The Virtual Pipe Organ at Groton Hill
Setting up the Audio System in Meta Organworks Studio

Dan Lemieux (Organ builder) in front of half the speakers
Making of the Touchscreen Jamb Podiums

Meta’s CNC machine cutting a component of the touchscreen podiums

Another CNC producing the Groton Hill organ’s touchscreen podiums

Ned Lemieux displaying the console monitor podiums (pre-finingishing) in Meta’s studio
Jim (center) with keyboard maker, Sebastian Luck of UHT

Jim Hutchison, Meta’s designer and CNC expert with UHT’s owner (Sebastian Luck) during a 2021 R&D trip to Germany
Constructing the Expression Pedal Assembly

Dan working with the console’s expression pedal assembly designed by Jim

*Expression pedals control the dynamics of the different divisions on an organ.*
Finishing the Console
Assembling the Console

Dan and Jack Case, doctoral candidate in acoustics at Penn State & Meta’s Acoustic Consultant (former intern), assembling the console in Meta’s studio to prepare for initial programming.
Console Specifications

- 4 Manuals and Pedalboard
- 3 Expression pedals and Crescendo pedal
- Full array of toe studs and manual pistons
- Entire console on wheels to move to one of four on-stage connection points
- Wood paneling designed to match concert hall’s paneling
- Integrated wireless page turning
- Both MIDI and WAVE file recording options with playback capability
- 4 headphone jacks for teaching purposes
- Ethernet cable to link to the dedicated audio system
The Virtual Pipe Organ’s Audio System

- 32 channel Lynx Dante interface for digital-to-analog conversion
- 32 - 800W channels of Ashly amplification for main speakers
- 8 - 3000W channels of Ashly amplification for subwoofers
- 6 channels of crossovers for the subwoofers
- 32’ Flue subwoofer deep-bass processor

A total of 49,600 watts
Subwoofer Speaker Construction

Gluing up subwoofer speaker cabinets

Jack and Dan prepping the subwoofer speaker cabinets for finishing

Finished speaker cabinets
Setting up Organ’s Audio System in Meta’s Studio

Jack assisting in wiring the audio system into a temporary set up in Meta’s studio

This was done in preparation for experimenting with audio channeling and testing of sample sets.
Experimenting with Audio Configurations

Randy and Dan in Meta’s Studio experimenting with different audio channeling and setting levels

Dan (foreground) and Randy working with programming and audio channeling in preparation for the Organ Concert on the Lawn
Organ Concert on the Lawn

Saturday, August 21st, 2021

Members of the Eastern New York and Binghamton, NY Chapters of the American Guild of Organists joined Meta Organworks on the studio’s lawn for a concert performed by organist Randy Steere.
Planning for Organ’s Audio System Installation

(To the left): Dan, Randy, Jack and construction crew member Carlos, discussing moving in speakers onto the “floating sidewalk” platforms

(To the right): Dan, Randy, and Jack taking final dimensions of the speaker platforms to model in speaker placement

Melissa (Meta Project Manager and Marketing Director) with Jack under speaker platforms
Planning for Organ’s Audio System Installation

Dan and Jack discussing the Lyntech power panel in the organ’s equipment room. This power panel has motorized breakers that control the powering up of audio equipment.

Dan, Jack, and Randy with Carlos and Spencer during a planning trip.
3D Speaker Placement Model

A speaker placement model designed and rendered by Jim on CAD software based on on-site measurements.

A special assembly (pictured below) was created to facilitate speaker angle experimentation on-site during voicing of the Meta Organ.
Moving in the Audio System

(To the left): Randy & Dan moving in speakers

(To the right): Carlos, Dan, and Randy lifting speakers onto speaker platforms prior to the installation of the projection screen
Behind the Projection Screen...

Dan and Randy with all 48 of the speakers installed on the speaker platforms behind the projection screen
Speaker Specifications

- 32 Main speakers
- 4 18” Subwoofers for 32’ Flues
- 4 18” Subwoofers for 32’ Reeds
- 8 15” Subwoofers for 16’ Stops
The organ equipment room houses the Lyntech power panel dedicated to the organ, as well as the audio equipment rack.

The organ console communicates with this audio room via a Dante connection (audio over Ethernet protocol).
Computer Specifications

- 128 GB of RAM
- 4 TB of solid state disk space
- Intel 8 Core i7 Processor
- Windows OS with 2 Touchscreens for virtual stop jambs
- Hauptwerk™ Virtual Pipe Organ Software

Hauptwerk is a registered TM of Milan Digital Audio
- The Meta Organ’s audio engine is a software program called Hauptwerk, a sampled Virtual Pipe Organ (VPO) technology developed over 20 years ago and now on version 7 after many refinements.

- Sampled in 24 bit/96kHz (96,000 samples per second)

- 17 instruments selected from several hundred available

- Other organ sample sets can be added to the organ in the future
How Sample Sets are Made - Part I

- An organ is selected for sampling and the contract is negotiated with owner
- Multiple weeks set aside to sample every pipe of every stop as WAV files
- Samples recorded in 6 or 8 channel stereo, 24 bit/96 KhZ in multiple locations
  - Direct (closest to the pipe)
  - Diffuse (middle of the building)
  - Rear (back of the building)
  - Surround (other placement)
- Between 4 to 12 samples of each pipe are made
  - With and without tremolo, swell box, staccato, marcato, held, etc.
How Sample Sets are Made - Part II

- Samples are de-noised and checked for quality
- Loops are determined and set by AI and verified by humans (at least 3 loops per sample)
- Software is programmed for all functionality of original instrument
- Graphics are created to recreate the console, with touch functionality added
- Sample set package is put together for sale
- Exhaustive testing is performed
Criteria for Selecting Virtual Organ Sample Sets for Inclusion in a Meta Organ

- Original organ in excellent condition
- Representative of an important school of organ building
- Useful for concert or teaching
- Excellent balance and blend with the orchestra
- Highest quality sampling
- Authentic “look and feel” for the organist
- Large enough to fill the hall authentically
How Samples Are Installed

- Sample sets are purchased and loaded into the Virtual Pipe Organ Software
- Audio outputs are assigned per channel per stop.
- Instrument is voiced for volume, brightness, mixing of channels, etc.
- Mix of original ambiance and current room ambiance is decided

The goal is the most realistic sound in the new room. This is tested and achieved by playing appropriate music on each sample set and making a determination about the fit of the sample set for the room.

This is more art than science! Builder and performer ask “Does it play itself?”, “Is it easy to register?”, “Is it satisfying to play?” and “Does it sound musical?”
Installed Instruments in Groton Hill’s Organ - Part I

- St. Etienne, Caen, France (Cavaille-Coll) - French Romantic
- SonnenOrgel, St. Peter and Paul, Goerlitz, Germany (Casparini/Mathis) - German Baroque
- Episcopal Cathedral, Portland, Oregon (Rosales) - North American Eclectic
- Martinikerke, Doesburg, Netherlands (Walcker) - German Romantic
- St. Martini, Groningen, Netherlands (Arp Schnitger) - Dutch Baroque
- First Presbyterian Church, Bellevue, Washington (Casavant) - Canadian Eclectic
- Temple Emanu-El, San Francisco (Skinner, opus 497) - American Symphonic
- First Covenant Church, Oakland, California (Aeolian-Skinner, opus 1301) - American Classic
- Hereford Cathedral, Hereford, England (Father Willis) - Late English Cathedral
Installed Instruments in Groton Hill’s Organ - Part II

- Trinity Methodist, Burton-upon-Trent, England (Hill) - *Early English Romantic*
- Dom Bedos Organ Model, St. Domenico, Rieti, Italy - *Early Baroque*
- Chapelet, Montpon-Ménésterol - *Spanish Castilian and Galician organs*
- Santanyi, Mallorca (Bosch) – *Spanish Baroque*
- St. Corpus Christi, Valvasone, Italy (V. Colombi) - *Italian Renaissance*
- Wurlitzer 3/31 theatre organ, Buffalo, NY - *1920s American Theater Organ*
- Flemish Harpsichord, Prague Academy of Music (2 manual Ruckers Replica)
- Harmonium, composite (Mustel, Debain, Robertson, Alexandre)
- The Carillon of Ghent Cathedral, Belgium
The organ has developed differently than any other instrument. The pipe organ has changed radically over time and across geographical regions, both in terms of artistic style and technology. As such, the pipe organ is a fascinating mirror of its time.

The development of the pipe organ has been influenced by the principles of various master organ builders, aesthetic preferences of master composers and organists, and the various church traditions they were built to support.
**Development of the Pipe Organ**

**Birth of the Pipe Organ**

Invention of the Hydraulis

The water organ called “hydraulis” was a product of the advanced urban lifestyle of the ancient Mediterranean city of Alexandria. Ctesibius, one of the most famous engineers of his time, built the first organ, which was operated by compressed air that was first channeled through a container of water to equalize the pressure. The sound emerged from a row of pipes of different lengths.

**Circa 1500-1750**

Early Renaissance and Baroque Instruments

- French, German, Spanish, Italian, English, etc.

**Circa 1600-1900**

Romantic Period

- French, German, English, Cathedral, American, Symphonic

**Circa Post-WWII**

American Classic Organ

- One organ to play anything “successfully”

**Circa 1940-1990**

Neo-Baroque

- Organ Reform Movement (Orchelbewegung)

- A return to Baroque organ building standards and historic performance practices

**1990-Present**

Resurgence of Romantic Organs along with Romantic composers and transcriptions

**21st Century**

Multiple Organs in one Venue

- Multiple organs to accommodate different styles - Memorial Church, Harvard, St. Thomas, NY, Thomaskirche, Leipzig

**2015**

Meta Organworks founded

- Virtual pipe organ technology executed by traditional organ builders for real-world, live performance spaces

**2023**

Groton Hill's Meta Organ Completed
Two Contrasting Styles of Organ Building

Baroque Pipe Organs
- Clarity of every voice
- Vertical registration (one stop per pitch crowned with a high-pitch ensemble known as mixtures)
- Werkprinzip - each manual and the pedal has a complete and distinct principal chorus
- Articulate pipe speech known as “Chiff”
- Lower wind pressures that are less stable due to hand pumping of bellows

Romantic Pipe Organs
- Blend over clarity
- Larger instruments
- Imitating Orchestral instruments (such as oboes, French horns, and traverse flutes)
- Wider dynamic range, multiple swell boxes for expression
- Higher wind pressure and “fiery” reeds
Benefits of VPO Technology & Multiple Sample Sets

• More diverse music can be played “successfully.” Pieces can be played on instruments they were composed for, as well as their school of organ building. For example, Baroque compositions, such as the works of Bach and Buxtehude, can be played on Baroque instruments, and French composers, like Franck and Messiaen, can be registered and played more successfully on French Romantic.

  • Organists have to “settle” less. Registrations of pieces no longer have to be modified due to limitations of the instrument.

• People can be exposed to different styles of pipe organs that they might not otherwise have the opportunity to hear, strengthening the pipe organ tradition.

  • Virtual pipe organ technology brings much-deserved attention to real acoustic pipe organs, without which there would be no recorded pipe samples. Pipe organ tourism has increased due to VPOs.

• Virtual pipe organ technology is more affordable and therefore more egalitarian.

  • Churches and other institutions, such as Groton Hill have access to the tonal resources of many organs that would cost millions of dollars to build as acoustic organs. VPO technology is less expensive, doesn’t go out of tune, and consumes less physical space in the venue.
How GHM’s Meta Organ Works

1. ORGANIST LOADS SAMPLE SET
   One entire instrument at a time is loaded in RAM for maximum speed.
   GHM’s Meta Organ has 17 complete instruments to choose from.

2. ORGANIST REGISTER A PIECE
   "Registering" selects what stops/sounds to play on touchscreen virtual stops jamb.

3. NOTES ARE PRESSED
   MIDI Interface sends audio message to VPO Software and then to audio interface (in organ equipment room) via Dante (audio over Ethernet protocol).

4. AUDIO INTERFACE
   Audio interface processes audio messages (the "note" being played) and converts them from digital to analog and sends to assigned amplifier/crossover.

5. AMPLIFICATION
   Amplifier sends audio signal (note) through roughly 300 feet of 10 AWG pure copper speaker wire to the organ's speaker array behind the concert hall screen.

6. MUSIC
   A large instrument has thousands of these samples to process simultaneously, especially when we pull out all the stops!

Music is made by sometimes few (pppp) and sometimes huge (ffff) numbers of simultaneous pipe samples (attack, randomized loops, and multiple releases).
Spanish Chamber Organ’s Virtual Stop Jamb Graphics

Organists engage with the exact layout of the original instruments via a virtual replica on the touchscreen. Touching a stop knob is the equivalent of pulling out a stop on a real pipe organ.

It’s called a “stop” because when pushed in, it breaks the flow of air through the wind channel to the pipe. In old mechanical action organs, it is done through a series of levers.

Late 17th-century Galatian organ

Castillian Organ from 1736
The American Organist, August 2023 edition.

Groton Hill's Meta Organ will be featured on the cover of The American Organist, August 2023 edition. This is a mock-up of the cover done by photographer, Will Sherwood.

Meta Organworks would like to thank the people who helped make Groton Hill's Meta Virtual Pipe Organ a reality.

Randy Steere: Consultant/Organist

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Jackson Hudgins
Alex Hug

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