September 26, 2005

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal for an Octophonic USB Electronic Guitar

Dear Dr. Rawicz,

Our ENSC 440 project group, GKS Digital, has set our goal to design an add-on system for guitars that allows recording via a simple connection to a PC. This system will allow more flexibility for musicians while significantly reducing the cost of recording. We have outlined our project in the attached document, *Proposal for an Octophonic USB Electronic Guitar.*

The proposal document gives an outline of our proposed product (Hydra), currently available solutions, a provisional budget, information on our team's organization and our plan for completing the GKS Digital Hydra.

Three dedicated, innovative and motivated final year undergraduate engineering students comprise the GKS Digital team. The team is led by our CEO Eli Gibson, driven by our CTO Kamil Kisiel and kept in check by our CFO Derek Sahota. Please feel free to contact me via phone at 604-299-4773 or by email at eli.gibson@gksdigital.com if you have any questions regarding this proposal.

Sincerely,

Eli Gibson CEO GKS Digital

Enclosure: Proposal for an Octophonic USB Electronic Guitar

cc: Mr. Steve Whitmore, Mr. Mike Sjoerdsma, Mr. Brad Oldham

GKS DIGITAL

Hydra

Octophonic Guitar Pickup

Management Team:	Eli Gibson, CEO
	Kamil Kisiel, CTO & Marketing Manager
	Derek Sahota, CFO & R&D Manager
Contact:	Eli Gibson eli.gibson@gksdigital.com
Submitted to:	Dr. Andrew Rawicz
	Mr. Michael Sjoerdsma
	Mr. Steve Whitmore
	Mr. Brad Oldham
	School of Engineering Science
	Simon Fraser University
Issued Date:	September 26, 2005
Revision Number:	1.00

Executive Summary

Over the past two decades, a digital revolution in audio has shaken the professional recording industry to its foundation. The insatiable desire of musicians to create music combined with access to affordable recording technologies has caused a shift in the balance of power from the recording industry to the musician. Lower costs have caused the pool of recording artists to swell considerably and have allowed some of these home recording musicians to become superstars.

One particularly stellar example of this trend is the artist Moby. His first hit album *Play* sold over ten million copies, yet it was recorded, produced and mixed by just one person: Moby himself [1].

Despite Moby's fantastic success, there are still significant barriers for musicians who want to record in a home studio. For a guitar recording set up, thousands of dollars are spent on audio cables, power wires, mixing boards, computers and sound cards, only to end up with a rats-nest of equipment. But there is a better way: GKS Digital proposes to develop a system that will reduce this down to just one simple wire and a basic PC. The Hydra system we propose to design will be cheaper, more flexible, easier to use, and produce better sound than any competing device.

The home studio industry is still in its infancy, yet many products are already available at many different price points. High end solutions include analog hexaphonic audio recorder setups, which require approximately $1500 of guitar accessories and equipment, and would provide quality and flexibility comparable to the Hydra. Mid range solutions include guitars with flexible on-board modeling, such as the Variax from Line6 [2], which allow impressive live performance, but limit the flexibility of post-processing by outputting only a single analog signal with poorer signal quality. Low end solutions, such as a single channel analog to USB converter, allow digital recording at a reasonable cost, but loses the flexibility and creative control of guitar modeling. In all the price ranges, no single product can offer the ease of use, low cost, high quality and flexibility of the Hydra.

The system proposed in this document allows a guitarist to simply connect their guitar to the standard USB port, available on nearly every modern PC computer, and begin recording. The vibrations of the string are measured using widely available bridge pickups and then converted into digital information. This information is sent along the USB bus to the computer for recording. During recording or post-processing, the musician is able to go to their computer and use GKS Digital's Chimera software to control the tone and alter the sound of their guitar to fulfill their creative desires. The final output is a high quality digital recording that sounds exactly as the musician intended.

To make this vision of home studio recording a reality, GKS Digital has a team of three final-year engineering students with a myriad of design, research and development experience. Included in this experience base are skills in analog and digital design, signal processing, audio processing, system modeling, and, perhaps most importantly, guitar. The

team has extensive software experience including real-time multimedia processing, microcontroller assembly programming and system level driver implementation.

The engineering cycle for this project is scheduled to take 18 weeks from September 16, 2005 to January 13, 2006. During this cycle, various stages of working prototypes of the Hydra system will be created. The final prototype will have the ability to record eight individual streams of audio from a guitar and store them on a personal computer. The development cost for the prototype and its demonstration suite is estimated to be $1080. We expect to obtain funding from external organizations, as well as from the owners of GKS Digital.

Table of Contents

Introduction

The digital revolution in the music industry has shifted recording from expensive professional studios right into the homes of the musicians. Advances in technology and ever increasing computing power have allowed even casual amateur musicians to obtain professional quality results for a fraction of the cost. Nevertheless, there is still room for improvement. One area where costs can still be reduced, and processing of audio made even more flexible, is in the pickup of audio from instruments. The GKS Digital Hydra allows musicians of all abilities to cut costs by eliminating the need for complex and expensive PC audio interfaces.

The direct USB connection allows artists to just plug in and record music without the need for any additional equipment like expensive recording interfaces or microphones. Effects can be applied live or after recording

By individually transmitting the sounds from each guitar string, the Hydra opens up a whole new realm of processing possibilities that were simply impossible with traditional means. For example, the signal processing software on the user's PC could recognize the notes being played and record them in to a musical score, or transform the sounds in to the sound of another instrument through synthesis. These techniques are not possible to implement if the guitar was recorded from a single analog source.

By moving the digital revolution even closer to the musician, the Hydra reduces the cost of recording music while giving musicians more control than ever before.

This document provides an overview of our proposed system, an analysis of potential competing products, details of our design, and an outline of future market expansion. Also covered are the project's budget and intended sources of funding as well as the schedule. Additionally, it provides some information about the team and profiles of the members.

GKS
DIGITAL
1396 El Camino Drive, Coquitlam, BC, V3E 2W6

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

System Overview

The technology behind the Hydra is designed to be applicable to any guitar. The purpose of the system is to convert the vibrations of the strings on the guitar into digital signals that are sent to a PC via USB. The saddles in the guitar's bridge convert the sounds of each string in to an individual electrical signal which are digitized by the digitizer module. The signals are then transmitted via USB to the user's computer. GKS Digital's Chimera software package will then allow changes to be made to the tone, mood and sound of the guitar. It will also allow modeling other guitars, turning one physical guitar into many different sounding instruments. The audio can then be processed digitally using any PC audio software package to turn it into a final product.
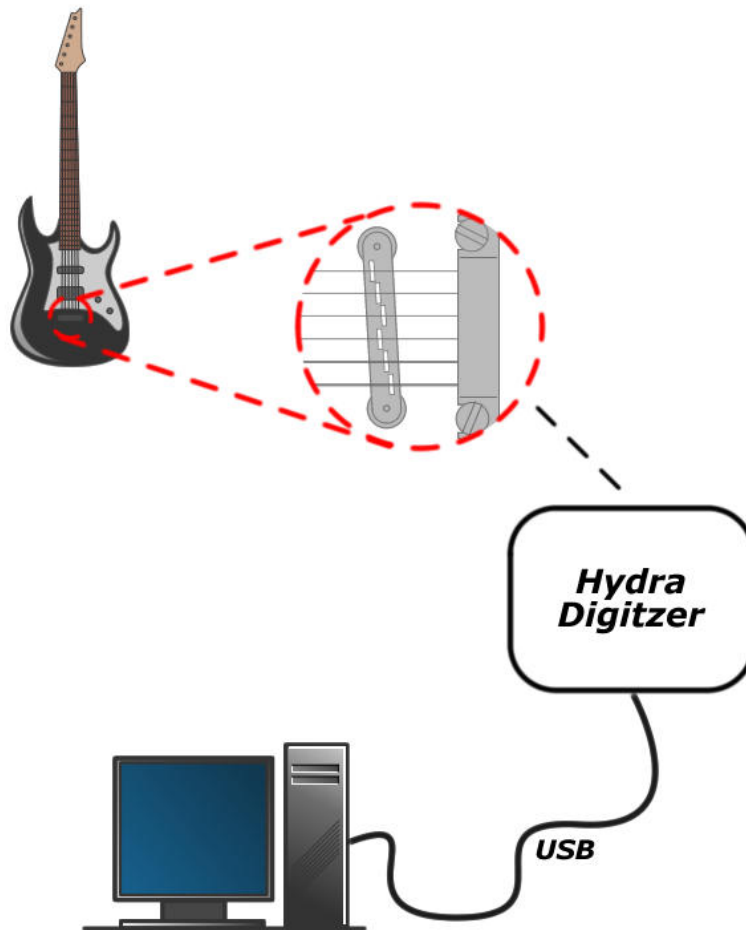

Figure 1: GKS Digital Hydra System Overview

Competitive Analysis

Several efforts have been made to give home recorders more control over their electric guitars, but each of them has drawbacks.

Traditional Analog Recording

Traditionally, electric guitars have been recorded in one of two ways, using a preamp made specifically for recording, or placing a microphone in front of a normal amplifier. The primary drawbacks of using an amplifier and microphone are the space required by the amplifier, the cost of the amp and microphone, as well as the requirement of a room with adequate acoustics. Also, most amplifiers need to be "cranked" to high volumes not typically tolerable in a home studio setting before they sound good. Preamps such as the Mesa Boogie Triaxis [3] or the POD from Line6[4] are suitable for direct recording in combination with a PC soundcard but can be quite expensive and do not offer the processing flexibility of a system like the Hydra.

Hexaphonic Analog Recording

To provide additional processing capability some manufacturers have produced so-called "hexaphonic" recording systems that allow separate recording of each string sound. The most mainstream of these, Roland's GK 13-pin [5] interface, uses 6-8 analog signals to transfer audio to a device. In order to separate the signals for processing the musician requires a fanout box such as the popular model available RMC [6]. The individual signals from the fan-out box then need to be connected to a professional quality audio card in the musician's PC. The biggest drawback of the system is the cost of extra components, with the pickups ranging from $150-$350 US, depending on the guitar model. Additional recording equipment adds at least another $600 to the price, putting the total at approximately $1000. The complexity and cost of such a setup puts it out of reach of the typical home recording enthusiast.

On-guitar Modeling

Another alternative is to add control by moving the digital processing system onto the guitar, and sending out the final signal as analog. This configuration is used by the Variax guitars by Line6 [2]. While this does allow for modeling a wide variety of guitars, it limits the musician to the features active in the guitar at recording time. In addition, the single analog output of the Variax means that there are 3 stages of signal conversion, which can lead to signal quality loss. Furthermore, unlike the full analog recorder, the users of the Variax are unable to do the sophisticated post processing on their playing as the signals from each string are mixed on the guitar itself. To achieve the full potential of the Variax system requires several hundred dollars worth of additional equipment from Line6.

GKS
DIGITAL
1396 El Camino Drive, Coquitlam, BC, V3E 2W6

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

Proposed Design

Our proposed design, the Hydra digital octophonic pickup, is a guitar accessory that can be built into new guitars or added on aftermarket. The design consists of a set of guitar saddles which rest under the strings, and record the string motion. The signal is immediately converted into a digital signal to preserve the purity of the original signal. This new digital signal is sent directly to the standard personal computer using a USB connector, where it can be processed in real-time or saved for later interactive processing. The recorded audio will be in a format that is usable by most audio software applications, allowing the musician creative control over her home studio environment. GKS Digital's Chimera processing package will be in the form of industry standard plug-ins to ensure that our system does not limit the work flow of the musician.

Advantages of the Hydra Project

- The use of digital signals allows the signals to be preserved without error as it is moved to the personal computer.
- The immediate digitization of the guitar signals ensures that minimal noise is introduced into the recorded signals.
- The use of a ubiquitous standard, such as USB, means that no extra costly recording equipment will be necessary.
- The use of a standard personal computer means most musicians will already have a system that can be used with the Hydra.
- Industry standard plug-ins for processing allows the musician to use a home studio set up that they are comfortable with.
- The software-based processing means that the power of the system can easily and cheaply be expanded.

Potential Difficulties

For this project, GKS Digital will be facing tight constraints on the allowable design time and cost. While this project is far from trivial, GKS Digital has taken several measures to ensure that we complete this project within our time and monetary constraints. The design of the Hydra will be broken down into several iterations. Each iteration will produce a prototype for a marketable product. The first iteration includes the guitar digitization and communication modules, and a minimal computer interface. Each additional iteration allows GKS Digital to enhance the Hydra system by adding software components, including real-time processing, guitar modeling and guitar lessons. These iterations not only provide an opportunity to bootstrap the finances of GKS Digital, but also provide an easy mechanism to segment our market through software capabilities.

Competitive Comparison Chart

	GKS Digital Hydra	Analog Hexaphonic Systems	Variax Guitars
Information from each string	✓	✓	✗
Low Cost	✓	✗	✗
Connects to PC	✓	✗	✓
Records to PC	✓	✗	✗
Guitar Effects for Live Performance	✗	✗	✓
Software for Better Sound Control	✓	✗	✓

Table 1: Comparison between the GKS Digital Hydra and two competing solutions

GKS
DIGITAL
1396 El Camino Drive, Coquitlam, BC, V3E 2W6

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

Future Market Expansion

While the initial target market for the Hydra is high caliber musicians recording in their home studios, our product offerings have the flexibility to expand into wider markets as well. The Hydra has the flexibility to move into these markets with little to no hardware redesign, leveraging the power of software modules for any necessary functionality enhancements.

Guitar Manufacturers

While our product is initially targeted as an aftermarket add-on to electric guitars, the ease of use of our system makes it an attractive option for building into guitars. With the relatively low cost of the Hydra, we will be able to approach high volume guitar manufacturers such as Fender and Ibanez to incorporate our hardware and software into their products. While this is by no means an easy market to enter, there is opportunity here as guitar vendors develop products to compete with the flexibility of guitars like the Variax from Line6. Smaller guitar builders or custom shops which are less conservative and traditional in their guitar designs are also a likely target for our product.

Consumer Level Musicians

A second market that the Hydra can enter is the lower end consumer market. At an estimated total system cost of around $200 it provides a simple low cost solution that allows budding musicians to easily record on to their PC's without having to invest in a lot of additional equipment.

Guitar Beginners

Another key advantage of the Hydra system is that by recording each string individually, it is much simpler to identify the notes and positions a musician is playing on the guitar. This opens up possibilities for interactive computer guitar lessons, where a teaching program can tell how well you are following its instructions and playing along with tutorials. With guitar lessons costing $30-60 per hour this type of system can provide a powerful alternative training solution.

Source of Information

In designing the Hydra, we will draw upon a myriad of informational resources available to us.

Market research will be drawn from sources including Kamil Kisiel's music industry connections, and the SFU Music department faculty and students. This will guide our functional specifications.

Technical research will be drawn from a variety of sources, including academic text books, manufacturer component datasheets, technical reference books such as *Complete USB* [7], and, of course, past experience. Another resource we hope to draw upon is the help of engineering faculty with an interest in music and multimedia, such as Lakshman One, Patrick Leung and Dr. Jie Liang. These resources will help guide both functional and design specifications.

Several previous undergraduate projects have used the same technologies that we are using in very different applications. In specific areas, however, this expertise will be very useful. Brandon Ngai and Josephine Wong both have experience with programming USB 2.0 interface devices and developing drivers to be used on a standard home computer. Several other groups have experience with A/D converters for audio applications and they will also prove to be valuable resources. Project Hydra will be able to draw on a wide body of technical expertise from both within the School of Engineering Science at SFU and from many other external sources.

Budget

An overview of the budget for our prototype Hydra is given in Table 2. This budget includes expenses for building both an engineering prototype and two production quality prototypes. Also accounted for are increased shipping charges to receive parts in time to meet our compressed development schedule. In general, a 20% overestimate has been used to buffer the budget for unforeseen circumstances.

The cost of both the engineering and production prototypes is significantly inflated by several factors, such as the necessity to buy certain parts from the retail channel. The cost for guitar manufacturers to integrate this technology in their products will be a small fraction of cost of the prototypes.

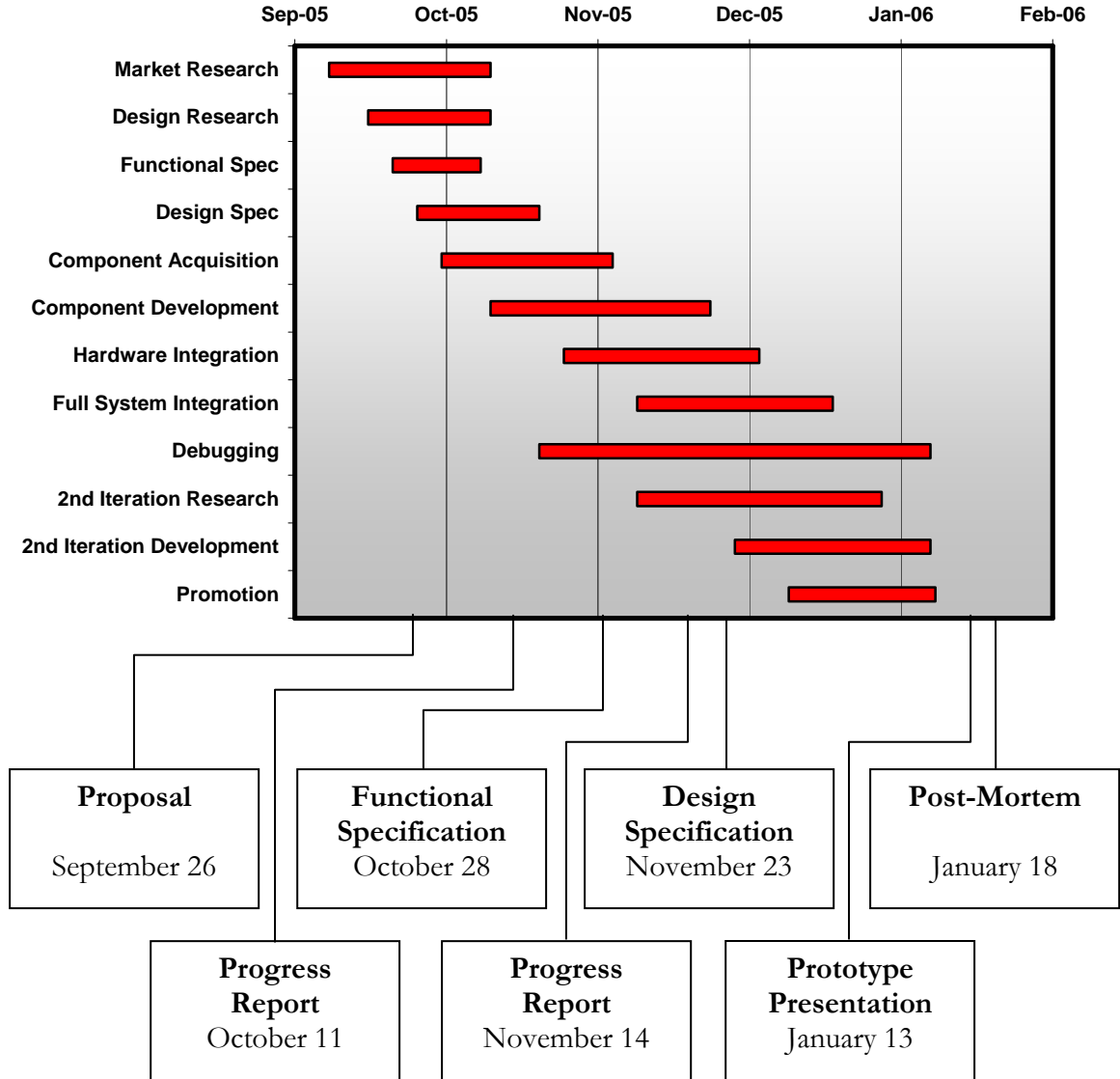|	
Guitar Body	$150
Guitar Saddle Kit	$195
Signal Conversion Electronics	$60
Prototyping Equipment	$310
PCB Fabrication	$300
Miscellaneous Electronics	$65
Total	$1080

Table 2: Prototype Development Budget for the GKS Digital Hydra

Funding

To offset these development costs, GKS Digital is applying to several organizations to procure funding. Proposals are being written for funding from both the Engineering Science Student Endowment Fund (ESSEF) and the Wighton Fund. Additional funding sources will also be explored as they become available.

In the case that accrued development costs exceed external funding, GKS Digital's management team accepts that they will have to bear these costs. Payment for total excess costs will be distributed amongst the entire management team. Our Chief Financial Officer will ensure that accurate records are kept for both expenses and reimbursements. GKS Digital also plans to enter the Hydra Digitizer Design into the annual Western Engineering Competition (WEC) in January 2005 and use any proceeds to fund development.

Project Schedule and Deliverables

	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06
Market Research						
Design Research						
Functional Spec						
Design Spec						
Component Acquisition						
Component Development						
Hardware Integration						
Full System Integration						
Debugging						
2nd Iteration Research						
2nd Iteration Development						
Promotion						

Proposal

September 26

Functional Specification
October 28

Design Specification
November 23

Post-Mortem

January 18

Progress Report
October 11

Progress Report
November 14

Prototype Presentation
January 13

Deliverables

gKS
DIGITAL
1396 El Camino Drive, Coquitlam, BC, V3E 2W6

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

Team Organisation

The three members of GKS Digital have a diverse mix of skills and experience allowing each team member to seamlessly fit into a number of roles within the project. Our three team members are in their final year of study in their undergraduate engineering degrees and have accumulated a significant amount of work experience through a co-operative education program. Two of our members are specializing in Computer Engineering and the third in Engineering Physics. A more detailed account of each member's experience is given in the Company Profile.

The three team members will each have dual roles within GKS Digital. From the corporate side, each team member will be responsible for one of the following roles: CEO, CFO and CTO. Each member will manage their respective corporate portfolio and ensure the proper corporate governance practices are followed. Eli Gibson will be the CEO in charge of the entire project and be responsible for maintaining team stability. Our CTO, Kamil Kisiel, will be responsible for the ultimate design and completion of the technological solution. As CFO, Derek Sahota will be responsible for maintaining the budget, organizing funding and resolving other financial matters.

The duality of each team member becomes apparent when the project is considered from an engineering stand point. Clearly the technological solution will require a significant amount of time input from all the group members. On the engineering side Derek Sahota will be in charge of researching and developing the solutions for modeling guitars. Kamil Kisiel will be responsible for the overall hardware design. Finally, Eli Gibson will be responsible for the overall software design. Smaller tasks will be assigned based on expertise and time availability to the group member who best fulfills those criteria.

GKS Digital will be using modern technology to the fullest to ensure good communication between group members. While weekly face to face meetings will be scheduled, online discussions via instant messaging systems will allow the members of the group to co-operate on the project even when they are not in the same location. To further encourage collaboration, all documentation and project work, including this proposal, will be completed via an online project management system. This system allows all team members constant access to the materials produced by the other team members as they are written and allow all members to simultaneously contribute to all documentation. GKS Digital believes that the combination of properly used technology and good people will allow us to complete the Hydra within the timeframe allocated and with very positive group dynamics.

GKS
DIGITAL
1396 El Camino Drive, Coquitlam, BC, V3E 2W6

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

Company Profile

Eli Gibson - Chief Executive Officer

Eli Gibson has served as CEO of GKS Digital since its inception in 2004. Prior to forming GKS Digital, he was CEO of Ambera Electronics. Mr. Gibson has several years of experience leading design teams, including firmware development and embedded design. He has received scholarship awards for innovation and academics. Five years of teaching experience, both in a classroom and out, have given him skills to manage fairly, but firmly. He has the charisma to succeed in management and is a trusted figure among all of his colleagues.

Kamil Kisiel - Chief Technology Officer and Marketing Manager

With his many years of experience with the semi-professional and home recording music communities, Kamil Kisiel brings deep domain knowledge to the team. His focus has always been on unique sounding software synthesis and digital audio processing technologies. As a musician himself, Mr. Kisiel has the insight necessary to make GKS Digital a success. His knowledge of the market, his network of music connections, and his love of music form a foundation upon which GKS Digital can develop.

Derek Sahota - Chief Financial Officer and R&D Manager

As the owner and operator of several small businesses, Derek Sahota has the financial acumen necessary for leading GKS Digital. As the Internal Accountant for Geostar Investments Ltd, Mr. Sahota has proved his ability to effectively manage financial assets. Additionally, his extensive background in the mathematical modeling of physical systems and noise effects, make him an ideal leader for our Research and Development team. He also has experience with a wide range of computer programming languages from Assembler to Python to XML; Mr. Sahota has the ability to find and use the best solution for the problem.

GKS
DIGITAL
1396 El Camino Drive, Coquitlam, BC, V3E 2W6

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

Conclusion

GKS Digital is committed to producing a high-quality, flexible and easy to use music equipment. The Hydra octophonic pickup system opens our product line with an accessory to make it easier than ever to get your music into a home studio computer.

Our powerful recording set up will make incredible musical control possible, and open up new markets for our products. Supporting industry standards from start to finish, our accessory is flexible enough to fit into musician's home studio, or to start from scratch with just a guitar and a computer. Our simple interface makes it easy for any musician to start recording their music. The Hydra is powerful, flexible, and easy to use at a price that is within the reach of the torrent of new amateur recording musicians.

This proposal shows the focus that is necessary to bring this project to fruition. The budget and timeline constraints demonstrate the processes that we know are necessary for success. Our committed team has the necessary drive to take this proposal and nurture it into the guitar recording system of tomorrow, the GKS Digital Hydra.

With the right product, at the right price, GKS Digital is ready to bring the digital revolution right to the musician's fingertips. Prepare for the GKS Digital Hydra.

Phone: 604-789-6840
Fax: 604-467-8142
Email: inquiries@gksdigital.com

1396 El Camino Drive, Coquitlam, BC, V3E 2W6

References

[1] Line 6 Inc, 2005. "Line 6 – Variax." http://line6.com/variax

[2] Tom Pareles, 2005. "Home Sweet Studio." *New York Times.* http://www.nytimes.com/2005/03/20/arts/music/20pare.html?ex=1127880000&en=93f4ca4bd74ad814&ei=5070&pagewanted=1&oref=login&oref=login

[3] Mesa Engineering, 2005. "Mesa Boogie Triaxis Pre Amplifiers." http://www.mesaboogie.com/Product_Info/Rackmount-Preamps/TriAxis/triaxis.html

[4] Line 6 Inc, 2005. "Line 6 – POD." http://line6.com/products/pods

[5] Roland Corporation, 2005. "Roland GK-3 Divided Pickup :: Overview." http://www.roland.com/products/en/GK-3/

[6] RMC Pickup Company, 2005. "RMC Pickups: The Fanout Box." http://www.rmcpickup.com/fanoutbox.html

[7] Axelson, Jan. "Complete USB" Lakeview Research. Wisconsin: 2001.