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October 13, 2002

Dr. Andrew Rawicz
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Simon Fraser University
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Re: Functional Specifications for the TactiVision Tactile Interface

Dear Dr. Rawicz,

Since receiving your approval to pursue the development of the blind-assist tactile interface proposed in the *Proposal for a Blind-Assist Tactile Interface*, Vindica Systems has been engaged in the detailed expansion of the design considerations therein.

Our research into the requirements of such a device includes the suggestions and concerns of two visually impaired consultants, whose inputs have been helpful in the development of the enclosed document, *Functional Specifications for the TactiVision Tactile Interface*.

The purpose of these functional specifications is to provide project managers and design engineers with a detailed picture of the project requirements. Our proposed design solution forms the basis for two levels of specifications. One level pertains to the proof-of-concept version and the other level specifies the requirements of the target production version of the device. The test criteria for the Level I design have also been included.

At Vindica Systems we respect your concerns as an investor and as a project manager, and we feel that these functional specifications will assist you in accurately assessing the viability of the project throughout its development. If you have any questions or concerns about the project or this document, please feel free to contact me by phone at (604) 936-9699 or at troy@vindica.ca.

Sincerely,

Troy Tyler
President and CEO
Vindica Systems Inc

Vindica Systems Inc.

Functional Specifications for the TactiVision Tactile Interface

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1.1 - October 16, 2002

Executive Summary

As advances in real-time imaging technologies bring the possibilities for alternative visualization devices ever closer to realization, the demand for inexpensive tactile displays increases. Though it is one of the major driving forces behind Vindica Systems' resolve to meet that demand, *TactiVision's* role as a blind-assist device does not begin to approach the limits of such a device's potential application.

Our goal at Vindica Systems is to redesign the tactile display with a focus on integration and cost reduction. It is also important that achievements in those areas not detrimentally impact the device's performance.

Every detail of the proof-of-concept design requirements has been closely scrutinized to produce the *TactiVision* functional specifications that follow. Additionally, a test plan has been developed and included to ensure that each of the prototype requirements has been met. Many of the requirements have already been incorporated into preliminary versions of the software and tactile pixels, with the controller design and hardware comprising the main focus of our cost cutting efforts. The precise details concerning the design of those system components shall be addressed in our upcoming *TactiVision* design specifications which are currently under development.

Vindica Systems' timeline for completion of the project is intact, and we are confident that we will be demonstrating the *TactiVision* prototype in early December of this year.

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Glossary

control hardware (CH)
TactiVision system control hardware consists of the I/O connectors, power supply, microcontroller, D/A converter, transistors and logic gates.

digital to analog (D/A)
Conversion of a signal from its computer based logic value to the actual voltage level it represents, which can be used to drive analog devices.

electrical overstress
Device damage resulting from excessive voltage and / or current levels.

grey-level
Pixel heights on the tactile display Level I system TUI shall be represented on the graphical display by greyscale, with white = high and black = low. The screen's grey-level is synonymous with tactile display's pixel-height.

input/output (I/O)
A short notation for an input and / or output.

interference
Undesired circuit operation due to the effects of surrounding electromagnetic fields produced by nearby electronic devices.

mean time to failure (MTTF)
The average time it takes before a device to stops functioning.

pixel
A small square of colored light on a graphical output device, or a small plastic / metallic rod displaced vertically to represent data on a tactile output device.

tactile user interface (TUI)
TactiVision system tactile user interface consists of the 8×8 array of tactile pixels, the pixels' nitinol (muscle wire) actuators and current latching circuits.

visual user interface (VUI)
The device from which visual information is fed to the tactile display through the control hardware. The Level I system VUI is a computer with software that is used to upload predrawn images to the TUI. The Level II system VUI will be implemented using advanced software or a compatible 2.5D terrain mapping device (such as scanning lasers or ultrasound).

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FIGURE 1 ~ TACTIVISION SYSTEM BLOCK-DIAGRAM 2

1. Introduction

TactiVision is a display device that transforms information from the visual world to the tactile world, allowing one to feel what they cannot otherwise perceive. Modern installations of such devices are extraordinarily expensive and are therefore out of reach to those who would likely find them invaluable. The goal of Vindica Systems Inc. is to eliminate this problem by redesigning and constructing a proof-of-concept tactile display prototype that meets the requirements of its intended applications as cost effectively as possible. The goal of this document is to outline the specific prototype and production version requirements of the *TactiVision* system as well as to provide test criteria for ensuring that each of these requirements has been met or surpassed upon completion of a prototype.

1.1 Scope

The specifications set forth in this document comprise the functional requirements of the blind-assist tactile display system previously introduced in the project proposal entitled *Proposal for a Blind-Assist Tactile Interface.*

1.2 Audience

This document was written for product managers and design engineers as a reference for the development of the *Tactivision* blind-assist tactile interface. Product mangers will use this document to assign project tasks, and define goals and timelines. These specifications also act as a basis for the managers to assess the viability of the project throughout its development.

1.3 Document Conventions

The tactile display system is most easily conceptualized as an integration of three interdependent subsystems. The subsystems consist of the visual-information interface, the control hardware and the tactile interface. Additionally, the requirements of each subsystem are two-tiered. The first level requirements (Level I) pertain to the requisite characteristics of the proof-of-concept prototype currently under development. The second level requirements (Level II) specify the ideal and essential system characteristics of future production versions of the device. These divisions were made to increase the efficacy of the design, development and integration processes. Each of the requirements that changes with the requirement context (i.e. Level I), or applies to more than one subsystem in either context, has been bulleted as one of the following requirement types:

- Operating Condition
- Reliability
- Compatibility
- Power Consumption
- Heat Dissipation
- Safety Features
- Measurement
- Packaging
- User Interface

2. System Requirements

The tactile display system requirements are subject to dual requirement levels, as mentioned in the document conventions. Level I requirements are those minimum requirements and test criteria to which the proof-of-concept prototype *TactiVision* system shall be held. The Level II requirements pertain to potential future production versions of the device, and are built upon the Level I specs.

Unless specifically restated in the Level II requirements section, the system and subsystem specifications appearing as Level I requirements shall apply to both requirement levels of the device.

2.1 System Overview

The *TactiVision* system overview is illustrated in *Figure 1*.

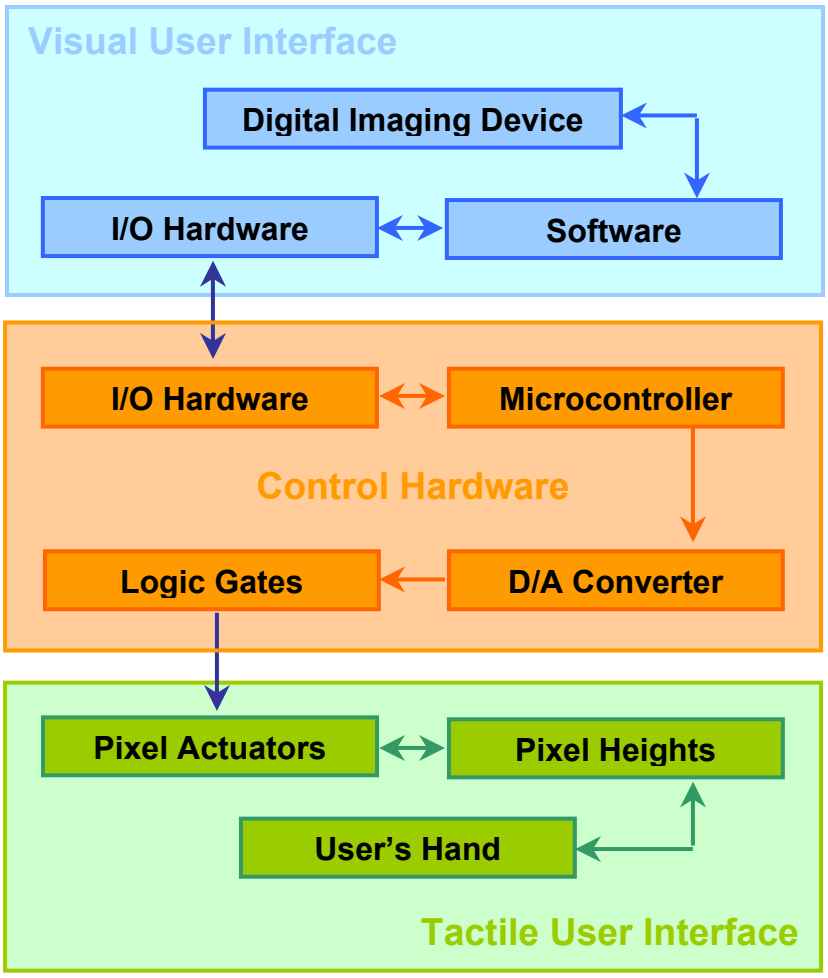

Figure 1 ~ TactiVision system block-diagram

2.2 Level I System

- *I.00* The system must operate over a temperature range of – 40°C to 45°C.
- *I.01* The system must operate over a relative humidity range of 5% to 90%
- *I.02* The system must not cause harmful interference.
- *I.03* The system must accept any interference received, including interference that may cause undesired operation.
- *I.04* The system must include an emergency shut-off mechanism.

2.2.1 Visual User Interface

- *I.05* The software shall be installed on a personal or notebook computer, and is therefore subject to their normal operating conditions.
- *I.06* The software must be compatible with Microsoft Windows 95 / 98 / 2000 / Me / NT / XP operating systems.
- *I.07* The software must communicate with the control hardware via the computer's serial / USB port.
- *I.08* The software must generate digital outputs that are compatible with the *TactiVision* control hardware to which it is connected.
- *I.09* The software must be capable of generating and transmitting digital signals to the control hardware at a rate of at least 80 kB / sec.
- *I.10* The VUI platform warranty must not be voided, and its lifetime must not be adversely affected by installation or operation of the software.
- *I.11* The software must enable the user to load pre-created greyscale images onto the display using the standard File-Open dialog box.
- *I.12* The software must generate outputs that represent the grey-level of screen pixels from the VUI, and transmit them to the controller.
- *I.13* The software must allow the user to select any of 256 shades of grey and modify the current image using basic drawing techniques similar to those employed in current graphics / imaging software.
- *I.14* The software must enable the user to select which section of the current image is to be loaded and displayed on the TUI.
- *I.15* The software must update the TUI through the control hardware
- *I.16* The software must be both user-friendly and aesthetically pleasing.

2.2.2 Control Hardware

I.17 The CH must operate independent of its physical orientation.

I.18 The CH must be immune to nominal electromagnetic interference levels.

I.19 The CH shall interface with the VUI device via standard USB or serial port connectors and connector cable.

I.20 The CH shall be compatible with digital outputs generated by the *TactiVision* software on the VUI device to which it is connected.

I.21 The CH must be capable of receiving and processing digital transmissions from the VUI device at a rate of no less than 80 kB / sec.

I.22 The CH shall not utilize any components having an MTTF of less than 5 years, and must have an estimated MTTF of at least 3 years.

I.23 The CH shall be free from failure due to electrical overstress or contamination by foreign materials such as dust, dirt, or food.

I.24 The CH shall be powered through a standard 120V, 60Hz outlet.

I.25 The CH must consume not more than 10 W during its operation.

I.26 The CH must mitigate the effects of any non-ideal operating parameters resulting from noise or fluctuations in the power supply.

I.27 The CH must recognize any absence of input from or connection to the VUI device, and deactivate the pixels accordingly.

I.28 The CH must use a single D/A converter to control every pixel height.

I.29 The CH must not generate an appreciable amount of heat when compared with the heat generated by the tactile pixel actuators.

I.30 The CH must shield the VUI hardware from any undesired feedback.

I.31 The CH shall have dimensions not exceeding 10 cm × 15 cm × 1 cm.

I.32 The CH shall not exceed 45 grams in weight.

I.33 The CH shall be assembled on a printed circuit board (PCB).

I.34 The CH PCB must be as compact as the circuit schematic allows.

I.35 The CH user interface shall consist of a DC supply port, USB / serial connector, and an emergency shut-off mechanism.

2.2.3 Tactile User Interface

I.36 The TUI must operate independent of its physical orientation.

I.37 The TUI must have a MTTF of not less than 10,000 cycles per pixel.

I.38 The TUI shall be free from failure due to electrical overstress or contamination by foreign materials such as dust, dirt, or food.

I.39 The TUI pixel heights must correspond to the corresponding VUI grey-levels to within an accuracy of ± 5%.

I.40 The TUI shall be powered through a standard 120V, 60Hz outlet.

I.41 The TUI must not consume power when all pixels are deactivated.

I.42 The TUI must consume less than 500 mW per fully activated pixel.

I.43 The TUI must vent or otherwise dissipate the heat it generates at a rate sufficient to maintain an enclosure temperature of 45°C or below.

I.44 The TUI pixels must be both thermally and electrically insulated.

I.45 The TUI shall not exceed [2mm × #x-pixels] in width by [2mm × #y-pixels] in length by 10 cm in height, excluding the enclosure.

I.46 The TUI shall not exceed a combined weight of 5 grams per pixel.

I.47 The TUI enclosure must be capable of withstanding repeated impacts whose magnitudes are the equivalent of being dropped on a non-compliant surface from a height of 4 ft.

I.48 The TUI enclosure must house the controller and power supply circuitry in addition to the display hardware.

I.49 The TUI enclosure size and weight shall be the minimum values necessary to satisfy these enclosure functional requirements.

I.50 The TUI must have a resolution of at least 20 pixels / cm².

I.51 The TUI pixels must be capable of achieving vertical displacements of not less than 2mm.

I.52 The TUI pixel geometry must be such that vertical displacements of as little as .1 mm between neighboring pixels are easily discernable.

I.53 The TUI pixels must be capable of withstanding the pressure of a hand's weight distributed evenly over its surface, without deforming.

2.3 Level II System

2.3.1 Visual User Interface

II.00 The software should be capable of interfacing with some of the most commonly used, and more useful visually oriented applications.

II.01 The software should be compatible with Microsoft Windows 95 / 98 2000 / Me / NT / XP, MacOS, Linux and all PDA operating systems.

II.02 The software should intercept the graphic outputs of applications, converting text to braille and images to greyscale height-mappings.

II.03 The software should use force feedback from the tactile display providing the user with 'click' functionality in the host application.

2.3.2 Control Hardware

II.04 The CH should have an MTTF of not less than 5 years.

II.05 The CH should consume a maximum of 5 W when operational.

II.06 The CH should be supplied from a lithium ion battery / wall supply.

II.07 The CH should have battery recharge circuitry.

II.08 The CH should not exceed 15 grams in weight excluding the battery.

II.09 The CH should be a dedicated, integrated technology.

II.10 The CH need not include an emergency shut-off mechanism.

2.3.3 Tactile User Interface

II.11 The TUI should withstand repeated cleanings with mild cleansers.

II.12 The TUI should have a MTTF of not less than 500,000 cycles / pixel.

II.13 The TUI pixels should be individually and easily replaceable.

II.14 The TUI should consume less than 50 mW per fully activated pixel.

II.15 The TUI should have a fan or electrically-inactive coolant to dissipate the heat generated by the tactile pixel actuators.

II.16 The TUI should not exceed [2mm × #x-pixels] in width by [2mm × #y-pixels] in length by 4 cm in height, excluding the enclosure.

II.17 The TUI should not exceed a combined weight of 2 grams per pixel.

3. Regulatory Requirements

Product regulations and restrictions vary significantly in the international marketplace, requiring that companies acquire multiple certifications on their products. The *TactiVision* system must comply with the following North American regulatory bodies' specifications.

3.1 Canada

The *TactiVision* prototype must meet the applicable testing standards of CSA Class B consumer electronics appliances, as required by Industry Canada to qualify for sale and distribution in Canada.

The *TactiVision* prototype must comply with all CSA C22.2 No. 1010-92 safety standards.

Vindica Systems' Level II *TactiVision* device support must comply with CSA customer service standard for people with disabilities of Class B No. 480-02.

All electrical parts and wiring shall conform to the specifications outlined in C22.2 No. 203.1-94 (Manufactured Wiring Products) and C22.2 No. 0.3-01 (Test Methods for Electrical Wires and Cables).

3.2 United States

The *TactiVision* prototype must meet the applicable testing standards of CFR 47 and ANSI regarding consumer electronics emissions, as required by the FCC to qualify for sale and distribution in the United States.

The *TactiVision* prototype must also comply with the Underwriters' Laboratories safety standards for consumer electronic appliances of UL 3111-1.

4. Prototype Test Plan

This section outlines the test processes that we will implement to test the Level I functions presented in this document.

4.1 Installation

4.1.1 The user shall plug the Tactivision into the wall socket and connect it to the computer.
4.1.2 The user shall install the Tactivision software onto a PC running Windows 95 / 98 / 2000 / NT / Me / XP.

4.2 Visual User Interface

4.2.1 The user shall push the software emergency stop.
4.2.2 The user shall load an image into the VUI.
4.2.3 The user shall draw/edit an image using the drawing functions.
4.2.4 The user shall select the current pixels that are to be mapped to the TUI using the pan option.
4.2.5 The user shall update the pixels of the TUI using the software.

4.3 Control Hardware

4.3.1 Every possible input / output combination shall be scrutinized for speed and accuracy.
4.3.2 The time for the current to drop by 10% of the desired latched value shall be tested in the lab.
4.3.3 The CH shall be subjected to contamination by foreign materials including dust, dirt and food while operational.

4.4 Tactile User Interface

4.4.1 The user shall push the hardware emergency stop button.
4.4.2 Vertical displacements of .1 mm between neighboring pixels will be hand checked for vertical resolution.
4.4.3 The user shall identify simple test objects on the TUI by touch only.
4.4.4 The pixels will be actuated randomly at the maximum speed for 24 hours, subjecting each pixel to no fewer than 10,000 cycles.
4.4.5 The pixels shall remain fully actuated for 24 hours.
4.4.6 The TUI shall be tested at the extremities of the normal operating conditions.
4.4.7 The pixels shall be subjected to constant pressure as well as impulses of pressure, and they shall be monitored for strain.

5. System Limitations

The *TactiVision* device is a step in providing some increased awareness of the outside world to the visually impaired. Ideally the tactile interface would be a true representation of a fully 3-D object including heat, texture, colour and true 3-D shape. Our device however, is obviously limited, as these sensory inputs are not mapped. *TactiVision* is a simple 2.5-D object mapping with limited resolution both in pixel and vertical resolution.

The software for the device at the Level I stage is very basic and is intended for demonstration purposes only. The visually impaired will not be able operate the software as is during the Level I stage. There is no clear visual display of the 3-D object we are attempting to model, rather there are only direct height mappings displayed. The software does not represent relevant data about the user's surroundings.

The hardware has a limited speed because there is only one D/A converter and therefore only one pixel's height may be actuated at a time. The device would optimally be portable but at this stage we require a standard household outlet. The interface should withstand harsh environmental conditions if it is to be portable. The tactile user interface pixels will not be able to change faster than the properties of the actuators allow.

6. Training Documentation

The Level I proof-of concept system training is based on the assumption that the user is not visually impaired. Clearly the training requirements of the Level II system are more involved, as that system is subject to use by persons who are visually impaired. The *TactiVision* documentation and training specifications outlined in this section apply to the prototype system user.

TactiVision users shall receive an 8 to 12 page user's manual with operating instructions written in English, French, Chinese, German and Italian. A second, Braille version of the user's manual shall also be included with an audio cassette or CD containing operating instructions in each language.

The user's manual shall utilize diagrams taken from the actual visual and tactile user interfaces to assist in identifying system components. Additionally, the software will include help and tutorial files that walk the user through hardware setup and operation procedures.

Vindica Systems shall also provide a tutorial and FAQ section on the company website, along with an interactive *TactiVision* hardware test page. The simplicity and self-explanatory nature of the software should bestow a steep learning curve on the *TactiVision*.

Users shall be encouraged to visit the interactive website to engage in automated tactile-recognition conditioning programs that will enable them to compare the perceived tactile image with the actual image through visual and auditory cues. The sensitivity required to accurately perceive the images output to the TUI may require considerable conditioning on the user's part.

7. Conclusion

Vindica Systems has developed these functional specifications to define the minimum functional requirements of the Level I *TactiVision* system. The success of the company in this endeavour shall be measured by our ability to meet each of the system test requirements specified in the prototype test plan. The Level I system must also meet the regulatory requirements identified herein, however many of these requirements are subject to change as the project continues to develop.

Vindica Systems is determined to find an economically viable solution to the design problems currently faced by modern tactile displays. We are on course to the completion of a prototype version of the *TactiVision* system by early December.

8. References

www.csa.ca	Canadian Standards Association
www.fcc.gov	Federal Communications Commission
www.iec.ch	International Electrotechnical Commission
www.ulc.ca	Underwriters' Laboratories of Canada