Design Appendix.

The *Big Thing*

I have included in this appendix the *Big Thing*. The *Big Thing* was a *Toy Symphony* project, which I worked on for one year, during the course of this thesis. This instrument was originally the final project proposed for this thesis. It was part of the larger *Toy Symphony*, for which I was the design director. Though many working prototypes and the communication hardware were completed for this project, for many reasons it was not finished. Collaborative work is complex. This project was originally intended to be a giant construction kit that allowed kids to compose music. Aligning the physical object with the composing of the music was difficult. In addition, the music concepts for this project took longer far longer to develop than the actual hardware. One major conceptual hurdle was the difference between a composition tool, (which analyzed the built structure and then "performed" the music), and a live instrument, (which reacted in real time to the actions of its player). This piece was also very expensive to build, because it

Figure A.1 Five foot, looks-like model of *Big Thing*, with upholstered base. This model had no electronics, but did have bungee cords for mechanical movement of the outer ring.

relied on the manufacturing of a limited number plastic objects, which involved expensive injection molds.

Though the project was not finished, there are a few very nice design decisions that might be helpful for later projects, including the sensing design for the individual *Chunks*. The following description is taken from my thesis proposal.

Description of The *Big Thing*

The *Big Thing* is a musical construction kit that gives kids a physical and direct way to twist, poke, prod, construct and perform their own musical compositions. The most basic building block of the kit is the *Chunk*. Chunks are both instruments for controlling real time music, and construction blocks for representing that music symbolically. In the *Poking Area*, Chunks can be poked and prodded into simple musical building blocks. They can then be constructed into a physical and musical arrangement on the construction *Islands*. *Operator Poles* are pieces that represent musical algorithms, which will rearrange the musical parameters of the Chunks. Kids will be able to use default algorithms in the Operator Poles, or program their own algorithms for the poles. *Stack Connectors* let the kids establish relationship between different parts of their composition. Kids can then perform and interpret their musical creation, just as they might perform and interpret a traditional composition, by manipulating the bouncy outer ring and stretchy the sensor bungee cords, or by adding their own feather sensors.

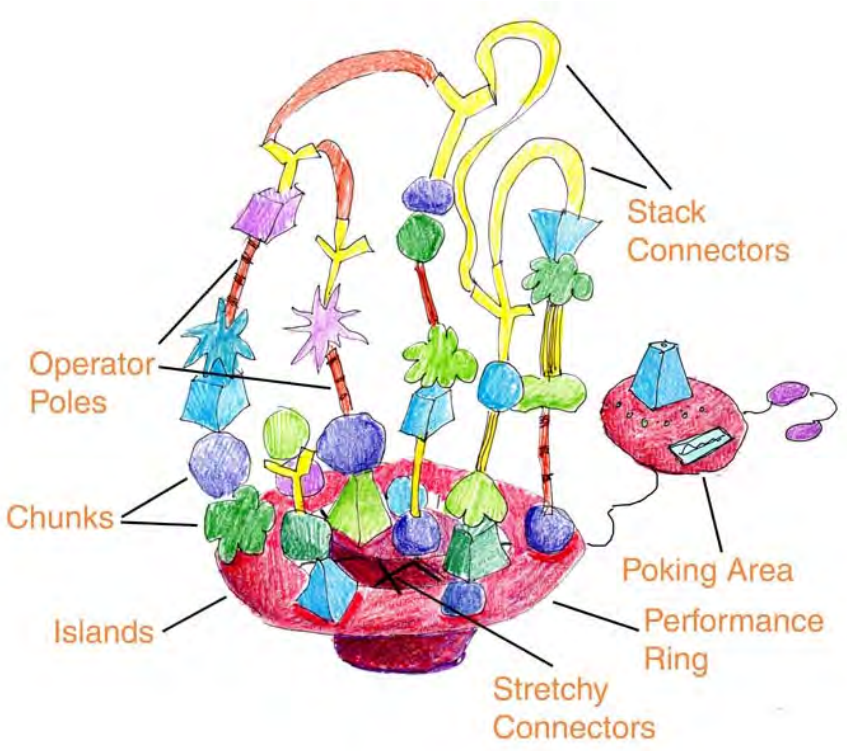

Figure A.2 Drawing of the *Big Thing*, Maggie Orth, 1999.

List of Kit Components

1 Construction Island
1 Poking Area
50 Musical Chunks
5 Reverse Direction Chunks
10 Stack Connectors
10 Y Connectors
10 Operator Poles
8 Stretchy Connectors
10 Feather Sensors
1 Musical Software GUI

The *Big Thing* is made for the stage and designed for performance in the *Toy Symphony*. In the *Toy Symphony*, there will be twelve musical islands, scaled UP to life size, for visibility from the stage. By keeping the underlying technology of the kit simple, The *Big Thing* can easily be scaled down for home play and produced as a commercial toy. In this way, the kit can be both a professional performance instrument and a home musical exploration tool. In the *Toy Symphony* there will be 1,000 Kit Components.

Description of Components

Islands

The Islands are the basic building platforms for the composition. Each Island contains 12 nodes into which chunks can be stacked. 4 of these nodes are located on the stable inner ring or base. This base houses speakers and other equipment. 8 of the nodes are located on the bouncy outer ring. The outer ring transforms the Island into an instrument that can be physically manipulated to create music. By pulling the

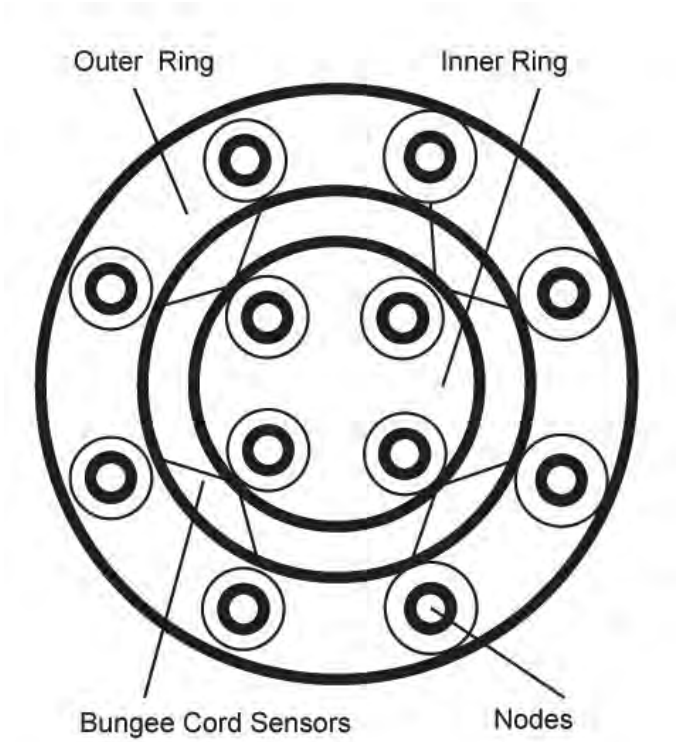

Figure A.3 Island form the *Big Thing*. Above, layout and plan. Below, artists sketch, Maggie Orth.

ring up and down, the Bungee Cord strain gauges are stretched, generating continuous data, which affects the parameters of the composed music. The Islands are 31 inches in diameter, allowing kids easy access to the building area, but providing enough room for a generous number of nodes.

Chunks

Chunks are the most basic building blocks of the BIG THING construction kit. Each Chunk represents a simple musical element that kids can compose themselves. When the Chunk is plugged into the Poking Area, its soft exterior can be used as a sensitive instrument. Careful design allows the Chunk to trigger pressure sensors located in the Poking Area, meaning it requires no on board sensors itself. Once the music is composed in the poking area, kids can mover the chunk to the Islands and make it part of a bigger composition. Each chunk contains a PIC, which has a unique ID for the Chunk and software to control serial and Chunk to Chunk communication. When a Chunk is plugged into a node, it transmits its ID serially to a main computer, which generates music. The software communication and physical building structure of the Chunks let players create simple linear stacks of Chunks. Both the identity and location of the Chunks can be known. The Chunks pass power, ground, serial communication and local communication over a 4 pin DC connector.

Poking Area

The poking area is flat base with a female connector where kit pieces can be plugged in. It contains four pressure sensors and few buttons. When a Chunk is

Figure A.4 Artist's drawing of Chunks, Maggie Orth.

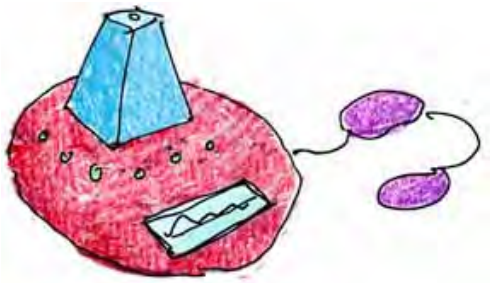

Figure A.5 Artist's drawing of Poking Area, Maggie Orth.

plugged into the Poking Area, kids can squeeze it to trigger sensors built into the base of the Poking Area. In this way, Chunks need no on board sensing capabilities. The Poking Area is also where kids can plug in Operator Poles to create their own musical algorithms.

Operator Poles

Operator Poles are long building blocks that represent musical algorithms. When an Operator Pole is plugged into a stack of Chunks it rearranges the musical parameters. Kids can plug the Operator Poles into the Poking Area and compose their own musical algorithms as well.

Figure A.6 Operator Poles.

Stack Connectors

Stack Connectors let kids connect stacks of chunks together and establish a relationship between the stacks. Currently, the plan is to use stack connectors to pull a longer musical melody form a sound and music texture.

Figure A.7 Stack Connectors

Stretchy Connectors (Conductive Bungee Cords)

Stretchy Connectors connect the out ring to the inner and let players manipulate and interpret the musical composition in real time. These bungee cords are made form woven conductive thread, (Stainless steel and polyester composite) and non-conductive thread around a stranded rubber core. When the bungee cord is stretched, the conductive fibers tighten together and the resistance across the woven structure of conductive threads drops. The change is resistance is measured in simple voltage divider.

Feather Sensors

Feather sensors will use the actual piezoelectric effect in real feathers to measure their movement when plugged into the construction base. Each feather will control a singe stack of Chunks, and in particular, the amount of the musical algorithm that affects the Chunks.

Implementation of *Big Thing*

Overall Schematic of *Big Thing* Infrastructure

One of the main goals of the *Big Thing* is to design a digital construction kit that can be easily translated into an inexpensive and manufacturable commercial toy. To do this, the physical construction kit will use the simplest technology possible, while the major computational and musical functions will take place on a PC and synthesizers. In the toy version, the PC and synthesizers can be replaced with less expensive elements, for instance, a SEGA game system, or simple on board, “toy” synthesizers.

The *Big Thing* will communicate serially with a PC, which will send MIDI to synthesizers, which will generate music in the speakers built into the Island. On each Island, each Node will send serial information from the Chunks plugged into it, to the PC. The PC will keep track of the physical configuration of the Chunks, changing the music accordingly.

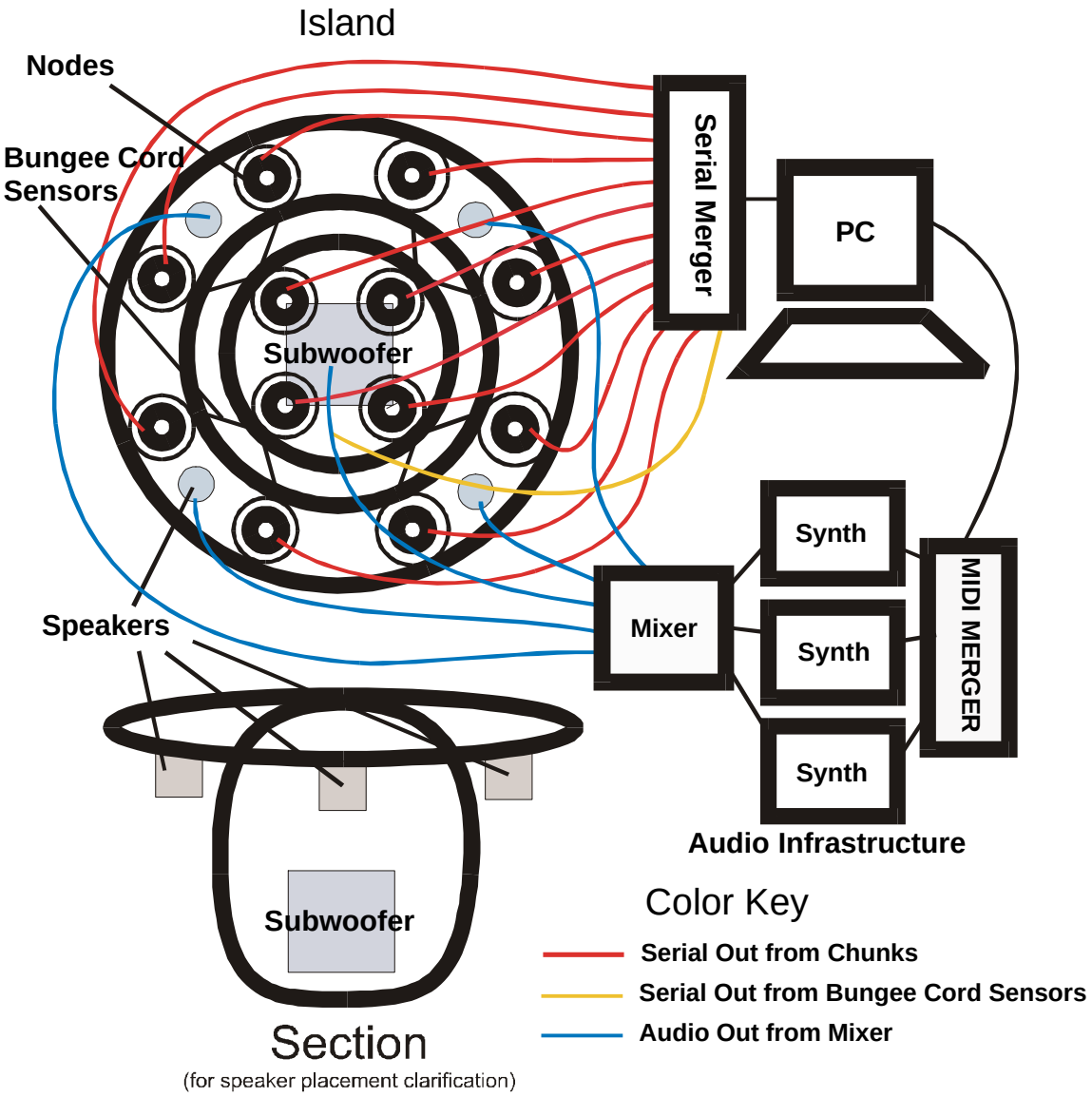

Figure A.7 Overall layout of *Big Thing*.

Physical Chunk Design

Each Chunk will contain the minimum hardware required to keep track of its identity, light LEDs (to communicate that it is musically active), and to communicate its location over a serial bus with a central processing unit, (PC). The Chunks communicate through a 5 pin, custom, DC electrical connector. While the Chunks have no sensors of their own, they can be used as a sensitive instrument when plugged into the Poking Area, where their soft, foam wings can be squeezed to manipulate the 4 pressure sensors, (and consequently music) that are built into the Poking Area itself. Building the sensors into the Poking Area keeps the Chunks simple and cheap. Each Chunk's central connector and wings will be injection molded. The Poking Area will be manufactured by hand.

Chunk Communication and Electronic Design

Each Chunk will contain a PIC programmed with a unique ID and a number of LED's. The Chunks will connect linearly into one of 12 Nodes in the Island. Each Node has its own serial management board, which manages communication between the Chunk stack and the PC. The Chunks use both serial and PIC to PIC communication, enabling them to communicate quickly (serial) and to know the order of the Chunks in the stack (PIC to PIC). The PC polls them over an serial bus. If a Chunk recognizes that it is the last Chunk (it sees no connection to ground on its "Last Chunk Identifier Pin"), it sends it's ID to the Chunk below it, which adds its ID to the one it received sends that ordered list of ID's to Node board, which forwards the ordered list to the PC.

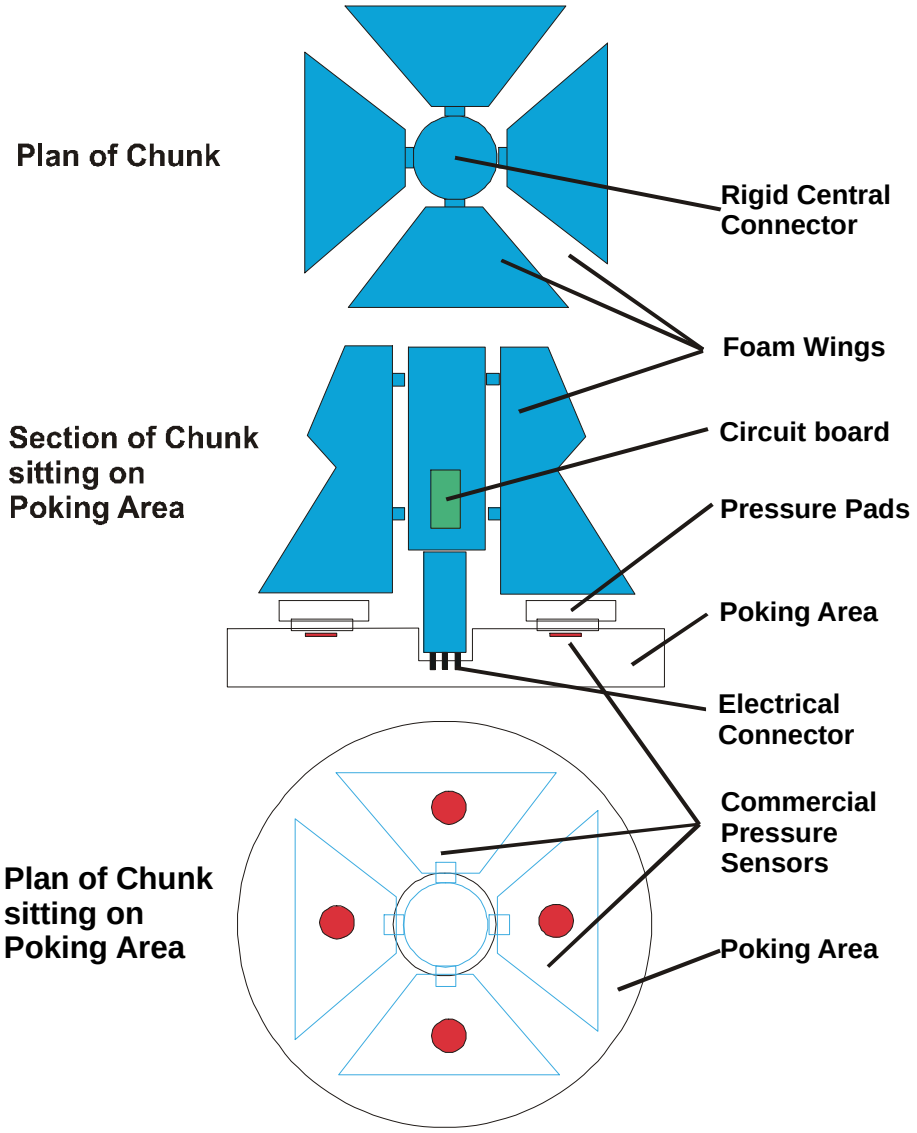

Figure A.8 Diagram of Chunk.

All the pieces of the kit that connect together, i.e., Y Connectors, Operator Poles and Stack Connectors, use the same hardware, the Chunk board. Stack Connectors contain one Chunk board at each end, but no internal connection. Y Connectors are merely wires. Operator Poles contain one Chunk board as well.

Figure A.9 Working prototype Chunk with electronics.

General Schematic

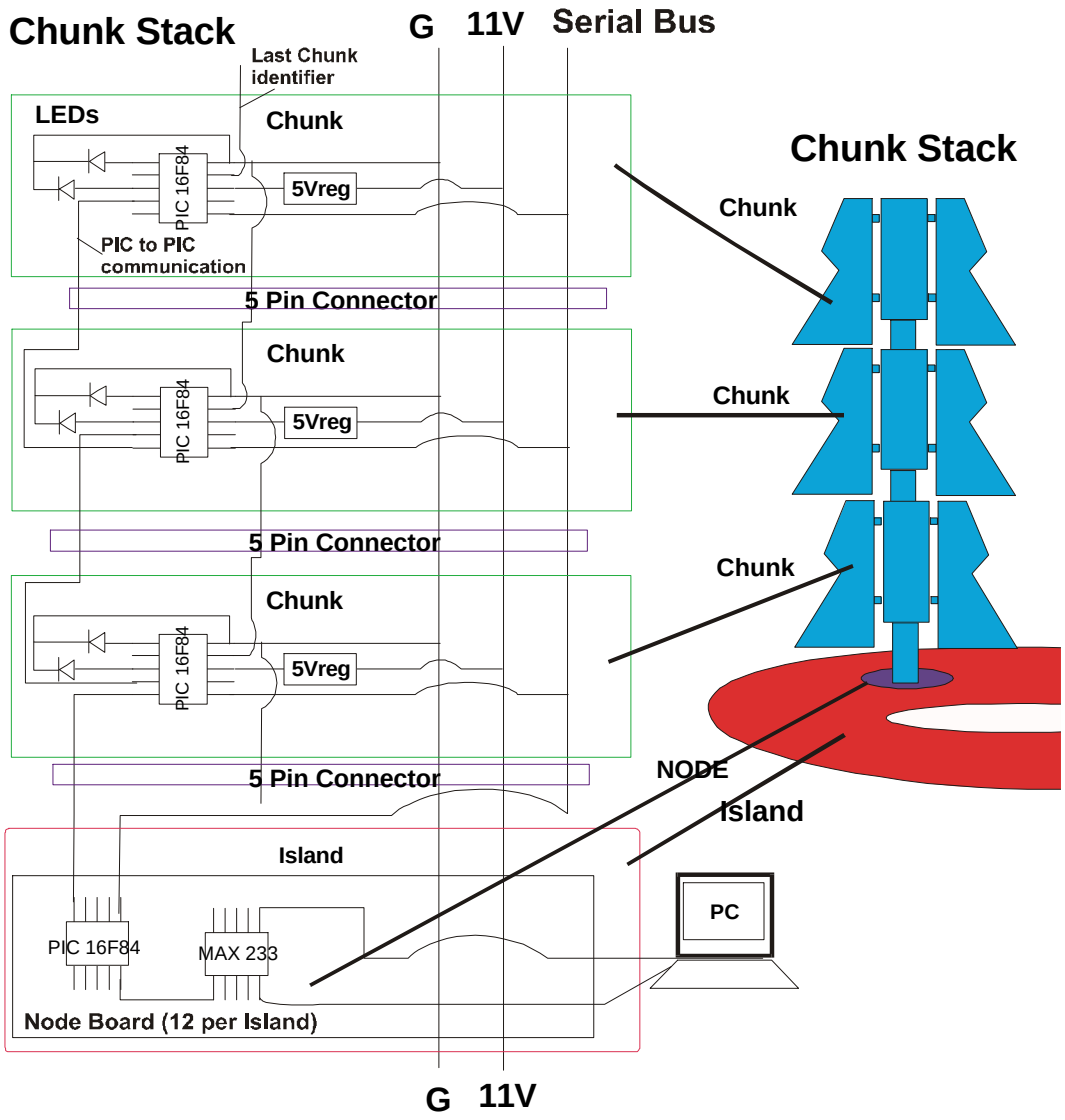

Figure A.10 Diagram of communication scheme and circuit design for a Chunk stack.

Bungee Cord Sensors

Each Island will have 8 bungee cords sensors woven from non-conductive and conductive thread. When the bungee cords are stretched, the resistance across them decreases in a predictable manner, allowing a microprocessor to measure this change with voltage divider. Because the conductive threads' resistance varies under tension in a non-repeatable manner, it is the woven structure of non-conductive and conductive thread together that creates a repeatable variable resistance in the sensor. As the sensor is tensioned, the conductive threads get closer together, increasing the sensors overall conductivity. For the sensor to work properly, it must be pre-tensioned, eliminating the change in resistance that occurs at the thread level, and letting the change in resistance that occurs at the woven level dominate the measurement.

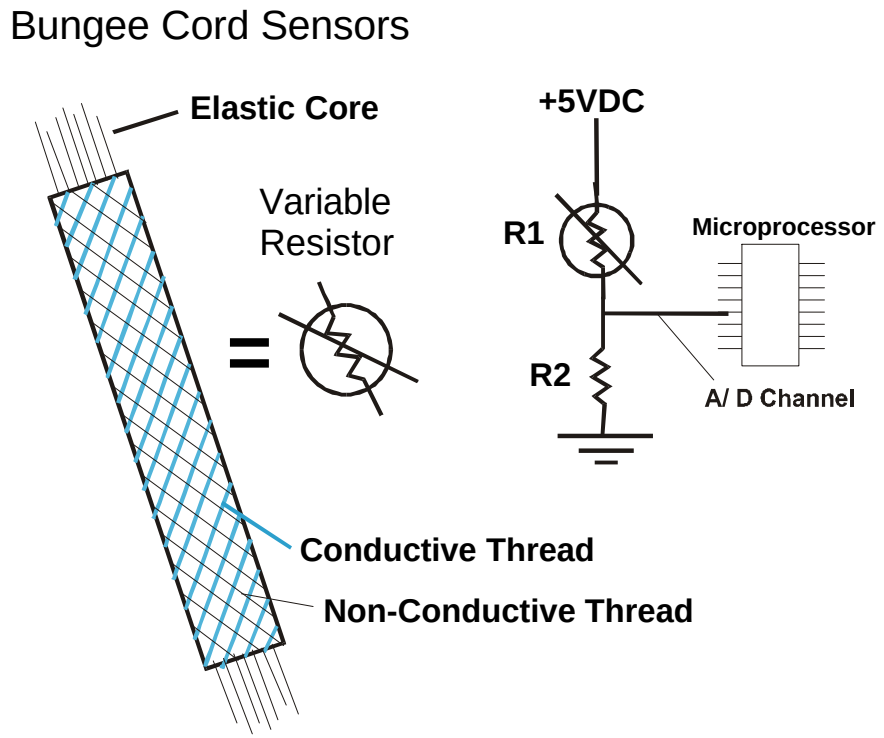

Figure A.11 Proposed bungee cord sensors, (not completed).

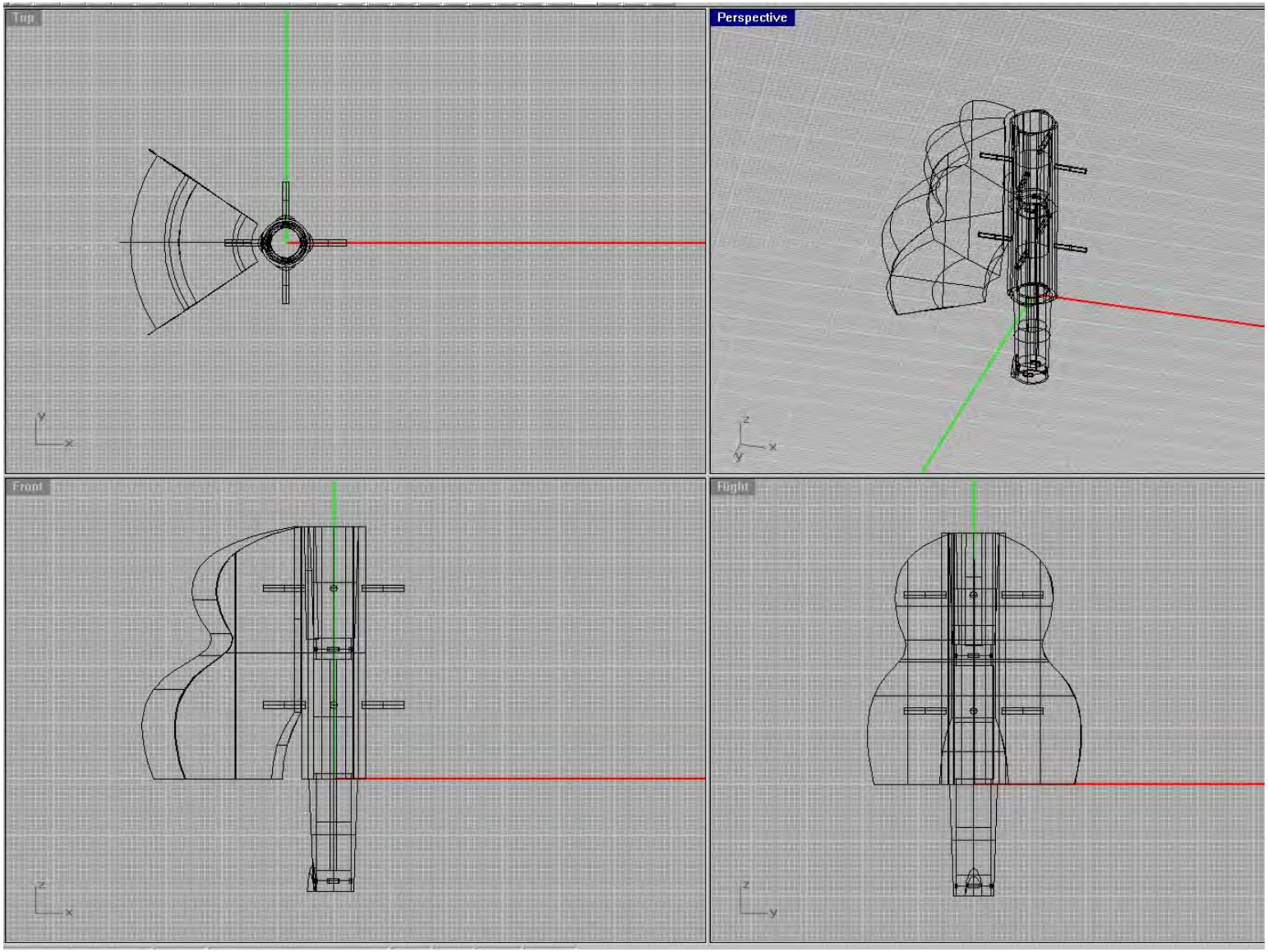

Figure A.11 CAD file of final Chunk design, with foam wing and connector core.