Compositional and Performance Impacts of the

*Innova MIDI Flute*

by

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Faculty of Music

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Abstract

This dissertation explores the background of the *Innova MIDI flute*, as well as the design, build, and compositional/performance impacts of the radically new design. Through the creation and introduction of a true MIDI-capable flute, my research addresses a need which currently exists within the field of contemporary performance. While MIDI capabilities have been used with piano, guitar, percussive instruments, and others, the flute has been neglected in the field of performance research. It is my desire to provide flutists with the opportunity to be at the forefront of an evolving art form, and to create music with MIDI functions on stage during live performance, with access to the acoustic flute tone, extended techniques, and MIDI-infused music. This research will not only affect performers, particularly flutists, but also composers. The introduction of this new instrument will provide an innovative tool for the contemporary field of music composition.

In designing and developing the *Innova MIDI Flute*, my primary objective was to fill a need for both performers and composers. From the onset of my research, I have worked with prominent MIDI experts, composers, and flutists to ensure my final product
would fulfill all requirements. Feedback from Dennis Patrick, and Bruno Degazio, leaders in the Electroacoustic field; Christos Hatzis and Russell Hartenberger, highly respected contemporary composers, both familiar with MIDI technologies; and Robert Aitken and Douglas Stewart, both professional flutists, has served to ensure the final design reflects the needs of both performers and composers. To date, an instrument has not been available for flutists, or composers, which is able to access all three forms of musical repertoire: classical, contemporary, and MIDI, on one instrument. The dissertation looks at how and why this new design for the MIDI flute evolved, and why its introduction is so significant in the music community.
Acknowledgments

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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>vi</td>
</tr>
<tr>
<td>Chapter One Previous Work in the Field</td>
<td>1</td>
</tr>
<tr>
<td>Chapter Two Design and Build of the <em>Innova MIDI Flute</em></td>
<td>10</td>
</tr>
<tr>
<td>Chapter Three Current Examples of the Use of Electronics in Flute Repertory</td>
<td>36</td>
</tr>
<tr>
<td>Chapter Four Impact on Performance</td>
<td>59</td>
</tr>
<tr>
<td>Chapter Five Impact on Composition</td>
<td>62</td>
</tr>
<tr>
<td>Chapter Six Future Development of the <em>Innova MIDI Flute</em></td>
<td>65</td>
</tr>
<tr>
<td>Works Cited</td>
<td>67</td>
</tr>
</tbody>
</table>
Introduction

This dissertation explores the background of the Innova MIDI flute, as well as the design, build, and compositional/performance impacts of the radically new design. Through the creation and introduction of a true MIDI-capable flute, my research addresses a need which currently exists within the field of contemporary performance. While MIDI capabilities have been used with piano, guitar, percussive instruments, and others, the flute has been neglected in the field of performance research. It is my desire to provide flutists with the opportunity to be at the forefront of an evolving art form, and to create music with MIDI functions on stage during live performance, with access to the acoustic flute tone, extended techniques, and MIDI-infused music. This research will not only affect performers, particularly flutists, but also composers. The introduction of this new instrument will provide an innovative tool for the contemporary field of music composition.

I designed and built the Innova MIDI Flute, using a solid-silver Boehm body as the base instrument. The Innova MIDI Flute has the capability to be used in performance as both a classical and MIDI instrument. To afford the performer ease of use and movement on-stage, as well as being aesthetically appealing, the connection to the off-stage technology is wireless. All hardware and electronics attached to the flute body, will not impede the sound of the instrument, or the performer. Two miniature omni-directional microphones were placed on the wall of the flute body to amplify the acoustic flute tone, as well as project percussive use of “key-clicks”, or other desirable sounds of performance. All sensors have been built into the padding system of the flute, allowing for consistent performance application. The performer has the ability to play with a
standard classical tone, contemporary extended techniques, and MIDI functions all within one instrument.

In designing and developing a MIDI flute, my primary objective was to fill a need for both performers and composers. From the onset of my research, I have worked with prominent MIDI experts, composers, and flutists to ensure my final product would fulfill all requirements. Feedback from Dennis Patrick, and Bruno Degazio, leaders in the Electroacoustic field; Christos Hatzis, and Russell Hartenberger, contemporary composers, all familiar with MIDI technologies; and Robert Aitken, and Douglas Stewart, both highly-respected professional flutists has served to ensure the final design reflects the needs of both performer and composer. To date, a wireless instrument has not been available for flutists, or composers, which is able to access all three forms of musical repertoire: classical, contemporary, and MIDI, on one instrument. The dissertation looks at how, and why, this new design for the MIDI flute has evolved, and the significance of the instrument to the musical community.
Chapter 1
Previous Work in the Field

Ongoing interest in a MIDI capable flute is demonstrated by the previous research attempts in the field. Given the ultimate abandonment of these instruments, however, it seems clear that crucial design aspects were missing. Composition is moving in a very forward-thinking mindset in which extended techniques and MIDI manipulated concepts are constantly being introduced. Electroacoustic music, combining that of electronics with acoustic instruments, has been used in performances since the 1970’s. As music progresses, the introduction of MIDI infused music will advance as well.

Many of the early examples of digital flutes used the flute as a digital controller, rather than an extended instrument. Given the limitations of previous MIDI flutes, and without a viable design, the flute has been somewhat forgotten from this form of composition. It is through the understanding of previous attempts and research, that one may better understand the necessity for the creation of the Innova MIDI Flute.

**Digital Flute (1983 – Present)**

In 1983, M. Yunik, M. Borys and G.W. Swift built the *Digital Flute* in Manitoba, Canada (see Figure 1).
The instrument was designed to aid in teaching music to beginning musicians, using a key system similar to piano. Each finger, or thumb, represented a number from one to ten, and the corresponding notes on a staff of music were given in both number and pitch. The inventors were hopeful that a musical background would not be necessary to learn the technique of reading and playing music. A small microphone was mounted in the mouthpiece of the flute, allowing measurements of air pressure to be sent to the computer system. The remaining equipment was built into the body of the flute, making it a solid instrument, and therefore unplayable using standard flute technique. The flute sound, including the attack, sustain, and decay, as well as the breathiness of the sound, were all controlled by the air pressure, and sound, captured by the microphone at the lip-plate. The concept behind this design was to enable students, of any age, to read music,

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and ‘play’ an instrument in accordance to relating numbers with pitches. The *Digital Flute* was the first MIDI flute invention remaining true to the appearance of a standard flute, but as it did not produce an audible flute tone, a flutist, as performer, would not use this instrument in a performance capacity.

**Possible Reasons for Abandonment**

From previous findings, it appears performance was never the intended use for the *Digital Flute*, rather it was designed as an educational tool for further understanding musical concepts, notation, and instrumental learning models.

**Commercial Wind Controller (c. 1970 – Present)**

A similar attempt to the *Digital Flute* is the modern day *wind controller* available through Yamaha, Akai, and other large equipment-branded companies (see Figure 2).

![Figure 2](image)

While wind-controllers are still available today, the technology has moved the performer closer to a clarinet-inspired instrument than a flute. Made of plastic, the wind-controller is held vertically, and has a reed-like mouthpiece, both attributes most similar

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to a clarinet or small saxophone body. The key system can be programmed to the 
performer’s fingering preference, be it flute, saxophone, clarinet, or oboe. The sound of 
the instrument is also programmable, dependent on the sound files available in the 
computer software, and MIDI sound files. While this instrument gives a performer the 
ability to change instrument sounds quickly and easily, while also adding effects such as 
reverberation, delay, and other sound modulations to the melodic line produced, it is not 
an acoustic, MIDI-controlled flute. Flutists interested in extending their instruments, 
while maintaining appearance, sound, and kinesthetic touch, would not be satisfied with a 
wind-controller. Wind controllers remain popular enough in the commercial musical 
scene that large branded companies are still offering these products within their 
inventory. They are most frequently used for situations where multiple instrument sounds 
are required, while appearance is of a secondary nature. Primary examples include pit 
orchestras and bands for musical productions, as well as off-stage work where one 
instrumentalist could perform using the various sound samples available through the 
wind controller.

Possible Reasons for Abandonment

While the wind controller is still being produced and used worldwide, it was not 
designed as a MIDI-flute, and consequently, has not been used in that context. 
Constructed of plastic, the clarinet-style controller was designed to allow a performer the 
ease of changing between instrument sound samples. While many performers would find 
this design aspect appealing because of its simplicity, a professional flutist in search of an 
electronic flute would be disappointed, as it neither looks, sounds, nor feels like a flute.
**Hyper Flute (2003 – Present)**

The most recently developed MIDI-capable flute is the *Hyper Flute*, which was created by Cleo Palacio-Quinten in 2003, Montreal, Canada (see Figure 3).

Figure 3

This instrument is built on a standard Boehm, solid-silver body flute, and includes the following technologies: magnetic field sensors, ultrasound transducers, mercury tilt switches, button switches, light sensor and microphone. Rather than using embouchure/air speed as a control variable, the microphone mounted on the exterior wall of the head-joint captures the sound of the instrument. The *Hyper Flute* has a blue, pressure-sensitive sensor positioned under the left hand, as well as the right; used for pressure sensitive technology communication with the computer. The button-switches are accessible by either thumb, while other sensors are not available during performance. The flute is connected to a Macintosh computer with wires from each sensor, limiting the performer in the staging possibilities for performance. Given it utilizes a Boehm model

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flute, this design is most similar to my vision for a MIDI-capable instrument. It is not wireless, however, and as such it must be connected via cables to the accompanying computer/electronics, making it a stationary instrument.

Possible Reasons for Abandonment

While the *Hyper Flute* remains the most similar to a standard Boehm flute, the technology mounted on the flute-body creates an entirely new instrument, very unfamiliar to flutists. If a professional flutist were given a *Hyper Flute*, without a detailed explanation of its functioning capabilities, or a tutorial on its use, it is unlikely they could deliver a successful performance. To make such a complicated instrument effectively takes it out of the mainstream flautist’s hands. Ultimately, the MIDI flute should be an instrument that is first and foremost a flute, and therefore accessible to all flutists, regardless of their background.

The *Hyper Flute* uses complex technology, which will require a performer to spend a substantial amount of time in learning *how* to use the instrument. As a performer, it would be best if one instrument could satisfy all performance genres, including classical repertoire, contemporary/extended techniques, as well as electroacoustic music. To require the performer to learn a new instrument, even with its similarities to a Boehm flute, will limit the number of flutists interested in performing on the instrument.

Through utilization of two pressure-sensors mounted under each of the flutist’s hands, the *Hyper Flute* depends on the measurement of hand pressure as a basis for communication to the computer software program. With every person’s hand strength varying, the measurement cannot be consistent between performers, and, by extension,
performances. From a compositional perspective, if the pressure sensors are used for a
given technique or effect, one cannot guarantee the same performance result from two
performers, or from one performance to another, even by the same flutist.

As the *Hyper Flute* is connected directly to a computer on-stage, choreography
would not be possible. This greatly reduces the use of the instrument in contemporary
repertoire, similar to compositions of Karlheinz Stockhausen, where choreography is
central to the overall work.

**Others (1992 – Present)**

Other examples of completed research in the field of MIDI technology being
applied to the flute are: *La Flute-Midi* created by D. Pousset in 1992 for IRCAM, the
*Virtually Real Flute* by S. Ystad and T. Voinier in 1998, and *On the Use of Flute “Air
Jet” as A Musical Control Variable* by Andrey R. da Silva, Marcelo M. Wanderley and
Gary Scavone in 2005. For each prototype built, a specific MIDI controlled operation
was analyzed. In the case of *La Flute-Midi*, fingering positions of the flutist were tracked
through MIDI protocol, while both the *Virtually Real Flute* and *On the Use of Flute “Air
Jet” As a Musical Control Variable* use the embouchure air speed, and pressure, as
variables for MIDI output. While all three projects created valuable measuring tools for
analysis of specific flute-related techniques, none used the flute as a complete MIDI-
capable instrument and controller.
Possible Reasons for Abandonment

Many of the other MIDI-flute attempts included “air-based” technologies, and were created to measure different aspects of a flutist’s playing abilities. As the experimental measuring systems were not intended for performance-based use, many of these models would not be used by a flutist outside of a lab setting.

Conclusions

Like most instrumentalists, flutists become accustomed to performing on their own instrument. If they are required to change flutes for a specific performance technique, or effect, they will likely refuse. Instead, they will choose not to take advantage of potential performance opportunities. With each ‘new’ instrument that differs greatly from the standard flute, a learning curve is present, requiring a period of time to learn how to ‘use’ the instrument. While other MIDI flutes require the flutist to significantly modify their performance techniques, the Innova MIDI Flute keeps the changes to a minimum.

It is this augmentation of the standard flute that allows a flutist to perform on the same instrument for all genres, and styles of music. At the same time, it affords the composer much greater artistic freedom, as they are able to seamlessly combine classical and MIDI flute in their compositions. By allowing for communications with the computer to be made through ‘key processes’, rather than alterations to the flutist’s performance techniques, the flute is performing a dual role.
If a flutist is able to perform without having to focus on technical requirements, the performance has the potential to be less inhibited, and ultimately more enjoyable for the performer, composer, and audience. The more complicated the ‘performing technique’ is, the less likely the model will be considered a success, and the more likely that composers will stop using the flute in future MIDI repertoire.
Chapter 2
Design and Build of the *Innova MIDI Flute*

1 Design Considerations

This chapter will detail the hardware and software used in the construction of the *Innova MIDI Flute*, provide the rationale for specific design choices, and outline how the flute has changed from previous models.

To meet the design criteria envisioned for a new MIDI-capable instrument, the *Innova MIDI Flute* would need to satisfy the following requirements:

- The instrument must use technology that is not dependent on specific pressure-based equations.
- It would have to be constructed using a standard Boehm flute. This over-arching requirement drives things such as audience perception, classic flute sound, etc.
- From an audience perspective, it must appear to be a standard Boehm flute. While some minor add-ons would be acceptable given its MIDI-capability, it must still appear to an audience that the performer is playing a flute, and not a conglomerate of wires and tubes.
- It must be able to produce an acoustic flute sound, extended techniques, and act as a MIDI controller, without any adjustments being required. Since it is built using a standard Boehm flute, it is imperative that it still produce the acoustic flute sound. Likewise, it must not impair extended techniques such as “key clicks”, etc.
And finally, it must be able to send MIDI signals as though it were a MIDI controller.

- It must not impede onstage choreography, via hardwired connections to on or off-stage devices. In effect, it must be wireless. Again, while some minor add-ons would be acceptable, many electronic pieces now require the performer to move on-stage, and therefore the flutist must be uninhibited by the hardware.

- It must not permanently alter (destroy) the flute. Should a flutist elect to have one of their existing instruments modified for MIDI capability, drilling holes into the instrument, etc. would not be acceptable. The ability to undo any modifications must be readily available.

- It must not be cost-prohibitive. For the *Innova MIDI Flute* to gain acceptance both within the performing and compositional communities, the instrument must be available to as many flutists as possible. Whether they are purchasing a new flute which has already been modified, or having one of their existing flutes modified, the cost must be equivalent to other professional instruments.

- The instrument must be accessible to any flutist interested in electroacoustic music and performance. Other MIDI-flute attempts have utilized mercury switches, foot-pedals, etc. These deviations from the standard flute technique/fingering make the instrument difficult to learn, thereby influencing its acceptance.

- The overall design must be adaptable to other padded instruments. While this requirement might be of slightly lesser importance, given the design in question is
for a flute, being able to modify a piccolo or oboe, for example, will provide musicians access to other MIDI-capable instruments not previously available.

- The performer must have the ability to employ “improvisational interpretation” without making changes to the instrument, off-stage setup, etc. This is critical not only from a performance perspective, but also from the perspective of composition. If, while performing, the flutist elects to change a 0.5 second delay to 1.0 seconds – perhaps due to the hall acoustics – they need the ability to do so. Likewise, if the composer elects to include a cadenza, they need to know the flutist has a full range of MIDI effects at their disposal.

- While it is one thing to work in the controlled environment of a recording studio, it is quite another to perform in a live acoustic space. The *Innova MIDI Flute* must be able to function in either situation equally well.

## 2 Innova MIDI Flute Design Solution

The block diagram below (see Figure 4) details the final end-to-end design solution for the *Innova MIDI Flute.*
MIDI Flute Conceptual Solution
Sarah Smith – University of Toronto – 2012

Figure 4

Custom Miniature Sensors
Sennheiser Wireless Receiver
Sennheiser Subminiature Omnidirectional Microphones
CONEX DT-11 DTMF Encoder
Sennheiser Wireless Bodypack Transmitter
Sennheiser Microphone Mixer
Shure Wireless Personal Monitor System
MIDI Sport UNO MIDI to USB Interface
SONUS G2M Guitar to MIDI Converter
Mackie Mixer
Hall Audio System
Macbook Pro equipped with Ableton Live Suite Software
3  Nano-Miniature SMT Top Actuated Membrane Switches

3.1  Importance to Overall Design

To allow the switches to be virtually invisible and touch-sensitive, while not impeding the normal playing action of the flute, membrane switches that could be embedded into each key cup were chosen (see Figure 5 and 6). It is with the depression of each key that the membrane switch is triggered, sending a contact closure to the DTMF Encoder. This data is then converted into a frequency (pitch), and sent via a wireless transmitter to the computer software located off-stage.

Figure 5

Dimension: 0.125” x 0.125” x 0.031”

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3.2 Application

Membrane switches are used extensively in current technology. Everything from the touch pad on microwave ovens, to the keys on TV remotes or cell phones utilizes membrane switches. The diagram below (see Figure 7) illustrates the design of a membrane switch. In order to include these switches in the MIDI flute, a portion of the pad was removed to facilitate the addition of the membrane switch, thereby allowing the flute to seal and function properly.

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5 S. Smith, Photograph.
4 Conex DT-11 Dual Tone Multi Frequency (DTMF) Encoder

4.1 Importance to Overall Design

Various options were considered for the wireless transmission of signals to a receiver offstage. It was critical that the signals not be misinterpreted, and for this reason a Dual Tone Multi Frequency (DTMF) encoder was chosen. The CONEX unit was selected because (a) the tones are momentary, and (b) it can be triggered via external contact closures (i.e., the key-cup membrane switches).

Commonly referred to as “touch tone” technology, the telecom industry has utilized the DTMF encoder since 1963. When making telephone calls, accurate interpretation of generated tones is obviously a critical requirement. The tone frequencies associated with the DTMF were chosen to ensure that harmonics and intermodulation would not create false signals. This feature is what made a DTMF encoder the ideal

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choice for the *Innova MIDI Flute* design. To ensure all triggered events are programmed and received correctly, the MIDI controller / sound module must perform in a consistent and repeatable manner. As will be noted in the illustration below (see Figure 8), each of the frequencies is unique, and is not a multiple of any other. Also, the difference between any two of the frequencies does not equal any of the other frequencies; nor does the sum of any two of the frequencies equal any of the frequencies. The DTMF encoder is hard-wired to the flute by means of soldering 3mm wiring to the encoder panel board and the membrane switches in each key-cup of nine separate keys. Embedded into the padding system of the instrument, they utilize the depression of each key to activate the switch, thereby sending an analogue pitch to the transmitter/receiver, which will then be translated into a MIDI cue.

![Figure 8](image)

If we think of the *Innova MIDI Flute* in MIDI terms, the combination of membrane switches, and the device used to transmit their changing state, forms the MIDI

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controller. Thus, it must be capable of correctly transmitting the intended effects wirelessly to an off-stage computer.

4.2 Application

In what might be considered the “standard” configuration, the DTMF encoder will translate the membrane switch contacts into momentary signals. In this configuration, when a key is depressed, the wiring circuit is closed, and a tone-signal 250 ms in length is sent to the MIDI sound module. This becomes the “note on” trigger. When the same key is depressed a second time a “note off” trigger is sent. Depending on how the software has been preprogrammed, the pressing of another key, or keys, between these two occurrences could interchange effects, layer effects, or perhaps do something entirely different. The *Innova MIDI Flute* allows for this kind of compositional flexibility. The less-often used configuration is likely to be the “durational” signal, where the Conex® DTMF encoder (see Figure 9) allows the user to program the encoder to generate a tone for as long as a contact is closed.
A critical design requirement of the *Innova MIDI Flute* was that it be a wireless instrument; not in the sense that there are no wires in the design, but rather that it not inhibit the performer’s ability to move freely on stage. Many composers of extended technique works, such as Karlheinz Stockhausen, choreograph very specific stage movements into their pieces. To allow for this type of flexibility in existing compositions, and to encourage it in new works designed specifically for the *Innova MIDI Flute*, the performer must be able to move freely, without being connected to an on-stage computer system. This design requirement also takes into account the aesthetics of the instrument. Illustrated below (see Figure 10) are the hardware components a performer must wear during performance. Concealed in one body-pack, the two transmitters, power-supply, DTMF encoder, and personal monitoring system would be self-contained, and easily worn in the small of one’s back.

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Digital transmission of the signal was a possible option, particularly given that a digital signal of “10101010” would not be confused with “01010101” -- thereby assuring accurate recognition of effects triggers. However, wireless digital transmission is difficult to achieve cost-effectively at a power-level suitable for off-stage communication. The technology used to transmit and receive the triggers cannot be compromised by other technological signals, such as cell phones, pagers, and other electronic devices. While the DTMF encoder generates analogue signals, which are typically more prone to misinterpretation, the unique nature of the dual frequencies ensures correct reception of event triggers.

10 S. Smith, Photograph.
5 Innova MIDI Flute Main Event Key

5.1 Importance to Overall Design

Accessible by the flutist’s right thumb, the *Innova MIDI Flute* “event key” is mounted on the underside of the instrument (see Figure 11a). As discussed previously, the DTMF encoder is hard-wired to the flute keys, creating recognizable numbering patterns to be present for event cues with each key depression. All wiring within the *Innova MIDI Flute* begins and ends at the event key, making it the central foundation of the flute as a MIDI controller. Once the event key is depressed, this closes the wiring circuit for the DTMF encoder, thereby interpreting all key combinations as MIDI signals. If any membrane switch is pressed, without the “main effect switch” first being depressed, the computer will not recognize it as an event (see Figure 11b). Once correctly triggered, the DTMF encoder sends an event cue from the transmitter/receiver to the Sonuus Guitar to MIDI converter, followed by the MIDI to USB hardware, and finally to Ableton Live where the MIDI signal is recognized. The event key is a key component in the acoustic flute’s conversion to a MIDI controller.
6  Sennheiser ME2-US Subminiature Omni-directional Lavalier Microphones

6.1 Importance to Overall Design

While a Boehm flute is quite capable in a performance setting, either as a solo instrument, or in a group/orchestral situation, many extended techniques benefit from the use of microphones. Given the introduction of MIDI effects, which are acting on the sound produced by the flute, microphones become a necessity. Chosen for minimal

11  S. Smith, Photograph.

visibility, professional quality (45Hz – 20kHz frequency response), and directional pattern, the Sennheiser ME2-US Subminiature Omni-directional Lavalier Microphones were an ideal choice (see Figure 12).

Figure 12

6.2 Application

Positioned at both ends of the main-body tubing, two miniature, omni-directional microphones were fastened to the post using 3mm wiring (see Figure 13). This placement captured a true representation of the acoustic flute sound, while remaining unobtrusive to standard flute playing procedures.

While it could be argued that additional microphones would improve the sound further, when factored against the cost, complexity, and weight – not only for added microphones, but also for extra body-pack mixers – two microphones were determined to be the optimal number.

7 AKG B9 Battery Power Supply Mixer

Due to the proprietary nature of the Sennheiser ME2-US omni-directional condenser microphones, the AKG B9 mixer must be utilized (see Figure 14). This compact unit mixes the two Sennheiser miniature microphones into a single source for transmission via the Sennheiser body-pack transmitter.

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14 S. Smith, Photograph.
8 Wireless Transmitter/ Receiver

8.1 Importance to Overall Design

The Innova MIDI Flute was designed to be played in either a live audience setting, or a recording studio. Therefore, any wireless transmitter / receiver combination must be able to overcome disruptive signals from cell phones, and other electronic sources. It must also be able to transmit and receive without requiring line-of-sight, thereby allowing for on-stage choreography. It needs to be of professional quality, to

*Sennheiser transmitter and AKG B9 Battery Power Supply Mixer

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15 S. Smith, Photograph
accurately transmit the flute sound. And lastly, since two are required, the body-pack transmitters need to be compact. The Sennheiser EW100 True Diversity Wireless Body-pack Transmitter/Receiver units meet all these criteria (see Figure 15). With an effective range of 300 feet, after initial set-up (i.e., the units select the optimum frequency for use), no line-of-sight is required.

8.2 Application

Since the *Innova MIDI Flute* is acting both as a standard Boehm flute, and as a MIDI controller, two transmitter / receiver pairings are required. The first pairing transmits and receives the acoustic signal from the flute. The second pairing transmits and receives the signaling tones from the DTMF encoder. As the Sennheiser EW100 selects the optimal frequency for signal transmission, there is no spillover “crosstalk” between the two sources.

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9 Sonuus G2M Guitar to MIDI Converter

9.1 Importance to Overall Design

To allow the DTMF encoder signals to be treated as a transmission from a MIDI controller, a converter is required to recognize the various frequencies, and translate them into MIDI signals. The Sonuus G2M is designed to connect directly with a guitar’s ¼” microphone output (i.e., as opposed to other split pickup styles), and convert audio signals to MIDI format (see Figure 16).

Figure 16

9.2 Application

While the membrane switches, DTMF encoder, and wireless transmitter / receiver each play a role in transmitting the MIDI effect from the flute to the offstage equipment, it is the guitar to MIDI converter that translates the audio signal to the correct MIDI information required for Ableton Live.

As detailed in the specifications for the Sonuus G2M:

The G2M™ is a simple-to-use, highly effective, guitar-to-MIDI converter. It is “Universal” because it doesn't need a special pick-up mounted on your guitar, but instead simply connects to your guitar like any other effects pedal or tuner. Designed to give accurate triggering, with very low-latency, it is a true plug-and-play solution for monophonic MIDI guitar.\(^{18}\)

10 MIDISport UNO MIDI to USB Interface

As the Macbook Pro does not possess a MIDI input jack, an interface was required to convert the MIDI signal, received from the Sonuus G2M, to a USB connection. The “MIDISport UNO MIDI to USB Interface” is a MIDI interface that is reliable and cost-effective, and will plug directly into any laptop’s USB port (see Figure 17).

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11 Ableton Live Suite Software

11.1 Importance to Overall Design

To allow for maximum performance flexibility, the MIDI software used must be able to (a) accept a live audio signal, (b) accept the data from a MIDI controller, (c) allow the MIDI effect to modify the audio signal in real-time, (d) allow for mapping of the MIDI controller to effects, pre-recorded tracks, etc. Ableton Live meets all of these criteria.

11.2 Application

While many portions of the Innova MIDI Flute design could be modified by the user – for example, the type of miniature microphones, bodypack transmitter / receiver combination, etc – the MIDI software chosen is perhaps the area most open to personal preference. While Ableton Live allows for seamless integration of live performances, with MIDI effects, prerecorded sampling, etc., other software has similar capabilities.

In use, the audio signal from the associated receiver is fed into the Macbook Pro’s “audio input” jack. At the same time the MIDI signal, after being converted from audio to MIDI by the Sonuus G2M, enters the Macbook Pro computer via the USB jack. Ableton Live treats these two sources independently, and will either pass the audio signal through unaltered, or will apply the desired MIDI effect, based on the MIDI trigger received.
Mackie 402-VLZ3 4-Channel Mixer

The Mackie 4-Channel Mixer is the final piece of hardware between the Macbook Pro and the hall audio system (see Figure 18). Rather than utilizing a ‘Y’ cable, where the signal is simply split into ‘left’ and ‘right’ outputs, the 4-channel mixer will enable the performer to independently adjust sound levels from the acoustic flute microphone, and the MIDI effects being applied through Ableton Live. In addition, the performer will also have a separate feed for a personal monitoring system, which can be worn on-stage during live-performance.

Figure 18

13 Shure P4TRE3 Wireless Personal Monitor System

13.1 Importance to Overall Design

With various MIDI effects available, it is critical that the flutist know, at any
given time, what effect is being applied by the Ableton Live MIDI software. This
knowledge is significant for two reasons. First, it allows for improvisation, as previously
discussed. Second, it ensures that any errors in audio to MIDI conversion – whether
through human error in applying / removing the effects, or electronic faults in the audio
to MIDI conversion – are promptly caught, and corrected.

13.2 Application

For all of the reasons previously identified, the personal monitor system must
allow for on-stage movement, and therefore be wireless. And as was the case with the
microphones, and transmitter / receiver pairings, it must be of professional quality. The
Shure P4TRE3 Wireless Personal Monitor System was selected as it met the criteria, at a
reasonable price-point when compared to other manufactures such as Sennheiser (see
Figure 19).
14 Key-mapping Processes of the *Innova MIDI Flute*

Since Ableton Live is not specifically designed for the *Innova MIDI Flute*, the MIDI key-mapping will need to be pre-programmed into the software for each composition, either by the flutist or composer. Assigning each fingering combination into Ableton Live, through key-mapping processes, completes this process. Once completed, these mappings are saved as a unique setup within Ableton Live.

One of the strengths of Ableton Live is its ability to easily map MIDI controls to effects. After entering Live’s “MIDI Map Mode”, by clicking on the MIDI switch icon in the upper right-hand corner of each page, the “Mapping Browser” becomes available. At this point, one simply clicks on the Live parameter you want to control, for example “Reverb”, followed immediately by fingering the note you want the effect to be assigned to, for example E6. This process sends a MIDI message (control) from the flute to

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Ableton Live. The control assignment and effect are now listed in the Mapping Browser. After assigning a name to the mapping, and exiting the Mapping Browser – by clicking on the MIDI switch icon again – the mapping is immediately available for use.

Similar to an organist pre-programming stops, and settings, prior to a performance of a given piece, the *Innova MIDI Flute* key-mapping process is very straightforward, and can be programmed by either the flutist or composer ahead of time. I envision composers will notate the Ableton live settings within the foreword of the composition, explaining the presets used for their work (see Figure 20).

Figure 20

<table>
<thead>
<tr>
<th>C#4 – 5 second delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4 – ring-modulator filter</td>
</tr>
<tr>
<td>E5 – atonal harmonics</td>
</tr>
<tr>
<td>E6 – infinite reverberation</td>
</tr>
<tr>
<td>A6 – frequency shifter</td>
</tr>
</tbody>
</table>

To better facilitate an understanding of the *Innova MIDI Flute*, I have provided a fingering chart to outline possible key-mapping processes (see Figure 21).
<table>
<thead>
<tr>
<th>LH</th>
<th>Pitches Related to Finger Depression</th>
<th>RH</th>
<th>Pitches Related to Finger Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thumb</td>
<td>B3, C#4, C4, D4, D#4, E4, F4, F#4, G4, G#4, A4, A#4, B4, D5, E5, F5, F#5, G5, G#5, A5, A#5, B5, D6, D#6, E6, F6, F#6, G6, G#6, A6, A#6, B6</td>
<td>Thumb</td>
<td>n/a (event key)</td>
</tr>
<tr>
<td>1</td>
<td>B3, C#4, C4, D4, D#4, E4, F4, F#4, G4, G#4, A4, A#4, B4, C4, E5, F5, F#5, G5, G#5, A5, A#5, B5, C6, D#6, E6, F6, F#6, G6, G#6, B6</td>
<td>1</td>
<td>B3, C#4, C4, D4, D#4, E4, F4, A#4, D5, D#5, E5, F5, A#5, D#6, E6, F6, A6, A#6</td>
</tr>
<tr>
<td>2</td>
<td>B3, C#4, C4, D4, D#4, E4, F4, F#4, G4, G#4, A4, D5, D#5, E5, F5, F#5, G5, G#5, A5, D6, D#6, E6, G6, G#6, A6</td>
<td>2</td>
<td>B3, C#4, C4, D4, D#4, E4, D5, D#5, E5, D#6, E6, A#6 (trill key #1)</td>
</tr>
<tr>
<td>3</td>
<td>B3, C#4, C4, D4, D#4, E4, F4, F#4, G4, G#4, D5, E5, F5, F#5, G5, G#5, D6, D#6, F6, F#6, G6, G#6, B6</td>
<td>3</td>
<td>B3, C#4, C4, D4, D#4, F#4, D5, D#5, F#5, D#6, F#6, B6 (trill key #2)</td>
</tr>
<tr>
<td>4</td>
<td>G#4, G#5, D#6, G#6</td>
<td>4</td>
<td>Pinky</td>
</tr>
</tbody>
</table>

This overview of fingerings provides the composer with each key used for notes within the acoustic flute range. While in most settings, the *Innova MIDI Flute* would utilize standard flute fingerings, this understanding of available options allows a composer the flexibility to assign alternate fingerings for a greater range of effects.
Chapter 3
Current Examples of the Use of Electronics in Flute Repertory

With the current fascination surrounding the manipulation of sound through electronic media, computers and digital recording devices are in some measure replacing the art of live performance. For the purpose of this chapter, I have chosen three works that illustrate the use of electronics in current flute repertoire: Kaija Saariaho’s NoaNoa (1992), Karlheinz Essl’s Sequitur I (2002), and Bruce Pennycook’s Praescio VI (2008). While each composition differs significantly in the demands placed on instrument and performer, all utilize both live and electronic artistry. In addition, each piece outlines a different compositional style in regards to the format of the score, as well as the techniques used for interaction between live and electronic material. Within this survey of compositions for flute and electronics, I will provide an examination of the following: notational descriptors within the score, synchronization of live-flute and pre-recorded materials, performance dynamics as well as aural impressions, and how the use of the Innova MIDI Flute could be applied to future performances.

14 Kaija Saariaho (b. 1952), NoaNoa (1992), 10’

NoaNoa (1992) written by the Finnish composer Kaija Saariaho (b. 1952), is a piece that serves as a new style of performance for the modern flutist, involving live electronic manipulation, achieved through the use of a foot-pedal by the flutist. The tools used for live electronic manipulation include playback of sound files, MIDI controlled infinite reverberation, general reverberation, mixer and stereo diffusion, and amplification of the flute through a microphone. Consequently, this piece requires
technical support from an audio technician, who cues the electronic sounds, and changes patches on the effects unit to create the real-time manipulation of the flute sounds.

14.1 Notational Descriptors/Synchronization

When first viewing the score of *NoaNoa*, one immediately notices the clear organization laid out for the performer. Tempo markings are often included with character descriptions such as *intenso, poco agitato*, etc., allowing the performer to better understand the intent of the composer. The eighth-note pulse remains consistent throughout the piece, ensuring a performer can easily adapt to the frequent meter changes. Sections are indicated with both bar numbers and letters above the staves, while performance related event changes, to be made with a foot-pedal by the performer, are indicated with numbers in circles below the stave. The compositional writing looks similar to most modern repertoire for flute, with rhythmic and technical virtuosity, and many common extended techniques included throughout, such as harmonics, multiphonics, and flutter tonguing. Due to the frequent markings of tempo, meter, precise rhythmic notation, dynamics and character/timbre changes, one would assume that by following the score carefully, different flutists could achieve similar performances.

The following are examples of performance “instructions” from the *NoaNoa* score:

- All software (Max patches, as well as the samples) is installed on a CD-ROM, available from Chester Music.
- The ideal sound for the amplification is a clear and rich “close” sound. The microphone should be placed rather close to the
instrument. The amount of amplification naturally depends on the concert space, but the amplified sound should not cover the acoustic sound of the instrument. The general level can be set rather loud, but not painfully so.

- The reverberation effect: the reverberation used in Lexicon LXP-15 consists of a program in which the reverb time is changed constantly by the amplitude of the input signal. The general idea here is: the quieter the sound, the longer the reverb. The amplified flute sound should blend well with the reverb sound, but nevertheless remain slightly in the foreground. The second reverb is used to soften the amplified flute sound, the Lexicon LXP-15 sound, and possibly the recorded audio material on direct-to-disk.²³

### 14.2 Aural Impressions and Performance Dynamics

Notation within the score gives an impression of rigidity, while the aural impression is one of improvised fluidity. The rhythmic precision is clear, as demonstrated in Figure 22.

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As Jonathan Buckley states:

More than any other major composer of her generation, Saariaho has made electronic and computer-generated sounds a constant ingredient in her music, while developing a compositional method in which the scientific analysis of instrumental sounds and timbres plays a major role. But what’s equally distinctive about her work is its constant ability to transcend its laboratory origins, and to create music not only of startling strangeness and originality, but also of haunting, other worldly beauty.  

In performance, *NoaNoa* creates a mysterious, ethereal sound-picture, blurring the lines between live and fixed mediums. As the electronic part is predominantly the melodic flute content distorted, one hears an immediate relationship between the flute and electronic sounds. Therefore, a flutist interacts with the electronic counterpart through a very natural sequence of events. This relationship also allows the flutist further flexibility in tone colour changes, as the nuances will have immediate response in the

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electronic counterpart. Saariaho explains that she “wanted to write down, exaggerate, even abuse certain flute mannerisms that had been haunting [her] for some years, and thus force [herself] to move onto something new.”

Extended techniques are used regularly throughout *NoaNoa*, which is perhaps her method of exaggerating standard flute tone. While technical virtuosity appears to be a focal point of the composition, I believe Saariaho’s true focus centers on the exploration of timbres, moods and colours of the flute. Through the use of “speak-flute” a duality is created within the live performer, adding an element of theatre to the stage with spoken word; once again, the new sound or voice has emerged from the flutist. Similarly, Saariaho mimics the colours and tonal qualities of multiphonics produced on the flute, through use of ethereal, breathy sounds and metallic chords with large dissonances heard in the electronic part.

### 14.3 *Innova MIDI Flute* Application

For the duration of *NoaNoa* the flutist is required to cue electronic events through the live use of a foot-pedal on stage. Since coordination with an electronic tool is unfamiliar to most flute players, changing MIDI patches and controlling technologies would be more easily accessible if the equipment were built directly into the instrument. If, for example, the flutist triggered an event earlier than what was notated, it would be the responsibility of the sound technician to make the necessary adjustments, and reprogram the sequence of events. The *Innova MIDI Flute* will allow for this technological adaptation, as each pre-programmed event cue corresponds with specific

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27 “Speak-flute”: words are spoken above the tone hole, producing both spoken, and melodic flute tones.
key-mapping fingerings. In the instance that a flutist triggers the wrong effect, it can simply be “un-done” by re-fingering that cue, thereby stopping the event.

Within *NoaNoa* the *Innova MIDI Flute* could be utilized to trigger events, be it pre-recorded material or sound sampling. At the opening of the piece (see Figure 23), the flute, through use of the event key and the preprogrammed fingering combination on E6, will trigger “infinite reverberation” to begin, while simultaneously producing an acoustic E6 on the flute. This triggering process utilizes the *Innova MIDI Flute* as an acoustic instrument and MIDI controller.

![Figure 23](image)

Previously this command would have been given by the flutist, through use of a foot-pedal. While a foot-pedal allows the flutist to be in control of the cue, it is still a foreign movement which must be made by a performing artist. In contrast, the *Innova MIDI Flute* utilizes the inherent fingering patterns used for playing the instrument, already engrained to flutists, thereby simplifying the overall process. The flutist is not required to understand the technologies built into the instrument; rather, they are responsible for performing the piece before them.

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As demonstrated in Figure 24, the flutist is required to combine the playing of a pitched C4, which evolves into a trill, followed by the introduction of “speak-flute”, all while changing the reverberation time with the foot-pedal at marker ‘6’. If utilizing the *Innova MIDI Flute*, an event cue would be triggered once the “main event key” is combined with the key-combination for C4. Once completed, the “speak-flute” technique would enter as before.

Figure 24

The following example (see Figure 25), illustrates an event requiring synchronization. Whether a sound engineer is involved, or the flutist is responsible for triggering the “pre-recorded, filtered and processed flute sounds” the alignment is critical. The *Innova MIDI Flute* could be utilized to cue the event once the multiphonic is achieved. Mechanically, the event key would be depressed on the D6, and through the fingering of the B-flat6 the cue would be triggered.

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15 Bruce Pennycook (b. 1949), *Praescio VI (1992), 11’*

Commissioned by Toronto flutist, Christine Little, *Praescio VI* (wir leben durch die Lieb’allein – we live through love alone) is the sixth piece within a series of compositions written by Canadian composer, Bruce Pennycook. Termed as “flute and interactive system” on the title page, *Praescio VI* combines the use of live-flute and an interactive, computer-controlled, MIDI system.

As Pennycook states:

> The name of the series, PRAESCIO, is derived from the Latin root of the English word *prescience* – to know in advance. At the onset of the project, I imagined a form of controlled improvisation in which each of the participants, computer and performer, would “know” a portion of the musical material for the work but only during the moment of realization – the performance – would the completely formed piece unfold. I also imagined that the computer would participate in the performance as a

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nearly equal member of the ensemble, contributing new but related
musical materials during the course of the presentation.”

15.1 Notational Descriptors/Synchronization

As Pennycook outlines in his prelude to the score:

This work is the first of the Praescio series of interactive pieces to use hard
disk recordings as a MIDI (hence performer) controlled audio element. It
is also the first to utilize the composer’s invention, The MIDI Time Clip.
This is a small MIDI device that permits the player to “see” commands
from the computer in the form of a 6-character display and a large red
bulb. In this piece, there are symbols to indicate the number of flashes and
the tempo of these flashes before a new event (MIDI or audio) occurs.

Through the use of Pennycook’s MIDI-LIVE software and the MIDI Time-Clip,
the flutist is provided necessary information, including tempo and entrance of cues, to
facilitate synchronization with the electronic counterpart (see Figure 26).

In the 1994 ICMC Proceedings, the following is illustrated regarding the MIDI Time Clip:

“The MIDI Time Clip is a small (4”x5”x3”) unit which attaches to a microphone stand and communicates with a computer via MIDI. It includes six, 14-segment LED’s for alphanumeric character display, one large red LED for flashing tempo cues, plus a pedal input attachment for volume, sustain, and trigger pedals. The performer in a studio or on stage receives visual messages from the computer during performance to assist with setting tempi, indicating rehearsal numbers, and to provide visual feedback to the player for actions which may have no audible result such as triggering new program changes or upcoming events.”

Generally, the MIDI Time-Clip cues are given when synchronization is crucial for the piece or after a short resting period for the flutist. Titled “System Guide”, the electronic portion is notated below the flute part on a separate stave.

When viewing the score, one would assume synchronization between the flute and electronic material would be fairly straightforward, as the score is easy to follow, and

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well formatted with the electronic cues. The quarter note remains consistent throughout the piece, in both tempo and meter changes, which is helpful considering *Praescio VI* contains twenty-one un-metered bars, eighty-six metered bars, and it alternates between 4/4, 8/4, and 5/4 time throughout. As Pennycook frequently details rhythmic alignment between the flute and electronic staves, it would appear that metered bars are portions where rhythmic synchronization is of particular importance (see Figure 27).

![Figure 27](image_url)

Throughout the composition, “pitched cues” are provided in the electronic part (see Figure 28). In many instances, this helps identify changes in tonal patterns, allowing the performer to visually see a harmonization heard within the electronic accompaniment.

![Figure 28](image_url)

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As the electronic part in *Praescio VI* is pre-determined, it is extremely important that the performer understands both the melodic content and functional necessity of the counterpart. Pennycook has clearly notated, within the score, where the electronic medium starts/stops. Where rhythmic synchronization occurs, Pennycook has included both pitch and rhythm markings in the electronic part. This level of detail will greatly assist in alignment of the live-flute and fixed medium, as well as be appreciated by the flutist in performance.

### 15.2 Aural Impressions and Performance Dynamics

While listening to a recording of *Praescio VI*, performed by flutist Christine Little, one immediately notices the presence of the electronic counterpart. Complementing the live-flute material, the electronic portion is truly a secondary “performer”, rather than an accompaniment. As noted previously, synchronization happens frequently throughout the piece, and without looking at the score, one wouldn’t be aware, except in obvious places, that the performer wasn’t synchronized with the electronic part. Rhythmic portions where the electronics are in time (Ex. beating quarter notes), and the flutist isn’t precisely lined up, is very noticeable. As a rhythmic, time-oriented piece, almost percussive throughout, synchronization in *Praescio VI* is fundamental.
15.3 *Innova MIDI Flute* Application

Through the use of the *Innova MIDI Flute*, I believe synchronization in *Praescio VI* will be more easily facilitated. While Pennycook’s “MIDI Time Clip” is a remarkable software implementation, I foresee issues that may negatively impact performance of the piece. As David Barclay states, “Praescio VI was performed in many cities without the presence of Pennycook to administer the technical set up. At every performance at least one minor problem was reported to the composer.” As the “MIDI Time Clip” is controlled by a sound engineer, the flutist has little, to no, control over the entrance of the electronic counterpart.

Once the MIDI-time clip is cued, the performer must enter at the given tempo, provided by the technology, to successfully synchronize with the electronics. If any event occurs during live-performance where the flutist is unable to meet those requirements, the MIDI Time Clip cannot make the necessary adjustments to accommodate the performer, and the performance may be greatly impacted.

Through the triggering of events on the *Innova MIDI Flute*, the MIDI Time Clip will no longer be necessary, and the performer will be in full control of their performance. I have chosen two examples which I believe demonstrate how the *Innova MIDI Flute* will improve the synchronization between flute and electronics.

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At the onset of the piece (see Figure 29), Pennycook requires the flutist to play a rapidly-ascending chromatic scale as a pick-up, while synchronizing with a rhythmic electronic cue that begins on the downbeat of the second bar.

Figure 29

While the MIDI-Time Clip provides a visual cue of four beats at 140 per quarter-note, the flutist must ensure their scale is properly timed to end on the downbeat of the bar with the electronic accompaniment. If the flutist arrives early, or late, the electronic part continues, and the lack of synchronization is obvious as the initial half note will not be in alignment. With the Innova MIDI Flute, an event would be triggered on the downbeat of the second bar, starting the electronic cue. From a mechanical understanding, the flutist’s right-hand thumb would hold down the main event key in combination with the A6 fingering, thereby triggering the electronic cue to begin.

Measure 29 (see Figure 30), provides an excellent demonstration of where multiple functions of the Innova MIDI Flute could be utilized.

A solo electronic cue begins the bar, having been triggered by use of the main event key combined with a one-key fingering. The flutist enters on the fourth beat, playing acoustic flute only. On the fifth beat, the flutist would hold down the event key, while playing A-flat6, which would trigger the electronic whole-note cue to begin simultaneously. While a sound engineer could cue each of these events, synchronization is going to be more easily facilitated, and more likely to be accurate, if the flutist is in control of both the live and fixed mediums.

16 Karlheinz Essl (b. 1960), *Sequitur I (2008)*, 7:32’

Austrian composer, Karlheinz Essl, describes *Sequitur I* (Latin translation, it follows) as having similarities to a “house of mirrors”, as each performer is “confronted with his own playing, [creating] a situation where identities become blurred.” 40 This “blurring” is created from the use of a MaxMSP software, that ‘composes’ the electronic accompaniment from the acoustic flute’s live-input. As Essl notes, “the software generates a complex canon on the fly, the temporal structure and density of which being

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controlled by random operations. This yields different results every time the piece is performed.\textsuperscript{41} In a similar style to \textit{Sequitur I}, Essl has also composed works for clarinet, trumpet, violin, cello, toy piano, electric-guitar, voice, tuba and accordion; all in combination with live, electronically manipulated accompaniments.

As Essl comments:

The aim is to create various pieces which use the same computer program, the so-called \textit{Sequitur-Generator} written in Max/MSP. It generates a complex 8-part canon from the instrument's live input as an accompaniment. Unlike traditional canons, the individual canonic layers do not enter at regular intervals but in a sort of acceleration which results in an increasing structural density. Moreover, the single canonic layers are getting gradually distorted - as if they were decaying. And at last, the 8 parts do not always play together, but are constantly cross-faded by using random operations which results in every-changing and unforeseeable structural interactions where the canon can vary between 1 and 8 voices.\textsuperscript{42}


16.1 Notational Descriptors/Synchronization

Considering *Sequitur I* is designated for “flute and live-electronics”, it seems unusual that Essl provides the flute portion only, omitting the electronic counterpart entirely. In any chamber group, be it two players or more, each performer should have a general, if not greater, understanding of the counterparts to ensure synchronization and true interaction can take place. Through Essl’s decision to not provide the electronic part, even in a simplified form, the flutist is greatly impacted, as she/he will not have any control or responsibility regarding synchronization. While respecting Essl’s vision for *Sequitur I*, to create a “real-time sound processing environment”\(^{43}\), exact notation of the electronic part is perhaps unnecessary, but I would argue that inclusion of the effects that will be heard by the performer would be useful for the flutist.

*Sequitur I* is consistent with standard electroacoustic and contemporary repertoire, utilizing techniques such as flutter tonguing, multiphonics, whistle-tones, jet-whistle, singing/playing, and key-rim variation playing\(^ {44}\). For any uncommon techniques, Essl has provided fingerings above the stave; otherwise, the score is sparse with instruction.

As the piece is without a time signature, the rhythm appears to be relative to note duration – including whole notes, quarter note triplets, etc. (standard notation) – as gestures, rather than strict time (see Figure 31). Upon review of the score, one notices the clear distinction between twenty-three events, each separated by a fermata.


\(^{44}\) “Key-rim variation”: opening fingerings to include rim of key cup only
16.2 Aural Impressions and Performance Dynamics

In a performance of *Sequitur I*\textsuperscript{46}, Essl is on-stage, as sound-engineer, with Guy Pelletier, flutist. A video screen illustrates graphic art behind them, transforming the performance into a “live-art” experience, where music and media are combined.

As manipulation of the live-flute is the predominant electronic effect, the relationship between flute and electronic sounds is evident. Sounding almost canonic at times, the two mediums interact almost seamlessly, blurring the lines between performer and electronic sounds. Essl utilizes techniques such as delay, reverberation, manipulation and distortion, all applied to the live-flute input.

Essl notes:

The computer-generated canon structures run through a series of sound transformers (like ring-modulator, de-tuner, flanger and comb filter) where the sonic shape of the sound is being altered. These are controlled by a sequence of pre-composed presets which can be evoked by the player by pressing the space bar on his computer keyboard according to the


indications of the score. At each key stroke, the next preset will be loaded which gradually changes the real-time sound processing.\(^{47}\)

While instructions may have stated this could be a stand-alone piece, where the performer is both flutist and sound-engineer, Essl is seen in the live-performance cuing the flutist for most entries throughout, as well as conducting on-stage. If instructions were included, such as “wait until previous texture is thin before beginning new material”, the flutist would be able to enter correctly, without requiring a visual cue.

16.3 *Innova MIDI Flute* application

Within *Sequitur I* the *Innova MIDI Flute* could be easily applied to facilitate the triggering of electronic events, or effects. Not only would this application remove the sound engineer entirely, but it would also simplify the performance process, and allow the flutist a greater level of control within their performance.

As demonstrated at the opening of the piece (see Figure 32), the flute begins on a sustained E-flat\(^5\), accompanied by electronic sounds. Considering Essl begins the electronic sounds simultaneously, the flutist could hold down the ‘event’ key, triggering an event at the onset of the first note. This would ensure synchronization between the flute and electronics is precise. With sustained pitches, as seen in this example, Essl could also utilize the *Innova MIDI Flute* to stop electronic cues through the release of the ‘event’ key, or by having the flutist press an alternate key to stop the triggered event.

Figure 33 illustrates an opportunity for multiple electronic cues to be triggered by the *Innova MIDI Flute*. While the flutist is playing the pizzicatos, each C4 could be used as a cue for a new electronic event. In this example in particular, synchronization between a sound engineer and performer would be quite difficult, and obvious if unsuccessful.

In the final example (see Figure 34), an expressive melodic line in the flute part is illustrated. In the previous bar, electronics are still present but gradually fading out, so the flutist may begin this melody as a solo gesture. Once the flutist plays the A5, the melody is repeated verbatim in the electronic accompaniment. If the *Innova MIDI Flute* were being utilized, this cue could be controlled by the flutist, through use of the event key being applied on the A5. While this cue is not overly difficult to synchronize with the

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sound engineer, it illustrates an example where the performer could gain control of their performance, and the overall process would be simplified.

17 Conclusion

In all three compositions, the electronic performance provides a counterpart melody or accompaniment to augment the solo flute. It both complements, and plays a significant role as a solo electronic instrument. Each work differs greatly from the others, but a common thread exists; all three compositions combine acoustic flute, manipulated sounds, and electronics.

While Saariaho utilizes amplification, MIDI patches on a reverberation unit, and effects with external hardware, she could utilize the *Innova MIDI Flute* as a MIDI controller, and amplifier, thereby removing both the sound engineer and on-stage equipment. Similarly, through use of the *Innova MIDI Flute* as a MIDI controller and amplifier, *Sequitur I* and *Praescio VI* will no longer require a sound technician. If a sound engineer is required to perform a work, rehearsal time will be necessary before a performance to ensure the performer and operator feel comfortable with the piece, and

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one another. The more simplified the process can be, through use of the *Innova MIDI Flute*, the less preparation time is required to “set-up” the stage and equipment, and the more time a performer can spend with the given composition.

As presented in each composition, it is evident the *Innova MIDI Flute* will simplify the overall process of interaction between flute and technologies. While having control of the interactive process, the performer will also have the ability to adapt to performance spaces, ensuring the timing of the electronics is appropriate for the sound space. In a large venue, for example, where the reverberation time is longer than other locations, a performer may decide to space out the events further than if they were in a dry sound space. Without this control, a very ‘wet’ sound space may create a muddy performance, simply due to a lack of control. I believe this to be a very positive feature not only for performers, but also composers, as this will help facilitate consistent performance in different venues and sound spaces.

Pirkko Moisala comments that:

Saariaho’s musical production reflects the development of musical technology, particularly electronic music. The technology involved in electronic music involves a large – and ever more developing – world of its own. In order to be able to utilize the electronic means available, the composer has to acquire and maintain an impressive working knowledge
of how the technology functions and a detailed understanding of the
sounding alternative they can achieve.\textsuperscript{51}

While making reference to Saariaho’s use of technologies, and knowledge
acquired, Moisala is also making an excellent argument regarding the composer’s
involvement in electroacoustic music. To fully utilize the \textit{Innova MIDI Flute} in
performance, composers must first understand the intricacies of the instrument.

As Pennycook states:

Like many other works of this genre, the relationships between the soloist
and the computer component can be divided into the following general
categories: instrument alone, instrument with signal treatments, instrument
with pre-recorded or computer-generated accompaniment, instrument with
all of the above, and computer-generated audio alone. These changes of
texture or ‘states’ are central to the formal organization of the piece.\textsuperscript{52}

While Pennycook references the fundamental relationship between instrument and
technology, he is also commenting on a style of composition where combinations of live
and fixed mediums are present. As the \textit{Innova MIDI Flute} is able to access all of these
functions within one instrument, greater performance flexibility is provided for both
performers and composers.

\textsuperscript{52} Pennycook, Bruce. “Who will turn the knobs when I die?” In \textit{Organised Sound}, 13(3): 204, Winter
Chapter 4
Impact on Performance

The *Innova MIDI Flute* was designed with the intention of creating an instrument that would be aesthetically, and kinesthetically a standard Boehm flute. If the final product differed too greatly from what flutists considered the norm, a steep learning curve would be required to understand the instrument. This may deter flutists from playing the instrument. The membrane switches, embedded into the keypad system of the flute, allow a performer to play with little or no awareness of the hardware. Mounted onto the body of the flute, the microphones do not interfere with the kinesthetic touch of the performer, and as they are extremely small and weighing only 60 grams per microphone, the weight of the flute is effectively unaltered. The goal of the *Innova MIDI-Flute* was that any flutist could play it, and be reasonably successful from their first attempt.

While some performers may elect to purchase a dedicated MIDI flute, most flutists have one, or perhaps two, instruments that they prefer over others. It might be due to the weight, wall thickness, lip-plate, sound color, etc., but flutists do have their favorites. To force a change in instruments may negatively influence the acceptance rate of a MIDI-capable flute. But as performers will be able to retrofit their current instrument with the necessary hardware to create a MIDI-capable flute, knowing that any alterations are reversible, it removes the necessity to purchase a new instrument.

While there is not substantial evidence indicating choreographed works will experience a resurgence in composition, a MIDI flute that is restricted in movement, will certainly not be utilized in this style of performance. Rather than limiting composers and performers in regards to movement, I would prefer to encourage new styles of
composition and performing with a wireless MIDI flute. Similar to the repertoire discussed earlier, if a flutist were interested in performing a work of Karlheinz Stockhausen, for example, a wireless MIDI flute would be necessary to facilitate the choreography.

A flutist is ultimately a performer, not a stagehand, or a sound technician. For this reason it is essential that the communication between flutist and technology be seamless, and unseen. Where a performer needs to shift focus to a foot-pedal, or function other than the repertoire before them, a key moment may be missed in the performance. From both a kinesthetic perspective, as well as the repertoire, the design of the flute must allow the performer to utilize MIDI technology, without being aware of the hardware components.

Acoustic reverberation is generally an aspect of performance which flutists have little or no control over. If the venue is small, or has poor sound quality, the flute sounds dull. The *Innova MIDI Flute*, however, allows the performer or engineer control over the sound delivered to the audience. The microphones mounted on the body of the instrument capture the acoustic flute tone. Once amplified, altered, modified, or manipulated, these sounds are sent to the sound system within the hall. This technological adaptation allows the performer to create the ambient reverberation of a large cathedral, while performing in an unfavorably dry recital hall, or an outdoor location. I imagine the ability to alter the perceived sound-space of the performance venue will be a welcomed feature of the *Innova MIDI Flute* to flutists, composers, and audience members.

As noted in a previous chapter, the design of the *Innova MIDI Flute* allows it to be used for any standard repertoire. In addition, as it is an amplified instrument, any composition requiring an “electric flute”, could use this instrument in its place. Due to the
microphone placement, a true acoustic flute sound is produced for recording purposes. Flutists have the ability to achieve better acoustic representation of their sound during live performances, or recording sessions.
Chapter 5
Impact on Composition

While the acoustic flute has undergone many changes throughout its history -- from a simple open-hole instrument, to the modern Boehm flute now in common use -- the instrument’s inherent capabilities have remained essentially unchanged. At its core, the flute is a single voice instrument. Extended techniques have allowed for additional flexibility, but their use is beyond the capabilities of many flutists. Of late, various MIDI controlled flutes have been introduced in an attempt to provide composers and performers more flexibility, but with limited success. The Innova MIDI-flute allows for three separate styles of performance in a single instrument. With it, the composer can write for the acoustic flute, either with or without extended techniques, for a standalone MIDI-controller, or for a combination of acoustic flute and MIDI-manipulated sounds (i.e., electroacoustic music).

Having the ability to draw upon the traditional flute sound, and MIDI-controlled alternatives, affords the composer tremendous latitude. They now have access to a new, and extremely diverse pallet of sounds, textures, and effects. With the addition of microphones mounted on the body of the acoustic flute, the composer also has amplification at their disposal. This will allow for greater control of audibility in relation to the standard acoustic tone, as well as extended techniques. In circumstances where key-clicks, percussive based sound effects, and “speak-flute” are utilized, this enhancement through amplification could be a useful feature. As the Innova MIDI Flute acts as a MIDI controller, while employing software designed specifically for live performances, changes in amplification are possible without having to employ foot
pedals, etc. Once a key-mapping for volume levels, or contours, is assigned in Ableton Live, the flutist would have the ability to alter the amplitude of either the acoustic flute, or electronic sounds during a live-performance. By programming the software to recognize an on/off duration, rather than a simple momentary on/off trigger, this effect, as well as reverb, delay, ring-modulation, etc. can be increased or decreased as desired.

By design, the **Innova MIDI Flute** appears to be a standard Boehm flute. When utilized as a MIDI-controller, however, the composer uses it to trigger event cues with the depression of key combinations only, without producing an audible tone. By writing a notational score familiar to flutists, the **Innova MIDI Flute** overcomes much of the learning curve, and performance complexity of other MIDI flute designs. The flutist simply reads the score, and fingers the music as written, producing an electronic sound performance. As the score notation is identical to what flutists are already accustomed to reading -- with both pitch and rhythm designated -- performance consistency is attainable. In much the same way extended techniques are notated, the fingerings to send MIDI signals are shown in addition to the acoustic score.

One of the most valuable features of the **Innova MIDI Flute** is its potential for compositional variation. By combining the two techniques of acoustic flute and MIDI-triggered events, and allowing for their simultaneous use, the composer has at their disposal a true electroacoustic instrument. It is the use of the main event key, a separate master membrane switch, which determines the function of the flute at any given moment. With this master switch open, the microphones wirelessly send the acoustic flute sound to the offstage equipment. When the master switch is closed (depressed), the membrane switches in the key cups are engaged, and the flute now acts as a MIDI

63
controller, sending MIDI signals wirelessly. Without pressure-based systems, mercury switches, etc. used in some other designs, flutists are able to play the instrument without technological inhibitors.
Chapter 6
Future Development of the Innova MIDI Flute

The field of electronic/MIDI composition has enjoyed tremendous advancements in recent years. Due to the lack of a viable design, however, music for a MIDI-capable flute has lagged behind that of the guitar, keyboard, etc. The flute has evolved during its history, and just as the traverso flute became the Boehm style instrument we use today, a MIDI-capable instrument is needed if the flute is to take its place in MIDI composition and performance.

While I believe the Innova MIDI Flute has overcome many of the intrinsic issues other MIDI flute models presented, I feel the instrument is still within the early stages of development. Once feedback is received from performers and composers, details of the design may be altered, while many features may remain unchanged. It is through use and experimentation that the instrument will evolve into an accepted main-stream MIDI flute. As previous models were either overly complicated to construct, to learn, or to play, I believe the Innova MIDI Flute has successfully corrected these issues.

While Ableton Live performed successfully within the application for the Innova MIDI Flute, I would prefer to see a software program designed specifically for the instrument. In this setting, I would pre-program all possible key-mappings of the flute, and the flutist, or composer would simply assign effects/filters/patches/etc. to the appropriate key combinations for each composition. While I do not foresee issues with flutists being required to pre-set key-mapping combinations in a software program, I would like to simplify the overall process for the performer and composer, and a custom-tailored software program would satisfy this requirement.
Within this project, my main goals were the following:

- To create a wireless MIDI flute, free for movement on stage
- To design an instrument that could access acoustic flute tone, solo electronics, and a combination of the two from one instrument
- To build a MIDI capable flute that would be accessible to flutists of any level
- To incorporate the technologies used into the padding system of the instrument

While the Innova MIDI Flute is by no means a finished instrument, I believe I have successfully fulfilled my goals in this research project. For the future of this instrument, I envision custom-tailored software development, membrane-switch pads designed and produced for the Innova MIDI Flute, and further development of the wireless technologies used.


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