February 20th, 2017

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

Re: ENSC 405W Functional Specification for MotoVise, an automatic sun visor control system

Dear Dr. Rawicz:

Enclosed is the functional specification document for MotoVise by Trap Bird Technologies. The objective of MotoVise is to create a control system for vehicles which enables self-movement and regulation of sun visor positioning while driving. MotoVise will ultimately alleviate a pain many drivers face while driving against the sun.

The attached functional specification document provides a framework of the high-level functionality requirements for MotoVise. These outlined requirements will be the foundation of the project moving forward and beyond the proof of concept and prototyping stages of MotoVise's development.

As a company, Trap Bird Technologies has always emphasized the importance of innovation and teamwork. The company currently consists of four essential members: Benny Chou, Christopher Chin, Ishita Malhotra, and Roxanne Ling, all of whom are highly capable and motivated individuals. Any questions and/or concerns regarding the functional specifications of MotoVise can be directed to me at bca50@sfu.ca . Thank you for your time and consideration.

Sincerely,

Benny Chou
CEO
Trap Bird Technologies

Enclosure: *Function Specifications for MotoVise*

Functional Specifications for

MotoVise

an automated solar tracking vehicular sun visor

By

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Abstract

MotoVise is designed to revolutionize the daily car commute when one is faced with oncoming sunlight shining in one's eyes. There is the traditional method of flipping down the sun visor to shield the sunlight, but this usually involve heavy fidgeting while it also obstructs part of the road visibility for the driver. Furthermore, unhinging the visor, then swinging it to the side can become quite a hassle while focussing on the road. Some may opt to wear sunglasses, but this may not be desirable for all users. Therefore, Trap Bird Technologies presents MotoVise: an automatic vehicular sun visor.

MotoVise will be developed over two phases. The first phase will demonstrate the functionality of all three components in the proof of concept and the final phase will implement everything in one unified system. Trap Bird Technologies' MotoVise will deliver an automatic sun visor capable of the following three components:

1) Real time **sun tracking** applied through sensors. MotoVise will be able to determine the location of the sun relative to the eye level of the front passengers within the vehicle's cabin. With this information, MotoVise's system will autonomously determine if the current light level and sun glare pose a hindrance to its passengers. If so, appropriate actions to relieve the situation will be taken by MotoVise.

2) **Automatic visor positioning** to cover both the automobile's front windshield and the front side windows. MotoVise will be capable of extending and retracting a visor akin to traditional car sun visors. Its uniqueness lies in the capability to translate laterally from the front of the vehicle to the side and vice versa. All operations of the visor will be hands free and completely automated through the implementation of an embedded system in conjunction with feature 1).

3) Retractable **sunshade** extension capable of covering the majority of a vehicle's windshield. This extension is intended to be a built-in feature that should only be used when the car is in a parked state. The extension will keep the cabin temperature of the car cool; ready for the car to be driven again. Activation of MotoVise's sunshade will be implemented through a switch: where the user may manually adjust the desired range of coverage.

By the final development stage, MotoVise will be powered in an enclosed wiring system connected to the automotive battery, removing the need for external power from an electrical outlet. MotoVise will adhere to standard guidelines outlined in BC Laws and Regulations act as well as modern vehicle handbook standards.

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Glossary

Colour temperature	Colour of light source compared to an ideal black-body radiator
dB	Decibel, unit of measurement for intensity of sound
mm/s	Measurement of velocity to displace a length in millimeters per second
User	Any person operating MotoVise. User will be either be the automobile driver or front passenger.

1.0 Introduction / Background

The concept of MotoVise is to fulfill the role of an automatic sun visor control system. Sun visors, in their current rendition, require manual effort to flip down and angle appropriately so that the visor is in the optimum between sun coverage and road visibility. Additionally, if the glare of sunlight is in one's peripheral vision, additional exertion is required to unhinge the visor and swing it in front of one's face to position it to the side. When the sun is no longer in your way, these actions are reversed to place the visor back into its original position as leaving it unhinged unnecessarily obstructs one's vision of the road. These processes, for many drivers, are repeated ad finem.

Being an overhaul replacement of traditional car sun visors, MotoVise will promote the ability to dynamically position itself within the vehicle's front cabin to block incoming sunlight from a multitude of directions without the necessity of user intervention. Luminosity sensors placed on the headrests of the vehicle's front seats containing spatial information of incoming sunlight relative to driver and front passenger eye levels will provide input to the control system's microcontroller. This information is processed and relayed to the system's actuators, which are capable of moving a sun visor in 4 degrees of freedom. The sun visor will be adjusted to a position which best blocks the unwanted incoming sunlight, while maintaining maximum visibility of the road. Additionally, MotoVise will function as a sunshade: protecting the cabin of the vehicle from prolonged exposure to parking lot heat. This protection is achieved by utilizing a secondary collapsible visor, which can extend to more than half of the windshield when the vehicle is in a parked state.

The objective goal of MotoVise is to eliminate the redundancy of constantly fidgeting with a vehicle's sun visor while operating the vehicle and to remedy the scorching pain of getting back into your vehicle after parking it in the sun for prolonged periods. The following document outlines the functional requirements of MotoVise.

1.1 Scope

This document will provide high-level functional requirements of MotoVise's operation. These requirements will be the infrastructure for the development of MotoVise throughout its various design phases and serve as a measure of quality. All design choices for MotoVise will, therefore, be a derivative of these functional specifications with the purpose of meeting all the requirements listed in this document.

1.2 Audience

The MotoVise functional specification document is created with its intended audience as the employees of Trap Bird Technologies, in addition to those involved directly with the design, manufacturing and testing of MotoVise. References to this document shall be made for the duration of the design and manufacturing processes to ensure product deliverables are met within regulations and standards. The functional specification document shall also be used during testing and quality assurance phases to guarantee operation of product as per outlined requirements.

1.3 Classification

The following convention shall be used to denote functional requirements:

[RX.Y.Z-P] A functional requirement.

X.Y.Z is the respective section header, sub header and number of the functional requirement within the sub header while **P** is the priority of the functional requirement in the development cycle as indicated by one of three possible 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.

2.0 System Requirements

General Requirements for the complete system of MotoVise by Trap Bird Technologies are presented below.

2.1 System Overview

The overall design of MotoVise is expected to resemble Figure 1 below which outlines the major components necessary for its complete motion and functionalities.

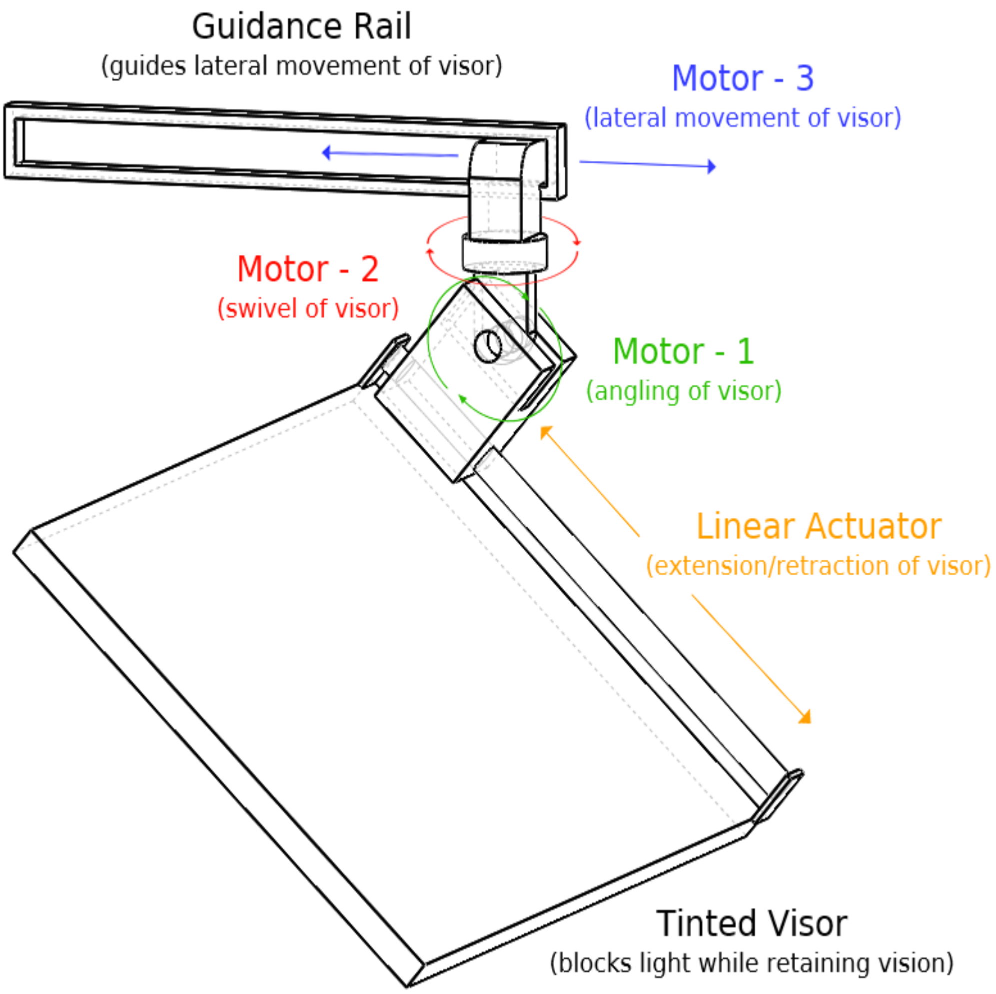

Figure 1: Conceptual drawing of MotoVise including actuation locations. Guidance rail will be mounted inside the vehicle cabin just above the front door. Right side of the image is oriented towards the front windshield of vehicle.

The flowchart in Figure 2 displays how the motion of the system is determined by its input and data analysis and processing.

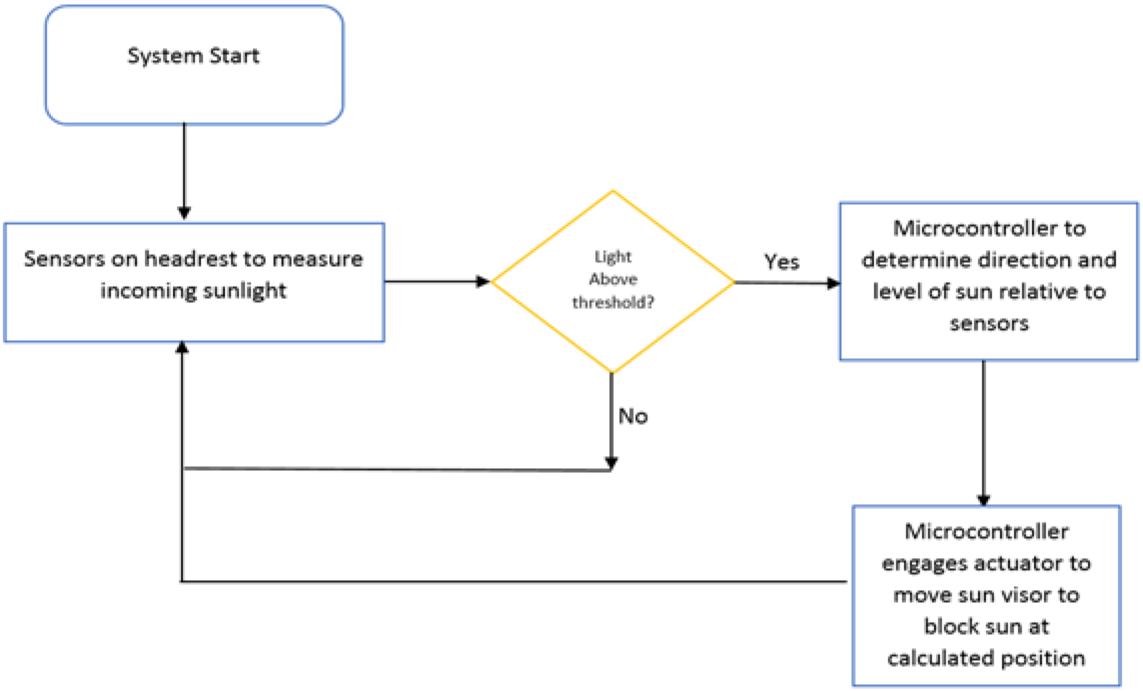

Figure 2: Flow Chart of Overall System Performance

The first stage of development will be focussed on developing the automatic motion of the visor based on the relative solar position observed. This phase's rendition of MotoVise is expected to be bulky and not as aesthetically pleasing as its sole purpose is to demonstrate the mechanical functionality.

We define **user** as any person operating MotoVise, someone sitting in the driver seat, or someone sitting in the front passenger seat. If the engine is powered off, MotoVise should still be able to operate manually. The main use of MotoVise is when the car is powered on and set to auto mode. After calibrating the user's head position, the visor will adjust itself per the sun position's incoming sunlight and the user's detected eye level to block the optimum level of sunlight while maintaining maximum road visibility.

The luxurious component of MotoVise consists of the extendable sunshade. This will be implemented in the latter half of the development stage once all other components are working.

2.2 General Requirements

[R2.2.1-II] The retail price of the MotoVise shall be under CAD $500.

[R2.2.2-II] The headrest must be adjusted to the height of the user for proper functionality of the sun visor.

[R2.2.3-III] MotoVise shall have minimal wiring and no outer protrusions.

[R2.2.4-III] Sensors, motors, and actuators shall be minimally intrusive to the user.

[R2.2.5-II] When powered off, users should be able to move the sun visor manually.

[R2.2.6-III] MotoVise shall have an idle state where all parts are retracted, locked, and static.

[R2.2.7-III] There shall be 2 modes available: auto and manual, which can be adjusted via a switch.

[R2.2.8-II] User visibility shall not be obstructed by the sun visor.

2.3 Physical Requirements

[R2.3.1-II] The total weight of MotoVise's freely moving parts not directly connected to body of vehicle shall not exceed 2.2 kg.

[R2.3.2-II] The length of the guidance rail attached to the body of vehicle shall not exceed 300 mm.

[R2.3.3-III] MotoVise shall function for any user of any size as long as their head position can be sensed by the headrest sensors.

[R2.3.4-II] MotoVise shall not occupy or obstruct the space directly above user's head position while seated in vehicle.

[R2.3.5-III] MotoVise must not be unmounted from its manufactured position at any time.

[R2.3.6-I] MotoVise shall be mounted as a blackbox for demonstration purposes.

[R2.3.7-III] MotoVise shall be embedded in the frame of the car when manufactured.

[R2.3.8-III] Overall aesthetics of system shall be sleek and minimalistic.

2.4 Electrical Requirements

[R2.4.1-II] MotoVise shall be connected to the closed circuit electrical system of the vehicle.

[R2.4.2-II] MotoVise shall only draw at maximum 12V nominal.

[R2.4.3-I] Power source of MotoVise shall be drawn from a 12V DC power supply.

[R2.4.4-III] Power source of MotoVise shall be drawn from an automotive battery.

[R2.4.5-III] All electrical components and wiring of MotoVise shall be concealed and unobtrusive of mechanical operation.

[R2.4.6-III] The embedded system shall enter an idle mode after 1 second of no required activity needed with respect to the sensors, allowing manual movement of visor parts.

2.5 Mechanical Requirements

[R2.5.1-II] Mechanical operation of MotoVise shall in no way impair the driving ability of the vehicle operator.

[R2.5.2-II] All automated mechanical movement shall also be capable of manual operation by the user.

[R2.5.3-II] MotoVise shall maintain its current position unless acted on by the controller or user.

2.6 Environmental Requirements

[R2.6.1-III] On auto mode, the sun visor shall only be activated when sunlight in the range of 5000K to 6500K colour temperature is detected.

[R2.6.2-II] The sun visor shall not be activated from manmade light sources such as lampposts or oncoming headlights.

[R2.6.3-II] Noise generated while MotoVise is active shall be below 70 dB.

[R2.6.4-II] MotoVise shall be silent when it is inactive.

[R2.6.5-II] MotoVise shall use materials that are non-harmful to the environment.

2.7 Standards

[R2.7.1-III] MotoVise shall conform to BC Laws Motor Vehicle Act Regulations [1].

[R2.7.2-III] MotoVise shall conform to IEEE standards.

[R2.7.3-III] MotoVise shall conform to Transport Canada's Motor Vehicle Safety Regulations CRC c.1038 [2].

2.8 Reliability and Durability

[R2.8.1-III] MotoVise shall be able to withstand everyday use on auto mode for the duration of the car warranty (5 years for luxury cars).

[R2.8.2-III] The user interface shall resist breakage under normal operating conditions.

[R2.8.3-II] The sun visor shall be able to continually adjust itself in auto mode when the engine is on.

[R2.8.4-II] The sun visor system shall function manually indefinitely in manual mode when power is not supplied to the system.

[R2.8.5-III] The system shall be serviceable by trained technicians.

[R2.8.6-III] Regular service should not be required.

[R2.8.7-III] MotoVise shall be water resistant.

[R2.8.8-III] MotoVise shall not have excessive heat dissipation.

[R2.8.9-III] The mechanical arm should not creak over time.

2.9 Safety Requirements

[R2.9.1-II] MotoVise shall not inflict any bodily injury to the user at any time.

[R2.9.2-II] MotoVise shall not combust spontaneously.

[R2.9.3-II] The system shall not physically obstruct the user at any time.

[R2.9.4-III] The system must not distract the driver at any point in time when the car is in motion.

[R2.9.5-III] The electronic components and power connections shall be enclosed.

[R2.9.6-III] The electronic components of the system shall not interfere with other devices.

[R2.9.7-II] Manual mode shall power down the system immediately.

[R2.9.8-III] MotoVise will be able to detect mechanical and electrical failure. If an error is detected, it shall notify user to switch to manual mode until a technician fixes the issue.

[R2.9.9-II] Upon start-up, MotoVise will run a calibration based on the user's head position with the headrest. If failure was detected previously and remains unresolved, MotoVise shall continue advising user to use in manual mode.

2.10 Performance Requirements

[R2.10.1-II] MotoVise shall only respond and actuate when detected illuminance at user eye level exceeds 32 000 lux, the lower bound of average day sunlight, for over 2 seconds [3].

[R2.10.2-III] The response time of MotoVise shall be within 5 seconds.

[R2.10.3-II] The maximum speed of system actuation shall not exceed 30 mm/s.

[R2.10.4-II] Sampling interval of luminosity sensors shall be 1 second.

[R2.10.5-III] MotoVise shall be operable between -40 to 85°C to account for possible extreme operating conditions of some vehicles.

2.11 Usability Requirements

[R2.11.1-II] MotoVise shall be intuitive and require minimal user input.

[R2.11.2-III] The visor shall have a manual disable button for the user to disable the visor in case of an emergency.

[R2.11.3-III] The visor movement while changing sides from the windscreen to the peripheral vision area should be smooth and comfortable for the driver.

2.12 Luxury Functions

[R2.12.1-III] The sun visor element shall contain a concealable mirror.

[R2.12.2-III] Usage of the sun visor's concealable mirror shall be accompanied with a lighting system.

[R2.12.3-III] The sun visor itself shall provide up to 30% tint from direct sunlight and provide up to 99% UV ray protection over covered area.

[R2.12.4-III] The height of sensors shall be adjusted through the user's headrest to provide optimized coverage to eye area for consumers of different heights.

3.0 Sun Tracking

The sun tracking sensors serve as the main inputs of the MotoVise control system. The information received from these sensors will prompt the system to move the visor using electromechanical components to provide coverage for the desired area created by the sensor setup. It was proposed that a total of three luminosity sensors be installed on a custom headrest by the auto manufacturer, which would then be used to create a plane (Figure 3). The user is expected to manually adjust the height of the headrest prior to starting the engine. Figure 4 shows the proper position of the headrest, such that the area covered by the visor system will represent the user's actual eye region.

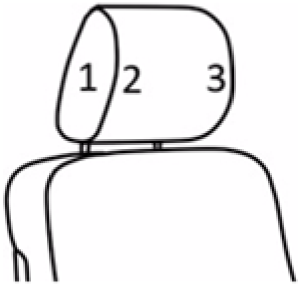

Figure 3: Location of sensors on headrest

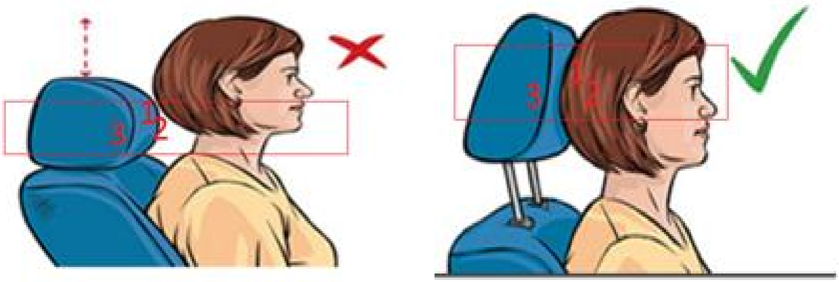

Figure 4: Correct headrest position [4]

3.1 General Requirements

[R3.1.1-II] The luminosity sensors shall be installed along the seat headrest 100 mm from the top.

[R3.1.2-II] Calibration of the coverage plane shall be made under the assumption that the top of the headrest is aligned to the top of the user's head.

3.2 Physical requirements

[R3.2.1-III] A headrest with a width of at least 300 mm is required by the manufacturer to install the sensor system.

[R3.2.2-III] The height of the headrests installed with sensors shall be adjustable manually or automatically.

[R3.2.3-II] Sensor 1 shall be centered at the side of the headrest facing the side window of the vehicle.

[R3.2.4-II] Sensors 2 and 3 shall be installed at the sides of the headrest facing forward towards the vehicle's windshield.

4.0 Visor Automation

To provide shade to the area depicted by the sensors, the movement of the sun visor will be actuated by the electromechanical components in the visor system. In addition to the retraction and extension of the visor along the windshield, the visor will also be able to adjust its angle.

4.1 General Requirements

[R4.1.1-II] The sun visor shall only extend to a length necessary to effectively block incoming sunlight without impairing road vision of the driver.

[R4.1.2-II] The sun visor shall be capable of extending and retracting from the roof of the vehicle's cabin.

[R4.1.3-II] The sun visor shall be capable of displacing laterally to provide sunblock coverage to the front of the vehicle and to the side where the guidance rail is mounted.

[R4.1.4-II] The speed at which the sun visor can translate along the side rail shall not exceed 50 mm/s to provide user with adequate reaction time to the movement of the visor.

[R4.1.5-II] The maximum angle at which the visor can be adjusted (automatically or manually) shall not exceed 90 degrees from the position parallel to the guidance rail.

[R4.1.6-II] The sun visor shall be adjustable manually only in the idle state or in manual mode.

4.2 Physical requirements

[R4.2.1-III] The sun visor shall contain a retractable sunshade feature.

[R4.2.2-III] The corners of the polycarbonate visor shall be rounded off to prevent cuts or pokes to the user while visor is in movement.

[R4.2.3-III] The width of the visor shall be 14 inches (allotting 2 inches off the sides for slider and motor gear and rack system, leaving 1 ft. of actual visor to provide sun blocking).

5.0 Sunshade Feature

An extendable sunshade feature is to be implemented to provide shade to the cabin when the vehicle is parked. The sunshade consists of an actuated gear and rack system along the sides of the cascaded visors, used to extend the sunshade down the windshield.

5.1 General Requirements

[R5.1.1-II] There shall be a ¼ inch spacing between the cascaded sheets of polycarbonate within the gear and rack system to eliminate friction when extending out as a sunshade.

[R5.1.2-II] The speed of the slider shall not exceed 50 mm/s to provide user with adequate reaction time to the movement of the sunshade if needed.

[R5.1.3-II] The extension of the sunshade shall commence only when the vehicle is parked and sunshade mode is engaged.

[R5.1.4-II] The angle at which the sunshade sits shall be adjusted manually to the user's preference after the sunshade extends completely.

[R5.1.5-II] The gear and rack system shall retract the sunshade when the vehicle is moved from parked gear or switched off from the user interface.

5.2 Physical requirements

[R5.2.1-III] The sunshade extension shall be made of the same material (tinted polycarbonate) as the initial visor to provide consistent coverage throughout the cabin of the vehicle.

[R5.2.2-III] The components of the gear and pinon system shall be covered in a heat proof material to prevent heat damage over time.

6.0 User Interface Unit

The user interface will be kept minimalistic to provide the user with a state-of-art automatic sun visor. MotoVise will have a two mode control panel. Automatic mode will allow automatic movement of the visor and manual mode will allow the visor to be operated manually. Table 1 shows the severity level for different usability problems that may arise while using the MotoVise. To mitigate these scenarios, the following requirements for the user-interface were formulated.

Table 1: Usability Severity Chart

	Low Frequency	**High Frequency**
Low Severity	Manual deployment of visor	Time lag while changing sides
High Severity	Visor Malfunctioning	Deployment in tunnels

6.1 General Requirements

[R6.1.1-III] The user interface shall have one togglable button between auto and manual mode and an additional button for the sunshade feature.

[R6.1.2-III] The primary source of user input to MotoVise shall be the auto/manual toggle button and the sunshade engagement button.

[R6.1.3-III] The buttons shall be labelled properly according to their functionality.

6.2 Usability requirements

[R6.2.1-III] The user interface shall be minimalistic and easy-to-use.

[R6.2.2-III] The user interface shall warn users if any failure is detected in MotoVise.

6.3 Physical requirements

[R6.3.1-III] The user interface shall be colour coded for easy maneuvering.

[R6.3.2-III] The user interface shall be located such that it is easily accessible in case of emergency.

[R6.3.3-III] The user interface shall be strategically placed in the sun visor enclosing.

7.0 User Documentation

[R7.0.1-III] User documentation shall include a website with general support information written in English.
[R7.0.2-III] User documentation shall be provided in French to satisfy product language requirements for Canadian markets.
[R7.0.3-III] The user manual shall be written for an audience with minimal knowledge of electromechanical devices.
[R7.0.4-III] The user manual shall be supplied with the car manufacturer manuals.
[R7.0.5-III] The user manual shall detail the operation of each mode.
[R7.0.6-III] The user manual shall include safety and liability information.
[R7.0.7-III] A detailed installation guide for technicians shall be created.
[R7.0.8-III] Customer support information will be available to consumers through the website.

8.0 Conclusion

The requirements presented in this document are analogous to the skeletal system of our project. General requirements of the system are given to express overall operations, while specific requirements pertaining to features such as sun tracking, visor automation, and the sunshade will be used to support product development. Priorities associated with each requirement will be used to differentiate the urgency and level of quality expected during development.

In summary, the functional specification document for MotoVise defines clear deliverables for this project in the form of requirements associated with various stages of development. In doing so, this document represents the realistic expectations for MotoVise, in addition to serving as a guiding force towards the project's completion. Trap Bird Technologies will continue to reference this document as the ultimate measure of quality assurance for the MotoVise product.

References

[1] “Motor Vehicle Act Regulations”, Bclaws.ca, 2016. [Online]. Available: http://www.bclaws.ca/civix/document/LOC/complete/statreg/--%20M%20--/47_Motor%20Vehicle%20Act%20[RSBC%201996]%20c.%20318/05_Regulations/29_26_58%20-%20Motor%20Vehicle%20Act%20Regulations/26_58_04.xml#section7.05 [Accessed: 28-Jan-2017]

[2] “Motor Vehicle Safety Regulations”, Transport Canada, 2017. [Online]. Available: https://www.tc.gc.ca/eng/acts-regulations/regulations-crc-c1038.htm [Accesses: 19-Feb-2017]

[3] B. Brown, *The Filmmaker’s Guide to Digital Imaging: for Cinematographers, Digital Imaging and Technicians, and Camera Assistants,* 1st ed. Focal Press, 2014, p. 100.

[4] *http://head2toeclinic.com/correct-position-of-headrests-in-the-car/*. 2017.