The Gabrieli Project: Live multipoint stereoscopic split-screen video via Internet2

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Introduction

At the fall 2003 Internet2 meeting, new-media artists and early-music performers teamed up to provide an immersive virtual experience to demonstrate real-time collaboration across Internet2.

The Performance

Getting two groups of people to work together in harmony can be a challenge. Introduce lag and the situation gets even more complex. People often think that latency is a modern issue, the effect of network distances, but in the early 17th century the Italian composer Giovanni Gabrieli faced the same issue when he composed for St. Mark's cathedral in Venice. The size and acoustic nature of the cathedral combined with the speed of sound creates latencies as high as 180 milliseconds.

This demonstration, however, deals not with the acoustic delays of sound through a cathedral but the delay of data over Internet2.

From backstage in Indianapolis, Dr. Darrel Bailey, Dean of the Indiana University Purdue University Indianapolis School of Informatics, conducted two ensembles of music students from Case Western Reserve University and Indiana University at Bloomington. Gabrieli's *No. 5 Canzon duodecimi toni. a 8* was performed in Cleveland by Debra Nagy, Doug Miliken, Jeffrey Quick, Brad Schwartz and in Bloomington by Juan Carlos Arango, Charles Keith Collins, Anna Marsh and Kathryn Montoya. The Cleveland students were coordinated by Ross Duffin and the Bloomington students by Wendy Gillespie.

Attendees at the Dean & Barbara White Auditorium in the Indiana State Museum in Indianapolis watched the live stereoscopic presentation while wearing polarized 3D glasses and listening to the auditorium's surround sound speaker system.

The demonstration simulated a 'global performance" by turning up the latency as if Cleveland was Tokyo and Bloomington was London and seeing the effects on the performance.

Behind the Scenes

The technical portion of the demonstration breaks down into:

Signal Acquisition
Signal Transmission
Signal Mixing
Signal Presentation

Detailed configuration of the demonstration can be found in the figures: Room Layout, Video Layout, and Audio Layout.

Signal Acquisition

The live 3D video was captured at each location using custom built stereoscopic camera rigs incorporating CCD security cameras, wide angle lenses, twin camera bars, and panoramic levelers. The individual 2D video feeds were combined into a field sequential video feed using a 3D Multiplexer.

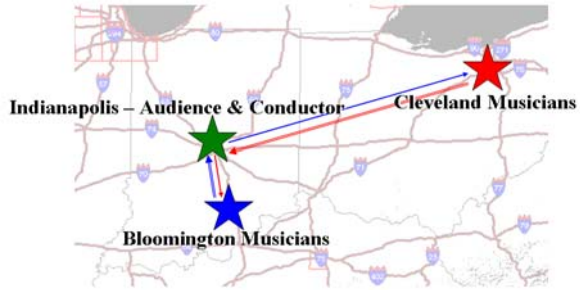
To achieve a dimensionally accurate split screen, both performance spaces (Cleveland and Bloomington) were calibrated to create one virtual room. This calibration involved locking down the 3D camera settings in Bloomington (building the geometry outward from a corner) and reproducing the settings (in mirror) in Cleveland. The Bloomington musicians were limited to camera right and the Cleveland musicians were limited to camera left. These limits and an additional front 'do not cross' line formed the stereo window. Since the ceiling lights and other details violated the stereo window, a mask was added in the final presentation mix.

The live audio was captured at each location using 2 mono instrument microphones (4 mono feeds in total).

Signal Transmission

The audio and video signals were transmitted over Internet2 using DVTS. DVTS (Digital Video Transport System) sends and receives DV based video and audio streams across a network with no additional compression. DVTS takes a DV feed, adds a header, and sends it over the network at a sustained data rate of 30 megabits per second. Simply put, it's a very long bi-directional IEEE1394 cable.

For this demonstration 4 DVTS boxes were used: one in Cleveland, one in Bloomington, and two in the control room in Indianapolis.



Signal Mixing

The video mix was composed of 5 separate video feeds, the 3D Cleveland ensemble, the 3D Bloomington ensemble, the 2D Conductor (in Indianapolis), the 2D PowerPoint, and the 3D Intro/Credits on DVD.

The ensembles were combined with a video split screen unit with Cleveland on the left of the screen and Bloomington on the right. A small window of the conductor as well as a rectangular window containing the PowerPoint location labels (and serving as a ceiling mask) overlaid the video mix. The entire feed was switched for the Intro/Credits DVD as needed.

A 2D monitor feed (of the mixed signal) was sent to the conductor and also back to both ensembles (via the DVTS).

The audio mix was composed of 2 single microphone feeds from Cleveland, 2 single channel microphone feeds from Bloomington, and the Conductor's microphone backstage (which also picked up some ambient noise of the auditorium).

The audio signals were mixed with Bloomington on the right and Cleveland on the left with reverb added to simulate a larger hall like a cathedral. The reverb also helped to mask some of the delays of the instrument sounds (as it does in a cathedral).

A raw radio audio feed was sent to the conductor and also back to both ensembles (via the DVTS).

Signal Presentation

Since the auditorium was not previously configured for stereoscopic video presentation, twin Barco 5400 projectors and an 84" Silver Screen were brought in for the demonstration.

The projectors were fitted with linear polarizing filters and calibrated for precise overlapping projection onto the silver screen. The master field sequential stereoscopic video feed was split into two monoscopic video feeds at the point of projection by a 3D DeMultiplexer and fed into the Barco 5400 projectors.

Attendees were handed out polarized 3D glasses with the event program.

Results

On October 15, 2003 the demonstration was successfully performed live at 7:30pm and again at 8:30pm.

The performance was the first live multipoint stereoscopic split-screen presentation over a high-speed network.

The performance was also the first public performance using DVTS for video transmission.

This project represented a series of challenges both musically and technically and pushed the envelope of collaboration over high speed networks.

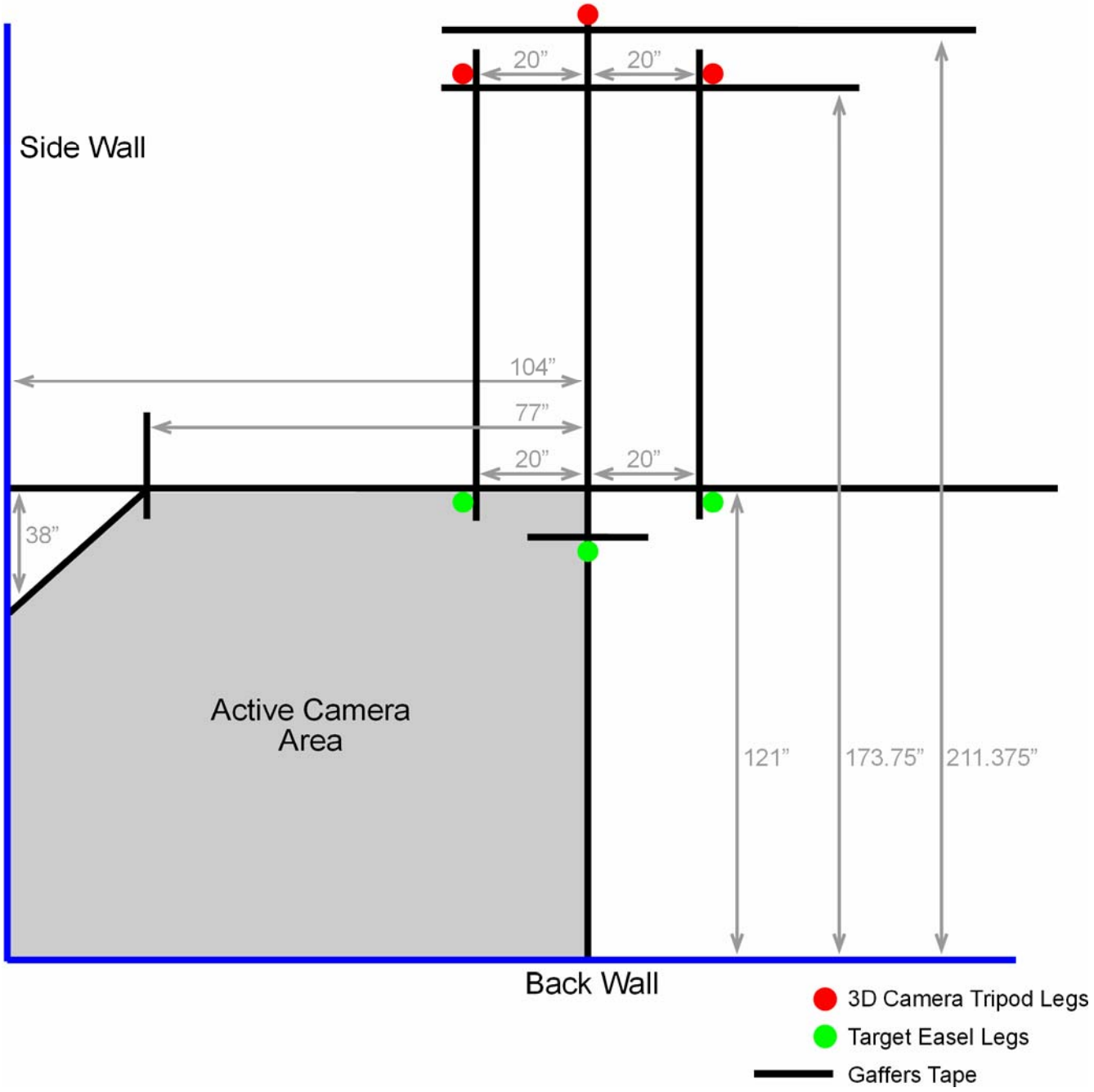
Acknowledgements

In addition to those already mentioned, this demonstration would not have been possible without the participation and support of:

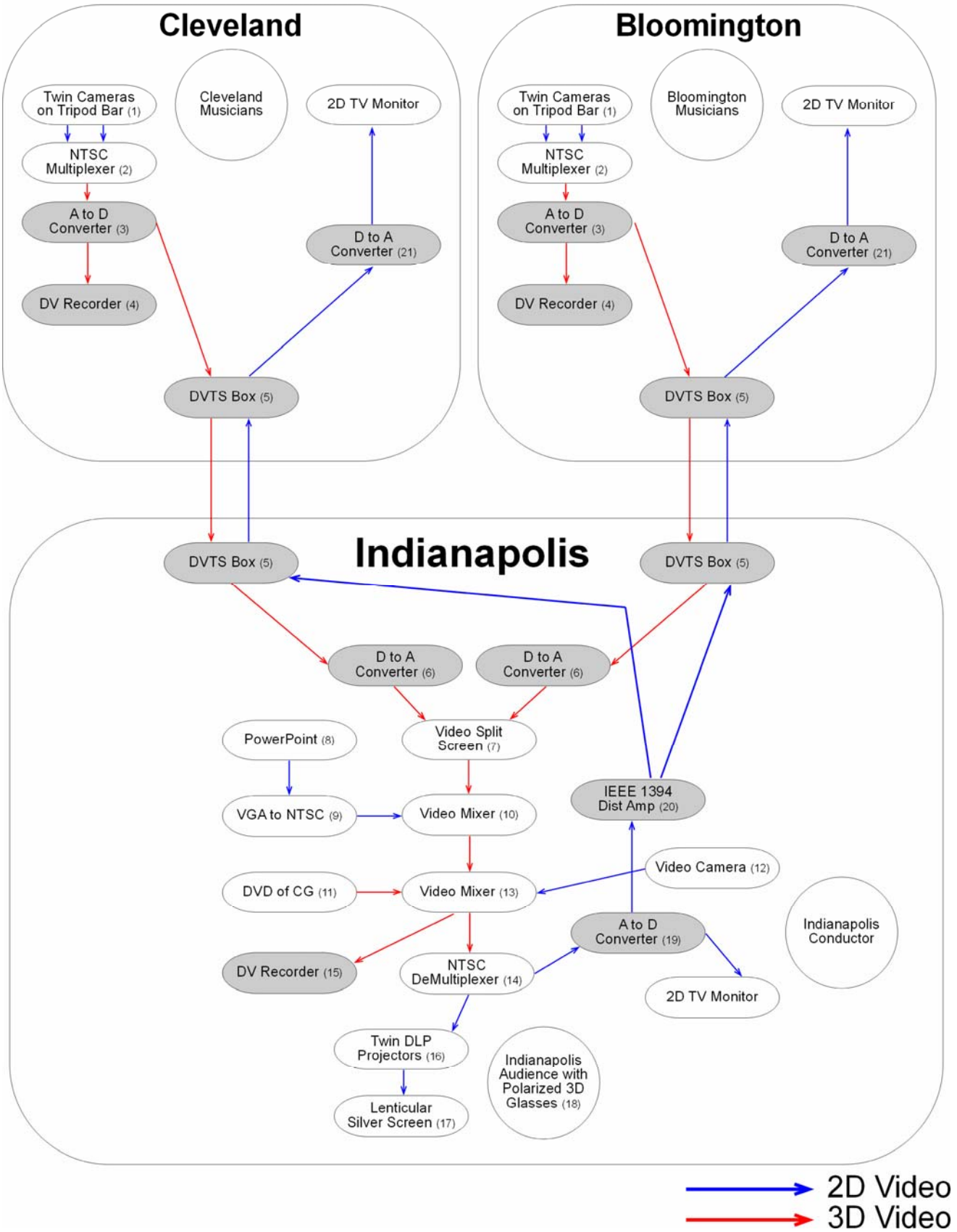
Barco, Yamaha, The Cleveland Institute of Music, Case Western Reserve University's MediaVision, Internet2, Network Operations Center at Indiana University

Lev Gonick, Wendy Shapiro, Steve Egyhazi, Pete Beurmann, Palmer Chin, Mike Kubit, Sam Milosevich, Doug Pearson, Kim Walker, Elaine Lauerman, and Bob Riddle.

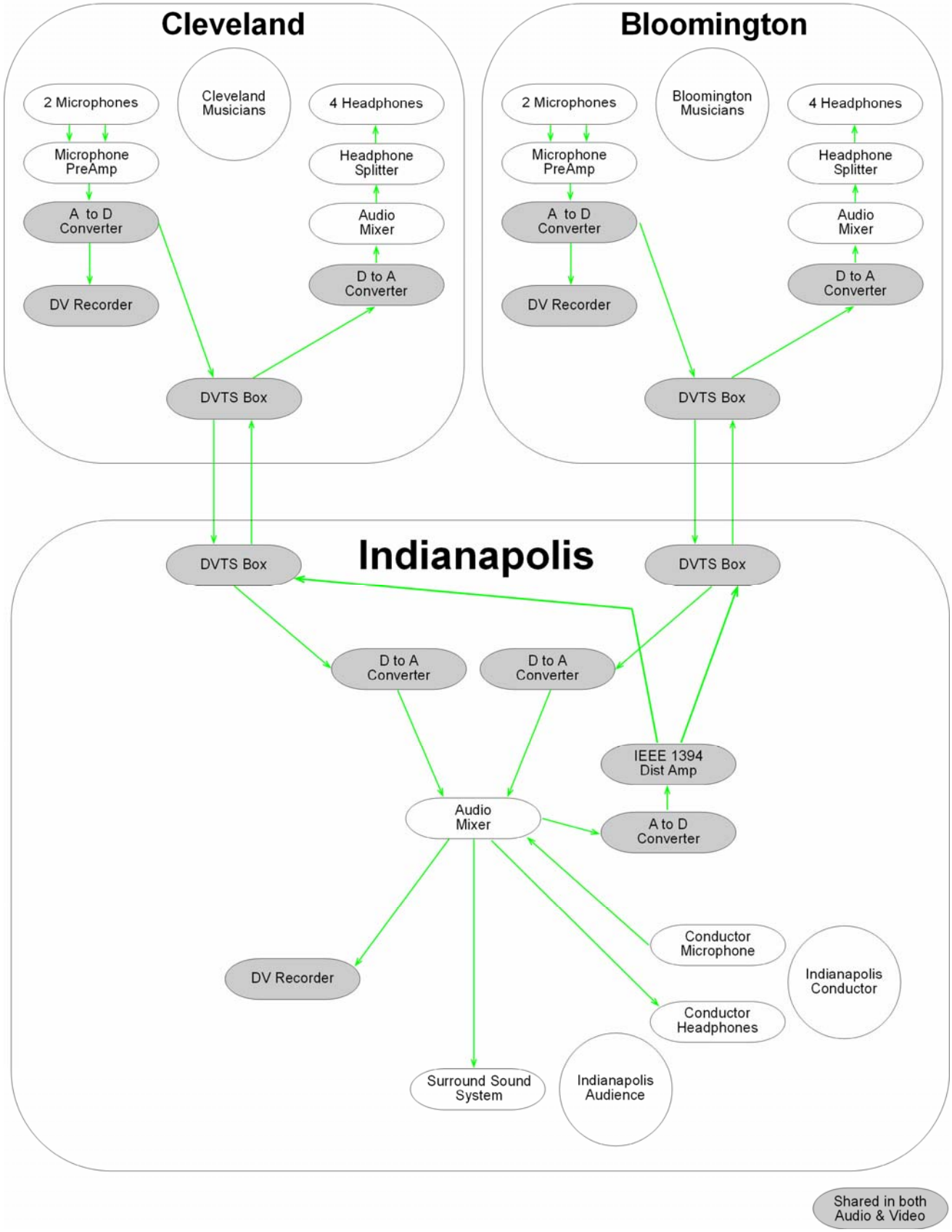
Room Layout


20”
20”
Side Wall
104”
77”
20”
20”
38”
Active Camera
Area
121”
173.75”
211.375”
Back Wall
3D Camera Tripod Legs
Target Easel Legs
Gaffers Tape

Video Layout



Audio Layout



Video Layout

[1] – Twin Camera Rig
Input: Live Performance of Musicians
Output: Two 2D Video feeds to Multiplexer [2]

Two Panasonic WV-CP244 480 Line Color CCD Cameras

Two 2.8mm-12mm Tamron 13VM2812 Manual Iris Lens

24Volt 50Amp Power Supplies 24V50VA

Two Kaidan QuickTilt Levelers

10" Dual Camera Mounting Bar

Video Tripod Legs with Head

Two Bulls Eye Bubble Levels

Note: Twin CCD cameras (spaced 1 ½" and slightly toed inward tip to tip 4 7/8") with matched aperture (all out), focus (all out), and focal length (focused on target), attached to levelers and leveled to the bubble levels. They are powered by a common power supply rigged with a 3 prong quick disconnect device (hand wired with standard parts from Radio Shack).

[2] – NTSC Multiplexer
Input: Two 2D Video feeds from Camera Rig [1]
Output: 3D Video feed to A/D Converter [3]

3DI-3000 Video Encoder / Multiplexer

Note: This creates a field sequential stereo video feed.

[3] – A/D Converter
Input: 3D Video feed from Multiplexer [2]
Output: 3D Video feed to DV Recorder [4]
Output: 3D DV stream to DVTS Box [5]

Datavideo DAC-2 A/D Converter

Note: The A/D Converter has a live analog pass though – that outputs both a DV stream AND an analog signal.

[4] – DV Recording Device
Input: 3D Video feed from A/D Converter [3]
Output: DV Tape

Panasonic DV Recorder

[5] – DVTS Box
Remote DVTS Box (Cleveland/Bloomington)
Input: 3D DV stream from A/D Converter [3]
Output: 2D DV stream to D/A Converter [21]

Destination DVTS Box (Indianapolis)
Input: 2D DV stream from Distribution Amplifier [20]
Output: 3D DV feed to D/A Converter [6]

Note: The DVTS Boxes are bidirectional and transmit the performance video feeds as well as the conductor monitor feed.

[6] – D/A Converter
Input: 3D DV stream from DVTS [5]
Output: 3D Video feed to Split Screen Unit [7]

Datavideo DAC-2 A/D Converter

Note [1]-[6] and [21] occur at both remote locations (Cleveland & Bloomington). Also, the destination location (Indianapolis) has (2) DVTS Boxes and (2) A/D Converters to bring the analog streams into the mixing room.

[7] – Video Split Screen Unit
Input: Two 3D Video feeds from D/A Converters [6]
Output: 3D Video feed to Video Mixer [10]

PXD310E series "PIX/2 DSP" Advanced Split Screen and Fade Controller

Note: The Split Screen Unit is set to a 50/50 vertical split.

[8] – PowerPoint on VGA
Input: PowerPoint
Output: VGA Output to Scan Converter [9]

Computer running PowerPoint presentation.

Note: For the titles - the PowerPoint words are created as word art and stretched to be very tall and skinny. When squashed in a later step they will appear normal.

[9] – VGA to NTSC
Input: VGA from Computer [8]
Output: 2D Video feed to Video Mixer [10]

T-View NTSC Scan Converter

Note: Alternately can use a computer with direct video out.

[10] – Video Mixer
Input: 3D Video feed from Split Screen [7]
Input: 2D Video feed from Scan Converter [9]
Output: 3D Video feed to Video Mixer [13]

Edirol V-4 Mixer

Note: The PowerPoint from the Scan Converter is presented as a Picture in Picture overlay with a 4 pixel black border squashed into a long and short rectangle that masks the ceiling from the remote locations.

[11] – DVD of Computer Graphics
Input: DVD with 3D Intro, Credits, and Cut Scenes
Output: 3D Video feed to Video Mixer [13]

DVD Player

Note: The computer graphics were created in Caligari trueSpace and combined with software Multiplexer 3DCombine.

Note: The DVD Player must NOT be progressive scan (as this may interfere with the field sequential video feed).

[12] – Video Camera on Conductor
Input: Live Performance from Conductor
Output: 2D Video feed to Video Mixer [13]

Camera on Conductor backstage listening to headphones and watching a 2D video feed on TV Monitor (from A to D Converter [19].

[13] – Video Mixer
Input: 2D Video feed from Conductor [12]
Input: 3D Video feed from Video Mixer [10]
Input: 3D Video feed from DVD Player [11]
Output: 3D Video feed to DeMultiplexer [14]
Output: 3D Video feed to DV Recorder [15]

Edirol V-4 Mixer

Note: The Conductor is presented as a Picture in Picture overlay with a 4 pixel black border in a small video window centered on and the same height as the PowerPoint overlay.

To View DVD:	To View 3D Mix:
- Fade Down Master Control	-Fade Down Master Control
- Unselect Picture in Picture	- Select Stereo Mix
- Select DVD Source	- Select Picture in Picture
- Fade Up Master Control	- Fade Up Master Control

Note: Switching between the Video Mixes requires some practice.

[14] – NTSC DeMultiplexer
Input: 3D Video feed from Video Mixer [13]
Output: Two 2D Video feeds to Two Projectors [16]
Output: 2D Video feed to A/D Converter [19]

3DI-3000 Video Decoder / DeMultiplexer

Note: The DeMultiplexer has a second 2D output for monitors and recorders.

[15] – DV Recorder
Input: 3D Video feed from Video Mixer [13]
Output: DV Tape

Panasonic DV Recorder

[16] – Twin DLP Projectors
Input: Two 2D Video feeds from DeMultiplexer [14]
Output: Polarized Projection on Silver Screen [17]

5” Square Linear Polarizing Filters

Two overlapped and aligned DLP Projectors.

Note: Polarization can be linear or circular but glasses and filters must match.

[17] – Silver Screen
Input: Polarized Video from Projectors [16]

Large Silver Screen

Note: Disney Black screens will also not diffuse the polarized light.

[18] – Audience with Polarized Glasses
Input: Polarized Video on Screen [17]

Polarized Glasses

[19] – A/D Converter
Input: 2D Video feed from DeMultiplexer [14]
Output: 2D DV stream to DV Distribution Amp [20]
Output: 2D Video feed to Conductor’s to TV Monitor

Datavideo DAC-2 A/D Converter

[20] – DV Distribution Amplifier
Input: DV stream from A/D Converter [19]
Output: Two DV streams to DVTS Boxes [5]

Laird LTM-DVDA5 DV Distribution Amplifier

[21] – D/A Converter
Input: 2D DV Stream from DVTS Box [5]
Output: 2D Video feed to TV Monitor

Datavideo DAC-2 A/D Converter

During Calibration and Post Production the Stereo Video was viewed with:

1) The i-Scape3D Stereoscopic Head Mounted Display (HMD) (now discontinued) – directly plays back the field sequential video signal.

2) Shutter Glasses and CRT
60hz NTSC to 120hz VGA 3D video scan
21” CRT VGA Monitor
NuVision 60GX Wireless Shutter Glasses
NuVision 60GX Stereo3D Sync Box
NuVision 60GX IR Emitter

To Calibrate Cameras and Rooms:
June Tailor Quilter’s Cut’n Press I (for use as stereo target)
Easels for holding Quilting Board vertically.
Tape Measure, Gaffing Tape, and Good Geometry Skills

Vendors Used:

3D Combine	http://www.3dcombine.com/
3D ImageTek	http://www.3dimagetek.com
B&H Photo Video	http://www.bhphotovideo.com/
Berezin 3D	http://www.berezin.com/3d/
CyberWorld	http://www.cwonline.com/
DirectLVS	http://www.directlvs.com
Kaidan	http://www.kaidan.com
MicroImage Video	http://www.mivs.com
NuVision	http://www.nuvision3d.com/

Audio Layout

2 Microphones
Input: Live Performance of Musicians
Output: Two Mono Audio feeds to PreAmp

Microphone PreAmp
Input: Two Mono Audio feeds from Microphones
Output: Line Level Stereo Audio feed to A/D Converter

A/D Converter*
Input: Stereo Audio feed from PreAmp
Output: Stereo Audio feed to DV Recorder
Output: DV stream to DVTS Box

DV Recording Device*
Input: Stereo Audio feed from A/D Converter
Output: DV Tape

DVTS Box*
Remote DVTS Box (Cleveland/Bloomington)
Input: DV stream from A/D Converter
Output: DV stream to D/A Converter

Destination DVTS Box (Indianapolis)
Input: DV stream from Distribution Amplifier
Output: DV feed to D/A Converter

D/A Converter*
Input: DV stream from DVTS
Output: Stereo Audio feeds to Mixer

Audio Mixer
Input: Two Stereo Audio feed from D/A Converters
Input: Mono Audio feed from Conductors Microphone
Output: Stereo Audio feed to DV Recorder
Output: Stereo Audio feed to Conductor's Headphones
Output: Stereo Audio feed to A/D Converter
Output: Surround Sound Audio feed to House Surround Sound System

Note: Audio mixer also serves as signal router and digital signal processor (including reverb added by mixer to simulate a large space like a cathedral in surround sound).

DV Recording Device*
Input: Stereo Audio feed from Audio Mixer
Output: DV Tape

House Surround Sound System
Input: Surround Sound Audio feed from Audio Mixer

Conductor
Input: Stereo Audio Headphones from Mixer
Output: Microphone to Mixer

A/D Converter*
Input: Stereo Audio feed from Audio Mixer
Output: DV stream to DV Distribution Amp

DV Distribution Amplifier*
Input: DV stream from A/D Converter
Output: Two DV streams to DVTS Boxes

A/D Converter*
Input: DV Stream from DVTS Box
Output: Stereo Audio feed to Audio Mixer

Audio Mixer
Input: Stereo Audio feed from A/D Converter
Output: Stereo Audio feed to Headphone Splitter

Headphone Splitter
Input: Stereo Audio feed from Audio Mixer
Output: Stereo Audio feed to Headphones

Headphones
Input: Stereo Audio feed from Headphone Amplifier

Note: Items with a ***** use the same hardware as the Video Layout