September 24, 2007

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

Re: ENSC 440 Project Proposal for Trans Dental Monitoring Solution

Dear Dr. Rawicz,

The attached document, Proposal for the Trans Dental Monitoring Solution, provides an outline for our proposed project idea for the Capstone Project. Our goal is to design a unit which allows the dentist be informed when the anaesthesia effect on the patient tooth is about to expire.

This proposal will provide an overview of the proposed product, discuss the design considerations, list our sources of information, and outline an estimate of the budget and funding required. In addition, the tentative schedule and team/company organization will be provided.

Trans Dental Technologies consists of four enthusiastic and innovative final-year engineering science students: Isabella Taba, Petar Ivaz, Bahman Sotoodian and Mohammadali Khorasani, each of which contribute to the diversity of the group while sharing the same interest of wanting to make a difference. Please feel free to contact me at skhorasa@sfu.ca with any questions or concerns regarding our project proposal.

Sincerely,

Mohammadali Khorasani  
Chief Executive Officer  
Trans Dental Technologies

Enclosure: Proposal for the Trans Dental Monitoring Solution
Proposal for the

TRANS DENTAL MONITORING SOLUTION

Project Team
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Submitted to
Dr. Andrew Rawicz – ENSC 440
Mike Sjoerdsma – ENSC 305

Issued date
September 23, 2007

Revision
1.0
Executive Summary

Evidence has been found of teeth having been drilled 9000 years ago. Therefore, for 9000 years people have dreaded their visit to the dentist! The two most hated events at the dental office are the administration of the needle to numb the teeth and the drilling of the teeth. The pain and anxiety experienced by some patients when a tooth is being drilled due to a lack of numbness can cause emotional trauma that lasts a lifetime. It is estimated that between 5 and 15% of the population in western countries avoid dental care due to fear.

After the administration of anaesthesia, the dentist gauges the level of the achieved anaesthesia by asking the patient about subjective signs such as numbness or tingling. At this point anxious patients fall into two categories: 1) Those who under no circumstance would like to receive another needle and tell the dentist whatever he/she wants to hear and profess profound anaesthesia, 2) Those who are convinced that the anaesthetic is inadequate and would like another injection “just to be sure” the tooth is frozen. The patients in category 1 will be tormented during the procedure and will likely shy away from dental procedures in the future or only seek dental treatment in extreme situations. Patients in category 2 will experience the untoward side effects of prolonged anaesthesia and run a higher risk of injury due to needle fracture, injection into an artery or vein, or even nerve damage and death.

During long dental procedures, the dental anaesthetic concentrations may drop below the amount required for numbness and the patient begins to squirm in the dental chair. The dentist will be forced to administer more anaesthetic in order to make the patient comfortable. However, the patient’s anxiety level has been increased and the confidence in the dentist shattered.

This document proposes the development of a device that can be placed on the tooth and monitors the activity of the tooth nerve. It is proposed that a tooth that is anaesthetized will show no nerve activity. Furthermore, a tooth that is “awake” or “waking up” will show nerve activity and the dentist can administer anaesthetic to achieve profound anaesthesia. This device will be the first objective method for measuring dental anaesthesia and will remove the guesswork for the practitioner. The device will also give the dentist a powerful tool in reducing patient anxiety by assuring complete numbness of a tooth that is being worked on.
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Introduction

Tooth anaesthesia is one of the main reasons patients avoid visiting the dentist. Needles may instil fear, but anaesthetic offers a perceived guarantee that no further pain will occur. Far too often this is not the case, and the numbing effect expires during the procedure.

Effectively freezing the patient’s tooth is sometimes a challenge for dentists. Administering the proper dosage is a challenge in itself, as is locating the appropriate spot. If the dentist fails to accomplish both of these factors, the nerves of the tooth may ‘wake up’ in the middle of the procedure.

In some situations the operation may take longer than anticipated by the dentist due to complications. In other circumstances the prediction of anaesthetic’s lasting effect becomes particularly challenging as each patient’s body responds differently.

All of the above can cause unforgivable consequences as most dental operations induce pain and as the numbing effect of the tooth nerve expires, the patient’s reaction can be unpredictable in response to sudden pain. Reactions include, pulling the tongue, closing of the mouth, opening the air way and so on; all of which can be dangerous even when simple procedures are being under taken.

This calls for an immediate need for a device that can facilitate the dentist to detect when the anaesthetic effect on the tooth nerve is approaching its final moments. The objective of this project is to develop a device that will provide the dentist with the opportunity to become aware of this critical point in the operation and take appropriate actions.

Our intention is to develop a device that can detect increased nerve activity in the tooth and alert the dentist. This indication may be lighting up a diode or creating a beep sound. If this is not possible, the device will induce a small current that will induce a sensation in the patients tooth. Upon feeling this non-painful sensation the patient will alert the dentist, and they will take proper action.

This proposal will provide an overview of the project. It discusses the following: the solution and the design being considered, timeline, the company profile, financial estimates and sources of funding.
System Overview

The Basic function of the Trans Dental Monitoring Solution (TDMS) is to monitor the level of nerve numbness while the dentist is working on the patient’s tooth. The operation of this device is based on sending current pulses in millisecond intervals and amplitudes above the threshold so that the patient would feel before injection of the anaesthetic and numbness of the tooth.

TDMS is connected to the patient tooth through a conductive clamp that goes around the tooth. It sends current in form of pulses to the numb tooth while the dentist is working on it. As soon as the amount of anaesthetic drops below the threshold for numbness (before passing the pain threshold), the patient will start feeling the electric pulses sent to the nerve and would alert the dentist. Ideally, the device will independently alert the dentist, before patient input is necessary.

![Conceptual Overview](image)

**Figure 1: Conceptual Overview**

Figure 2 shows the simple block diagram of the proposed device.

![System Block Diagram](image)

**Figure 2: System Block Diagram**
Proposed Design Solution

Our proposed design solution is to build a device, which will constantly monitor the behaviour of tooth nerve fibres, and alert the dentist when the nerves have become active again. The Trans Dental Monitoring Solution will be mounted on the tooth, and form a closed circuit inside the mouth of the patient. Initially the dentist has to determine the perception threshold (the minimum current intensity evoking sensation) and the pain threshold (the minimum current intensity evoking a pain sensation). The obtained data will be fed as input to our TDMS. The device has to check the electrical resistance between the electrodes to make sure of constant contact with the tooth.

First, the dentist performs the appropriate anaesthesia on the patient. Based on the input data our device will send appropriate signals to the nerve fibres. The current amplitude (intensity) and the pulse durations have to be determined according to the patients’ tooth threshold levels. The patients are under constant current signals and do not have any sensation while the anaesthesia is still effective. The signals will be set so that they would pass the patient’s perception threshold and not the pain threshold. As soon as the nerve signals become partially active, the device would capture this transition and send an alert to the dentist. The signals would also evoke sensation in patients, so they would too inform the dentist.

The device can be applied in other fields of medicine where physicians require knowing the effective level of anaesthesia. In some cases, the patients may not be able to tolerate the pain and it is very crucial to constantly monitor the nerve fibres. The development of this device may seem challenging due to required vast knowledge of neurology and dentistry; however the group members’ background, and the sources that we have in dentistry, will be of great assistance.

Time and funding are the main limiting agents in our project. With more time and funding, we would be able to provide a much more sophisticated nerve-fibre monitoring unit. Such unit would automatically measure the perception and pain threshold of patient’s tooth nerve fibres. It would fasten the process and save more time and money for dentists.
Sources of Information

The Trans Dental Monitoring Solution is targeting a problem in the dental field; therefore our primary sources of information will be dentists. Perhaps the most intriguing source of information with this regard is one of the team members’ husband, who is a dentist. His first hand daily experience with this problem will be of great use.

Devices previously developed in other fields that target the stimulation of the nerve or detecting its activity, are a valuable resources to our project. For instance the manufacturer’s components specification sheets for devices such as an Electric Tooth Pulp Vitality Tester can be a great starting point.

Internet sources will provide valuable information and ideas about the similar attempts by others in the field, as well as technical information pertaining to our product. Estimating our budget will for the most part be done through online research.

Other invaluable sources of information to our project include; faculty members, biomedical or non-biomedical, here at SFU. Researchers in other department such as biology, microbiology and kinesiology will play a role; due to the biological nature of our project.

Finally, other sources include, but are not limited to, textbooks, publications and journals available through the library, electronic periodicals and anything/anyone else that can possibly make a contribution.
Budget and Funding

Budget

We have presented the details of the required components for our innovate product. The estimated cost for each one has been provided in table 1. Most of the sub-circuits have been grouped in two main systems: variable amplitude constant current source and pulse generator, to provide the proper signals. We have over estimated our components by at least 20% to compensate for any unexpected additional cost, which may rise during our implementation.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Back up power System</td>
<td>$100.00</td>
</tr>
<tr>
<td>2. Power Supply</td>
<td>$150.00</td>
</tr>
<tr>
<td>3. Variable amplitude constant current source</td>
<td>$450.00</td>
</tr>
<tr>
<td>4. Pulse generator</td>
<td>$50.00</td>
</tr>
<tr>
<td>5. Cables and tooth clamps</td>
<td>$20.00</td>
</tr>
<tr>
<td>6. Alerting Beeper</td>
<td>$25.00</td>
</tr>
<tr>
<td>7. False condition audible alarm</td>
<td>$30.00</td>
</tr>
<tr>
<td>8. Capacitors, conductors, diodes and op-amps to build the required circuits</td>
<td>$35.00</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$810.00</strong></td>
</tr>
</tbody>
</table>

Table 1: Tentative Budget

We are also very determined to build our own variable amplitude constant current source to reduce our cost. The current source, which is required for our design has to have very high accuracy. The high precision of our current source provides a vital safety margin for the patients.

Funding

For any prototype, the initial estimated cost is usually considered slightly higher than the actual cost to compensate for any unexpected financial issues that may arise during the project. Several resources to finance our project have been considered. We are going to
apply for the Engineering Science Student Endowment Fund and the Wight on Development Fund. These financial resources may not cover the entire cost of our project, and hence, we are looking for some private investors to contribute.

Due to the great potential of our product, we would like to keep it confidential – this would constrain us from approaching many potential investors. We may contact several companies, which sell dentistry equipment, to support our project. They will most likely require detailed information regarding our final product; information we may not be willing to provide at this stage. This does make financing of our project a bit challenging. In the circumstances where we would not be able to provide sufficient funding to support our project, our team members have agreed to bear the remaining financial costs of the project equally.

We are also planning to participate in several competitions in the future to compensate for our cost. We want to nominate our product for WECC (Western Engineering Conference and Competition) in 2007-2008 and other potential contests, to pay back our members. We are searching for other potential competitions in the field of medicine or dentistry, to nominate our product. The dual relevance of our product in engineering and medicine would provide us with more flexibility to seek potential investors.
Schedule

Table 2 displays the amount of the time we expected to expend on various tasks involved in our project. Figure 3 shows expected compilation dates for those tasks, as mentioned in table 1.

Table 2: Gantt Chart

<table>
<thead>
<tr>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>8</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td></td>
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<td>5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 3: Milestone Chart
Team Organization

Trans Dental Technologies consists of four ambitious and industrious engineers: Petar Ivaz, Mohammadali Khorasani, Bahman Sotoodian and Isabella Taba. All members are nearing completion of the Engineering program at Simon Fraser University.

The roles of the team members are not set in stone, however TDT has embraced the following corporate structure: Mohammadali Khorasani is Chief Executive Officer, and will oversee the general progression of the project. Petar Ivaz is Chief Financial Officer, and will be responsible for keeping the product within the defined budget; as well as dealing with all other financial matters that pertain. Bahman Sotoodian is Vice President of Operations, and will be in charge of the technical aspects of the project. Isabella Taba is Vice President of Marketing. As engineers, we often get so involved with technical aspects, that we lose sight of the human factors. Isabella will be in constant dialogue with Dr. Kevin Aminzadeh (Dentist), to ensure that our product is user-friendly and practical.

We have decided to meet formally once a week to discuss the project. In order to meet the various deadlines set throughout the semester, we have resolved to appoint an alternating leader. With this scheme, one person will always be responsible for the completion of a certain stage. Being senior students, we have had a great deal of experience working with groups, and all agree that leadership is absolutely vital to a project’s success.

The project is in its infant stage and as such, there is not a need for specialization. As we progress further into the project, it will become clear how to division the work into specific components, ultimately resulting in specialization.

ENSC 440 has a reputation for ruining long lasting friendships and creating more drama than a daytime soap opera. The experience and maturity of each one of our group members will lead to continuous and constructive dialogue within the group, paving the way for quick and efficient resolution of conflict.
Company Profile

Mohammadali Khorasani – Chief Executive Officer

I am in my final year of studies in obtaining a bachelor of applied science-electronic engineering. My particular interest is in biomedical engineering where problem solving techniques developed throughout the engineering degree can be applied to make a positive and rewarding difference. I have diversified my knowledge with regards to living organism by taking various courses in the organic chemistry, general and microbiology departments. I have completed a cooperative education semester in Iran working in the field of biomedical instrumentation and a semester in the research labs here at SFU where I tried to develop the optical coherence tomography technique to study developmental biology, in particular folding of chick embryo’s heart through different stages of its development. I also have acquired knowledge and practical skills in electronic circuitry and software programming in multiple languages through taking various courses at Simon Fraser University.

Petar Ivaz – Chief Finance Officer

I am in my final year of the Engineering Science Program at Simon Fraser University; specializing in Electronics. I have completed a co-op term at Canada Safeway working as a software tester; where I was responsible for developing and running test plans. I also have a wide range of experience with electronics. Most recently, I built a circuit that displayed a NTSC television signal on an oscilloscope. My aptitude in math and science led me to choose Engineering, but I believe my ability to work in a team environment has made me succeed.

Bahman Sootodian – Vice President of Operations

I am currently perusing my last year of study at Simon Fraser University (SFU). My logical thinking and talent for problem solving in math and physics persuaded me to choose a career in Engineering Science. I have performed very well in this field; and have been honoured to receive various scholarships due to my high academic performance and community services. I have performed research internship for Dr. Craig Scratchley at SFU. I worked as a software developer and was in charge of experimenting with and documenting software development tools. I managed to perform very well and satisfy my supervisor.
Isabella Taba – Vice President of Marketing

I am a fourth year electronics engineering student at Simon Fraser University. I gained valuable knowledge in semi-conductor devices, micro fabrication, design and analysis of analog and digital devices and real time programming in C++, through a variety of courses I took at school. In my second co-op I was responsible for design and analysis of multistage amplifier in 0.18 μm with Cadence software. In one of my project I was responsible to program movements of a robot arm with real time programming in c++.
Conclusion

We are positive that our innovative product can substantially reduce patients’ pain and improve productivity in dentistry. There is a high market demand for our innovation in dentistry and medicine. The nerve-fibre monitoring unit will be a vital step toward more ambitious products, which could have even greater market opportunities.

Our time charts in the schedule section clearly demonstrate that our project should reach its goals within the assigned time frame. We have vividly explained the issues that we want to address, and outlined the proposed solution. Our shared enthusiasm, and belief in our product will facilitate its success.
References


2. Dr. Kevin Aminzadeh, Dentist


4. [http://www.shopbot.ca](http://www.shopbot.ca)

5. [http://www.eaglecreekdental.ca](http://www.eaglecreekdental.ca)