BREAKTHROUGH INNOVATIONS GROUP
Go BIG or Go Home

15/02/2016

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

Re: ENSC 305W/440W Functional Specifications for the Omega Key

Dear Dr. Rawicz,

The following document will outline the functional specifications for our dynamic display keyboard named Omega Key for capstone. The goal of our group is to design a keyboard with programmable key displays, allowing the user to fully customize the language and position of letters on the keyboard.

The functional specifications will describe the high level requirements for the functionality of our product in both the proof of concept and eventual marketed product. Our group will use these specifications as a guideline when designing and researching the product.

Breakthrough Innovations Group (B.I.G) has six very talented engineering students: David Pallmann, Chase Kwak, Steven Liu, Steven Timotius, Steven Luu, and Frank Tran. If you have any questions or concerns about our functional specifications, please feel free to contact me by email or phone at dpallman@sfu.ca or (604)-928-9269

Sincerely,

DPallmann

David Pallmann
President and CEO
Breakthrough Innovations Group (BIG)

BREAKTHROUGH INNOVATIONS GROUP
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ENSC 305W/440W

Functional Specification:

Omega Key

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Dr. Andrew Rawicz – ENSC440W
Steve Whitmore – ENSC305W
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Issue Date: 15/02/2016

Revision: 1.0

Abstract

This report contains the user requirements and functional specification for the Breakthrough Innovations Group Omega Key customizable LCD keyboard. It will define the user and system relationships as well as provide technical background and specification of the project. This report will elaborate on the development phases of the product. It will provide a basis for its target users as well as the potential applications.

The technical specifications will be covered in detail within this report. It will include in depth descriptions of how the keyboard shall be made as well as its components requirements. Furthermore, it will outline each component and their purpose in ensuring the system functions as a whole from both the software and hardware perspective.

This report will also cover the environmental and safety aspects of the product. International standards for electronic devices as well as local standards will be covered in detail. Moreover, potential safety and environmental hazards will be included in this report.

Lastly, this report will cover the development route of this project and its design process. This includes the motive and target goal of manufacturing such product.

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Glossary

Term	Meaning
BIG	Breakthrough Innovations Group
Standard Functionality	Functionality that is present in everyday keyboards
Extended Functionality	Added functionality such as dynamic displays, direct symbol input, macros.
Controller	The microprocessor onboard the keyboard
Firmware	The software running on the controller
Host Software	The software running on the computer
Keyboard Layout	The mapping of characters, symbols, or macros and the corresponding images to physical keys
Macro	A series of preprogrammed instructions to be executed from a single key press
RSI	Repetitive Strain Injury, a broad term to describe injuries derived from repetitive actions
PLA	Polylactic Acid, a biodegradable plant-based thermoplastic aliphatic polyester
ABS	Acrylonitrile Butadiene Styrene, a common thermoplastic polymer
PCB	Printed circuit board

C2C	Cradle to cradle, a design approach for product life cycle assessment
HID	Human Interface Device
USB	Universal Serial Bus
MTTF	Mean time to failure
RAM	Random access memory
ROM	Read only memory

1 Introduction and Background

The Omega Key is a keyboard featuring display screens under each key. The keyboard will allow users to quickly switch between different keyboard layouts and have the screens update to display new key mappings. The Omega Key fixes the everyday struggle of a standardized keyboard fitted for the English language if an user is trying to write in a different language that may not be using the 26 letter alphabet systems. The Omega Key will also provide convenience to users that often require specialized symbols such as those found in the field of mathematics as well as provide gaming enthusiasts the freedom to remap all available keys. This type of customization freedom will offer users of all backgrounds a new typing experience.

1.1 Scope

This document will cover the specifications of the product for the proof of concept (shown in figure 1 below), and the final market version. Along with the specifications, this document explores the health and safety regulations and any potential standards the Omega Key will need to meet.

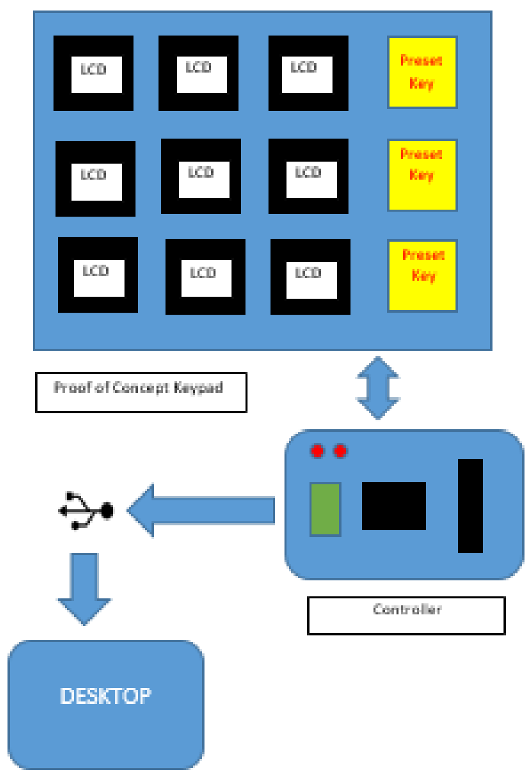


Figure 1: Proof of concept system diagram

1.2 Intended Audience

The intended Audience is for all members of BIG engineering team to refer to upon constructing both the proof of concept and final production model of the Omega Key. Stakeholders can also reference this document to ensure product specifications satisfy all user requirements and regulatory standards.

1.3 Classification

Throughout this document, the following convention shall be used to denote functional requirements:

[R**n**-**p**] A functional requirement.

where **n** is the functional requirement number and **p** is the priority of the functional requirement as denoted by one of the following three values:

I The requirement applies to the proof-of-concept system only.
II The requirement applies to both the proof-of-concept system and the final production system.
III The requirement applies to the final production system only.

2 System Requirements

2.1 System Overview

The goal of the project is to create the Omega Key, a dynamic display keyboard that will be able to display and output any symbol, language, or layout that the user wishes.

Due to the time and budget constraints our proof of concept model will only consist of the keys in a number pad (3 keys across and 4 down), however our goal is to make a full keyboard in the version for the market.

The Omega Key will be able to store its custom display settings on the memory of a microcontroller. When a user presses one of the four preset buttons, the keyboard will display the current character mapping (the map that translates the pushing of an individual key to a character/symbol to be outputted to the computer). Above all else, the keyboard shall feel, and perform like a regular keyboard.

Figure 2 below show the flow chart of common use cases of the system

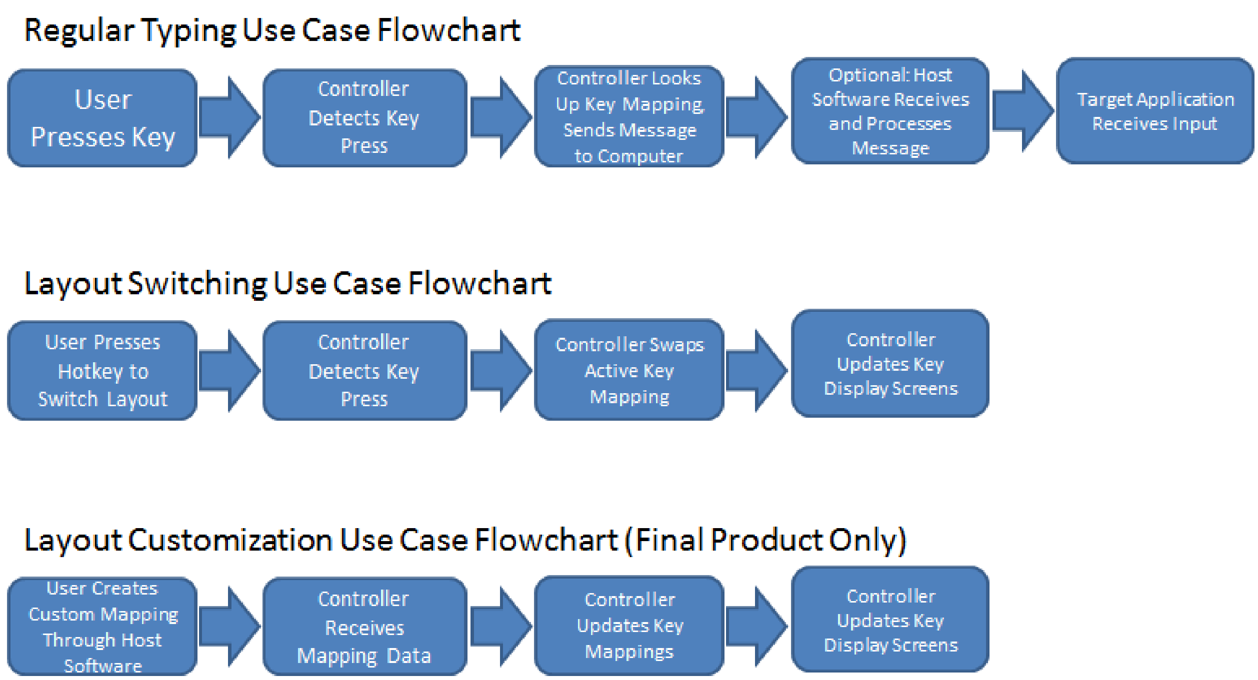


Figure 2: Flowchart of Common Use Cases

2.2 General Requirements

[R1 – II] The keyboard shall connect to the computer through a standard USB2.0+ port.

[R2 – III] The retail price shall be under $300 CAD.

2.2.1 Standard Functions

[R3 - II] The keyboard shall allow input key layout in the standard QWERTY keyboard layout.

[R4 - III] The keyboard shall display the status of caps lock, num lock, and scroll lock.

[R5 - III] Standard functions shall be compatible with any PC without added software.

[R6 - III] Standard functions shall be compatible with Windows, Apple OSX, and Linux.

2.2.2 Extended Functions

[R7 - II] The keyboard shall allow users to switch between key layouts.

[R8 - II] The keyboard shall allow users to input all symbols found in the extended ASCII table.

[R9 - III] The keyboard shall allow users to input macros.

[R10 - III] The keyboard shall support user defined keyboard layouts.

2.2.3 Physical Requirements

[R11 – III] The size and weight restrictions, as shown in table 1 below, were chosen based on measurements of regular mechanical keyboards.

Width	400 – 450 mm
Depth	120 – 200 mm
Height	25 – 40 mm
Weight	< 900 g

Table 1: Keyboard physiscal properties

[R12 - III] The keyboard shall look visually appealing (color, shape, screen smoothness).

[R13 - III] Keyboard shall be ergonomic.

[R14 - II] The keyboard shall have rubber pads to remain firmly in place when used.

2.2.4 Electrical Requirements

[R15 - III] The Keyboard shall draw its power through USB port.

[R16 - II] The wiring shall be neat and easily diagnosable.

[R17 - III] A PCB shall be used to reduce loose wires.

2.2.5 Mechanical Requirements

Keys and casing are important as they determine the usability and aesthetics of the product. Each key is composed of a screen and 3D printed keycap, which will enclose the screen.

If the spacing between each key is too large/small, the user will feel discomfort when typing. If the space in between each key is not enclosed, unwanted items can enter the keyboard and may impact the keyboard's performance. Keys need to be leveled and stable on the casing so that they do not exhibit any unwanted motion when typing. Keyboard layout will be very similar to the ISO/IEC standard keyboard for the final production model.

Figure 3: ISO/IEC 9995-1 standard keyboard layout [19]

- Alphanumeric section
  - Alphanumeric zone (indicated by green coloring)
  - Function zones (indicated by purple coloring)
- Numeric section
  - Numeric zone (indicated by darker red coloring
  - Function zone (indicated by lighter red coloring
- Editing and function section (covering all parts which do not belong to alphanumeric or numeric section)
  - Cursor key zone (indicated by darker grey coloring)
  - Editing function zone (indicated by lighter grey coloring)

[R18 - II] The keyboard case shall allow opening for maintenance and repairs

[R19 - I] The proof of concept shall have 12 keys in a 3x4 layout, similar to a numpad

[R20 - III] The keyboard shall all the 104 keys present in a standard keyboard with numpad, and possibly more keys for extended functionality.

[R21 - II] The Keyboard shall have dedicated buttons to switch between preset keyboard layouts.

2.2.6 Environmental Requirements

[R22 - II] The keyboard shall operate in a dry environment at temperatures between 0°C - 50°C

2.2.7 Standards and Specifications

[R23 - II] The product shall communicate with computers using USB2.0+ standards [12]

[R24 - II] The product shall conform to the Device Class Definition for Human Interface Devices 1.11 [13]

[R25 - III] The keyboard layout for standard functionality shall follow ISO-9995 standards [14]

2.2.8 Reliability Requirements

[R26 - III] All components of the keyboard shall have an MTTF of at least 6 years

2.2.9 Performance Requirements

[R27 - III] The keyboard shall update all displays within 0.5 s

[R28 - III] The keyboard shall have no more than 25 ms latency between a physical key press and the key registering on the computer

2.2.10 Usability Requirements

[R29 - II] All interactions involving the user shall be intuitive or well explained

[R30- II] The keyboard shall be able to boot up and operate with standard functions without requiring additional host software

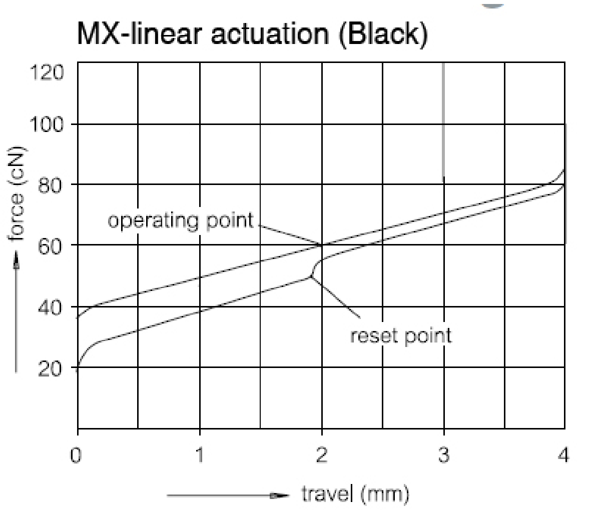
3 Keyboard Display Screens

	Proof of concept	Final production
Screen size (diagonal)	< 40 mm	< 25 mm
Screen resolution	> 16x16 pixels	> 48x48 pixels

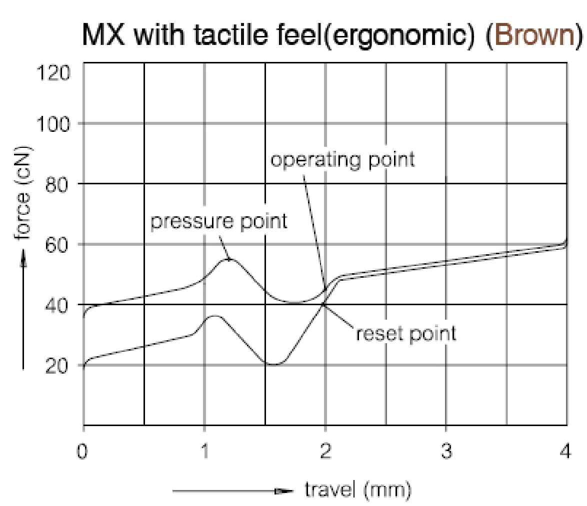
Table 2: Display screen properties

3.1 Key Switch

The key switch shall provide tactile feedback in the form of a click in resistive force right before the switch is activated. This click, shown on the right side of figure 4, informs users to release the switch and move on to the next key press. Users can type faster and also prevent the loud noise of the key casing hitting the bottom.



Force Graph of key switch with linear actuation. The steady increase in resistive force from the key switch means there is no tactile feedback on actuation.



Force Graph of key switch with tactile feedback. The increase and decrease of resistive force from the key switch provides tactile feedback when the switch is actuated.

Figure 4: Force graph of key switch with and without tactile feedback

3.1.1 General Requirements

[R31 - II] Keyboard shall consist of mechanical keys to provide tactile and audible feedback (See figure 4 for explanation of tactile feedback) [15]

[R32 - III] Key switches shall be rated for over 1 million presses to improve durability.

[R33 - II] Keys shall be positioned firmly on the casing so that keys do not become lose while typing

3.2 Controller

Controller for Omega key shall serve the following important functions:

- To process user input and return output signal to output devices such as screens
- To support performance speed for the devices it is connected with
- Size of RAM and ROM will determine the size of the firmware that controller can support [20]
- To provide software processing requirements

3.2.1 General Requirements

[R34 - I] The controller used for the proof of concept shall be a readily available development board to reduce cost

[R35 - II] The controller shall have the enough I/O ports by itself or through the use of I/O port expansion for display screens, switches, and any other external peripherals it is connected with

[R36 - III] Controller shall meet the computing requirements such as speed of processing and ability to handle multiple tasks efficiently and effectively [18]

[R37 – II] Controller shall have enough RAM and ROM to hold the firmware and data such as keyboard mapping and images.

[R38 - II] The controller shall support communication with the host using HID protocol.

[R39 - I] The proof of concept may use more than one controller.

3.2.2 Firmware Requirements

Figure 2 above illustrates how the firmware interacts in the context of the entire system behaviour.

[R40 - II] The firmware shall detect keystrokes and signal the corresponding message to the computer or host software.

[R41 - II] The firmware shall allow for inputting symbols not present in standard keyboards, such as **Σ**, **Ω**, and **Π**.

[R42 - II] The firmware shall update each display screen with the corresponding image on boot up and when the layout is switched.

[R43 - I] The firmware shall be preprogrammed with 2-4 keyboard layouts that the user can switch between.

[R44 - III] The firmware shall accept user defined keyboard layouts from the host software.

3.3 Host Software

[R45 - I] Host software may not be necessary for the scope of the proof of concept

[R46 - III] Host software shall allow users to select and modify key layouts for the keyboard

[R47 - III] Host software shall communicate with the controller to trigger changes in the keyboard layout and displays

[R48 - III] Host software shall allow for extended functionality not within the capabilities of the basic HID protocol or the computing capabilities of the controller, such as macros with delays.

[R49 - III] Host software user interface shall be intuitive or clearly explained.

4 Safety and Sustainability Analysis

4.1 Safety Requirements

At BIG, we aim to ensure that our products are high quality, safe to use, and promote sustainable manufacturing. Our products meet safety standards but there are safety considerations that need to be acknowledged for the end user. We use C2C design in consideration in our product designs and do our best to meet product certification.

5 Safety Considerations

5.1 Electrical Safety

As with any computer peripheral there are concerns regarding heat and electricity. With standard USB 2.0 regulations [1] the maximum amount of voltage and current available are 5.00 ± 0.25 V and 0.5A respectively. The displays on the Omega Key require 2.8V to be powered. The USB port shall provide enough power for the keyboard and displays to function properly, and it shall not have any issues regarding heat or electricity.

5.2 Injury Risks

The main concern with spending long hours on a computer is the risk of developing RSI. RSI is an umbrella term for conditions that originate from repetitive tasks which includes Carpal Tunnel Syndrome, Tendonitis, and Ganglion cyst [2]. The most dangerous part of RSI is that it can take years to develop with little to no symptoms and is caused by repeatedly placing stress on a tendon or muscle. There are several treatments available however as RSI covers a variety of conditions the effectiveness varies.

Prevention is vital in avoiding RSI and can be done with ergonomic adjustments and developing good typing habits [3]. Examples of poor typing habits includes typing for extended durations without taking breaks, straining fingers to reach keys, twisting hands to type, contorting hand to type key combinations, and bending wrists to type. It is recommended to take frequent breaks when typing for extended periods, roughly a 10 minute break for every hour of typing. Good ergonomics practices are necessary when using a computer to reduce chances of developing RSI.

5.3 Health Risks

Health issues concerning sanitary conditions is a concern for keyboards as they are typically not cleaned often, especially those used in public places. Publicly used keyboards have the greatest risk of contracting illness as the current user does not know the health and sanitary conditions of previous users [4]. Bacteria is commonly transferred from our hands so it is recommended to wash your hand before and after using a public keyboard [6]. Cleaning the Omega Key can be done by shaking out loose debris, using a can of compressed air to remove debris in tough spots, and wiping the keys with a disinfectant wipe. Making sure our product is cleaned once every few months should reduce bacteria growth and chances of contracting illnesses.

5.3.1 Safety and Health Requirements

[R50 - II] The case itself shall be grounded

[R51 - II] Usage of the keyboard shall not cause undue strain on the user's hands or arms (RSI)

6 Environmental Considerations

6.1 Proof of Concept Model

For the proof of concept model of the Omega Key we shall be using components shipped in from China and the United States. The display modules are manufactured in a factory in China while the switches, microcontroller, and adapters shall be bought from various sellers from the United States. The keycaps are to be custom made locally using Simon Fraser University's own 3D printers, acrylic plastic is used to cover the display module on the keycap, and the housing shall be made using either refurbished wood or by using the 3D printer as well depending on the complexity of the wiring.

The proof of concept may not be extremely environmentally friendly due to costs, availability, and limited production number. Fortunately the components and materials can be reused and recycled at local recycling centers [7]. The keycaps is most likely going to be printed from ABS plastic which can be recycled, the switches can be reused and disassembled for its metals and plastic, and the display modules can be reused but unlikely to be recycled beyond PCB components.

6.2 Production Model

The production model of the Omega Key is planned to be more sustainable compared to our proof of concept but it is unlikely to be fully C2C. The production model is likely to be manufactured in China due to materials and manufacturing costs, and then shipped to retailers. Plastic injection moulding shall be used for rapid production of the keycaps and housing. Our electronic components shall be selected to be RoHS compliant to ensure hazardous material is not used in production [8].

The packaging consists of cardboard with some documents including warranty and manual which are biodegradable. Our product shall feature parts that are easily repaired or replaced to reduce waste. The Omega Key uses cherry MX switches which is relatively simple to repair or replace, the keycap are able to be removed with a standard key puller, and circuitry skills is required to replace or repair the display module.

The user can bring broken units to an electronics store to be refurbished or a recycling center to be disassembled into technical and biological nutrients [9]. The plastic components of the keyboard shall be made from a plant-based plastic namely PLA which boast high heat resistance and similar durability to ABS plastic [10]. PLA plastics biodegrade within 6-12 months in a composting environment and nourish more plant matter for raw materials [11]. The switches, display modules, acrylic, and electronic components can be harvested to extract their technical nutrients to be used again in the manufacturing process.

6.3 Certification Analysis

To receive C2C certification the product must have be analyzed through five quality categories: material health, material reutilization, energy management, water stewardship, and social fairness [17].

The Omega Key is intended to have good material health with most of the materials being moderate to low risk of use. The plastic material made from PLA requires a plant based source, the display modules require glass and metal sources, the switches use ABS plastic and metals, the electronic components including the microcontroller need metal and plastic, and the cardboard packaging requires a wood source. Most of these materials can be decomposed into technical and biological nutrients to be reutilized in the manufacturing process and nourish new materials.

The process of manufacturing should take quite a bit of energy as soldering is required to combine the electronic components, and injection moulding process requires a fair amount of heat. A sum of energy is used to ship the product to various retail stores. Reusing and recycling the materials should reduce the overall energy usage and should improve energy consumption over time. The materials should consume a fair amount of water for creating the plastic injection molds, processing the raw materials, and manufacturing the product.

The social responsibility of producing the Omega Key is tricky to determine as the labour practices of factories in China vary in treatments. BIG aims to promote fair labour practices and shall have regular check-ups at the factories where our products are produced. Our product aims to promote green practices but manufacturing in China impacts the waste and pollution produced.

7 Conclusion

The Functional specification clearly defines the capabilities and requirements of the Omega Key. The development of the product includes 2 distinct phases as outlined by the document: the proof of concept keyboard and the commercialized version. The proof of concept model which includes the key features (classification I and II) of the product is under development and is expected to be completed by April 03, 2016. The design team is expected to adhere to all functional specifications outlined in this document.

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