4.0 Software

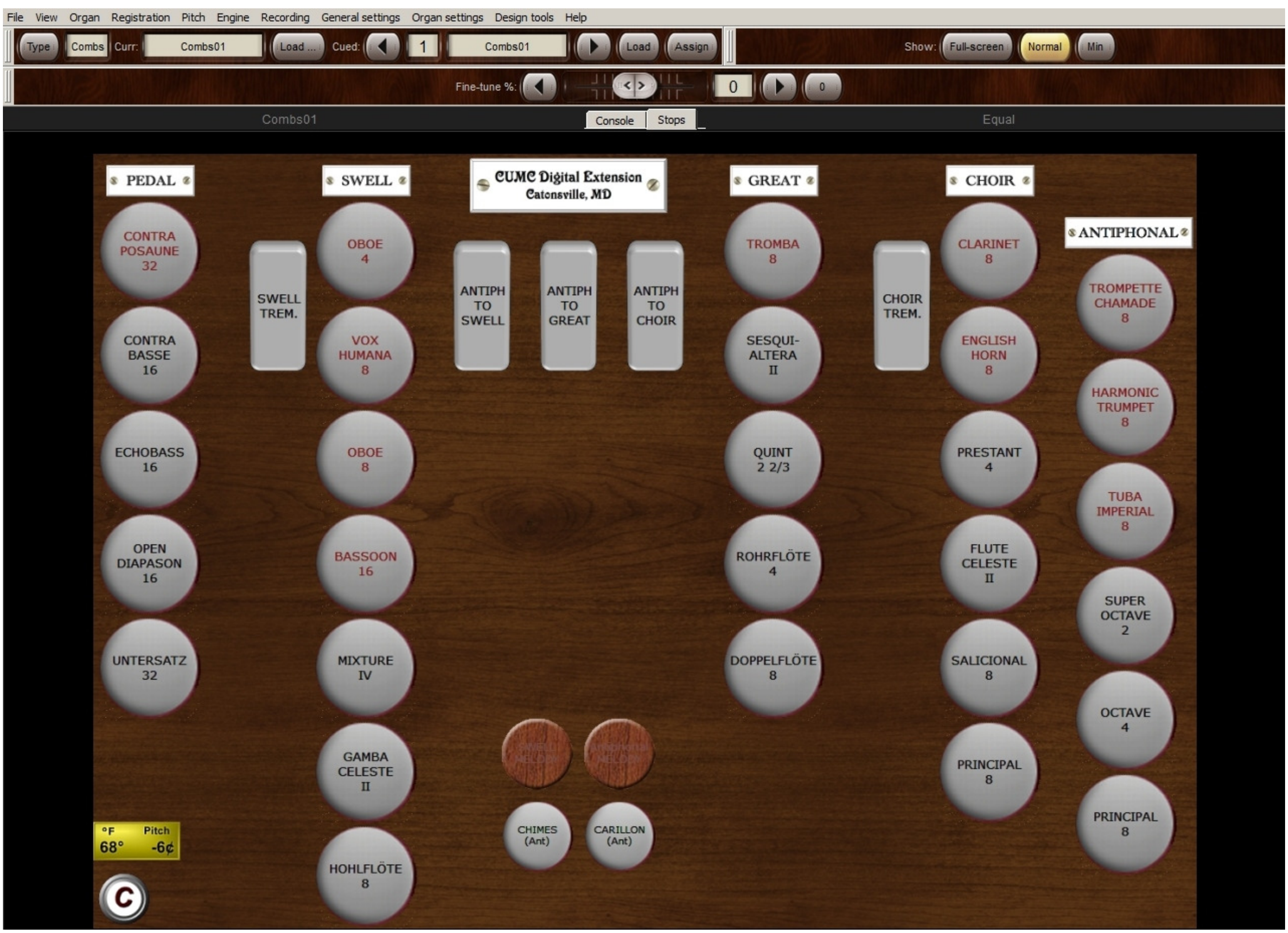
4.1 Hauptwerk Program Installation

Digital extensions to the organ are manipulated through the software program “Hauptwerk” from Milan Digital Audio. The Advanced version of the program is used and the church’s license is contained in the USB “dongle” installed in the computer. Detailed operation of the program is always available in the installation manual available from Milan Digital Audio. Hauptwerk version 4.2.1 is used and it would be unwise to ever update it. Some of the custom programming (temperature control and rotary switch reads) depends on specific Hauptwerk protocols which could be changed by future whims of Milan Digital Audio.

The organ sample set normally loaded is named “Moller 3m103-autotune”. The “Stops” screen page contains all the touch controls that are required for normal use. This screen does not show the four additional stops that are assigned to physical drawknobs which were available on the console. These stops are the Gt: Principal 16’, Gt: Trompete 8’, Sw: Tuba Mirabilis 8’, and the Ch: Erzahler Celeste 8”.

The two tremulant controls on the touch screen are normally activated automatically when the “Tremulant” drawknobs are pulled on the console. The touch screen controls can be used override this setting, however.

The large “C” button can be used to quickly cancel just the digital stops and does not affect the physical drawknobs. The indicator in the lower left corner displays the current air temperature and the correction which has been applied to the digital stops by the autotune circuitry. This can be tweaked by the “Fine Tune” slider at the top of the screen, but this is not normally necessary.



4.2 Sample Set Programming

Only one sample set is normally used with this installation and it has been customized to augment the Möller opus 10236 and the Peterson control system that was installed in 2001. The ODF (Organ Definition File) is based on a standard CODM compilation. The only unique programming is that which is necessary to add the automatic temperature compensation.

The pitch of any pipe organ varies significantly with the air temperature. The digital electronics are constant with temperature and the two thus become out of tune with each other when the temperature varies from where the organ was tuned. The Hauptwerk software allows the digital pitch to be manually adjusted to match the pipes over temperature. It is inconvenient (and embarrassing) to adjust the digital tuning when the congregation is present, especially if the temperature varies during a service. For this reason, it was worthwhile to incorporate an autotuning feature in the digital system.

Figure 4.2.1 shows the effect of temperature on the speed of sound in air. When the temperature rises, the speed of sound increases and the effective length of a pipe (in wavelengths) increases. This causes the pitch to go flat. For an organ tuned at 72° F, the pitch changes 32% of a semitone (cents) for a temperature change of 20° Fahrenheit. The autotune system is programmed to correct for a temperature range of 72±20 °F which corresponds to a pitch range of ±32 cents.

Temperature of air ϑ in °C	Speed of sound c in m/s
+40	354.94
+35	351.96
+30	349.08
+25	346.18
+20	343.26
+15	340.31
+10	337.33
+5	334.33
0	331.30
−5	328.24
−10	325.16
−15	322.04
−20	318.89
−25	315.72

Figure 4.2.1 Effect of temperature on sound

The autotune circuit board produces a voltage which is proportional to temperature. This analog voltage can be read into the software system through any analog MIDI input – just as is commonly done with expression pedals. The MIDI information is then used to adjust the pitch of the audio samples so that they track the temperature shift of the organ pipes. Standard CODM does not contain the proper statements for this task and it necessary to alter the XML ODF file itself.

For each pipe defined in in "Pipe_SoundEngine01_Layer" the line for the pitch offset is incremented by 32 cents, the maximum amount that the pitch is to be raised:

<PitchLvl_DetuningPercentSemitones>32</PitchLvl_DetuningPercentSemitones>

and the line calling out a continuous control for pitch is altered:

<PitchLvl_ScalingContinuousControlID>261</PitchLvl_ScalingContinuousControlID>

This is done with a simple XML editor such as "XML Marker". The required changes are illustrated using the parsing tool output of XML Marker on the ODF.

Two Continuous Controls are defined and added to the ODF:

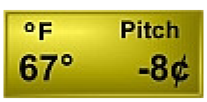
Tag name/Text	Text
ControlID	260
Name	TUNE
DefaultInputOutputContinuousCtrlAsgnCode	260
AccessibleForInput	Y
AccessibleForOutput	Y
DefaultValue	63
RememberStateFromLastLoad	N
Clickable	N
ClickingHigherIncreasesValue	N
ImageSetInstanceID	200

Tag name/Text	Text
ControlID	261
Name	TUNEScaled
DefaultInputOutputContinuousCtrlAsgnCode	261
AccessibleForInput	N
AccessibleForOutput	Y
DefaultValue	63
RememberStateFromLastLoad	N
Clickable	N
ClickingHigherIncreasesValue	N
ImageSetInstanceID	

ControlID 260 is the visible indicator for the the touchscreen display and is also the control that will be connected to the analog MIDI input port. ControlID 261 is the control called out in the <Pipe_SoundEngine01_Layer> for actual pitch control. The default value for the controls is the midrange value of 63, since controls have a 0 to 127 range and the midrange value must lower the default 72° pitch from the maximum 32 cent offset which was set in the <PitchLvl_DetuningPercentSemitones> statement.

Tag name/Text	Text
ImageSetID	140
Name	Autotune
InstallationPackageID	800626
ImageWidthPixels	100
ImageHeightPixels	44
ClickableAreaLeftRelativeXPosPixels	0
ClickableAreaRightRelativeXPosPixels	69
ClickableAreaTopRelativeYPosPixels	0
ClickableAreaBottomRelativeYPosPixels	69
TransparencyMaskBitmapFilename	

The image set for the input control and indicator.



There are 41 images in Image Set 140. This is number 16, F67.jpg

Tag name/Text	Text
ImageSetInstanceID	200
Name	Tindicate
ImageSetID	140
DefaultImageIndexWithinSet	21
DisplayPageID	2
ScreenLayerNumber	12
LeftXPosPixels	0
TopYPosPixels	770

The image instance for the input control and indicator.

There are 41 stages to the output indicator, 52° to 92°, in 1° steps. The SetStage and SetElement tags are set thusly:

Tag name/Text	ImageSetID	HighestContinuousControlValue	ImageSetIndex
ContinuousControlImageSetStage	140	3	1
ContinuousControlImageSetStage	140	6	2
ContinuousControlImageSetStage	140	9	3
ContinuousControlImageSetStage	140	12	4
ContinuousControlImageSetStage	140	15	5
ContinuousControlImageSetStage	140	19	6
ContinuousControlImageSetStage	140	22	7
ContinuousControlImageSetStage	140	25	8
ContinuousControlImageSetStage	140	28	9
ContinuousControlImageSetStage	140	31	10
ContinuousControlImageSetStage	140	34	11
ContinuousControlImageSetStage	140	37	12
ContinuousControlImageSetStage	140	40	13
ContinuousControlImageSetStage	140	43	14
ContinuousControlImageSetStage	140	46	15
ContinuousControlImageSetStage	140	50	16
ContinuousControlImageSetStage	140	53	17
ContinuousControlImageSetStage	140	56	18
ContinuousControlImageSetStage	140	59	19
ContinuousControlImageSetStage	140	62	20
ContinuousControlImageSetStage	140	65	21
ContinuousControlImageSetStage	140	68	22
ContinuousControlImageSetStage	140	71	23
ContinuousControlImageSetStage	140	74	24
ContinuousControlImageSetStage	140	77	25
ContinuousControlImageSetStage	140	81	26
ContinuousControlImageSetStage	140	84	27
ContinuousControlImageSetStage	140	87	28
ContinuousControlImageSetStage	140	90	29
ContinuousControlImageSetStage	140	93	30
ContinuousControlImageSetStage	140	96	31
ContinuousControlImageSetStage	140	99	32
ContinuousControlImageSetStage	140	102	33
ContinuousControlImageSetStage	140	105	34
ContinuousControlImageSetStage	140	108	35
ContinuousControlImageSetStage	140	112	36
ContinuousControlImageSetStage	140	115	37
ContinuousControlImageSetStage	140	118	38
ContinuousControlImageSetStage	140	121	39
ContinuousControlImageSetStage	140	124	40
ContinuousControlImageSetStage	140	127	41

Tag name/Text	ImageSetID	ImageIndexWithinSet	Name	BitmapFilename
ImageSetElement	140	1	AutoTuneStage01	Images/AutoTune/F52.jpg
ImageSetElement	140	2	AutoTuneStage02	Images/AutoTune/F53.jpg
ImageSetElement	140	3	AutoTuneStage03	Images/AutoTune/F54.jpg
ImageSetElement	140	4	AutoTuneStage04	Images/AutoTune/F55.jpg
ImageSetElement	140	5	AutoTuneStage05	Images/AutoTune/F56.jpg
ImageSetElement	140	6	AutoTuneStage06	Images/AutoTune/F57.jpg
ImageSetElement	140	7	AutoTuneStage07	Images/AutoTune/F58.jpg
ImageSetElement	140	8	AutoTuneStage08	Images/AutoTune/F59.jpg
ImageSetElement	140	9	AutoTuneStage09	Images/AutoTune/F60.jpg
ImageSetElement	140	10	AutoTuneStage10	Images/AutoTune/F61.jpg
ImageSetElement	140	11	AutoTuneStage11	Images/AutoTune/F62.jpg
ImageSetElement	140	12	AutoTuneStage12	Images/AutoTune/F63.jpg
ImageSetElement	140	13	AutoTuneStage13	Images/AutoTune/F64.jpg
ImageSetElement	140	14	AutoTuneStage14	Images/AutoTune/F65.jpg
ImageSetElement	140	15	AutoTuneStage15	Images/AutoTune/F66.jpg
ImageSetElement	140	16	AutoTuneStage16	Images/AutoTune/F67.jpg
ImageSetElement	140	17	AutoTuneStage17	Images/AutoTune/F68.jpg
ImageSetElement	140	18	AutoTuneStage18	Images/AutoTune/F69.jpg
ImageSetElement	140	19	AutoTuneStage19	Images/AutoTune/F70.jpg
ImageSetElement	140	20	AutoTuneStage20	Images/AutoTune/F71.jpg
ImageSetElement	140	21	AutoTuneStage21	Images/AutoTune/F72.jpg
ImageSetElement	140	22	AutoTuneStage22	Images/AutoTune/F73.jpg
ImageSetElement	140	23	AutoTuneStage23	Images/AutoTune/F74.jpg
ImageSetElement	140	24	AutoTuneStage24	Images/AutoTune/F75.jpg
ImageSetElement	140	25	AutoTuneStage25	Images/AutoTune/F76.jpg
ImageSetElement	140	26	AutoTuneStage26	Images/AutoTune/F77.jpg
ImageSetElement	140	27	AutoTuneStage27	Images/AutoTune/F78.jpg
ImageSetElement	140	28	AutoTuneStage28	Images/AutoTune/F79.jpg
ImageSetElement	140	29	AutoTuneStage29	Images/AutoTune/F80.jpg
ImageSetElement	140	30	AutoTuneStage30	Images/AutoTune/F81.jpg
ImageSetElement	140	31	AutoTuneStage31	Images/AutoTune/F82.jpg
ImageSetElement	140	32	AutoTuneStage32	Images/AutoTune/F83.jpg
ImageSetElement	140	33	AutoTuneStage33	Images/AutoTune/F84.jpg
ImageSetElement	140	34	AutoTuneStage34	Images/AutoTune/F85.jpg
ImageSetElement	140	35	AutoTuneStage35	Images/AutoTune/F86.jpg
ImageSetElement	140	36	AutoTuneStage36	Images/AutoTune/F87.jpg
ImageSetElement	140	37	AutoTuneStage37	Images/AutoTune/F88.jpg
ImageSetElement	140	38	AutoTuneStage38	Images/AutoTune/F89.jpg
ImageSetElement	140	39	AutoTuneStage39	Images/AutoTune/F90.jpg
ImageSetElement	140	40	AutoTuneStage40	Images/AutoTune/F91.jpg
ImageSetElement	140	41	AutoTuneStage41	Images/AutoTune/F92.jpg

When a <PitchLvl_ScalingContinuousControl> goes over it's full range, the pitch changes from the starting value all the way to zero, which is of course too much. So the linkage from input Control 260 to action Control 261 must be scaled for the much smaller desired range. This is done thus:

ContinuousControlLinkage

(This tag has no attibutes.)

14 Subtags:

Tag name/Text	Text
SourceControlID	260
DestControlID	261
Name	TuneScaled
LinkTypeCode	1
WillisTypeIncSpeedInMillisecondsPerStepWithOneStepDiff	0
InertiaModelTypePositiveAcceleratingCoeff	
InertiaModelTypePositiveDampingCoeff	
ConditionSwitchID	
ConditionSwitchLinkIfEngaged	N
ReevaluateIfCondSwitchChangesState	Y
InvertSourceControlValue	N
SourceControlValueIncrement	3338
SourceControlValueCoefficient	.036661
SourceControlValueIndex	1

The values for the <ContinuousControlLinkage> which does the scaling may be calculated thus:

ContinuousControlLinkage

(This tag has no attibutes.)

14 Subtags:

Tag name/Text	Text
SourceControlID	260
DestControlID	261
Name	TuneScaled
LinkTypeCode	1
WillisTypeIncSpeedInMillisecondsPerStepWithOneStepDiff	0
InertiaModelTypePositiveAcceleratingCoeff	
InertiaModelTypePositiveDampingCoeff	
ConditionSwitchID	
ConditionSwitchLinkIfEngaged	N
ReevaluateIfCondSwitchChangesState	Y
InvertSourceControlValue	N
SourceControlValueIncrement	a
SourceControlValueCoefficient	b
SourceControlValueIndex	1

$$F = fo * \frac{((ctrl+a)*b)}{127}$$

Where “ctrl” is the value of the continuous control and goes from 0 to 127

For the frequency to vary over a 64 cents range (±32 cents) the multiplying factor $\frac{((ctrl+a)*b)}{127}$ must go from 0.963339 to 1.0 as the continuous control setting changes from 0 to 127.

The formula can be solved by simple algebra to give a=3337.154 and b=0.36661, which are the values inserted in the scaling linkage.

4.3 Sample Preparation and Voicing

All the samples used are “dry”with the intent that the digital sounds will mimic the exact acoustics of the “dry” actual pipes. The samples are played through speakers which are next to the real pipes of their respective divisions. There are no multiple releases to program, and since the Swell and Choir speakers are in the actual expression boxes, there are no artificial expression chambers to simulate.

The loudspeaker placement was diagramed in figure 3.3.1. It can be seen that no direct sound enters the seating area of the sanctuary from the Great, Swell or Choir speakers. All sound reaching the listener arrives after first bouncing off multiple walls and objects. This is also the case for most pipes since only the Great and Pedal Principals are exposed on open chests which are cantilevered above the chancel. Accordingly, the perceived placement of the “digital pipes” in each division is identical to that of the real pipes.

Each division uses between two and four speakers. The multiple reflections reaching a listener, from the multiple speakers and multiple paths, results in very good mixing with no noticeable comb filtering. There is, however, a very strong effect on the the overall transmission frequency curve, and very strong compensation was applied to the rank samples before amplification.

Frequency compensation was derived by broadcasting and recording white noise from each speaker group. An FFT was used to calculate the overall effects of the speakers, their placement in the chambers, and the actual room reflection characteristics. A reverse frequency offset was then applied to all the audio samples using batch processing in an audio editor. The results are very good, and the perceived sound, through all the reflections, speakers, and chamber characteristics, is very realistic.

Because frequency compensation was applied directly to the organ samples, they are highly customized to the CUMC Möller installation and no longer resemble the original samples.

5.0 Credits

Many thanks to Jiri Zurek for kind permission to use dry samples from Sonus Paradisi as the basis of many Möller Extension stops. Thanks to Clinton Scott for his fearless skill at installation of speaker cabinets in elevated, cramped organ chambers.

Otherwise: