankly, having someone else other than this PI managing the new server would have severely hampered this research project's reporting efforts. For this reason, the Memorandum of Understanding that ConnDOT and DOIT signed designates this PI as Streaming Media Administrator (SMA). This title comes with a unique set of duties and responsibilities and provides the opportunity to gain familiarization and expertise with configuring the new media server.

The SMA ensures that network bandwidth is being conserved when serving up streaming videos. This effort protects other operational areas' network-based applications from being adversely impacted. The Windows Media Services™ (WMS)

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plug-in, running on the server, provides this functionality. While the primary function of WMS is to constrain bandwidth usage, WMS is also useful for assessing server performance and documenting server usage in real-time.

Because daily log files are routinely downloaded from the server, the SMA has the ability to submit reports on media server usage to ConnDOT's *Manager of Research.* The reports summarize what the Internet audience is watching and how often they are viewing media.

The Web-based media server's functionality and various parameters can be remotely configured by employing Microsoft XP's *Remote Desktop Connection™.* This can be run from any PC workstation with an Internet connection. Some additional responsibilities for the SMA during the research project were:

- Establish ConnDOT's new streaming media encoding parameters for video size (pixels), audio and video bit rate, and video frame rate

- Delineate which video and audio CODECS are to be used when creating new media for reaching the widest audience for both ConnDOT and the Public

- Determine which software should be used in-house to encode video

- Create and configure the server' publishing points for both "live" Webcasts and Video-on-Demand (VoD) content

- Create folders on the server, used for organizing streaming videos, which are accessed via the VoD publishing point

- Upload the properly encoded WMV video files to the appropriate publishing point folder

Right from its startup date, the media server has performed reliably. Four months afterwards, streaming video presentations (VoD) were being routinely viewed 24 hours a day/7 days a week. Throughout this testing period, the network was never impacted by this new service. This successfully demonstrated that streaming media can peaceably coexist with all the other applications running on ConnDOT's wide area network (WAN). This relatively brief but positive track record provided the basis for proceeding to investigate "live" Internet webcasting.

4.11.3: Determine the Network Connectivity Requirements for Webcasting

In order to conduct live Internet webcasting from within a studio or classroom, a reliable and robust *local* network connection must be available. This link is used during the Webcast to upload the video from the studio's PC-based media encoder to the remote, Internet-based media server. In this way, the presentation is constantly moved up to the server and out to the Web, almost in real-time. The word *almost* denotes a fifteen-second latency period that exists between what the live classroom audience sees and what is actually being viewed by the remote viewing audience. If a reliable connection is not maintained between the encoding-PC and the remote server, the Internet audience will experience a less-than-optimal viewing experience, due to video-frame drop-outs and rebuffering.

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At the onset of the research project, the connection between the webcasting studio's encoding PC and Web-based media server consisted of a single T1 line. The T1 was also used to route this facilities' outgoing network traffic to ConnDOT's centrally-located Data Center in Newington CT. While the T1 was only leased at 1.54 mbps, its maximum throughput remains the same whether downloading (when viewing emails and browsing) or when uploading (during Webcasts). If the total available T1 bandwidth had been solely dedicated for exclusive use during Webcasts, it would have sufficed. Unfortunately, the 1.54 mbps was shared at this facility among its 100+, network-based PC-users. This meant that staff utilizing email, browsing the Web, accessing databases and file servers etc., consumed a good portion of the T1 line's capacity, leaving an inadequate amount for reliably-conducting webcasts. As a result, special procedures were put in place on Webcast days. This primarily consisted of cautioning staff to keep their use of the network to a minimum on these occasions. This practice was not seen as a practical one.

Later on in 2005, DSL-lines were installed at most of ConnDOT's outlying facilities to improve network connectivity. While DSL increased download speeds from 1540 kbps to around 4000 kbps, the upload speed was reduced from 1540 kbps to around 364 kbps. From this research project's perspective, this was not an improvement, since it significantly lowered the upload-throughput capacity available for webcasting.

It became evident that the DSL-line could not be relied upon to maintain the integrity of the transmitted video packets during ConnDOT's Webcasts. To address this issue, the T1-line, which had been retained as a backup for this facilities' network, was pressed into service on Webcast days. ConnDOT's OIS attempted to selectively tag and prioritize video packets as they traversed across the T1 from the encoding PC-workstation to the Newington Data Center. Unfortunately, even after this was done, there were still some episodes of rebuffering and video frame freeze-ups that were experienced by the remote viewing audience. This may have been a consequence of heavier than normal network traffic on the local DSL-line. However, the problem may be related to congestion across the OC3 cable that runs between ConnDOT's Data Center and DOIT's Data Center.

Figure 5 below shows the OC3 line (drawn in green) that connects DOIT's Data Center (CATER) and ConnDOT's Data Center as it existed in 2003. While a full OC3-line can attain burstable data-rates as high as 155 mbps, ConnDOT typically leases a small fraction of this bandwidth to support its WAN-based computer operations.

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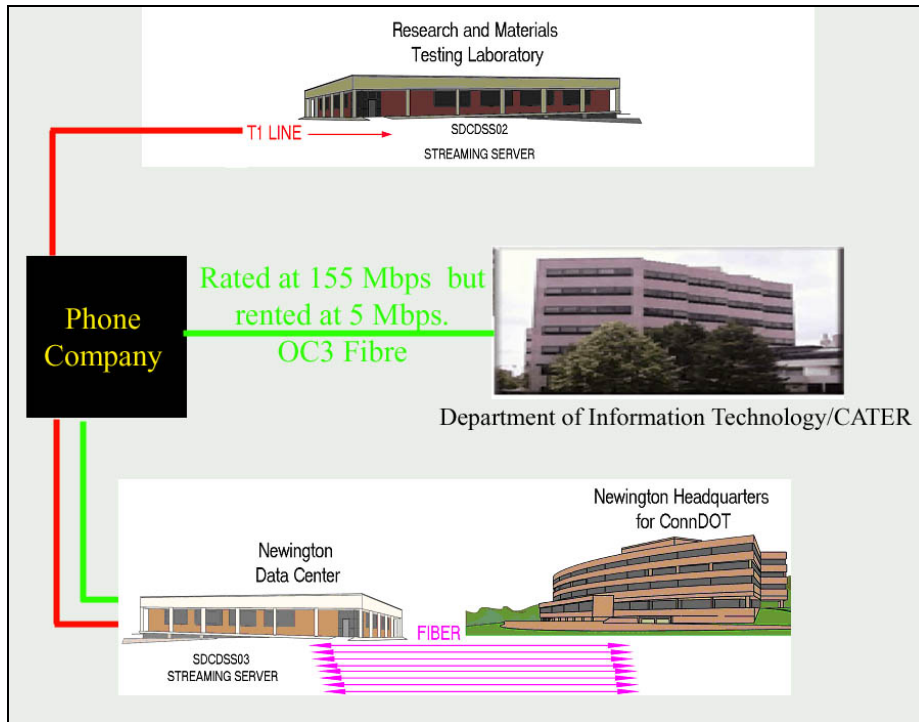
Figure 5:   Internet Connectivity and Infrastructure (2004)

4.11.4:   Conduct Live Webcasts via the Internet

ConnDOT conducts Webcasts for workshops and meetings within the confines of a classroom setting. In order to capture the proceedings, a "large" conference room was transformed into a video production studio.

| A) Conference Room used for Meetings | B) View of Back of Room |

Figure 6:   Conference Room/Filming Studio

Within this environment, ambient lighting and sound can be carefully controlled. This room has a maximum seating capacity of sixty people. Figure

6A shows the room being used during a meeting. Figure 6B shows how the filming crew is isolated from the proceedings by using partitions.

During Webcasts, a video camera is occasionally used to capture questions from those in attendance. That is why it is important to provide guidance in the form of basic Webcast etiquette. The link http://www.ct.gov/dot/Webcast_remarks gives a behind-the-scene look into the classroom, prior to actually going "on-the-air".

When conducting a "*live*" Webcast, the word "live" means that the presentation can only be viewed while it is actually occurring in real-time. While most Webcasts have a keynote speaker that makes a presentation in front of a *live* classroom audience, Webcasts can also be conducted from pre-recorded content on video cassette tape. This is done via an emailed "invitation" that must be sent well in advance of the Webcast event. It provides the URL to the media server as well as the time to "tune in". However, this method provides little advantage over viewing video-on-demand (VoD) content which can be conveniently viewed anytime, 24/7.

In order to view ConnDOT's Webcasts and VoD content, both Windows Media Player and Internet Explorer are required. This Office provides the end-user with a way to assess whether their PC has both of these, well in advance of the actual Webcast event. A webcast training[25] video was created to validate that the correct versions of software are installed. This video has the added benefit of testing whether the PC hardware is robust enough to play the video smoothly. And finally, the video will help determine whether the end-users' Internet connection-speed is adequate for viewing the video. If any hardware or software deficiencies are encountered on the end-user's PC, they can hopefully be remedied in a timely manner.

The training video explains how to use special features that can enhance the whole Webcast experience by providing the audience with the ability to ask questions. ConnDOT's utilizes a generic Webcast "wrapper" (see figure 7 or view it on-line from the link http://www.ct.gov/dot/webcast).

Figure 7: ConnDOT's Generic Webcast Webpage

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[25] http://www.ct.gov/dot/webcast_training

Upon closer examination of the Webcast wrapper, and starting from the upper left hand corner, video controls are provided for playing or stopping the Webcast. The volume can be adjusted using the corresponding buttons. If a larger video picture is desired, a "view in media player" button triggers the external Windows Media Player and allows the video to be played in full-screen mode. If the end user doesn't have the correct version of Windows Media Player, a link to Microsoft's site is provided for downloading it. Clicking on the "submit questions" button generates a self-addressed email form to whoever was designated as contact person for that specific Webcast. Viewer comments are actively solicited after an event. These are usually received after going "off-the-air" but are sometimes generated during the Webcast if problems are experienced. The remote viewing audience clicks on the Webcast Evaluation[26] button, which is embedded on the Webcast page.

The minimum hardware requirements for conducting Webcasts are surprisingly modest. In its simplest form, all that is needed for conveying a Webcast is one video camera, a PC running Windows Media Encoder™, and a high speed Internet connection (DSL or Cable). In addition, a dedicated media server that is situated on a robust Internet backbone would be required as well.

ConnDOT's Webcasts are "streamed" at a modest 300 kbps. This requires that video and audio quality be optimized as much as possible during each event. A six-person team of volunteers was assembled for ensuring that level of quality. The team consisted of three camera operators, Sound Engineer, Director, and Streaming Media Specialist. Through their combined efforts, a classroom-like viewing experience could be effectively captured and conveyed onto the PC-desktops of the remote viewing audience. Figure 8 (on next page) shows this team conducting their first off-site Webcast in 2004 for the National Research Advisory Committee Meeting. Videos recorded from this 4.5 day event were later used to create streaming media content. This can be viewed "on-demand" 24/7 in its entirety at RAC2004[27].

Figure 8: Webcast Team shown at Off-site Location

When a 'live' workshop is being broadcast to the Web, a video camera is easily employed to Webcast the presenter, who typically stands in front of a lectern. What is more challenging is adequately capturing and conveying

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[26] http://www.conndot.ct.gov/media/evaluation.aspx
[27] http://www.ct.gov/dot/rac2004

accompanying graphics, PowerPoint slideshows, and Web pages. These are typically displayed from the presenter's PC-desktop and then projected onto the classroom's wall-mounted screen. *Section A* of the Appendix describes how best to Webcast this for the benefit of the remote Webcast audience.

Before ConnDOT can broadcast an event via the Web, the streaming media administrator must configure a new broadcast publishing point on the remote media server. The media server utilizes a "plug-in" called Microsoft *Windows Media Services* (version 9), which provides a publishing point "wizard" that simplifies this setup. The new publishing point can be setup as either broadcast "push" or broadcast "pull". Once created, publishing points can be reused again and again. There are some primary differences between push and pull. Microsoft provides detailed documentation covering the push vs. pull issue on its Website which can be accessed from the following link[28]. For the majority of past ConnDOT broadcasts, the push method was employed.

After selecting push or pull, the WME session must be appropriately configured for both video and audio stream settings.   ConnDOT's Webcasts utilize video and audio that is encoded using the following parameters:

- *Windows Media Video 9* - video bit-rate(242 kbps)
  - 640 X 480 pixels, frames per second(15), key frame interval(8)

- *Windows Media Audio 9* - audio bit rate(44 kbps)
  - 48 KHZ(mono)

Please note that constant-bit-rate (CBR) must always be used when webcasting via the Internet. Variable bitrate encoding is not appropriate for use via the Web.
    Now that the new server publishing point has been established and the new WME session has been configured, there is one last step to take before starting the encoder. A setting needs to be changed within the local PC-encoding workstation's Internet Explorer's (IE) menu. This is necessitated by the fact that ConnDOT's network employs a proxy server to guard against outside intrusion. However, the proxy server cannot be utilized during a ConnDOT Webcast and therefore, must be bypassed. If this is not done, a timeout error will occur (not immediately) and the connection to the media server will be dropped. The IE menu settings are changed as follows.

- Under the IE *tools panel,* select *internet options.*
- Select *connections,*
- *Select LAN settings,*
- Deselect "*use a proxy server for your LAN*".

What makes ConnDOT's remote server such an invaluable tool is that the publishing points can be utilized to Webcast from any location with a reliable Internet connection. This may include both Hotels and Convention Centers.

During the research project, additional Webcasts were conducted off-site later in August 2004 when ConnDOT hosted a one-day conference for a FHWA-sponsored *Mechanistic Empirical Pavement Design Workshop*. This well-publicized event provided further opportunity to "stress-test" the media server, since more than one hundred simultaneous connections were made. This number appeared to represent the upper limit for when end-users began to experience video frame

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[28] http://www.microsoft.com/windows/windowsmedia/forpros/server/faq.aspx#3_1

dropouts and rebuffering of their Media players. Real-time monitoring of the media server's CPU-utilization remained well under 2%, so this was not a contributing factor.

Rebuffering incidents continued to sporadically occur throughout the Webcast event, so the video bitrate and frame-rate settings were scaled-down during a scheduled coffee break. Unfortunately, this meant dropping everyone's connection. This came as a consequence of having to restart the Windows Media Encoder which was running on the PC at the Hotel. The bitrate was lowered from 300 kbps to 200 kbps and the video frame rate was lowered from 15 fps to 10 fps. While these values slightly reduced the overall video quality, it also reduced the frequency of rebuffering. The VoD link for this past event is http://www.ct.gov/dot/pavement101.

4.11.5: Summarize ConnDOT's Webcasting Experiences

By the time the research project concluded, ConnDOT had successfully hosted a number of Webcasts. These were "attended" on-line by our national transportation research colleagues. One Webcast was simultaneously viewed by over one-hundred participants who provided this office with feedback via an on-line survey. Comments were mostly positive in that they voiced almost unanimous support for using this technology for *distance learning*.

There were various reasons offered as to why one person would choose watching a Webcast over attending a workshop in person. When asked, the most common explanation was not being given permission to travel out-of-state. A number of participants said that viewing a Webcast from their PC-desktop provides the opportunity to be part of a workshop, while still maintaining a presence in the office.

While Webcasts have proven very useful at ConnDOT, there are still some unresolved bandwidth or connectivity issues. During the broadcast, the end user may experience occasional rebuffering and video frame dropouts.   These "blackouts", however brief, can disrupt the flow and continuity of a session. Webcast participants can visit ConnDOT's Website at a later date and view the entire uninterrupted event as VoD at a more convenient time of their own choosing. The following paragraph was submitted for inclusion in this report by Mr. Robert McCoy PE, from the New Mexico Department of Transportation.

"*NMDOT chose to participate in this Webcast because it was free and there was no red tape to go through. Ten engineers and technicians from this office watched this compulsory on-line training. We estimated that traveling to CT would have cost $25,000 for three days of training, including 2 days of lost productivity back in our office. While it is possible that management would have approved four people to attend the training in CT, the cost would have been around $2500 per person. Although folks here experienced a few technical difficulties while viewing the Webcast, it was no different than other interruptions that occur during a classroom workshop such as bathroom breaks, answering cell phone calls from the home office, or being pulled out of class to answer critical questions about the "BIG" project. Therefore, I felt that attending the Webcast in this way was the most cost effective means for obtaining this important training.*"

To view additional examples of Webcasts as VoD, please see FHWA's Empirical Pavement Design Guide Workshop[29], Introduction to the NCHRP 1-37A Pavement Design Guide Workshop[30], and a course that was sponsored by the Northeast Modified Asphalt User/Producer Group[31]. Please note that navigating to one specific topic is simplified by perusing the event's actual agenda and then locating the desired presentation. Each one is provided with a unique hyperlink that corresponds to that specific video.

Webcasting from off-site locations like hotels and conference centers is another potentially powerful capability. However, when conducted outside this facility's studio, webcasting is more costly as well. This is primarily due to manpower requirements. A substantial amount of rack-mounted video equipment needs to be packed and setup. While the equipment is on wheels and portable, many wires still need to be disconnected. Then, upon arriving at the new location, the racks/equipment must be unpacked and reconnected once more. Supplemental lighting must be brought in and setup along with the video cameras. Several microphones must be deployed and managed. This set-up work is physically demanding as well as time consuming. In addition, night-time security personnel were required to monitor the site and this added to the overall cost. For these reasons, Research management carefully weighs the costs vs. benefits before electing to conduct a Webcast, off-site.

4.11.6: Sonic Foundry® and Mediasite™

This section describes a "turnkey" solution to webcasting that is initially expensive to procure, but has the potential to simplify broadcasting from any off-site location.

MediaSite™ is offered by a company called Sonic Foundry®. The local reseller provided both the equipment and expertise to evaluate it at this facility on March 3, 2005 when ConnDOT was hosting a FHWA sponsored *Pavement Profile* Software Workshop.

According to the company, the MediaSite system is available in two basic configurations; a portable box for off-site use and a rack-mounted unit to be use in a dedicated studio. Overall list price of the systems including software licenses and support is around $30,000. While this system is costly, it does create excellent quality video and slides.

If broadcasting to the Web, a dedicated Windows Media Server on a robust Internet backbone is recommended for streaming of the video. In addition, a Web Server is needed for the HTML pages and graphics (slides). The Mediasite unit captures analog-RGB from the presentation PC in the desktop's native resolution. PowerPoint slides are typically acquired at about one frame per second, but the sampling rate can be varied. Captured images were extremely sharp and conveyed excellent readability via the remote viewing audiences' PC desktop. An even higher frame rate can be used for slides to convey mouse-cursor position and movement but this increases overall bandwidth consumption. The Sonic Foundry unit has an NTSC video input (S-VHS) which can be fed from a single camera or from a video mixer.

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[29] http://www.ct.gov/dot/pavement1
[30] http://www.ct.gov/dot/cwp/view.asp?a=1617&q=277542
[31] http://www.ct.gov/amap

Applications running on the Web server provide the remote viewing audience with a *graphical user interface* (GUI) that has a number of features including a button called "*Max Slide*". This makes the slides full screen. In the example shown in Figure 9, the right hand region is occupied by the presentation video while the larger left-hand panel is comprised of a snapshot of the presentation PCs desktop, captured via its VGA connector.

Figure 9: MediaSite User Interface and Media Player

4.12: Provide Presentations to State and Federal Personnel as Required

Prior to this research project being formalized with FHWA, a meeting request was made with this Department's computer policy making group called the Strategic Information/Communications Systems Committee, or SI/CSC. Initially, there was some trepidation whether it would give permission to procure and deploy a streaming media server onto this Department's well-utilized network. However, a presentation outlining the new project proposal was given by this PI and shortly thereafter, permission was received from the SI/CSC to carefully move forward. As the study and work progressed, additional meetings and presentations were conducted by this PI to demonstrate streaming media. Only the most significant meetings are listed below:

- July 20, 2004 – This PI made a presentation in Mystic CT. at the AASHTO Research Advisory Committee Meeting. To view the video, click on the shortcut http://www.ct.gov/dot/drew_RAC2004.

- November 18, 2004 – A meeting was initiated by this Office and held at the Rocky Hill Lab. During the presentation, this PI suggested to DOIT's Director of Business Development, Mr. Chuck Hoadley, that DOIT was the logical candidate for providing other state agencies with procurable streaming media-

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related services. During the meeting, ConnDOT stated that agencies like the Departments of Motor Vehicles (DMV) and Environmental Protection (DEP) could significantly benefit from this new service, which had the potential to enhance existing Web-based services for the public. ConnDOT also proposed that DOIT could form a new "creative communications" group, which could offer a total "turnkey" solution. This would eliminate the need for each agency to buy its own server hardware and software. It was suggested to DOIT that it could provide video presentation development and on-site video production, video encoding, media publishing, and media-server hosting via its robust Internet backbone. In other words, "*one-stop shopping*" for streaming media.

- March 28, 2005 – This PI made a presentation about this research project's streaming media initiative for DOIT's new Chief Information Officer Ms. Diane Wallace when she toured ConnDOT's *Research and Materials Testing* facility. The video can be seen at the following link http://www.ct.gov/dot/doit_demo[32].

- May 17, 2005 – A meeting was held at DOIT with their *Chief Technology Officer* Mr. Mark Bannon. Mr. Bannon affirmed that his Office is aware of the growing interest by State agencies for using streaming media technologies and that his staff are currently investigating how best to implement and support this new capability. Mr. Bannon concluded the meeting by stating that ConnDOT's past Webcasting activities presented no concerns relating to excessive bandwidth use.

- December 16, 2005 - A handful of guest presenters were invited to attend the quarterly meeting of the *CT Training and Development Network*. In addition to this PI demonstrating the research project's interim findings, representatives from DOIT and DAS, the Marketing Director from CT-N, and the Director of the Video Production Department from the UConn Health Center, provided information relating to their own experiences using streaming media. In addition, two of the guest speakers described video production-related services they can provide to State of CT agencies. The video can be seen in its entirety from the link http://www.ct.gov/dot/TDM.

- June 1st, 2006 – On this day, a presentation was made for the Transportation Research Board's (TRB) Annual Correlation Visitor, Ms. Kimberly Fisher. The link to the video is http://www.ct.gov/dot/2006TRBvisitor.

- January 31, 2007 – At the same time the research project's final report was being finalized, this PI had the opportunity to make a presentation before ConnDOT's Strategic Information and Communications Systems Committee. This consisted of summarizing numerous project milestones. Afterwards, Mr. James Sime from this Office suggested that the Committee consider endorsing use of streaming media as a service. The following paragraph represents the committees' reaction to this suggestion. It was recorded in the SI/CSC meeting minutes dated January 31, 2007:

    "The streaming media presentation and the positive potential of the service were recognized by the committee. Prior to full committee endorsement to continue with further development/rollout, it was agreed that the committee should first develop a comprehensive list of technology projects for prioritization and for potential integration opportunities."

4.13: Assess the Feasibility for Any Department-Wide Implementation

This section of the report presents some key implementation issues concerning streaming media technologies at ConnDOT. This feasibility assessment considers the Department as a whole and not just the Division of Research. Please see the *Recommendations* and the *Conclusions* section of this report for additional comments relating to implementation. The following subheadings (in bold print) serve to categorize the primary implementation issues.

PC-hardware compatibility: Because streaming media is viewed from the PC-desktop, it was important to ascertain whether the department's computers would provide adequate performance when viewing streaming videos. ConnDOT's OIS supplied some basic PC specifications as it relates to the majority of ConnDOT's PCs. It was surmised from this information that the Department's 2000+ network-based PCs were ready and able to view the new streaming media format.

PC-software compatibility: Viewing ConnDOT's new streaming media does require the use of specific software. Thankfully, most new PC-purchases come with the required software already installed. This comes as a consequence of the Department's continued use of Microsoft's operating systems (OS). The OS is bundled with both *Windows Media Player* and *Internet Explorer*. This means that the majority of the Department's PC-workstations are able to play streaming videos based on the Windows Media Video format without installing any additional software.

Network connectivity as it pertains to the Administration Building: A large part of ConnDOT's Engineering workforce is assigned to ConnDOT's Administration building. Most of its employees are provided with PCs and many of these have Internet access. At present, viewing ConnDOT's streaming media library or ANY Web-based video utilizes an OC3 line. This high capacity cable traverses between the State's Data Center (CATER) and ConnDOT's Data Center in Newington. This is not the most efficient way to provide work-related video to the Agency. Instead of putting additional load on the OC3, dedicated media servers should be deployed at key ConnDOT facilities. One of these locations is ConnDOT's Data Center.

Beginning in 2002, a dedicated media server was deployed at the Data Center and tested for a number of years. The machine performed well until it suffered a catastrophic hardware failure out of warranty in 2005. At the time of this writing, a new server is scheduled to be purchased, configured for multicast, and redeployed at ConnDOT's Data Center sometime in 2007.

Network connectivity as it pertains to Maintenance Garages: By 2005, the majority of the Department's 90+ outlying facilities were connected to the ConnDOT Data Center's WAN via leased DSL-lines. This includes Maintenance Garages which are strategically scattered across the state. Most highway workers assigned to these facilities have duties that take them into-the-field on a daily basis. This means that primarily, only their supervisors are assigned an office PC. Since the local network traffic is so "light" at these facilities, there would be little need for a dedicated media server. Instead, whenever Webcasts or other group training opportunities arise, a small conference room or office, outfitted with a computer, network connection, LCD-projector, and speakers, could be pressed into service.

Network connectivity as it pertains to District Offices and Rocky Hill Lab: It was anticipated by OIS that switching to DSL would provide adequate network

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bandwidth for ConnDOT's computer-based applications and related tasks. With the appearance of the new media library, this now includes the *occasional* viewing of streaming media-based presentations for those employees with Internet access. However, if the use of Webcasts is to be expanded upon for training staff, distance learning, and internal meetings, one dedicated media server will need to be deployed at each of the four Districts as well as one server at the Rocky Hill Lab.

       Well-utilized Video-on-Demand (VoD) Library: A streaming media library was established in February 2004 and continues to be accessible but only via the Department's Internet Website. The media is available 24/7 and is currently organized into seven categories, comprised of 44 topics. The majority of the videos are ADA-compliant. Viewer usage has been tabulated by year, as shown in figure 10.
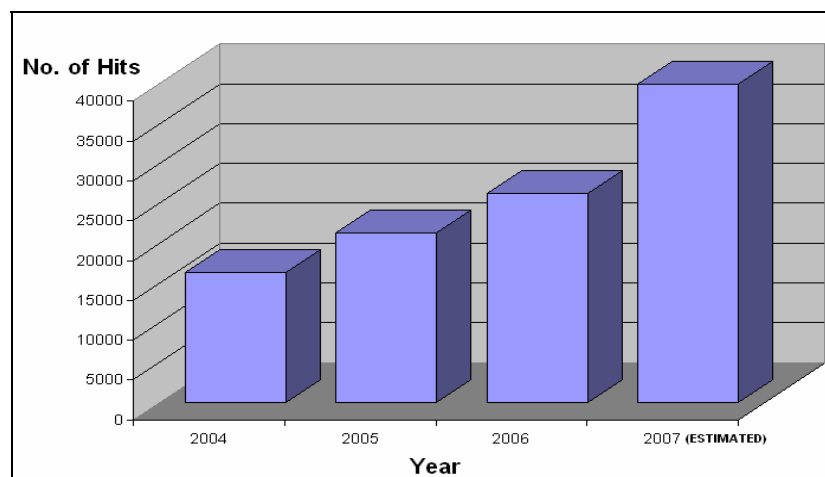
Figure 10: Frequency of Usage on the Media Server

Over the last four years and up to the conclusion of the research project, the media library had a total of 44 separate video-topics available for viewing. Frequency of usage has grown from around 15,000 hits in 2004 to over 21,000 in 2005. Usage continued to expand in 2006 to more than 26,000 hits. Current projections are for 2007 to receive over 40,000 hits.

       Staffing levels to support streaming media's use: During the research project, this PI administered the Web-based media server and provided most of the labor for content-creation after 2002. This included media encoding, generating WMV-files and posting videos to the media server. Throughout this effort, ensuring that the media was ADA-compliant was paramount. This task was occasional performed in-house by secretary/typist. Then, the text transcript was synchronized to the audio portion of the video using free Magpie™ software. Vendors would occasionally be enlisted for most presentations exceeding 30 minutes. The next few paragraphs delineate additional areas that provided manpower or assistance during the research project:

o   *Visual Media Designer*

The Office of Communication's *Visual Media Designer* has played a significant role throughout the research project by acting as Director during ConnDOT's Webcasts. Additionally, he helped develop b*est practices,* which continue to be employed during these types of events.

o   *Webcast Team*
    In the past, this group has been mostly comprised of six staff members from the *Research and Materials Testing Laboratory*. Key responsibilities are assigned to the *Director*, *Streaming Media Specialist*, and Sound *Engineer*. When three (3) video camera operators were utilized, the resulting presentation tended to be most interesting and engaging. While using experienced camera operators is preferable, it is not mandatory. Through trial and error, it has been shown that almost any available staff member can perform this task after providing cursory training. It is anticipated that remote-controlled robotic cameras may significantly reduce staffing requirements in the future.

o   *Webmaster*
    To date, the Department's Webmaster has been instrumental in helping move streaming media into the limelight for ConnDOT. Implementation of this technology at ConnDOT will require a similar commitment.

o   *Secretary/typist*
    As time permits, this offices' secretary provides a valuable service by creating text transcript of the presentation's spoken word. When accomplished in-house, this can significantly reduce ADA-related costs.

4.14: Lend Assistance to Other State of Connecticut Agencies

ConnDOT's Web-based media server went on-line at CATER in February 2004. Shortly thereafter, it became evident that the research project's streaming videos were being viewed by personnel from other State agencies. Inquiries were being directed to this office concerning streaming media production and media-hosting.

Over time, Division of Research management began to recognize their obligation to provide assistance, however limited. To that end, a Pilot Project was undertaken with DAS but due to ongoing commitments within this office, all future requests for help will need to be considered on a case-by-case basis. ConnDOT will provide media streaming and space on its server to help other state agencies in CT demonstrate proof of concept to their management as required. The following paragraphs describe some of these efforts.

4.14.1: Department of Motor Vehicles

The CVISN/PRISM Project[33] was a collaborative endeavor between ConnDOT's Division of Research, the Department of Revenue Services, and the Department of Motor vehicles (DMV). Web-based training was developed for use with the *Commercial Vehicle Operations Credentialing System.* One example of this training is the CT-ePASS Automated Routing Training[34]. Of this effort, the DMV project's manager, Mr. Keith Kennedy said

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[33]http://www.ct.gov/dmv/taxonomy/ct_taxonomy.asp?DLN=30287&dmvNav=|30287|&dmvPNavCtr=|42569|#42569
[34] http://www.ct.gov/dot/ct-pass

"*Our commercial motor carriers can now be afforded with the same training that was previously made available to only those individuals able to attend past training workshops in-person. It is provided at no expense to the carrier and is more convenient for them to access*".

4.14.2: Department of Administrative Services

Around 2005, the Department of Administrative Services (DAS) had identified a number of new business initiatives. This included exploring the use of streaming media technologies for better meeting its customer's needs. The Division of Research was asked by Procurement Services staff to help demonstrate proof-of-concept to DAS management. This was successfully accomplished on June 8th, 2005, when ConnDOT hosted a live webcast called <u>Procurement Training</u>[35] for purchasing officers from across the state. Ms. Donna Camillone of DAS said

"*Future business applications may include vendor conferences, training classes and providing public service information. Working with this streaming media project's PI allowed us to spring-board off the extensive knowledge that this study had amassed during the last four years*."

The following link <u>http://www.ct.gov/dot/DAS_business_needs</u> is part of an informational meeting that the Division of Research hosted for the CT Training and Development Network in 2005. In the video, DAS provides insight as to how ConnDOT was able to assist that agency with addressing its business needs.

4.14.3: Office of State Ethics (OSE)

In May 2006, the research project extended assistance to the *Office of State Ethics* (OSE) by producing and publishing a training workshop for use by state employees on the *Code of Ethics*. Ms. Meredith Trimble, the OSE's Director of Education said the following about streaming media:

"*This agency (OSE) is continuously seeking suitable and substantive ways to meet its mandate. The Web-based version of our comprehensive training on <u>Part I of the Code of Ethics for Public Officials</u>[36] provides one such alternate avenue for us. Streaming media offers a unique convenience for state employees and agency ethics compliance officers. This training can be individually viewed anytime it is convenient. The streaming media option provided by ConnDOT has provided and will continue to provide our agency with a substantive and effective outreach tool.*"

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[35] http://www.conndot.ct.gov/media/das.aspx

[36] http://www.ct.gov/dot/ethics

Chapter 5

CONCLUSIONS

In addition to the Division of Research, other operational areas within ConnDOT and FHWA have been motivated into utilizing streaming media as a new tool. This came as a consequence of extensive collaboration during the research project. Therefore, this section of the report will not only present this PI's conclusions, but also provide some of these collaborators' conclusions as well.

1. Throughout the research project, streaming media technologies have been effectively used to enhance communications between ConnDOT's Division of Research and the national transportation research community. This has been especially true each and every time ConnDOT hosts Webcasts of FHWA-sponsored Pavement Design workshops. An article published in Public Roads Magazine (Jan. 2005) highlights one of these. The link to the article is http://www.tfhrc.gov/pubrds/05jan/iwatch.htm. Based on these successful events, FHWA has indicated its approval for continuing to use Webcasts in the future. This was inferred by Mr. Monte Symons who wrote:

> "*As the team Leader for the Pavement and Materials Technical Service Team in FHWA's Resource Center, we have observed that ConnDOT's Webcasting and hosting for three separate FHWA-sponsored training sessions proceeded without interfering with the ongoing classroom activities. Numerous comments supporting the Webcasting of future events were received. Positive remarks were also noted on the quality of the presentation and production techniques utilized by the ConnDOT staff. We therefore conclude that based on the present environment of restricted out-of-State travel, ConnDOT's Webcasting efforts made possible through the SPR-2231 project have provided a very good alternative to actually being there.*"

Katherine Petros team leader of FHWA's *Pavement Design and Performance Modeling Team* recently indicated that agency's interest in webcasting. She mentioned in a phone conversation in 2007 that FHWA is presently exploring the development of an in-house webcasting capability, modeled on past ConnDOT successes. In May 2005, Ms. Petros submitted in part, the following paragraph:

> "FHWA currently uses videoconferencing and webcasting whereby the participants need to dial into a specific location for the audio. In contrast, ConnDOT's Webcasts are readily available to anyone who knows the URL or has been provided with the link via email. This mechanism has allowed FHWA to effectively promote the availability of the Webcasts far and wide. In fact, while our promotion was focused through FHWA, NCHRP, and AASHTO, the power of the Internet has informed many users overseas about upcoming FHWA workshops. After each event, we notify our stakeholders that they can view the Webcasts hosted by ConnDOT as video-on-demand, 24/7. For these and other reasons, I am working to develop the same capability for webcasting within FHWA. In this instance, imitation really is the sincerest form of flattery."

2. The research project explored new uses of for streaming media at ConnDOT as it developed a number of videos for use by the *PC Support* Help Desk. Of this effort, IT Manager Mr. Jose Romero said:

> "*OIS will continue to use streaming media for improving communications with all of ConnDOT's customers. It will serve as an efficient means to promote and announce new technical services to our many PC-users. In the future, we will encourage other Departments to consider using streaming media for the potential benefits it can provide*".

3. The Office of Communications contributed time and extensive video expertise to the research project. This effort resulted in identifying potential new uses for this technology. Robert Moore, the Department's Visual Media Designer, concluded with the following paragraph:

> "*Numerous accolades have been received from past collaborations with other state agencies on streaming video-related projects. In addition, the research project has allowed us to focus on ways to implement this technology for the benefit of this agency and the public which it serves. Overwhelmingly positive feedback sends a clear message that this technology should become an important component of future communication efforts. To that end, upgrading the Administration facilities' large conference room is currently underway. This investment will pay dividends by facilitating the recording and webcasting of advanced presentations or other important events.*"

4. ConnDOT's Training Division was seen as a predominant area where streaming media could be effectively used to augment classroom-style workshop training for either sick or absent employees. The *Director of Training and Staff Development* Cheryl Malerba said:

> "*Streaming media holds great promise for distance learning. It ideally allows an employee or a supervisor to pick and chose the "right time" to learn without penalty. It provides remote viewers with the opportunity to participate in conferences and classes they might otherwise miss. With good planning on its best use, streaming media could be a great asset to this agency.*"

5. Throughout the research project, ConnDOT's Division of Research responded to numerous requests to assist others with their presentations or events. Sometimes this was done in cooperation with ConnDOT's Office of Communications and the FHWA. Many of these streaming videos were used to populate ConnDOT's new Streaming Media library. Moreover, with greater availability and utilization in the future, the 44 topics contained within the library might someday be seen as the "tip-of-the-iceberg" of what can be accomplished with streaming media at ConnDOT.

Chapter 6

RECOMMENDATIONS

1. Further implement streaming media technologies at ConnDOT. This makes good business sense because studies into human learning habits suggest that *"we remember only 10 percent of what we read but 50 percent of what we see and hear"[37]*. Viewing streaming video presentations from the convenience of the PC-desktop meets all of these criteria and has the potential to yield substantial cost savings to the department.

2. Solicit additional ideas from ConnDOT personnel for expanding the use of this technology throughout the department. ConnDOT ranks among the Top Ten[38] of *State of Connecticut* agencies by virtue of its 3100 person workforce. This means that a sizeable and talented engineering staff can help ramp-up ConnDOT's Website with useful streaming media-based information. By contributing their own ideas and talents, streaming media can become a powerful tool for better meeting the demands of this agency and the public which it serves.

3. Investigate multicasting as a new task within a future research project. While multicasting was not evaluated during this research project, it is anticipated that it could significantly enhance internal communications via this agencies' internal LAN/WAN network. Some potential uses for multicast are distance learning and the delivery of directives from Department executives.

4. Improve the existing infrastructure required to support the internal use of streaming media at ConnDOT. This would consist of purchasing one additional streaming media server at each of the four District offices. These servers typically cost approximately $13,000 each. One should be initially procured and then tested at a remote District office as a new task within a future research project.

5. The Division of Training should conduct informative "how to" workshops for staff on how to create their own streaming media presentations. Then, inexpensive DV video cameras/equipment should be made available to department personnel for developing content that can further their respective offices' mission.

6. Hire additional personnel to create streaming media presentations when required by any office in the Department. The new position might reside within the office of Communications or the Training Division. Existing and appropriate DAS titles are *Visual Media Designer* (class code 4196) or *Media Production Technician* (class code 5608).

7. Utilize the UConn Health Center's Video Production Department as required, to supplement ConnDOT's existing video production capabilities. A pilot should be undertaken for evaluating UConn's services and then guidance and guidelines should be established for its best use. (see Appendix A1.1)

8. As the Department adds more media servers to its existing infrastructure, hire additional personnel to administer the new servers. This would require creating a new IT position in OIS or reassigning the responsibilities to an

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[37] "Communication for the Safety Professional" Robert Kornikau and Frank McElroy, National Safety Council: Chicago (1975) page 370

[38] http://www.cga.ct.gov/2005/rpt/2005-r-0654.htm

existing person. The appropriate designation for this position is referred to as a *Streaming Media Specialist*. (Refer to Appendix I for additional information).

6.1: Closing Remarks

ConnDOT's Division of Research concluded that implementing streaming media technologies is not only feasible, it is potentially very beneficial and would be cost-effective to do so. However, the adoption of these technologies by other State DOT's and Federal Transportation agencies will require substantial effort and resources to move forward with any implementation of their own. Therefore, outside help and technical assistance may be required from national transportation organizations that are in a better position to address nationwide implementation of streaming media technologies for the benefit of all. In the next several paragraphs, Mr. James Sime, ConnDOT's Manager of Research, will elaborate further:

"Streaming media technologies could be used by the National Academies' Transportation Research Board (TRB). It runs cooperative research programs in the areas of highways, transit, airports, freight, and hazardous materials. Through its cooperative research programs, a broad array of research is conducted and TRB has responsibilities for dissemination of findings. Informative streaming videos could supplement TRB's communication capabilities at a modest cost, if shared among the cooperative research programs.

National assistance and support could potentially be provided by the American Association of State Highway and Transportation Officials (AASHTO), which could establish its own Internet-based media server. The server would become a central repository for use by all fifty states and the AASHTO committees. This would serve as a clearinghouse for a wide variety of transportation-related streaming video-based content. If properly managed, these resources could also be made available, as needed, for webcasting from any location in the country.

Perhaps in the future, the U.S. Department of Transportation's Research and Innovative Technology Administration (RITA) will establish the streaming media server architecture to support dissemination of research findings, training, and other types of information. This on-line repository could then be populated with content from the various University Transportation Centers."

Another opportunity to explore is obtaining the establishment of a streaming media server for disseminating video-based technology transfer information for both assistance and training personnel in local transportation agencies. This would become a shared resource for the 58 technology transfer centers under the Federal Highway Administration's Local Transportation Assistance Program.

Much like our transportation infrastructure, once the required streaming media infrastructure is in place, an unending flow of new uses and benefits will be realized nationwide. However, without easy-access to new tools like media servers and webcasts, state DOTs will be forced to fend for themselves and ultimately, all may not be able to afford the associated staffing and technology costs required for sharing and disseminating information via streaming media."

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APPENDIX A

A1: Obtaining Video Production or Related Services

ConnDOT's Division of Research and Office of Communications each have one staff member with significant expertise in video production. If deemed to be important in the future, ConnDOT is currently well-positioned to further develop streaming media-based training and distance learning using in-house resources. Outside of ConnDOT, there has been a perceptible groundswell of interest coming from other State of Connecticut agencies for utilizing streaming media technologies. They are not as fortunate as ConnDOT, in that they must seek outside assistance or services when undertaking video production tasks. This PI has fielded numerous phone calls which usually focus on the question of "where can video production services and media server hosting be obtained". Up until and as recently as September 2005, the same reply would have been given; "no individual State of CT agency provides this service". Thankfully, there are at least two viable organizations that can be turned to for some level of assistance. Please see the next section for details.

A1.1: UConn Health Center

In September of 2005, it was learned that the Video Communications Department at the UConn Health Center is available to provide video, multimedia, and teleconference services to its direct affiliates and federal and state government agencies and billed at the Center's cost, which is currently $120.00 per hour. The Center will then host those presentations it creates on its Web-based media server at no additional charge. The Video Production Center's Director was asked if they provide and host offsite Webcasting. Mr. William Hengstenberg replied "if our clients' communications needs require this service, we will provide it or coordinate it." Other Connecticut State agencies can use these services without the need for formal contracts or bidding. According to information taken from the Center's Website, "the *Department of Administrative Services* encourages all state agencies to first utilize services that can be provided within the State system before contracting with outside companies. Since the funding is transferred from one state account to another, the money stays within the state system. Programs of any type can be produced for any Connecticut State agency, and programs that fall within our missions can be produced for all others that fall within this category."

Before ConnDOT considers utilizing UConn and its Video Production Department's (VPD) reasonably priced services, it is important to acknowledge that the VPD's primary mission is to support the UConn Health Center. This currently comprises up to two-thirds of its daily workload and responsibilities. The remaining one-third of its time is made available for state agencies to utilize at cost. The concern this PI has is "what happens in the future as a consequence of the VPD taking on more and more new clients? Should state agencies who enlist these services expect ever-increasing delays in product-turnaround?" This would not be an issue as long as the VPD grows in step to match the ever increasing demand that will inevitably occur.

A1.2: Connecticut Network (CT-N)

Streaming media-based information pertaining to local State government has been available to Connecticut's citizens for a number of years via the Web.

Commencing in 1999, CT-N Connecticut Network[39] continues to provide streaming media-based programming from media servers that are deployed on CATER's Internet backbone. A service of the Connecticut General Assembly and managed and operated by the Connecticut Public Affairs Network, CT-N continues to exemplify public service excellence by producing and streaming content for both live and video-on-demand (VOD) topics of public-policy-interest via the Web. CT-N's longevity with providing streaming media has earned it the distinction of being a local pioneering leader in this field.

While CTN does not provide video production services per se, it could be viewed as a potential resource for State of Connecticut agencies to turn towards for disseminating their messages via Cable TV and or the Web. The one caveat is that the topic must meet CT-N's criteria. Mr. William A. Bevacqua, who is the Marketing Director at CT-N said in part "CT-N covers a wide variety of events for the executive branch, including public meetings and press availabilities of state agencies, and events such as conferences, lectures and forums hosted by an agency for the purpose of furthering public understanding of the public policy issues under its purview. State agencies may receive a complimentary videotaped copy of their events upon request. However, CT-N does not provide web hosting, streaming media hosting or post production for anyone else at this juncture, and does not have plans to do so in the foreseeable future."

To date, this office has obtained videotapes and DVD's from CT-N of past ConnDOT-related events it has covered. Once received, permission must be requested from CT-N before ConnDOT encodes them into streaming media. Then, the video files (WMV) can be hosted on ConnDOT's Web-based media server.

A1.3: Estimated Video Production Costs when Work is done by Vendors

In 2005 a DAS research committee was created and focused on identifying available resources within the state and vendor community for creating multimedia content. As a gesture of inter-agency collaboration, Ms. Donna Camillone provided the following paragraph for inclusion in this research report.

> *"We contacted local state vendors, many of the state's community colleges and universities, as well as, other state agencies. Our goal was to gather information relative to availability of resources and services, and estimates of costs. We found there were a number of local vendors who could create, or subcontract for the creation of multimedia content. We met with a few of the vendors and received presentations illustrating what types of services they could provide. During these presentations we inquired, informally, as to approximate costs associated with these media services. The information reported here is merely information gleaned from those meetings and may not reflect cost structures that might be bid in a formal RFI or RFP process. With that in mind, costs for the media content would vary based on length of the filming sessions, complexity of multimedia content, and method of delivery of final product. Estimated costs ranged approximately $1,200 - $1,400 per day for preparation, editing and final delivery of media content. Additional costs include the cost for filming; a film crew*

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[39] http://www.ct-n.com

consisting of a director, cameraman and audio man was estimated
to be approximately $3,000 - $5,000 per day. We believe it would
be of benefit for the state to further research and potentially
establish a contract with vendors to provide these services to
state agencies."

A2:   Select and Integrate Video Production and Encoding Hardware

•   Video Production Studio

In lieu of procuring professional video production services, an in-house video
production studio can be configured in any available room whereby ambient
lighting and sound can be controlled. This same environment can also be used
for webcasting. If the studio is contained within a large conference room, it
is necessary to balance the lighting requirements between that of the live
audience and the remote Webcasting audience. At times, overhead lighting is
required for classroom use. Unfortunately, ambient room lighting can wash-out
and thereby degrade the video cameras' ability to capture the room's video
projection screen. This problem can be negated by connecting the presentation
PC to a video scan converter.

•   House Sound System

     When selecting which room to use as a recording studio, examine how it is
constructed. Rooms whose walls are made of brick or cement provide a hard
audio-reflective surface that can induce feedback onto the room's house sound
system. If given the luxury of designing a studio from scratch, consideration
into audience maximum seating capacity, comfort and layout (theatre vs.
classroom) should be undertaken. Carpeting, acoustical wall panels and ceiling
tiles can be employed for improving the room's overall audio-performance.

     It may be advantageous to incorporate a "house" sound system into the room,
depending on its physical size and layout. The sound system can be used for
amplifying a presenter's visual aids such as pre-recorded videotapes, DVD movies
or even the output of the PC's soundcard. Also, a house sound system can help
compensate for those presenters who are inclined to be soft-spoken.

•   Communication Headsets

     A four-person wireless headset was used for communicating during Webcasts.
This device is worn by the Director and three camera operators. The units need
to be charged-up before use. The particular units that ConnDOT used induced RF
interference into the video recording equipment. This problem was related to
the proximity of the units to the recording equipment. For this reason, a hard-
wired system may provide better reliability, image quality and lowered-cost over
wireless when being utilized in a dedicated video recording studio.

•   Stage Lighting

     The room should be provided with a lectern. Then, dedicated stage lighting
should be properly installed. Controls that regulate the illumination intensity
should be mounted away from the lectern. The lighting fixtures should be
manually-focusable from spotlight to a floodlight pattern. The number of

fixtures, bulb wattage selection, distance from the lectern, and illumination intensity setting, will influence the lighting's color-temperature. In addition to the stage lighting, downwards pointing lights should be used to "wash" the curtain/backdrop with light, thereby minimizing any shadows cast from the stage lighting. This becomes more important when chroma-keying the backdrop "out" in post production. Poor lighting of the backdrop produces uneven shadows which will complicate the chroma-keying process by introducing unwanted and varying shades of black/gray.

Figure 11: Stage Lighting (shown with control module)

- Backdrop

   A blue or green screen or backdrop is typically used in back of the lectern area for providing a video chroma-keying capability during post-production. In this way, the presenter can be seamlessly superimposed on top of their accompanying visual aides, as shown below in figure 12. The blue backdrop is also suitable for everyday use/presentations. If chroma-keying is to be utilized, presenters must be advised to dress appropriately prior to being videotaped. Not wearing any blue clothing is mandatory. A high contrast level must be maintained between the presenter's head/body and the blue or green backdrop. The green backdrop tends to be a little "busy" for everyday use. If using the green backdrop, the rule-of-thumb to follow is to not wear green clothing.
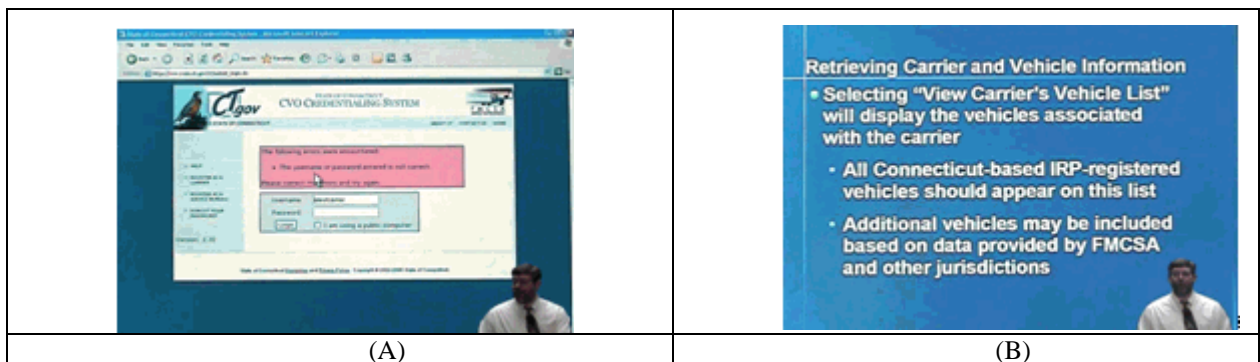

| (A) | (B) |

Figure 12: Example of "Talking Head" Region and use of Chroma Keying

- Teleprompter

   A teleprompter was procured for assisting the "less-polished" public speaker/presenter with recording their presentations in a "closed" session. The unit basically consists of a flat screen computer display which utilizes a one-

way mirror. A video camera is positioned on the other side of the mirror. The teleprompter is mounted on a tripod and connected to a laptop or portable PC. Running special software, it can be made to scroll the typewritten text/words as they are spoken. The rate at which text scrolls can be adjusted.

- Video Camera, Tripod, Remote-focus and Zoom Controls

   A variety of video cameras were used throughout this research project. Cameras that incorporate a three CCD image sensor typically produced better quality images than those utilizing a single CCD sensor. Not surprisingly, those models employing 3 chips are usually larger and more expensive.

   Cameras are always mounted on tripods during Webcasts and other types of presentations. Zooming-in and focusing by the novice camera operator can be facilitated by use of tripod mounted LANC controllers. Figure 13 illustrates various camera perspectives that can enhance the remote viewer's Webcast experience.

Audience View	Wide-room View	Podium/Presenter
Shot from front corner of the room	*View shot from the back of the room*	*View from back and center of room*
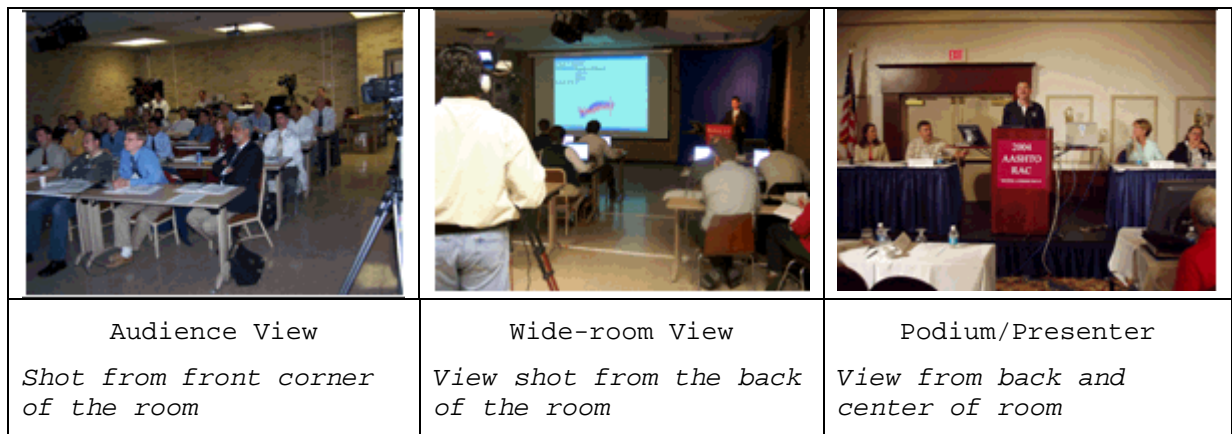
Figure 13: Variety of Video Camera Views used to Enhance Webcasts

- Video Mixer

   Use of a video mixer during any live video presentation can dramatically reduce the need for post-production work later but does increase the staffing requirements. Referred to as the "Director", this person is charged with determining what the final program "mix" will look like. Composing the various video camera angles with the video mixer's picture-in-picture feature can be effectively used to create a finished final product. This research project initially procured a video mixer that had composite, S-video and DV inputs/outputs. Later on in the project, a mixer with four SDI inputs/ 1-output was procured. While SDI is a superior format to S-video, it does increase the overall cost of the video production chain-of-hardware.

- Title Generator

   A title generator was used to overlay information about the presenter etc. The unit provided both composite and S-video inputs/outputs. In the future, the titler should be upgraded with a model that can provide SDI-input/outputs.

- Microphones

    Wireless lavaliere and hardwired microphones were utilized throughout this research project. Depending on the type of presentation being given, as many as eight microphones have been simultaneously utilized during panel discussions. It was commonly observed that audiences are somewhat uncooperative when it comes to waiting for a microphone to be passed to them before they speak. They simply begin talking when called upon to do so. Therefore, ceiling or wall-mounted boundary microphones should be installed in the room for facilitating recording during meetings. These are less intrusive than hand held microphones and encourage audience participation. All microphones and wireless lavaliere receivers are plugged into an eight channel audio compressor/limiter.

- Audio Compressor/Limiter

    Employing an audio compressor/limiter during Webcasts means that ConnDOT's audio engineer does not need to constantly "ride" the microphone level controls of the audio mixer. This was especially useful during panel-type discussions, whereby the voice of each presenter was automatically limited and normalized to the same output level. The absence of fluctuating volume levels means that the audio won't need to be normalized during post-production. The output from the compressor/limiter is fed directly to the audio mixer.

- Audio Mixer

    An eight microphone-input audio mixer is used to combine audio from a variety of sources during a Webcast or video presentation. These consist of audio from the keynote speaker, or may be questions from the audience. There may be audio used in a PowerPoint presentation, coming from the PC. All of these sources are then mixed and fed into the S-VHS tape deck. Then, while recording onto tape, the audio is passed-through the recorder to the encoding PC workstation where it is captured, digitized, and encoded in real-time along with the video.

- S-VHS Recording Deck

    As the video and audio signals exit both mixers, it is "laid-down" onto magnetic tape using magnetic tape recording decks. Two analog S-VHS decks were used to create two copies of the audio/video final-program. These source tapes were sometimes retained for encoding into streaming media content later. Doing so necessitates storing lots of videotapes as an archive. In the future it is recommended that digital video recorders (DVR) be used to replace magnetic tape machines. Recording directly onto DVD-R media or even encoding as a digital video file would save space or time if post production editing is needed later.

- Encoding PC/Workstation

    After the video and audio exits both mixers, it loops through the recorder, and is captured and digitized in real-time on a PC using a video capture card. This machine is referred to as the encoding PC workstation. This same "box" is used during webcasts as well. This requires a network and Internet access. A

local network connection also comes in handy for moving the WMV files from the studio's encoding PC to other office-based PCs if editing is for any editing. Microsoft's Windows Media Encoder was routinely used to create content for broadband delivery at 300 kbps bit rate. A video size of 640 x 480 pixels and 15 fps is typically used. In order to avoid dropping video frames, the encoding PC should have a Pentium-IV processor running at least 2 GHz. Memory (RAM) should be at least 512 MB. This will help ensure that CPU utilization stays below 80%.

A3:   Identify Factors that Influence the Quality of a Streaming Video

- Video and Audio Production

Creating good quality streaming media begins with recording the best quality video and audio possible. A good quality video camera that has a progressive-scan feature will produce better results than recording in interlaced mode. Digital video (DV) cameras can simplify the offloading of video/audio to the PC via by employing a firewire connection. A built-in digital-image-stabilization (DIS) feature will aid in minimizing camera movement when hand-held in the field. Using a tripod and slowly panning of the camera will yield better quality content, when later encoded into streaming media.

Keeping the subject's detail to a minimum helps individual frames of video compress more efficiently when compared to those containing complex detail. As an example, when shooting people during an interview, use single colored backgrounds whenever possible. People being "filmed" should be asked in advance to wear clothes that don't have high-contrast patterns or lots of detail. Plain colored clothing works best, since stripes or checkered patterns can create undesirable results once encoded.

Lighting can make a big difference in creating a good quality production. A properly lit subject or scene encodes better than under- or over-exposed material. Low-light conditions produce degraded video that lack detail. The best practice to follow is to always shoot correctly exposed video. Don't rely on post-processing to fix overexposed video, missing detail or excessive noise, as it can never be fully restored.

Audio production is equally critical to achieving professional movie results. Most built-in video camera microphones do not perform adequately once the optimum subject-to-camera working distance is exceeded. Remote-wireless microphones can overcome this issue, acquiring the subject's voice while eliminating camera servomotor noise in the process. Ambient room noise such as air handlers and air conditioning can introduce distracting background noise as can electrical equipment such as overhead projector fans and slide projectors. Directional shotgun microphones can help minimize this type of background noise. Lavaliere microphones are appropriate for interviews. When recording directly into a desktop computer, be cognizant of the noise the hard drive and PC fan can generate. To minimize its impact, establish the necessary working distance between microphone and PC.

A3.1:   Preserve the Image Quality of the Keynote Speaker's Slideshow

During workshops or meetings, the Presenter may use visual aides such as PowerPoint Slides. The easiest way to capture these is electronically via some type of video connection to the PC-desktop. If this is not possible, a video

camera may be used to directly "shoot" the projection screen. There is another way to do this and consists of importing the presentation during the post production process. However, this is more labor intensive and time consuming.

In order to proceed, discreet TIF images must first be exported from the PowerPoint slideshow. The TIF format yielded better quality than either JPEG or BMP. These are then imported into the non linear editing workstation using programs like Adobe Premiere Pro™. The slides are then manually synchronized to the presenter's dialogue and video on separate video/audio tracks.

A3.2: Optimize the PowerPoint Slideshow before the Presentation

ConnDOT developed some *best practices* which can help improve the overall readability of the presenter's PC desktop during a Webcast or when producing content for on-demand viewing later. It is recommended that the presentation use a dark, solid color background and a minimum Arial font size of 28. While this limits the amount of text that can be placed on any one slide, it was initially seen as a necessary step. The font color should be white or some light color in order to improve contrast against the darker background. If using a light colored background, use dark colored text.

Presenters are contacted well in advance of a webcast or meeting and asked to follow these guidelines for making their Web-based presentations easier to read. It does take extra time and effort to tweak the presentations and as a result, some presenters will not comply with this request. Unfortunately, the presence of tiny fonts, semi-transparent graphics, and gradient background colors only served to diminish their value. Thought was given as to whether Research staff would tweak the presentations for presenter's who weren't willing to, but it was deemed too time consuming to accomplish.

A3.3: Capture the Keynote Speaker's PC-desktop during a Presentation

Presenters are discouraged from using laser pointers during their sessions because it is difficult to capture and preserve the readability of the small moving red dot once recorded. Also, this would require shooting the projection screen with a video camera but this will result in a less than satisfactory outcome. A more effective way is for the presenter to use the mouse cursor as a pointer. This necessitates capturing the PC-desktop as full motion video via the PC's VGA or DVI connector. Please note that most operating systems provide the ability to change the style or size of the mouse/cursor as well as enabling a mouse trail. The next section describes other ways to capture the Presenter's PC-desktop.

A3.3.1: PC Video-in/Video-out (VIVO)

Laptop/notebook PCs may provide a composite or S-video output signal that can be used to display what is referred to as the "cloned" PC desktop. Additionally, desktop PCs utilize either integrated video graphics adapters (VGA) or installable video cards which can provide a similar video-out capability. Generally speaking, the composite video signal provides poor readability of PowerPoint slides when displaying smaller-sized text or detailed graphics while in comparison, use of the S-video output signal will somewhat improve readability. Converting higher resolution PC signals to lower resolution video signals is referred to as down-converting or scan-converting.

A box called a scan converter can be used to improve the captured PC desktop's quality.

A3.3.2: Scan Converters

Scan converters can be used to optimize the quality of the PC desktop video when capturing and recording. Those units that provide outputs based on the serial digital interface (SDI 601) standard yield significantly better resolution over equipment that output S-video. During the research project, two different companies' scan converters were evaluated that accept both VGA and DVI inputs from the presentation-PC's graphics connector. Prices start at about $5,000 and go up from there. Each unit provides one serial digital output via a single BNC connector. This signal is then acquired by a PC with a digital video-input capture card/SDI-input.

During the evaluation, both DVI and VGA input signals were acquired from the presentation PC with the DVI-input providing somewhat sharper text then the VGA-input. One of the units was put to the test during a March 2005 Webcast. It was used to capture the PowerPoint presentation, running on the presenter's PC-desktop. Please note that the presentation was also recorded and archived onto S-VHS tape. This tape was later used for encoding into a streaming video which can be seen by clicking on the following link Pavement Design Workshop[40].
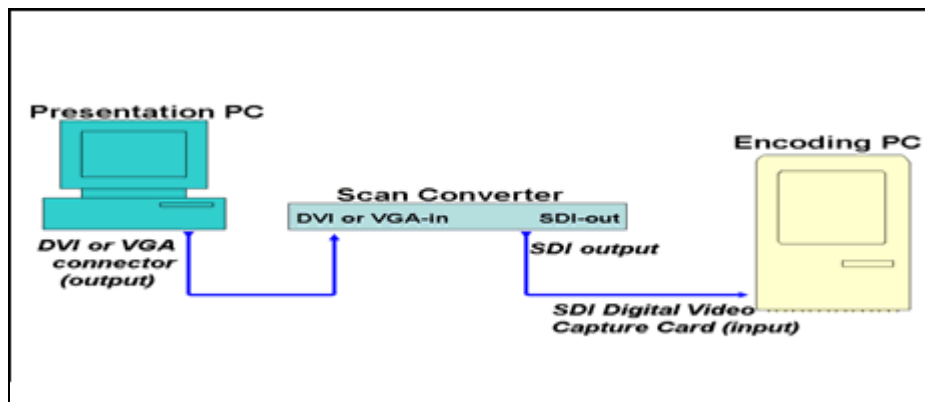
Figure 14: Use of Scan Converter for Acquiring PC-Desktop as Video

The second scan converter to be tested was evaluated later in September 2005. It was also evaluated for its ability to capture the PowerPoint slideshow as video, taken from the presenter's PC desktop. This was used for creating the following video, which is viewable from this link[41] Please note that this presentation was captured in real-time by using a PC/video capture card that had an SDI-input. Video quality was noticeably improved as compared to encoding it later from an S-VHS tape. In other words, staying totally within the digital realm is a good way to maintain quality.

The research project concluded that scan converters with DVI-input and SDI-output can be effectively used to acquire the PC-desktop in full motion video.

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[40] http://www.ct.gov/dot/cwp/view.asp?a=1617&Q=300236&PM=1
[41] http://www.ct.gov/dot/dave_anderson

This should be done in conjunction with a video mixer having SDI I/O and a PC/video capture card with SDI-input.

A3.3.3: Video Camera for Shooting Projection Screen or LCD-Monitor

A video camera can be used to acquire the video projection screen during a presentation. One stationary unmanned camera can be used for the full-screen view, as well as an additional manned camera for zooming-in on the finer details of a slide or graphic. There is a tendency for room lighting to "wash out" the projection screen, thereby degrading the resulting video. Documenting the PC-desktop in this fashion tends to yield less-sharp (softer) video because projection screens are made of fabric or similar materials.
One way to improve the video quality is to train a video camera directly onto an auxiliary LCD monitor that is connected to the presentation PC. The video camera that is shown below in *figure 15* is being utilized for exactly this purpose.

The monitor is fed from a four-port VGA-splitter that connects to the PC's VGA connector. It also feeds the overhead video projector and the lectern's PC monitor. Make sure to situate it away from any overhead room light sources. Otherwise, the resulting video may be washed out. Cathode ray tube (CRT) monitors are not suitable for this technique because the CRT electron beam will be visible, rendering the end product unsuitable for use. However, LCD monitors don't have this problem and can yield very good results. The monitor screen's surface should be free of dust and fingerprints.

Situate the camera and monitor away from where people are walking around. The equipment occupies a fairly large footprint which is somewhat vulnerable to passersby, who can unintentionally bump into and thereby misalign the camera/LCD monitor.

Figure 15: Use of Video Camera for Capturing PC-Desktop Video

Small video cameras like the one shown above in Figure 15 utilize mini DV tapes. This particular model has its tapes loaded through the bottom of the unit. During an all day filming session, tapes must be swapped-out every hour or so. This process may require interrupting and asking the presenter to pause while tapes are changed. This requires removing the camera from its tripod mounting plate each time a tape is replaced. The camera must then be remounted and "dialed back" into proper alignment with the LCD screen. This task takes time for precise repositioning and manual focusing, or else keystoning and

blurring of the captured screen image will result. Procuring a top-loading model would remedy this problem.

A3.3.4: PC-Screen Capture of the Presentation using Windows Media Encoder

Version-9 of Microsoft's Windows Media Encoder has the ability to capture the PC desktop and export the video as MPEG, Windows Media, or uncompressed video (AVI). The software can be manually configured to capture the whole desktop or just one particular window or region of the screen. While this application could be utilized during a live Webcast or videotaping session, it would not be ideal. Running WME in screen capture mode requires a very robust PC for high video-frame and data rates since it is being used to run two simultaneous applications; That being the application software being demonstrated to the audience in attendance as well as the WME screen capture utility.

A4: Capture, Digitize, Edit, and Encode, Video and Audio

This section will describe methods for optimizing the quality of the presentation as it is being captured by a computer. Then, the captured video and audio will be digitized within the PC environment.

A4.1: Capture and Digitize Video/Audio using a Computer

Prior to the advent of DV and firewire, the majority of new computer purchases did not come with hardware for capturing video from an external source, such as a video camera or VCR. Initially, this research project employed an analog video capture card (Figure 16-A), which was installed in a PC for creating project-related demonstration videos. This provided good quality when using the camera's analog S-video and unbalanced stereo audio connectors, but did require three video/audio cables. In order to simplify the hookup and offloading of video from the camera and improve on the overall quality if possible, the card was upgraded to a digital model (Figure 16-B) with both DV and SDI-inputs. DV is reputed to offer higher image quality and resolution than either of the Hi-band 8, S-VHS and VHS formats and is immune from generational loss, which does result when duplicating from an analog tape. SDI is an uncompressed format that is superior to DV. One particularly useful feature of some of these capture devices is the ability to adjust in real-time, the luminance and chrominance levels of the video source while it is being captured and digitized.

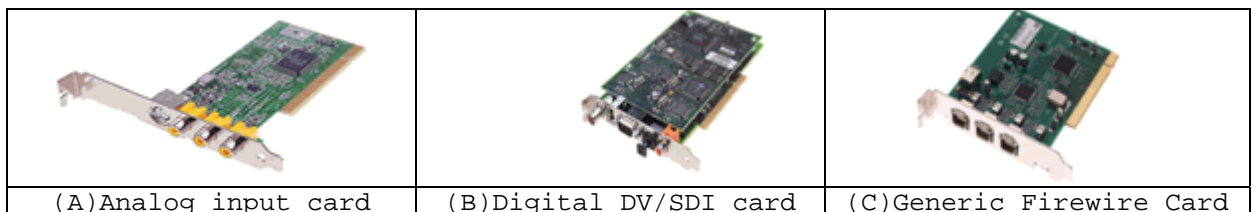| (A)Analog input card | (B)Digital DV/SDI card | (C)Generic Firewire Card |

Figure 16: Video Capture and Generic Firewire Card

A less expensive alternative to using video capture cards would be generic DV firewire card (Figure 16-C), which can be procured for less than $50.00. However, these can only be utilized with DV/firewire-capable video cameras.

Unfortunately, Microsoft's Windows NT operating system (OS) didn't support the IEEE-1394 driver of the OHCI-compliant firewire cards. During this project, the majority of all videotaped material was offloaded from the camera and then captured into the DV format using Microsoft's Movie Maker software for creating a high-quality DV-formatted AVI file for later use when encoding into the various streaming media formats.

When capturing video into the PC environment, software profile settings should be selected that provide either 15 fps or 30 fps and full-screen resolutions of 640x480 pixels for analog (NTSC), or 720 x 480 pixels for DV. The resulting file can be quite large but the content is then suitable for later use with other streaming architectures, or can be converted into different pixel-delivery sizes and bitrates. Having this capability is commonly referred to as scalability.

Audio capture settings should be optimized as well for obtaining the highest possible quality through the video/audio capture device, rather than using the PC's sound card/integrated hardware. One of the analog cards tested did not provide audio inputs so the computer's sound card was utilized for capturing audio. Settings such as 44-kHZ, 16-bit mono provide good quality.

A4.2: Edit Digital Video using the Computer

Once the presentation has been "shot", captured, and digitized, video editing can be undertaken if needed. Desktop video editing and publishing have become much more user-friendly and affordable with the evolution of operating systems such as Microsoft Windows XP®. It comes bundled with video production software called Microsoft Windows Moviemaker®. In addition, firewire cards can be purchased and come bundled with desktop publishing software. These applications have user-selectable quality settings for determining how much compression is applied to the video/audio during both video capture and when creating the final movie.

Proper editing of digital video movies prior to final encoding into streaming media, can help ensure a good quality final product is produced. Elaborate and complex transitions are more difficult to encode and often look degraded in the final movie. Hard cuts are usually the easiest transitions to encode. If using fades is unavoidable, make their duration as brief as possible. If difficult transitions are encountered, some editing software provides the ability to encode after two passes.

A4.3: Encode Digital Video using Appropriate Video/Audio Codecs

The last step required to create a streaming video presentation is encoding of the video and audio into the appropriate streaming format. Each of the streaming media technology platforms provide encoding software, whereby the author must select a profile that offers the desired data bitrate, video frame rate, as well as other parameters that influence overall quality of the delivered audio and video streams. Profiles should be chosen based on such factors as whether the streaming media presentation will be played from local hard-drive, removable media, or remotely accessed via a network or the Internet.

When distributing content onto CD and DVD, or even a PC's hard-drive, the final streaming movie must be physically able to fit onto this media. A presentation's total duration in minutes, pixel size, and encoded bitrate will

determine how much storage space will be required. An additional consideration
is whether the end-user's PC-hardware will meet the minimum performance
requirements for providing smooth playback of the movie without "choking" or
dropping frames.

In addition to being playable on the PC from removable media, streaming
media presentations can be remotely accessed and viewed from an Internet-based
streaming media server using a relatively slow 32 kbps dial-up modem to as fast
as a 1,000 kbps data transfer rate, if using a cable modem. When viewing
streaming media presentations via a LAN or WAN, one must consider that the total
volume of network traffic on the Intranet is dynamic and therefore somewhat
unpredictable, and may result in bandwidth congestion. This can substantially
reduce the actual bandwidth available to other applications. Therefore, some of
this research project's earlier demonstration streaming media content was
encoded at a modest 150 kbps data rate.

The end-user's available bandwidth, which is the maximum bitrate that a
connection can sustain without dropping frames or losing packets, is the primary
factor that will limit overall movie quality. Therefore, knowing who the
audience is and how they will access the streaming media is crucial to the
encoding profile selection process and subsequent creation of the streaming
media files. Table 7 below provides some common Internet connectivity methods
and the bitrate that this project had deemed appropriate for encoding.

Table 7: Data Rates for Various Internet Connectivity Methods

Connectivity Method	Data Rate in kilobits/second (kbps)
28.8 K Dial-up Modem	20 kbps
56.6 K Dial-up Modem	32 kbps
Dual ISDN	96 kbps
T1/DSL/Cable Modem	300 kbps and up

Initially, most project-related demonstration media was optimized for
delivery via the Department's Intranet. This was accomplished by encoding
content at the lowest data rate possible, while still ensuring that acceptable
audio and video quality was maintained. An encoding workstation was utilized
and was comprised of a Pentium IV, 1.5 GHz processor with 256 MB RAM. An
initial encoding profile was developed for this project and consisted of a video
output size of 320 X 240 pixels, 30 fps, and a 300 kbps data transfer rate. It
was later decided to halve the video frame-rate to 15 fps, as well as reduce the
data-rate to 150 kbps, in anticipating delivery to a broader audience. This
resulted in a moderate but acceptable reduction in the movie's overall audio and
video quality. The lowering of the video frame rate was hardly noticeable in
the final movie but did reduce the overall file size by almost half. Encoding
of streaming media can be a CPU-intensive task. A 933 MHz PIII machine with 256
megabytes (MB) of RAM provided poor performance that was made evident by
observing that the CPU load maxed-out at 100%, while encoding into the Windows
Media Video (WMV) format, using version 7.1 of the Windows Media Encoder (WME)
software.

Codecs are proprietary algorithms that are utilized by software or
hardware encoders as well as media players, for the purpose of compressing and
decompressing data. Codecs are usually employed for their ability to decrease a
digital video presentation's overall file size, but also play a role during the

rendering of audio and video content, by reducing the amount of data bits transferred per second. The smaller file sizes allow for a greater quantity of streaming media content to be stored on removable media such as CDROM, while the lower bitrates reduce the demand for both network and Internet bandwidth. Choosing which codec to employ during an encoding session will ultimately determine what quality a movies' video and audio will convey to the end-user.

During this project's RealNetworks® phase-of-work, it was determined that RealProducer-Plus and RealPresenter utilized a codec referred to as RealVideo G2 and provided acceptable quality when viewed with the RealPlayer on machines running both Windows NT 4.0 as well as the Windows 2000 OS.

Later, during the Microsoft phase, Windows Media Encoder software utilized a variety of codecs, depending on the version of the WME and what the intended audience's operating system and media player version was. The NT 4.0 OS comes pre-bundled with Windows Media Player (WMP) version 6.4 and is ready to play media created with the Windows Media Video/Audio V7 codec. If attempting to play a Windows Media presentation is unsuccessful or returns only the audio stream, or the video region minimizes upon buffering, then the problem may stem from the fact that the required decompressor is not loaded on the client machine. In this case, it can be downloaded from the Internet and installed on the end-users' PC. This process can be automated in an HTML page by providing a codebase tag which then points the browser to a uniform resource locator (URL) which could be for example, the Microsoft web site download area. Unfortunately, administrator privileges are required to successfully install most if not all codecs.

APPENDIX B

RealNetworks Software

- **RealPlayer and Intranet Administrator-8 Description**

    At the time the initial research was conducted, RealPlayer-8 was
RealNetworks' free media player and was capable of playing many types of popular
media files but was not compatible with Microsoft's .WMV/.ASF streaming formats
and vice versa. Proprietary media extensions for RealPlayer are .RM; video and
audio, and .RA; audio only.

    To alleviate management's trepidations regarding the inappropriate use of
streaming media in the workplace, evaluation and testing of RealPlayer-8 and
RealPlayer-Intranet were undertaken. These are intended for use in the
corporate environment and can ensure that only work-related content is accessed
and viewed.

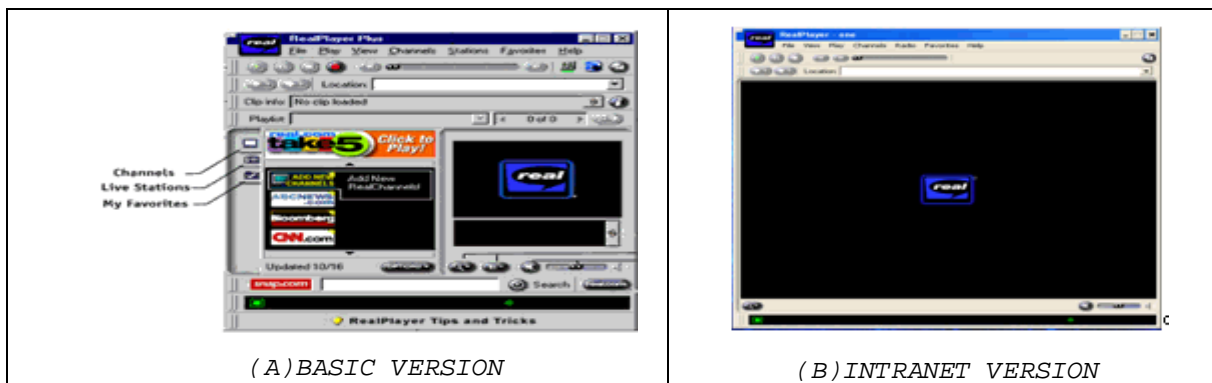| (A)BASIC VERSION | (B)INTRANET VERSION |

Figure 17: RealPlayer-8 Basic Version Compared to RealPlayer 8 Intranet

    As visualized in Figure 17 above, the main difference between the two
versions of the player is the presence of *channels*, *live stations,* and *my
favorites*; visible only in the basic version. The Intranet version shown in
Figure 17-B has been configured with the RealPlayer Intranet Administrator tool,
which aids in customizing, deploying and managing RealPlayer on Department
desktops. Being able to remove or disable "links" to non-job related Websites
has helped assuage network administrators' fears of blatant misuse of the
product by Department personnel.

- **RealSlideshow-Plus 2.0 Description**

    RealSlideshow-Plus version 2.0 is a presentation tool that integrates
digital still-images and audio into a streaming media-form of slideshow. It can
be accessed locally from CD-ROM or from across the network and Internet using
RealServer and the RealPlayer client viewing tool.

    Figure 18 on the next page illustrates the main project timeline on which
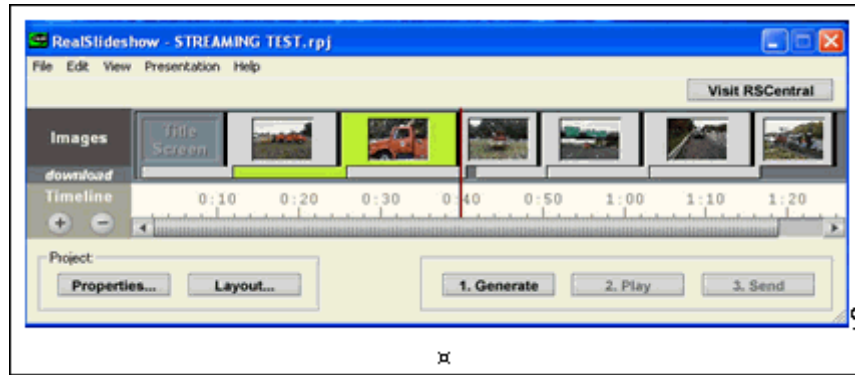still-images and audio clips are assembled and organized.

Figure 18: RealSlideshow Project Main Timeline

RealSlideshow's tools assist in creating a narrative audio track for annotating to any slide. It automatically resizes that slides' duration on the timeline to correspond with the audio's duration.

In order to determine the suitability and utility of this product, only good quality BMP images and CD quality audio WAV or MP3 files were imported for creating the best possible results. The software provides a user-selectable RealPix default setting of 10 kbps that is used for determining JPEG image compression. It was anticipated that raising this value to 150 kbps would significantly increase the overall text-clarity which was evident in the final presentation, but no improvement was noted. Therefore, using the default RealPix setting would be prudent, as larger values wastefully increase the presentation's bandwidth requirements. Another attempt at optimizing text-readability was to change the default layout setting of 320 X 240 pixels to the custom size of 640 x 480 pixels. This was determined to be an unnecessary step as well, since readability was not dramatically improved.

In order to illustrate any capabilities or weaknesses when using this product, demonstration media[42] (2.85 MB zipped) was created, revealing this software's weakness when rendering text-based slides, as readability was once again markedly impacted. Captions were not created for the two slideshows.

After creating the slideshow, the software generates a variety of support files/streams. They may consist of:

o   **HTML** Allows launching of the application from a web browser.

o   **RAM** Triggers and launches the RealPlayer window.

o   **SMIL** Synchronizes RealText (.RT) for captions and title screen

o   **RealPix** (.RP) for all compressed images and their properties, and

o   **RealMedia** (.RM) for audio commentary.

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[42] http://www.conndot.ct.gov/research/realslideshow_eval.zip

- **RealSlideshow 2.0 Summation**

 RealSlideshow was relatively easy to install and did not require any special skills or abilities to use. There is a correlation between the number of incorporated slides and the length of the initial buffering period. This delay is negligible for presentations with less than twenty slides, but can be extensive for larger quantities. This holdup could become troublesome at dial-up modem connection speeds. The image quality of the streaming slideshow was somewhat less than satisfactory, when compared to Microsoft PowerPoint presentations. For example, referring to figure 19 below, an Arial style font of 20, 32, and 44 points were used for text in a PowerPoint presentation. After converting into its corresponding RealSlideshow slides, text readability became an issue. This was most apparent for the smallest font size (20 point) and is most likely due to JPEG compression, which is applied during encoding for RealPix.


Figure 19: Screen Capture of Typical RealSlideshow Slide

 RealSlideshow's potential usefulness as a streaming presentation application must be weighed against Microsoft PowerPoint's excellent image and text quality which happens to be a non-streaming application. Since many within the Department rely on PowerPoint on a daily basis, any streaming slide-show contender must inevitably rival PowerPoint's quality.

- **RealPresenter-Plus Description**

 This product was selected for its purported ability to directly utilize an existing PowerPoint slideshow. In fact, once RealPresenter-Plus is installed, it can be activated directly from the PowerPoint menu bar. It was envisioned that any streaming media version of a PowerPoint presentation would convey a more bandwidth-friendly capability for not only the Internet but the Intranet as well. This premise was based on some rudimentary bandwidth measurements that were obtained while accessing PowerPoint presentations via the local network whereby a large "spike" in network bandwidth consumption is noted, but only for a short duration.

Upon launching the RealPresenter-Plus application, the startup screen appears and is depicted below in Figure 20-A. Shown in Figure 20-B is the "audio/video equipment" configuration screen. Any installed audio/video capture devices must be selected prior to recording.
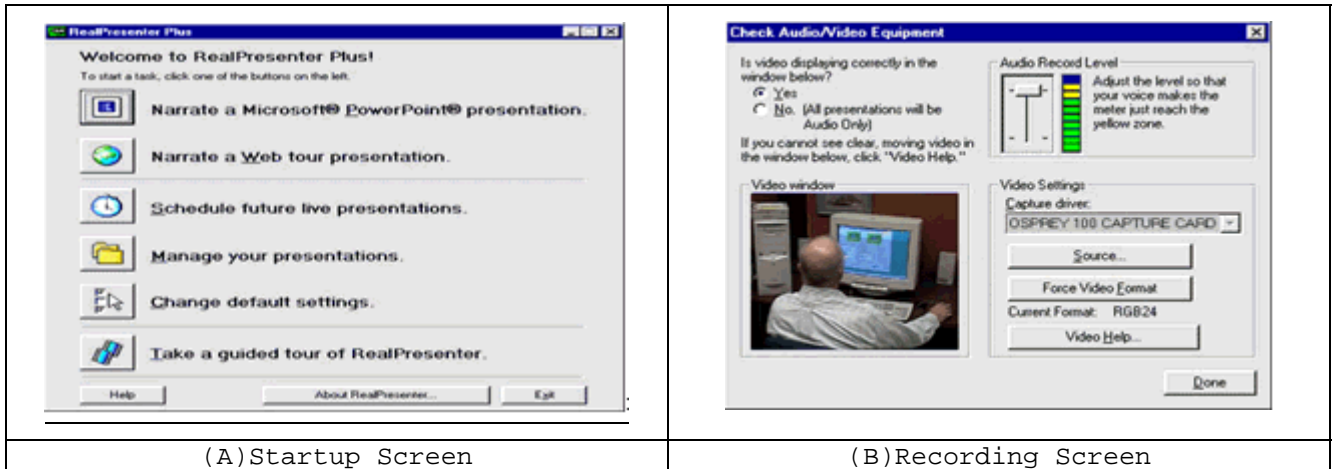
(A)Startup Screen	(B)Recording Screen

Figure 20: RealPresenter-Plus Startup and Recording Screen

An easy-to-use encoder interface is illustrated in Figure 21 below. It provides controls for start, pause, and stopping of the PowerPoint presentation while the user dictates and annotates audio to it with a microphone.

Figure 21: RealPresenter-Plus Encoder Controller

- **RealPresenter-Plus Summation**

At the time of this writing, it was discovered that the RealPresenter-Plus application has not been supported by RealNetworks since May 2002. The product replacing it is called "PresenterOne by Accordent" but was not evaluated, due to having already concluded that phase of work.

RealPresenter-Plus was very easy to install and use. The primary interest in this software was for creating streaming media slideshows from existing PowerPoint presentations. The program simplifies creation of audio narration by annotating a voice-over to each slide using a microphone. In-house testing determined that the overall image and audio quality of the resulting streaming media slideshow was acceptable. However, the software did not provide an "out-of-the-box" capability to create captions. A workaround would be to manually generate a RealText (.RT) caption file with a text editor and then SMIL can be used for synchronizing it to the slides. However, this can be time consuming and

tedious. RealPresenter-Plus is capable of creating remarkably good quality streaming media at bitrates as low as 43 kbps. This ability is quite impressive. On the other hand, PowerPoint is extensively relied on throughout the department, recognized for its excellent image quality and utility. As previously stated, any streaming slide-show application must rival PowerPoint. Therefore, reliance on RealPresenter-Plus is not warranted at this time.

• **RealProducer-Plus Description**

RealProducer-Plus is RealNetworks' streaming media "workhorse" and is used for encoding various types of content into its proprietary streaming media format. The product can perform three basic functions as shown below in Figure 22.

Figure 22: RealProducer-Plus Recording Wizard Options Screen

The first option, "*Record from File*" provides the ability to convert various formats of existing audio or video files into a streaming file for later viewing. Some supported files to convert from are WAV, AVI or MPG formats. The resulting streaming media file would have an RM extension for video or a RA extension for audio-only.

The second option "*Record from Media Device*" allows encoding to take place from external video or audio sources such as videotape decks, video cameras, or even just a microphone. Once again, it creates the RM or RA streaming media formatted file.   Before encoding begins, the software must be configured for any installed PC video/audio capture cards. These will appear in the pull-down boxes of the recording-wizard as shown in Figure 23. In this example, the Osprey-500 card was selected.

Figure 23: RealProducer-Plus Record-from-Media Screen

The last option, *"Live Broadcast"* is typically used to stream a live camera presentation onto the local network or the Internet. Minimal energies were expended on this aspect of the product so this will not be reported on at this time.
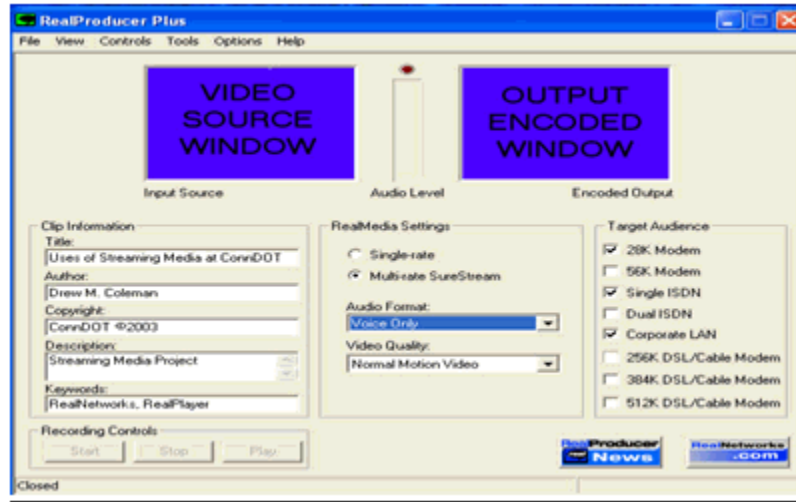

Figure 24: RealProducer-Plus Encoder Screen

Figure 24 above illustrates the RealProducer-Plus main control panel. In this example, the "multi-bitrate" option was utilized by selecting three different target-audience bitrates. The resulting single RM file will be comprised of three separate streams for viewing via a 28 K dial-up modem, ISDN, or LAN connection. When this RM file is accessed from a RealSystem server, the RealPlayer client application will display the most appropriate stream, dictated by the user's available bandwidth and connection. If RealProducer-Plus is configured for using the "single-rate" option only a single RM file is created, and comprised of one individual stream.

Relevant clip information for the presentation's title, author, copyright, description and keywords can be annotated to the presentation at the time it is encoded. Once this process has begun, the input source window displays the

subject video and the encoder's output window provides almost real-time visual assessment (dependent on CPU power), by providing a representative view of the new streaming RM media file as it is being created.

RealProducer-Plus provides a range-of-settings for configuring the presentations quality such as the streaming media's video frame-rate and encoded bitrate. Ultimately, if a robust server and Internet backbone are in place, overall movie quality is only limited by the end-user's own connectivity method, The following table provides four presentations created using RealProducer-Plus. The fifth presentation is the MPEG-1 source video that was used for converting into these first four streaming presentations. Note that the streaming media files are substantially smaller in size than the source digital video MPEG-1 file. To evaluate this on a local PC, click on the link below in table 8 to download the ZIP file. Then unzip to view.

Table 8: Comparison of RealProducer-Plus Media to MPEG-1 Source

Link to download all Media (113 MB zipped)[43]	File Size	Pixel Size	Frame-Rate	Encoded Bitrate	Optimized for Connectivity Method
RealMedia File _28K_180x120 pix_8fps_	625 KB	180x120	8	20 kbps	Dial-up modem
RealMedia File _56K_180x120 pix_10fps_	1,059 KB	180x120	10	34 kbps	Dial-up modem
RealMedia File _150k_352x240_15fps_	4,607 KB	352x240	15	150 kbps	LAN
RealMedia File _150k_352x240_30fps_	4,636 KB	352x240	30	150 kbps	LAN
MPEG-1 File _Source_352x240_30fps_	162.3 MB	352x240	30	N/A	N/A

- **RealProducer-Plus Summation**

RealProducer-Plus was found to be easy to install and use. The "record from file" and "record from media device" options both performed well and produced acceptable quality media. "Live broadcasting" (webcasting) was not thoroughly evaluated during this phase of the project as it was determined to be secondary in importance to creating an "on-demand" library of demonstration media. This was thought to be crucial for successfully marketing this new technology within the Department. In this way, staff could conveniently peruse a variety of content and topics.

- **RealText, SMIL, and Captioning Description**

RealText's with its RT file extension is a proprietary format that utilizes the _Synchronized Multimedia Integration Language_ (SMIL) for coordinating the displaying of captioned text with audio and or video. This can help address accessibility concerns for multimedia productions. A variety of RealNetworks media clips can be synchronized by using SMIL and RealText. They are RealMedia (RM), RealAudio (RA) and RealPix (RP). SMIL can coordinate the

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[43] http://www.conndot.ct.gov/research/realproducer_eval.zip

timing and duration of each element concurrently as well as sequentially. SMIL
is somewhat similar to hypertext markup language (HTML) and can also be created
and visualized with any text editor or by using the free SMIL authoring
application and generating tool called MAGPIE which can be obtained from the
WGBH Education Foundation website. The RealPlayer can utilize and display
captions when the requisite RealText file and SMIL file is provided. The RT
file defines how the RealPlayer will display the captioned text's content, font
and color and the text region's height and width, as well as an intrinsic
duration, from a few seconds to several hours. Once again, a text editor can be
utilized for making and viewing the RealText file.

- **RealFlash and Macromedia's Flash Description**

    RealNetworks' RealPlayer and Macromedia's Flash 5.0's functionality were
merged into a format initially referred to as RealFlash. The "Real" component
of RealFlash supported the streaming audio while the "Flash" component provided
the vector-based graphic animations. RealNetworks later referred to this
merging of products as "*RealG2 with Flash*". In working with this format, it was
determined that in the process of creating RealFlash files, audio/video
synchronization was lost within the accompanying Macromedia SWF movie file.
This problem is encountered if Flash's actionscript commands are utilized for
controlling program flow such as when pausing and then restarting a
presentation. A work-around to this problem was to split the audio from the
digital video movie and save it as a .WAV file and then "sync-up" the (.WAV)
file to the streaming video's RealMedia (RM) file, using an SMIL file. This
procedure proved to be very tedious but can be accomplished.

    To view a demonstration, click this link [44](165 MB zipped) to download the
demo with its accompanying support files consisting of SMIL, SWF, RM, RT, and
WAVs. After downloading and unzipping, see the readme.rtf file for more
information.

- **RealSystem Server Intranet 200 Description**

    Early investigation into RealNetworks' streaming server software and
licenses revealed that the company initially offered a free-of-charge, 25
simultaneous-user license. However this was rejected and instead ConnDOT
purchased the 200 simultaneous-user license/software.

- **RealSystem Server Intranet 200 Summation**

    Because RealPlayer does not come pre-loaded on new Department PC
acquisitions, the SI/CSC agreed with this offices' assertion that implementing a
Microsoft streaming media player and server solution would be easier to address
from a PC Support staffing perspective. This is due in part to existing
Microsoft server licenses as well as Windows Media Player client software
residing on most if not all Departmental PCs.

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[44] http://www.conndot.ct.gov/research/realflash_eval.zip

APPENDIX C

Microsoft Software

• **Windows Media Player Description**

The most current version of WMP can be downloaded free from Microsoft's Website. WMP version 6.4 is used with the Win95, Win98 and NT 4.0 OS and WMP version 7.1 is bundled with the Windows Me, Win98 and Windows 2000 OS. Windows Media supports data delivery over a wide variety of networks and protocols while still providing a local playback capability from CDROM or hard drive.

The WMP provides faster access to and viewing of video movies by delivering them (streaming) via a client/server application. Packeting of data occurs over time and is initiated by filling the player's buffer with primary information from the movies beginning point. This process is referred to as buffering, and depending on connection speed, can be experienced as an initial lag or delay, prior to the content being viewed. Figure 25 below illustrates where in the *Statistics Menu* the amount of packets-received is displayed. In this example it was 505.
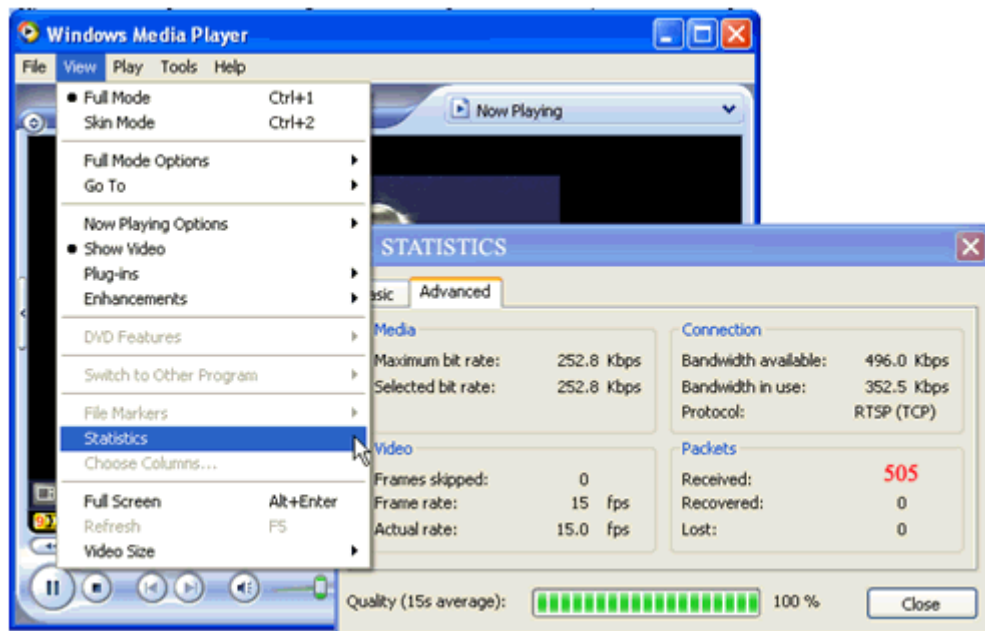

Figure 25: Windows Media Player 9 Series Statistics Screen

The newest media player to be examined was the 9 Series, which is based on the Windows Media Audio (WMA) and Windows Media Video (WMV) 9 Series codecs. When delivered and streamed from a Windows 2003 server and viewed using the version 9 player, the video can be made to appear almost bufferless; depending on how the server was configured (fast buffering) and if surplus bandwidth can be allocated for this purpose. The player is shown below in figure 26-A.
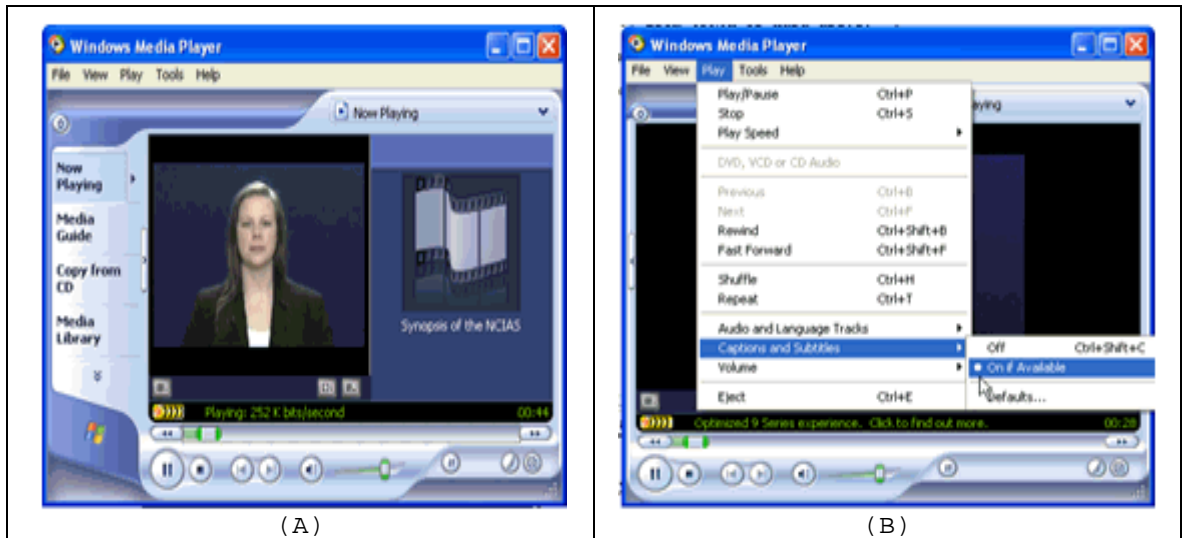
Figure 26: Windows Media Player 9 Series

- **Windows Media Player and SAMI Captioning Description**

        In order for the end-user to see *closed captions* when available, they must navigate the task bar and determine whether the captions feature is turned on or off. This can be confusing since earlier versions of WMP relocate this option in various places on the menu bar. Figure 26-B above shows the task bar and how to enable the player's captions feature.

         Microsoft did not follow the existing SMIL standard for captioning, which was adopted by the World Wide Web Consortium (W3C) and embraced by RealNetworks. SMIL is used to enable simple authoring of audio/video presentations. Instead Microsoft developed and utilized the Synchronized Accessible Media Interchange (SAMI). It is a proprietary authoring format for captions and audio descriptions that has been designed to provide multiple languages and style support. The free MAGPIE SMIL *authoring and generating tool* can be utilized for simplifying the task of creating the requisite text-based SAMI files. The SAMI file extension is (.SMI).

- **Windows Media Encoder Description**

        Window's Media Encoder (WME) Series 9 continues to be Microsoft's primary authoring and publishing tool for creating files in the Windows Media video (WMV) and audio (WMA) file format. Version 4.1 of the encoder was initially evaluated and output an Advanced Systems Format (ASF) file by default. This file format was originally designed by Microsoft to store synchronized multimedia data. With the later release of WME version 7.1 with its newer WMV/WMA version-8 codecs, Windows Media video and audio became the default format when running the encoder application.

        Towards the end of this research project, the WME 9 series was evaluated and well utilized. The version 9 audio codec was typically utilized when encoding most audio content and the WMV version-7 video codec was typically used as well. Use of both of these codecs helped ensure that this research project's demonstration media could be viewed by an expanding ConnDOT audience.

WME provides three basic option or session selections, similar to RealProducer-Plus. The first of these capabilities to be discussed is "broadcast live event".

Preliminary testing of *broadcast live event* determined that a latency period of about 20 seconds exists between the live camera video source and what the end-user sees at the other end. This lag was not a consequence of poor PC-hardware performance, but instead appears to be inherent in the software or could be a network-related issue.

The second capability of WME is for capturing, digitizing and encoding audio or video from an external source into one of the Windows Media streaming formats. A typical external device would be a VCR, video camera or microphone and would require utilizing some form of PC-based video/audio capture card. Figure 27 below illustrates the device options wizard, used for selecting and configuring any attached video capture cards or devices.


Figure 27: Windows Media Encoder (WME) Version 7.1 Device Options Screen

Windows Media Encoder Series-9 supports multi-bitrate streaming. Figure 28-A illustrates this capability by having selected/checked three separate boxes (streams). When initiated, the WME will generate one WMV file that contains all three streams. Figure 28-B shows the screen whereby the video codecs are selected and 28-C provides a zoomed-in view of the audio codecs screen.

C-3
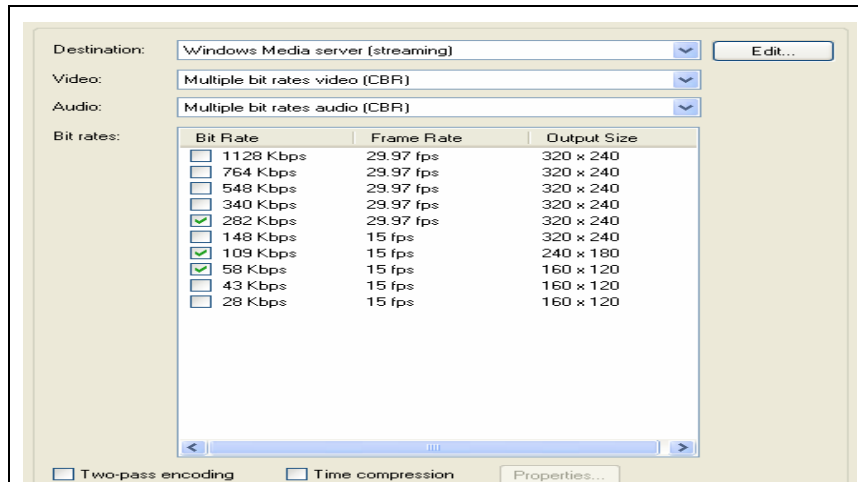
A: Selecting Multiple Streams
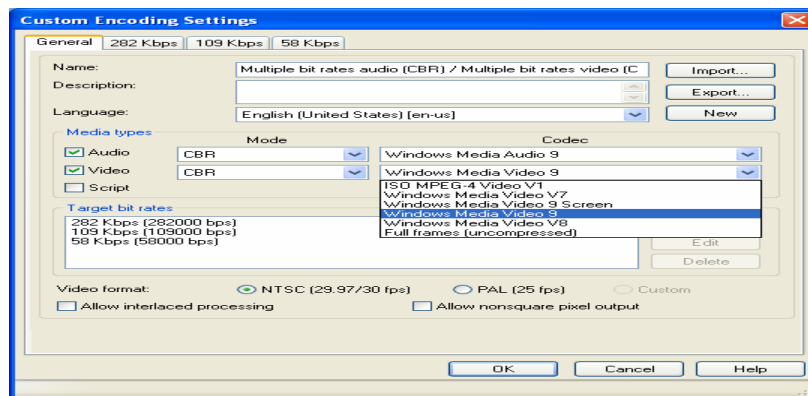
B: Selecting Video Codec
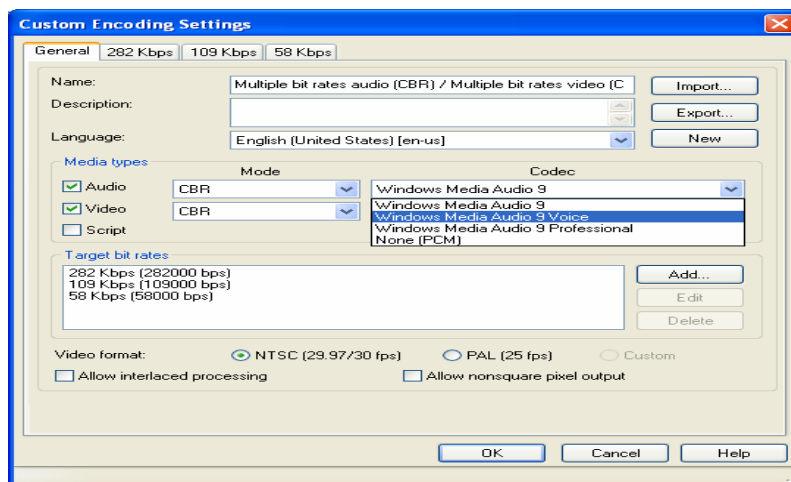
C: Selecting Audio Codec

Figure 28: WME Series 9 Properties Screens

The following table provides a side-by-side comparison of overall quality of a presentation that was encoded at three different bitrates.

Table 9: Side-by-Side Comparison of Dial-up, DSL, and Cable Streams

Connectivity (click on links)>	Dial-up Modem Stream	DSL Stream	(Cable Stream)
Bitrate	33 kbps	100 kbps	300 kbps
Frames per Second	3-5 fps	10 fps	15 fps
Physical size	180 X 120 pixels	320 x 240 pixels	640 x 480 pixels

When version-8 of the WMP was used to play back multi-stream content created with the WME Series-9, it did not display the correct stream. Instead, WMP version-8 always played the lowest quality stream (dial-up), regardless of the connection speed. This problem was not encountered during playback with the WMP Series 9. Therefore, it was decided that three discrete streams would be created, published, and accessed from three individual Web-links. Thankfully, the multi-bitrate feature of the WME 9 Series can still be pressed into service for accelerating production by using a utility called "*Windows Media Stream Editor Series 9*". This application can be used to "carve up" a multi-bitrate presentation into individual streams if the source file was encoded in that manner. This procedure can save a lot of time, compared with running the WME two or more times.

Figure 29: Windows Media Stream Editor 9 Series

Figure 29 above illustrates the ability to take a single multi-bitrate source file (multistreamfile.wmv) shown on the left-hand side and then the three

discrete streams contained within the source file; shown on the right-hand side. Clicking on the "Create File" button will add any of desired "output audience" streams to the "Output Files" list and then export the desired streams.
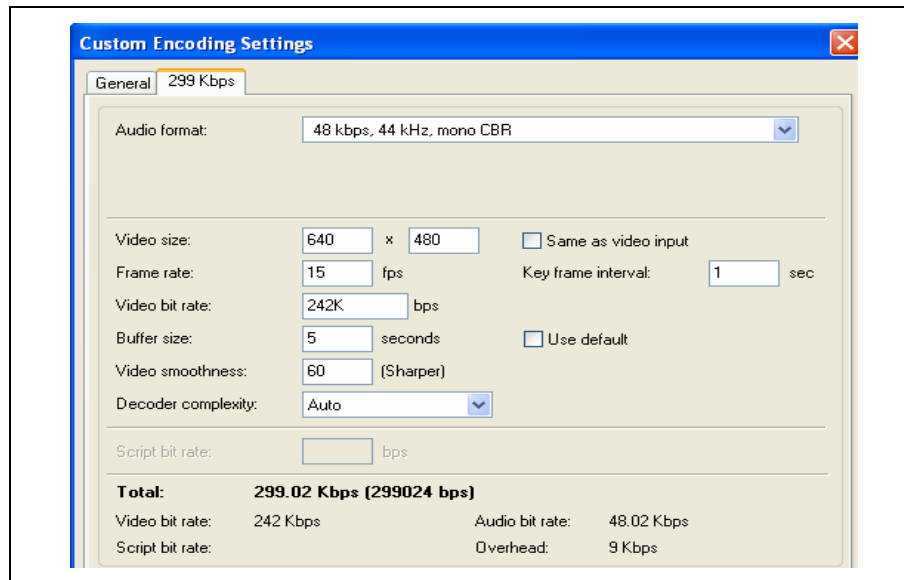

Figure 30: Windows Media Encoder 9 Series Screens

The physical size (pixels), frame-rate (fps), and bitrate (kbps) of a movie are configured within the custom encoding settings screen, as shown in Figure 30.   Once the encoding process has begun, the input source window displays the subject source-video and the video output window provides real-time quality checking of the new streaming media WMV file as it is being created.

The last of the WME functions to be tested and described is the "*convert existing audio or video file into Windows Media*" option, which provides the ability to import and convert large and CPU intensive AVI movies and MPEG into a WMV streaming media formatted file.

The *Microsoft Windows Media File Editor* Series 9 is used to edit any Windows Media file with a .WMV, .WMA, or .ASF file extension. It proved indispensable for trimming the starting and ending points of a WMV/WMA file. With this editing ability, a videotape deck could be left unattended while capturing and encoding with the Windows Media Encoder. Once the videotape reached the end of the recorded program or tape end, the encoder will continue to capture only video noise. However, this utility, can quickly remove it through simple editing.

Another function that this utility performs is as a Windows Media script editor. Windows Media can contain script commands that provide a synchronization capability for use with other applications, such as triggering external Web pages or being able to jump ahead to specific points in a WMV from a Web-page.
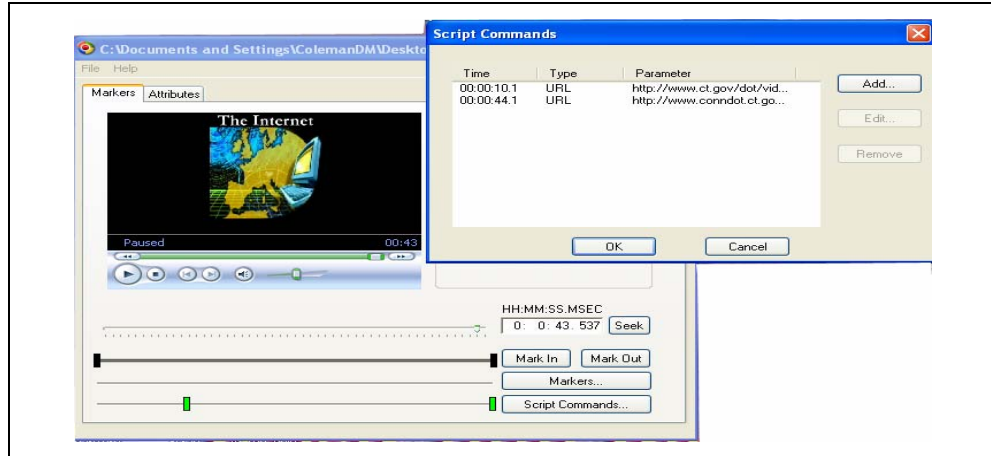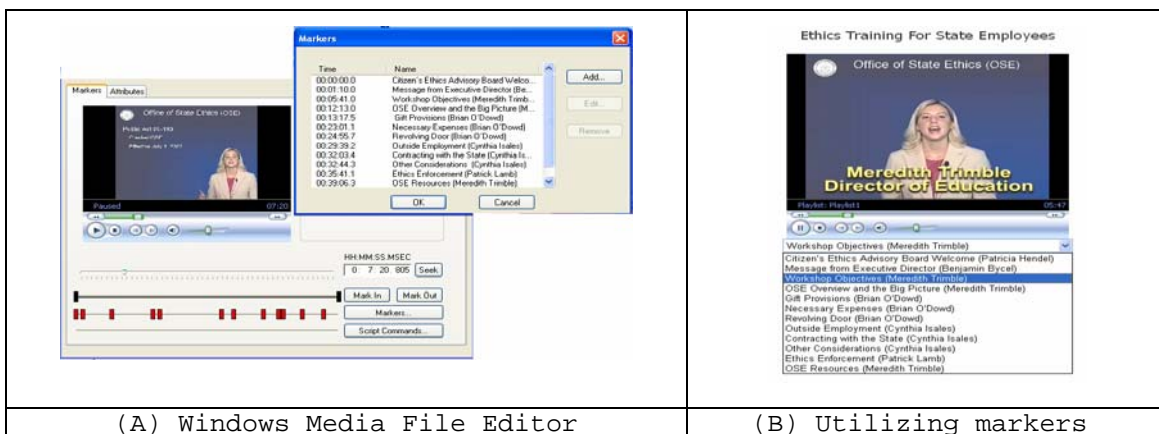
Figure 31: Windows Media File Editor showing Script Commands

Figure 31 above illustrates that scripts appear as a series of vertical bars located in the lower part of the image. The upper box on the right side shows two script commands corresponding to an event. The following link[45] will demonstrate how a Windows Media Video file and embedded-scripts can be made to trigger any specified URL at a pre-determined time interval; in this case at the 44 second point. At that specified time, a new URL/Webpage will be triggered and displayed.

One additional feature of the File Editor is for inserting markers to be used as navigable bookmarks within a WMV file. These appear as red bars as illustrated below in figure 32-A. These bookmarks can be used to quickly jump around within any video. The Windows Media Player has a menu feature found under <View> called <File Markers>. If markers are present in a video, this option will not be "grayed out". A better way to provide users access to markers is by creating a webpage utilizing JavaScript. A "pull-down" menu can be created that references each bookmark (as shown in figure 32-B). Click on http://www.ct.gov/dot/t2 to try this out.

(A) Windows Media File Editor	(B) Utilizing markers

Figure 32: Windows Media File Editor showing Markers

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[45] http://www.ct.gov/dot/larsenintro

Table 10 below provides a list of codecs that can be used with the Windows Media Encoder 9 Series. Microsoft purports that its newer codecs (higher number) produce better quality video and audio as compared to their earlier codecs. Since video by nature is comprised of both sound and images, this research project initially utilized WMV 7 codec for images (video) and WMA 9 codec for sound (audio). This was done to ensure the broadest codec compatibility for any of ConnDOT's older legacy PCs.

Table 10: Microsoft Video/Audio Codecs Supported by WME 9 Series

Microsoft Windows Media Codec	Brief Description and Use
Windows Media Audio 9 Professional	Intended for data rates of 128 to 768 Kbps. Supports full surround sound and dynamic range control.
Windows Media Audio 9 Lossless	Provides lossless encoding of audio content
*Windows Media Audio 9***	Provides a 20 percent improvement in compression over the version 8 codec. Supports VBR audio encoding.
Windows Media Audio 9 Voice	Offers superior quality for audio content with voice emphasis. For playback at bitrates at less than 20 Kbps
Windows Media Video 9	High quality video codec. Provides a 15 to 50 percent improvement in compression over version 8.1 codec.
Windows Media Video 8.1	Supports a wide variety of network bandwidths.
*Windows Media Video 7***	Enables users having Windows Media player 7 to view content without downloading latest codec.
Windows Media Video 9 Screen	Provides screen capture capability with one and two pass CBR and VBR encoding with no frame dropping.

In summary, demonstration media based on Microsoft's WMV format was initially created using WME version 7.01. Around May 2003, WME 9 Series was released and was subsequently utilized for the duration of this research project. "*Live*" streaming (Webcasting) with WME 9 Series was thoroughly tested and successfully utilized July 18-22 of 2004 off-site during the National Research Advisory Committee meetings.

"*Capture audio/video*" worked well for capturing and digitizing audio and or video from an external source such as a VCR or video camera. It was easy to use for converting existing videotapes into an "on-line" network-based streaming media resource.

"*Convert an existing video/audio file into Windows Media*" proved to be very useful because it reduced the file size of AVI and MPEG digital video files. Once converted, the resulting WMV file is much smaller and requires less space on the server hard drive.

The WME Series-9 software provides the ability to encode using a variable bitrate (VBR), as an alternative to constant bitrate (CBR). Encoding as VBR is only appropriate when media is to be downloaded or played from removable media or local hard drive, because bandwidth consumption fluctuates. Therefore, it is not advisable to encode content using VBR when it will be streamed via a network or Internet-based server.

The utilities that are packaged with the WME 9 Series were found to be very useful. Of particular value were the "*Windows Media Stream Editor*" and the "*Windows Media File Editor*".

- **Producer for Microsoft Office PowerPoint 2003**

Microsoft Producer[46]is a free "add-in" from Microsoft for use with PowerPoint. It can be used to capture audio and video, synchronize the video to slides and images, and finally, publish and deploy the presentation to the Intranet, Internet, or removable media such as CD-R.

Version 1.1 of the software was evaluated and was noted to run under both Windows XP (Professional and Home) and Microsoft Windows 2000 (Professional) operating systems. A wide variety of enterprise scenarios are incorporated into Producer's templates for simplifying the effort required to create and publish streaming presentations. A "bug" was discovered in the early version when encoded on a PC running NT 4.0. This required "patching" newly-created content with a Microsoft-revised "*gogoprod.js*" file. *Producer for Microsoft Office PowerPoint 2003* came out in later as version 2.0 but requires that PowerPoint 2002 or 2003 be installed on the PC. The previously mentioned bug was not found in this later version.

Producer for Microsoft Office PowerPoint 2003 was used to create the following four presentations. These demonstrate ADA and captioning. Rather than using closed captions, open-captions were used to display text that was synchronized to the video.

- 1) Coordination of Pavement Activities in the Northeast [47], (*hit go*)

- 2) Thin Lift Maintenance Treatments of Modified Asphalts[48],

- 3) Evaluation of Streaming Media Technologies[49], and

- 4) The Synopsis of the Narrow Connecticut Impact Attenuation System[50],

In summary, Producer has proven to be very useful here at ConnDOT Research for creating Web-based training materials. It did take some additional effort to determine how best to address ADA for this type of presentation. It was decided that a "black box" would be generated using HTML for creating and displaying the synchronized text. The appropriate tags were then inserted within each new project's "default.htm" file. Two other files; "gogoprod.js" and "0mm0.smi", must be modified and included within each new project as well.

Typically, Producer presentations incorporating slides must first download (preload) them as JPEG images before beginning to play. In fact, the play button does not become visible until this occurs. This delay is directly proportional to the quantity of slides contained within each Producer presentation. This JPEG preloading period and the delay it creates are counterproductive and annoying.

Microsoft addressed preloading in a later offering via a feature called *Rich Media Streaming* (version 2) which encodes both the slides and the video/audio within the Windows Media Video file. The slides are encoded within

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[46] http://www.microsoft.com/downloads/details.aspx?FamilyID=1b3c76d5-fc75-4f99-94bc-784919468e73&DisplayLang=en

[47] http://www.conndot.ct.gov/dougan/default.htm#nopreload=1#autostart=1

[48] http://www.conndot.ct.gov/media/producer.aspx?url=http://www.conndot.ct.gov/keithdemo6_files/default.htm

[49] http://www.conndot.ct.gov/media/producer.aspx?url=http://www.conndot.ct.gov/eval/default.htm

[50] http:www.conndot.ct.gov/media/producer.aspx?url=http://www.conndot.ct.gov/ncias/default.htm

the first part of the WMV file and the video portion follows afterwards. A Pre-Roll Offset marker is scripted within the WMV file and is used by the Producer presentation for ensuring proper playback. In order not to preload all of the slides, add the string *#nopreload=1* to the end of the rich media streaming presentations' URL. As an example, paste http://www.conndot.ct.gov/eval/default.htm into your explorer's address bar and click <go>. This will download (preload) all of the presentations' slides before displaying the play button. Then try copying and pasting the following string into your browser's address bar **http://www.conndot.ct.gov/eval/default.htm#nopreload=1#autostart=1.** The "Go" button in the IE menu may need to be clicked on to display the page but then the play button should immediately become visible. Adding the *#autostart=1* string to the end of this URL will quickly start the presentation without having to click on the play button.

- **Windows Movie Maker**

The recent release of Microsoft XP was somewhat monumental in that for the first time, a basic digital-video editing application came pre-bundled with a Microsoft OS. Since no additional video-editing software needed to be purchased or installed, PC-users running XP now have the ability to capture, edit, and publish their own streaming media-based content. At the same time, it also strengthened the position of proponents for streaming media utilization here at ConnDOT, by negating the need for PC Support to install any video-editing software on PCs running the XP OS. However, an analog-video capture card or firewire port is still needed for capturing from a video camera or tape deck.

- **Microsoft Windows Server 2003 and Windows Media Services**

Microsoft's streaming media architecture is based on Windows Media technologies. Windows Media supports server-based network delivery of video and audio for providing scalable quality via "intelligent streaming"[51]. Intelligent streaming is a mechanism that provides a client's Windows Media Player (WMP) with the ability to negotiate and view the best quality stream for that given session's connection speed with the media server. If the network or connection performance further deteriorates, the video portion of the presentation begins to drop frames until finally, only the audio portion remains. Windows Media Services is part of Windows Server 2000 and 2003 and can ensure that network bandwidth is safely utilized and adequately protected.

Table 11: Comparison of Microsoft Windows Media server vs. Web Server

Supported Features	Media server	Web Server
Stream through most firewalls	*Yes*	*Yes*
Stream without downloading	*Yes*	*Yes*
Stream media with Digital Rights Management	*Yes*	*Yes*
Windows Media security	*Yes*	*No*
Broadcast live	*Yes*	*No*
Intelligent streaming	*Yes*	*No*
Optimized for streaming Windows Media	*Yes*	*No*
Indexing	*Yes*	*No*
Administering and logging	*Yes*	*No*

---

[51] http://www.microsoft.com/windows/windowsmedia/howto/articles/intstreaming.aspx

To ensure optimum streaming media quality and dependable service, a dedicated server was purchased and installed on both the 100-user LAN as well as the 2000-user WAN. Microsoft Windows Media Services 4.1 software must be installed for servers running the Windows NT Server 4.0 operating systems. However, the Windows 2000 Server software comes bundled with Windows Media Services and can be configured so that a Windows media server can provide broadcast-unicast, broadcast-multicast (network only), and on-demand unicast.

On-demand streaming is automatically configured by default for Windows Media files with .WMV, .WMA, and .ASF extensions. These files can be located in the ASFROOT directory on the server. This directory is automatically created upon installing the Windows Media Services software version 4.1.

Windows Media Services 9 can provide a fast buffering capability when used with the Windows Server 2003 software. Selecting this option allows the end user to see the video presentation quicker than normal but it will only work with *Windows Media Player for XP* or later versions. There is the ability to limit the amount of bandwidth that the *Fast Start* feature uses to stream to each player. The Fast Start feature is only used by clients that connect to a unicast stream. Figure 34 shows a screen shot of ConnDOT's primary *publishing point* from where most "on-demand" content is accessed. Note that Fast Start is set to 3500 kbps and the Fast Cache delivery rate is set to 5.

- **Microsoft Windows Media Services Summation**

Having been assigned the roll of streaming media administrator for the duration of this project, this PI continues to post all newly created WMV-based content via the network using FTP. This is conveniently accomplished by using this Offices' PC, then copying files directly to the remotely located streaming media server at CATER. Additionally, Microsoft's *Remote Desktop Connection* application provides the ability to fully configure all administrator-selectable streaming media server options. One of the most important server-side settings is for limiting player connections and bandwidth used per each player connection as shown below in Figure 33. Folders have been setup and organized into a variety of media categories on this server, whereby WMV files are uploaded to the appropriate folder.
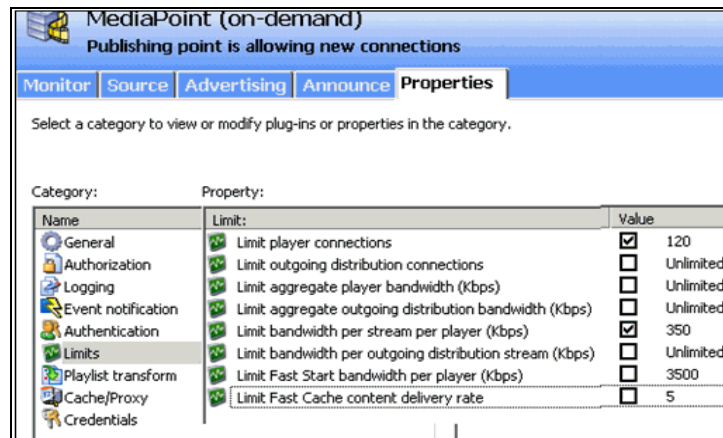

Figure 33: Windows Media Services Limits Screen

APPENDIX D

<u>Apple Streaming Software</u>

- **Apple QuickTime Player Pro**

    Version 5.0.2 of the QuickTime Player Pro was used in the project when converting MP3 music files into the WAV format. It was also used for "splitting" the audio from the video portion of an AVI movie and then saving it as a discrete WAV sound file. Trimming was easily accomplished by setting an in-point and out-point. Additionally, exporting to a multitude of file formats was possible, including its native QuickTime (.MOV) movie format.

    Apple requires that the QuickTime-Pro application be downloaded directly via their Website by using an installer front-end. The company will not provide hard copies of the applications. Installing via the Apple Website has proved to be difficult, due to network firewall and security issues. This has prevented utilizing Apples' software licenses and automated updating software.

- **Apple Darwin and QuickTime Server**

Both of these applications could not be tested and evaluated on ConnDOT's network. Again, this stemmed from concerns that OIS had regarding WAN security. Therefore, the Apple G4 machine was configured and deployed offsite. The testing period was therefore very limited but the server software did work because it was able to stream Quicktime "hinted" movies.

E1: Other Software Used in Creating Streaming Media Presentations

New tools were required for designing and creating compelling and innovative new content. It was envisioned that these videos would effectively demonstrate streaming media's potential value. The following software was evaluated and is described in the following section.

E1.1 Macromedia Flash-5 and Flash-MX

Macromedia's Flash® software was chosen for its ability to create illustrative and engaging vector and graphics-based demonstration material. Since the software did not support the ability to directly publish Windows Media Video (WMV), it was solely used to design animations for new training materials. The software was then used to export uncompressed AVI formatted files. Windows Media Encoder was later used to convert the AVIs to WMVs. Macromedia's next version of Flash was capable of importing and integrating a variety of popular digital video formats such as MPEG, DV, AVI, and QuickTime's MOV when it debuted later as Flash-MX.

The Flash native movie format has a SWF file extension. The letters SWF were derived from the earlier generation's Shockwave™ player. Using Flash 5.0 and Flash-MX requires a good understanding of digital graphics. Optimizing bandwidth for each individual Flash SWF-movie was deemed to be very tedious, so Flash would not be recommended for Department-wide use. Secondly, most if not all of ConnDOT's PC users would require installation of the Macromedia Flash player plug-in. It is required before playing of the SWF Flash movie can occur. On a more positive note, Flash was well suited for use as a low-cost desktop non-linear editing workstation. AVI files take a considerable amount of time to render and then export from Flash, and they consume gigabytes of hard-drive storage space. A 933 MHz PC/CPU performed adequately for creating the uncompressed AVI-formatted files which convey excellent overall quality for archival purposes.

Flash provides a default frame rate of 12 fps at a physical size of 550 X 400 pixels for its project design *stage*. These same settings were utilized for the majority of media created throughout this project. Increasing the pixel size to 640 X 480 and the frame rate to 30 would increase the overall quality of the final movie but Flash "hangs-up" the PC when rendering the SWF movie at these settings. This was even experienced when running on a PC at 2.0 GHz/512 MB RAM. Therefore, higher frame rates and pixel sizes should not be used unless a very robust PC is available. Increase the amount of PC memory (RAM) as well.

E1.2 Sonic Foundry Sound Forge XP

Version 4.5 of this software was utilized with Macromedia's Flash-MX for normalizing movie sounds and adjusting volume levels. This was also useful for balancing the sound level between background music and the narrative voice track. In addition, a graphic equalizer and noise gate functions were relied on for post-processing of WAV files for reducing room noises like air handlers etc. The MP-3 sound format was not supported by this version of the software.

E1.3 Discreet Cleaner 5

  This product provides a significant amount of features that can be used to enhance a wide array of digital video and audio formats. The software's main use within this research project was in batch-processing multiple files when applying a wide-range of imaging adjustments for MPEG, AVI, and DV formatted video files. Figure 34-A shows some of these settings for video brightness, contrast and gamma correction.
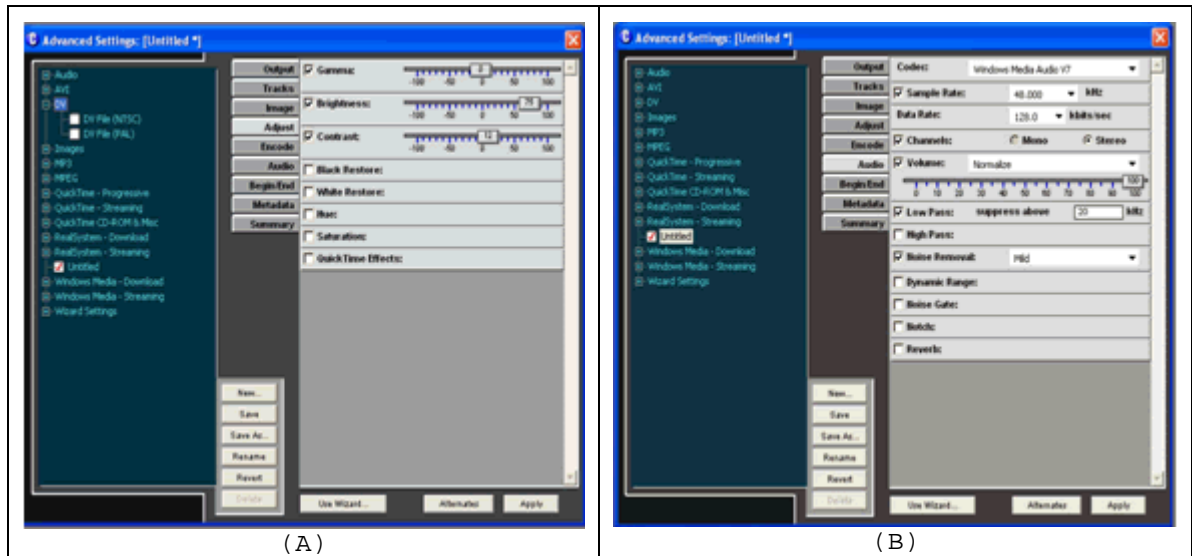

            (A)   (B)

Figure 34: Cleaner-5 Video and Audio Adjustment Screen

  Audio files such as WAV and MP3 can be digitally manipulated and enhanced by adjusting noise filtering settings. Exporting, importing, and converting between different audio file formats makes this software very valuable for digital-video production. Figure 34-B shows the array of features that are available for post-processing of audio files. This version of Cleaner would not recognize the WMV format. However, renaming the files' extension to ASF allowed the files to be accessed by the program.

  The latest version to be evaluated was Cleaner XL but its user-interface had been totally re-designed.

E1.4 Macromedia Authorware 6

  This product was investigated for its potential to integrate and synchronize Flash movies, digital graphics and audio. An ActiveX® control was used to display and play WMV-movies that were streamed from a dedicated media server. Authorware presentations can seamlessly integrate all of these above-mentioned capabilities, while also providing an interactive capability to the end-user. Authorware presentations are well suited for computer and Web-based training. Developing a presentation starts off by selecting, dragging and then dropping library-based icons containing object-oriented code onto the design stage. The author determines the desired appearance, control and flow in this manner. Some typical project screen shots are shown in Figure 35.
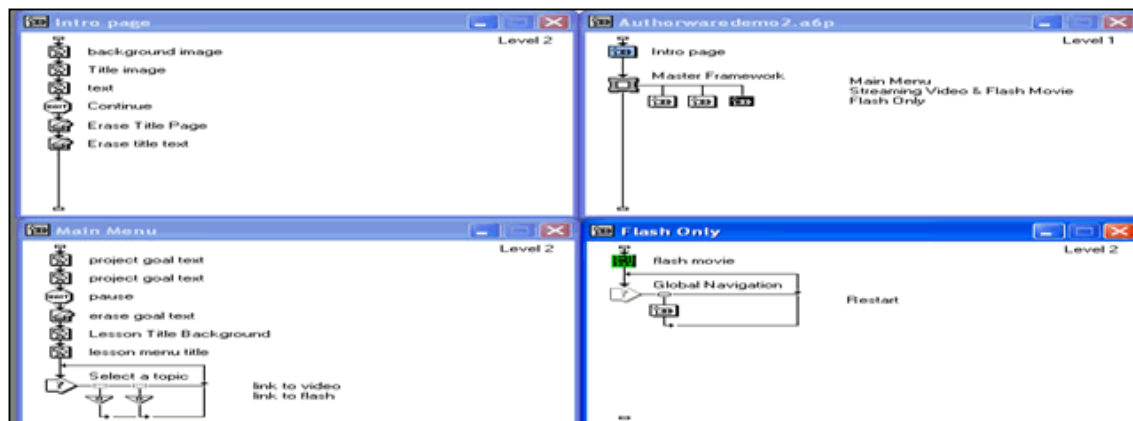
Figure 35: Macromedia Authorware-6 Icon and Designing Stage

Two presentations were created for demonstrating the capabilities of Authorware-6. Authorware's free *web player plug-in* is required for viewing this project's demonstration media. A link to Macromedia's download area[52] is provided if downloading of the plug-in is desired.

The following presentation demonstrates how Authorware-6 can utilize embedded activeX controls, in this case a Windows Media player, which is then used to display an ASF video stream. The link is http://www.conndot.ct.gov/research/MinnDOT_GeometricDemo.zip

This final Authorware-6 demonstration illustrates how it can be used to synchronize a Flash SWF movie to a streaming WMV movie file. The link is http://www.conndot.ct.gov/research/Authorware1.zip. It was envisioned that the software might be utilized to develop potentially useful Web-based interactive training applications

- Authorware-6 Summation

Authorware-6 was found to be well suited for developing customized computer and Web-based in-house training materials by virtue of its well designed project wizards, icon-based object library, and Visual Basic-like object-oriented environment. The program's "one button publishing" simplified the creation of Web-based applications. If this product is to be utilized here at ConnDOT, the Authorware plug-in must be installed by an administrator, prior to any Department-wide viewing.


[52] http://www.macromedia.com/shockwave/download/download.cgi

Best Practices to follow when Designing PowerPoint Slideshows for Use in Webcasts

Prior to videotaping a streaming video presentation, PowerPoint slideshows should be optimized in the following manner.

1)   Select as large a font as much as possible, Arial size 28 or larger. This will limit the amount of text that can appear on any one slide and obviously increases the total number of slides but will dramatically improve the readability of the encoded streaming video. The same information on more slides can also make the presentation more interesting and help with pacing. Remember; the person viewing this on a PC has a different perspective than the live audience. The following picture illustrates what should be avoided. In this example, there is one bulleted topic and three paragraphs. The font size used is approximately 20. The solution here is to break this slide into three individual slides. Then increase the font size to 28 or larger. Also, don't put graphics, like the column below, on the sides. Try to use the top and left parts of the slide to optimize font size. The idea is to make the important information as big as possible for the viewer. Use graphics when they help to convey information but not as design elements that use up valuable screen real-estate.
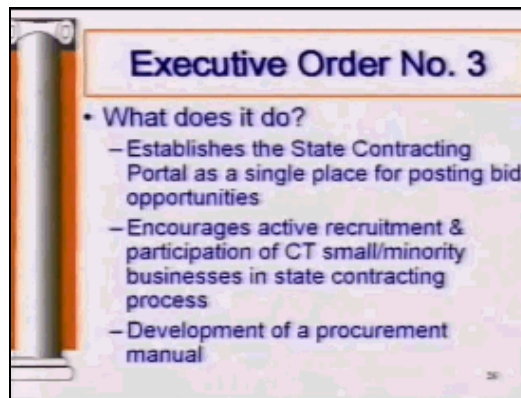
2)   When designing a slideshow, avoid using gradient background colors. However, there are exceptions. The picture below shows how a gradient (dark blue to lighter blue) can be effective when used with contrasting-colored yellow text
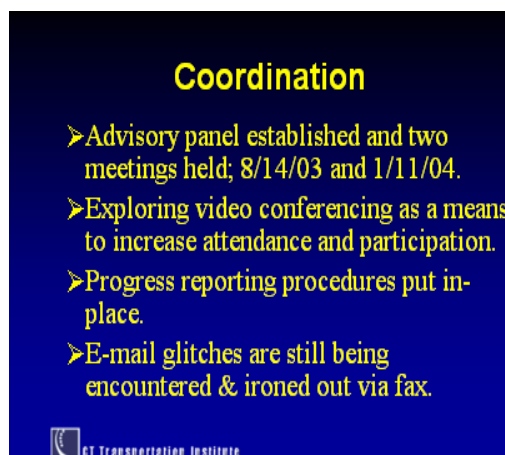
3)   Try not to use a semi-transparent graphic for a background on the slides, as shown below


4)   It is ok to use a light background color with dark fonts, or a dark background color with light colored fonts. The key is to have as much contrast between font and background for improving overall readability.

5)   When designing slides, reserve space in the lower right hand corner for use with a "talking head" for the presenter as shown below. Typically, this will occupy about 25% of the total slide region and should be confined to the lower right corner. A "talking head" will not usually be placed alongside of a graphic or chart as in (A) because it can be distracting, but its use can be advantageous with most slides
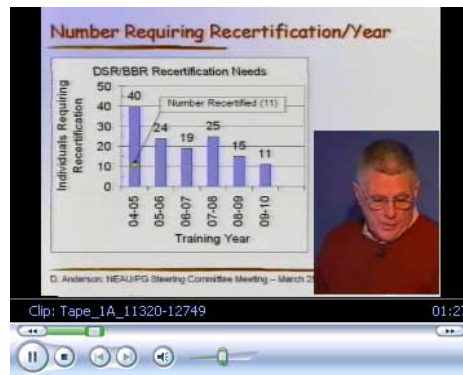
6)   Aligning text flush-left rather than centering will help allow bigger fonts and keep the right corner more likely to be available. Avoid flying text, as animations tend to look jerky on screen. Cuts are the best transitions.
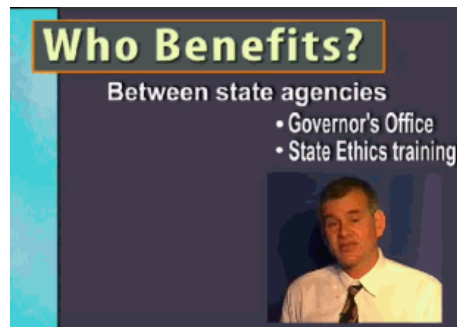
7)   The following picture illustrates one person's presentation-"style", which is walking up to the screen and pointing to it. While this may be acceptable in front of a live audience, it is suggested that the presenter remain behind the podium at all times. Ideally, use the PC-mouse as a "pointer" for emphasis, if required. This is especially important if acquiring the screen electronically through a scan converter. A laser pointer would not be visible but the mouse cursor would.
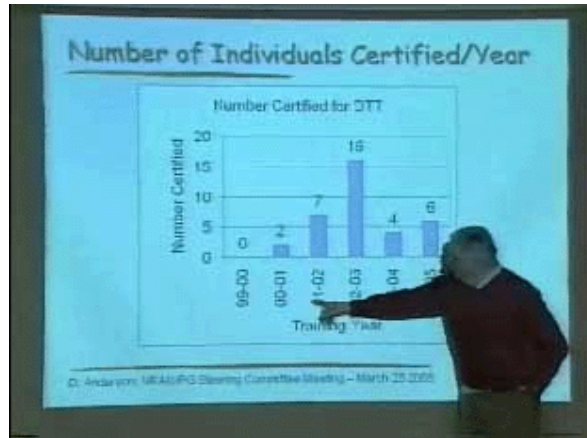
Suggested Dress Code for Presenters

Presentations are conducted in ConnDOT's video studio under controlled lighting and in front of a Podium. The stage has a blue drape which can be advantageously used during post production for chroma-keying. When properly utilized by the videographer, it can allow the presenter to appear to "float" on top of the slides and can make for an effective presentation. See photo below.
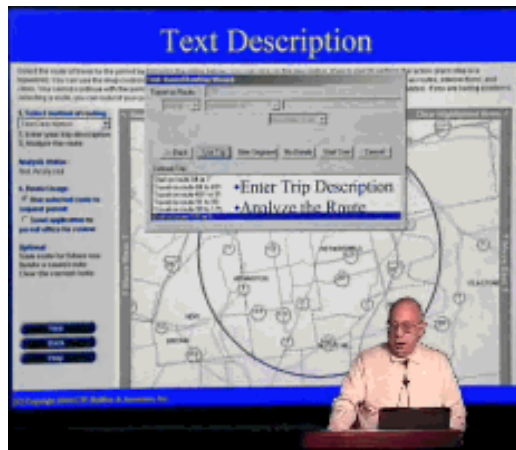
Presenters should wear lighter colored blouses or shirts. (But not stark white if possible) Definitely avoid the blue/green color if possible. Dark sport coats should not be worn. Ties should be used for professionalism, but do not wear blue ones. Avoid fine or complex plaid patterns whenever possible. Glasses can be worn if needed but wearing contact lens is best as it reduces the glare from the spot lights.

APPENDIX G

<u>Memorandum of Understanding</u>

Between the Department of Information Technology
And the Connecticut Department of Transportation

MOU # XX-XX

The Department of Information Technology (DOIT) and the Connecticut Department
of Transportation (ConnDOT) do hereby enter into a Memorandum of Understanding
(MOU) under the following terms and conditions.

1. In order to accomplish our goals, there is a need to install a dedicated
   streaming media server on the DOIT/CATER Internet backbone for the purpose of
   disseminating transportation-related streaming video- and audio-based content
   of research findings on federally funded projects. ConnDOT has the immediate
   need to deploy all streaming demonstration media that was developed under the
   federally funded project entitled "Feasibility of Streaming Media for
   Transportation Research and Implementation."

2. DOIT, is willing to provide rack space for one (1) Dell 2650 PowerEdge server
   as well as Internet/network bandwidth (amount to be determined) on its East
   Hartford facilities infrastructure.

3. DOIT will provide ConnDOT the following:

   a) Installation of a Dell 2650 server (provided by ConnDOT in (4a)).
   b) Cable and interconnect server to network/Internet
   c) Provide uninterruptible power and surge protection.
   d) In the event of experiencing any server hardware (4a) failure, DOIT will
      immediately contact Dell service/support and provide service tag number in
      order to access ConnDOT's three-year type-2 service contract.
   e) Installation of service packs/patches to the operating system as
      recommended by Microsoft or reinstallation of operating system if required.
   f) Provide ConnDOT's designated streaming media (SM) administrator with access
      to a mediapoint/publishing folder located on the streaming server (4a) for
      independently uploading streaming media files to the streaming media server.
      This may be accomplished via either the Internet or the network.
   g) Provide ConnDOT's designated SM administrator with server (4a) usage log
      files on a monthly basis or when requested.
   h) By mutual agreement, the Department may change or add additional designated
      SM administrator(s).
   i) Make a reasonable effort to provide 24/7 availability of the server (4a) on
      the Internet.

4. ConnDOT will provide:
   a) One (1) Dell 2650 PowerEdge rack mount server with RAID-5 capability, dual
      2.8 GHz Xeon Processor, 2 GB DDR, 173 GB data storage capacity
   b) Microsoft operating system (Windows 2000 Server or better)
   c) Streaming media demonstration materials developed for dissemination via the
      Internet from a streaming media server.
   d) Copies of its streaming media project publications, including both interim
      and final reports, which will include guidelines for production and
      deployment of streaming media.

e) At the option of ConnDOT but mutually agreed upon by DOIT, provide upgrades to hardware and software.

5. Upon execution of this MOU, DOIT agrees to waive its labor/personnel costs to install and maintain the server onto the DOIT/CATER Internet backbone, in exchange for providing DOIT with access to up to not more than one quarter of the total computer-processor utilization and up to one-half of the total available data storage capacity of the dedicated streaming media server. *Please note. While the above paragraph/language was originally proposed by ConnDOT, it was not agreed upon in the final MOU by DOIT. Instead, DOIT elected to impose a monthly service charge and not share ConnDOT's resources.*

6. In the effort to responsibly utilize available streaming bandwidth and resources, both ConnDOT and DOIT agree to limit the encoded bitrate to not more than 300 kilobits-per-second for any one stream.

7. The term of this MOU will begin August 1st 2003.

8. Any changes in the substance of the provisions of this MOU may be made only with the mutual written agreement of both parties.

9. This MOU may be terminated by either party with 60 days written notice, but not before December 31, 2005.

ACCEPTANCES AND APPROVALS

Department of Information Technology   _____Date

Connecticut Department of Transportation _____Date

DOIT IT Project Profile

<table>
<tr><td>

Project Name & High Level Summary
Please provide the name of the project and a few descriptive sentences
summarizing what the project will accomplish.

</td></tr>
</table>

Project Name: Feasibility of Streaming Media for Transportation Research and Implementation

Summary: This federally-funded three-phase study was undertaken for the purpose of initially determining the feasibility of, and later the benefits derived from obtaining a streaming media capability for use by the Connecticut Department of Transportation's Division of Research. A Department Intranet streaming media server was established on the network for the purpose of testing and evaluating streaming media technologies in-house. Utilization of a streaming server in excess of two years has yielded significant expertise in this area. An Internet streaming capability is now required to meet our Federal reporting responsibilities for disseminating this project's demonstration media via the Web. The main focus areas that were accomplished to date have been:

a) Implemented Microsoft's streaming media platform in a way that minimizes network congestion and ensures bandwidth efficiency by constraining overall usage whenever streaming media technologies are utilized;

b) Addressed ADA compliancy as it pertains to streaming media by synchronizing captioned text for both Internet and Intranet-based content; and,

c) Encouraged additional use of streaming media within the Department through development of numerous applications that showcase the benefits of this technology.

We are currently pursuing a streaming-media Internet capability to provide video-based informational content and project findings for both ongoing and completed transportation research projects to the state, national, and international transportation community.

Agency: Transportation

Agency Division/Unit/Bureau: Research

Status: ☐ Future (3-5 Yrs.)   ☐ Planned (1-3 Yrs.)   ☒ Current Initiative

Profile Submission Date: September 29th, 2003	**Profile Type:** ☒ New ☐ Amended
Agency Project Number: SPR-2231	**DOIT Project Number:**

Mission Critical Application: ☒ Yes ☐ No

<table>
<tr><td>

(i)Business Requirement
        Identify and explain the business need(s) driving the project
and how the project fits with the agency's overall strategic business
objectives.

</td></tr>
</table>

ConnDOT's Division of Research is required to provide information and project findings for both its ongoing and completed research projects to the state, national and international transportation community. In the past, no efficient means existed for dissemination of these Research & Implementation Activities (R&IA) unless they were where distributed solely as text-and-graphics based printed documents and more recently as electronic Adobe Acrobat PDF documents. Through this project, information about our research activities is now available as brief, yet effective streaming-video project overviews. Our remaining business requirement is to deliver these streaming media presentations through an Internet-based streaming media server.

<table>
<tr><td>

Benefit
Provide a sentence or two stating what benefits this project will deliver to the agency, its clients,
and state citizens (e.g. personnel savings, improved efficiency, increased revenue, reallocation of resources,
compliance with state or federal mandates, etc.)

</td></tr>
</table>

To comply with Title 23, Code of Federal Regulations, Subchapter E, Planning and Research, the State must disseminate its research findings to the Federal Highway Administration, the National Transportation Research Information Service, and to all the state DOTs. To accomplish this and to address the video-nature of this project and its report, a streaming media server capability for the Internet is required to support live hyperlinks from the electronic publication. Project results have been encouraging, to the extent that additional operational areas within the Department have expressed interest in utilizing streaming media tools and procedures for enhancing communication with the public, who will benefit by obtaining a superior level of streaming video-based information services 24/7, via the Internet. Additionally, the costs required for streaming media have been modest and the skills required to create effective streaming content are reasonable.

Impact
Explain how this project will impact the agency's business, its clients, and state citizens.

For over two years, this project has successfully demonstrated how streaming media technologies can effectively enhance and deliver video-based information, while peacefully coexisting on a busy Intranet. With continued reductions in staffing and resources and restrictions on out-of-State travel, streaming media has shown potential to be an invaluable tool for reducing their negative impact on the dissemination of research and implementation information.

When streaming media technologies are implemented for use via the Internet, video-based assets of all Research projects can be efficiently disseminated with our final reports, providing a powerful communications resource to FHWA personnel, and the national/international transportation research community.

Although the following statements go beyond the scope of the Department's research, lessons learned during our project and the newly purchased Internet streaming-server are offered as a shared resource to DOIT, who must inevitably provide these same resources for future use in promoting tourism and business opportunities in Connecticut and for all State agencies that use the State's Data Center for its Internet Web hosting services. Once our modest streaming media server is in place at CATER, DOIT can begin to consider where and when to provide streaming media services to the Governor's Office as well as other State agencies.

```
        Number of users affected?   50-500 initially
```

List the state agencies impacted.
ConnDOT's Division of Research, PC Support, Office of Communications, Training Division, Traffic Management, FHWA, other State DOT's, National Transportation Library.

```
and explain significance of any state/federal guidelines or mandates that
                       are applicable.
```
Title 23, Code of Federal Regulations, Subchapter E, defines requirements for States to disseminate their research findings.

User Access	Level of Data/ Information Privacy
☒ Internet	☒ Public
☐ Intranet	☐ Sensitive
☐ Extranet	☐ Highly Sensitive

Typical Job Description For A Streaming Media Specialist

(This document was copied in-part from a job listing for the federal government) http://federalgovernmentjobs.us/

Job Title:	Streaming Media Specialist

Job Description:

This position is located in the Information Resources Management Division which provides information management leadership and technology representation on behalf of the Bureau of Administration. The purpose of the position is to serve as an integral member of a small team and perform several roles including video/multimedia specialist and daily operations support for the Departments events channel. As a career ladder position, the incumbent receives progressively more responsible assignments as experience and training are received to reach the next higher grade level.

Major Duties:

At the full performance level the incumbent performs the following duties: plans, coordinates, promotes, produces, and presents multimedia and audiovisual imagery support; provides technical advice and expertise to Department staff and other customers; plans compelling programming to include news features and information spot programming for Department wide broadcast, schedules air time; exercises resourcefulness, imagination, and ingenuity in creating and compiling electronic multimedia imagery, electronic special effects, and equipment techniques and capabilities to convey a wide variety of visual information; encodes program material to streaming media clips, archives media clips, prepares advertisements for programs, and posts clips on website; develops broadcast schedules and makes necessary administrative and logistical arrangements in support of the program; operates professional broadcast quality multimedia electronic and digital equipment to include television master control suite equipment and broadcast-type closed circuit television; conducts equipment tests and aligns equipment, modifies configurations, and improves systems capabilities; and serves as a Web Editor responsible for planning, organized, and designing, the website.

Qualifications:
To qualify applicants must have completed at least one full year of experience providing highly skilled broadcast television production expertise in planning, and producing programs using a variety of multimedia, audiovisual, audio, electronic and other technical systems

and equipment necessary in support of broadcast and visual communications to internal audiences; applying technical knowledge of the functions, capabilities, and operations of professional broadcast quality production equipment and troubleshooting problems with this equipment; skill in producing streaming media using industry-standard equipment and software; developing, administrating and publishing websites as another avenue of multimedia communications; creating graphics for web and broadcast media; determining program format, the manner in which information will be presented, conducting research on programs, and the most effective use and distribution of resources to achieve maximum technical quality; determining communications objectives; closed-circuit broadcast, or other similar productions; evaluating the impact and effectiveness of broadcast programs; and reviewing materials for style, emphasis, and editorial aspects before release.

I have completed at least one full year of experience providing highly skilled broadcast television production expertise in planning, and producing programs using a variety of multimedia, audiovisual, audio, electronic and other technical systems and equipment necessary in support of broadcast and visual communications to internal audiences; applying technical knowledge of the functions, capabilities, and operations of professional broadcast quality production equipment and troubleshooting problems with this equipment; skill in producing streaming media using industry-standard equipment and software; developing, administrating and publishing websites as another avenue of multimedia communications; creating graphics for web and broadcast media; determining program format, the manner in which information will be presented, conducting research on programs, and the most effective use and distribution of resources to achieve maximum technical quality; determining communications objectives; closed-circuit broadcast, or other similar productions; evaluating the impact and effectiveness of broadcast programs; and reviewing materials for style, emphasis, and editorial aspects before release.

The following criteria will be used to evaluate your level of knowledge, skill, or ability in certain areas required for this position. For each item, choose the statement from the list below (A-E) that best reflects your level of experience and/or training in that area. Darken the oval corresponding to that statement in Section 25, on the form. Please select only one letter for each item.

Provide broadcast television production expertise in planning, and producing programs using a variety of multimedia, audiovisual, audio, electronic and other technical systems and equipment necessary in

support of broadcast and visual communications to internal audiences.

Provide technical knowledge of the functions, capabilities, and operations of professional broadcast quality production equipment including: analog equipment, digital audio equipment, digital video storage system, character generator, digital camera equipment, digital encoding software, multicasting technologies, broadcasting automation systems and graphics

Manage the production process for productions for television or video broadcast.

Evaluate impact and effectiveness of broadcast programs and advise management if emphasis should be changes or coverage expanded.

Provide technical direction, guidance, and advice, as necessary, to ensure effective and efficient utilization of limited production time and resources.

Develop, administer, and publish web news media sites.

Apply the basic principles of IT operating systems, media services products, and network technologies when developing and designing websites.

Provide technical advice and support in electronic multimedia imaging, multimedia and audiovisual productions, operations, applications, and administration.

Review the latest in complex audiovisual editing equipment and make recommendations concerning purchases for a variety of sources.

Plan compelling programming to include news features and information spot programming.

Encode program materials to streaming media clips, archive media clips, prepare advertisements for programs, and post clips on website.

Develop broadcast schedules and make necessary administrative and logistical arrangements in support of required programs.

Negotiate rights to air programs.

Obtain relevant programming from commercial and public sources.

Perform operator maintenance on audiovisual equipment.

Select visual and audio products to be used in the communication of information, design placement, appearance, and media format of visual and audio materials.

Interface with IT personnel such as network engineers and system administrators.

Research and analyze best practices in streaming media.