February 15, 2016

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

Re: ENSC 440W Functional Specification for the Direct Interference System for Coordination Limitation by Amplified and Stimulated Emission of Radiation (DISCo LASER)

Dear Dr. Rawicz:

The following document, *Functional Specification for the Direct Interference System for Coordination Limitation by Amplified and Stimulated Emission of Radiation (DISCo LASER)*, contains an overview of the functional requirements of our project for ENSC 440W. The goal of the project is to develop a nonlethal alternative to weapons used in war and minimize casualty count by utilizing light to temporarily blind enemies in an area.

The purpose of the functional specification is to provide high-level requirements for the project, outlining the functions that our product will need to perform, both in the proof-of-concept stage as well as the final product stage. This document will be used as a reference during the development of the product, and the final product will be tested and compared with these requirements to ensure that all of the functions outlined in this document are included.

If you have any questions or concerns, please contact Fabio Bollinger at fbolling@sfu.ca.

Sincerely,

Ashley Francke, CEO
DISCo

Enclosure: *Functional Specification for the Direct Interference System for Coordination Limitation by Amplified and Stimulated Emission of Radiation (DISCo LASER)*

FUNCTIONAL SPECIFICATION

For the Direct Interference System for Coordination Limitation by Amplified and Stimulated Emission of Radiation (DISCo LASER)

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Executive Summary

The world needs more security, and the DISCo LASER (the/this product) is one tool to achieve such a thing. Designed primarily for use in non-combat military operations, the product provides squadrons of soldiers' peace of mind knowing that the risk of violence against themselves and against innocent civilians has been significantly diminished. The product acts as a sort of invisibility cloak for its users, by ensuring that both civilians and hostiles cannot look in the direction of the users without a blinding flash of light striking their eyes. This product instantly recognises non-user faces with a combination of infrared and light cameras, and targets them with a precise beam of light. The best part: this light is specially designed to never cause permanent damage. The soldiers are then free to complete their tasks, completely protected by light.

This product is designed in a modular fashion, to allow continuous parallel processing of each element. It is comprised of 4 main components: the Sensor Unit, the Processors, the Motor Unit, and the Lighting Unit. Once the device is powered up and initialised, the each unit simply receives input and produces an output. It begins with the Sensor Unit. The infrared camera senses heat signatures, which are used to approximate the locations of the various faces in range. The light camera then scans the approximate locations and determines precisely where faces are found. All of this information is being calculated by the first processor, which outputs a steady stream of face coordinates to the next processor. The next processor receives a queue of coordinates and reads them in the order they arrive. It uses the coordinate information to calculate the horizontal and vertical rotation needed to position the lighting unit. It then arms the motor unit to move to the aforementioned position, and sends a signal to the lighting unit to fire once the position is reached. All processes repeat for the duration of the usage of the device.

Some important functional requirements as outlined below include mechanical requirements, hardware requirements, software requirements, and physical requirements for the light. The device must primarily be functional in all expected weather conditions of -10 to 60 degrees Celsius in rain, sunshine, and dust. It must be portable and mountable, and as such should be battery powered. The hardware is expected to complete one entire cycle, from scanning the face to the light flash, in less than 1/6th of a second. This number was chosen as a reasonable estimate for human movement speed. The software must be efficient, and consists primarily of communication between each component and of course the facial recognition. Finally, the lighting unit will be designed to emit a parallel beam of light at a fixed intensity. The width of the beam must be wide enough that there is an allowable error in the targeting precision. The light emitted cannot be filtered by the targets, as such we recommend changing wavelengths each time light is fired, or using a wide spectrum of white light.

As this device deals with electricity, it must conform to international standards for electronics and electrical technology. The lighting unit in particular will be high-powered, and the device must remain safely operational for the entirety of its intended life. As the goal of the device is to improve lives around the world, the device will be designed with strict sustainability and environmental standards. In the following pages the entirety of the devices functional specifications will be outlined and elaborated, including operational requirements as well as safety and sustainability requirements.

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Glossary

ANSI:	American National Standards Institute
Anthropometry:	Science of defining physical measures of a person's size, form, and functional capacities
DISCo:	Direct Interference System Corporation
DISCo LASER:	Direct Interference System for Coordination Limitation by Amplified and Stimulated Emission of Radiation
IEC:	International Electrotechnical Commission
IEEE:	Institute of Electrical and Electronics Engineers
ISO:	International Organization for Standardization
LED:	Light Emitting Diode
Microcontroller:	Small computing system containing a processor, memory, and programmable input/output peripherals
RoHS:	Restriction of Hazardous Substances
Processor:	Hardware circuit which executes programs
Servomotor:	Rotary or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration
Time-to-Target:	Time from the sensor acquiring the image to the time the motor unit has targeted the position
UL:	Underwriters Laboratories, a safety organization

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1. Introduction and Background

Welcome to the future of security. For so long, violent and lethal tactics have been the only choice for soldiers to control crowds of enemies even when civilians are mixed in. Even during non-combat related missions, soldiers would have to be prepared for unpredictable firefights and risk their own lives, as well as the lives of innocent people. Death was inevitable. It might even be argued that the deaths of the enemies were unnecessary, if the missions could have been completed without those deaths. Alas, there will always be resistance to military missions. In an ideal world, soldiers would be able to carry out their missions while the potential enemies were completely incapacitated and unable to start violent firefights. Having the enemies incapacitated would not only keep the soldiers and civilians safe, but would also allow much more efficient use of the soldier's skills while reducing their payload. Welcome to the future of security.

The DISCo LASER is the vehicle with which soldiers will be brought into this future. Figure 1 is a basic preliminary design for the DISCo LASER prototype, which includes all of the functional features of the device. Fundamentally this device is a face targeting non-lethal incapacitation turret. Traditionally soldiers would use non-lethal weapons to incapacitate a small number of potential threats, but this would become cumbersome and inefficient. The DISCo LASER will be used to find and target all human beings in a certain area and within seconds completely incapacitate all of them using powerful light. This phenomena of light incapacitation has been studied well and is known to not cause any permanent damage to humans.

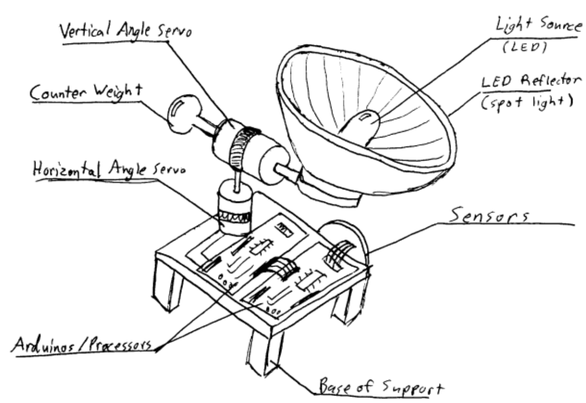

Figure 1 Basic Design of the DISCo LASER Prototype

The technology found in the DISCo LASER uses many facets of engineering science. The 'S' in DISCo stands for *System*, and as such the DISCo LASER is a true system comprising of electronics, mechanics, physics, and sensors all communicating with each other through computer processors. For example, the main mechanical components will be 3D printed (or otherwise manufactured) enclosures driven by 2 servomotors. Both motors will aim the lighting unit vertically and horizontally, according to where the processor determines the next face to be located. The sensors will include colour video sensors as well as infrared sensors. The processors will use data from both to track the coordinates of every face in the sensing region. There will also be some basic electronics used to control the lighting unit intensity and when it will be on and off. In the following pages the functional specifications of each component of this device will be described in detail.

1.1 Classification

Throughout this document we will employ the following conventions to denote functional requirements "FRm.n-p", where **m** is the section number, **n** is the functional requirement number, and **p** gives the priority, denoted by "1", "2", or "3", denoting that the requirement applies to the proof of concept system only, both the proof of concept system and the final production system, or only the final production system, respectively.

2. System Overview

This system comprises of four main components: A sensor unit, processors, a motor unit, and a lighting unit. All components work together to form a completely automated system. Figure 2 is a flowchart describing the order of functionality between each component. After initializing all the systems, the sensor unit and its associated processes continuously locate faces and determine their location in space relative to the lighting unit. It also determines the order in which to target the faces, optimized for speed. The sensor processes will output a queue of coordinates to the motor unit processor, which will control the servo motors to target the lighting unit to the next coordinate in the queue. Once the lighting unit has flashed the LEDs, the processor repeats its actions for the next target in the queue. If there is no signal incoming to the lighting unit, it will re-calibrate brightness according to light intensity.

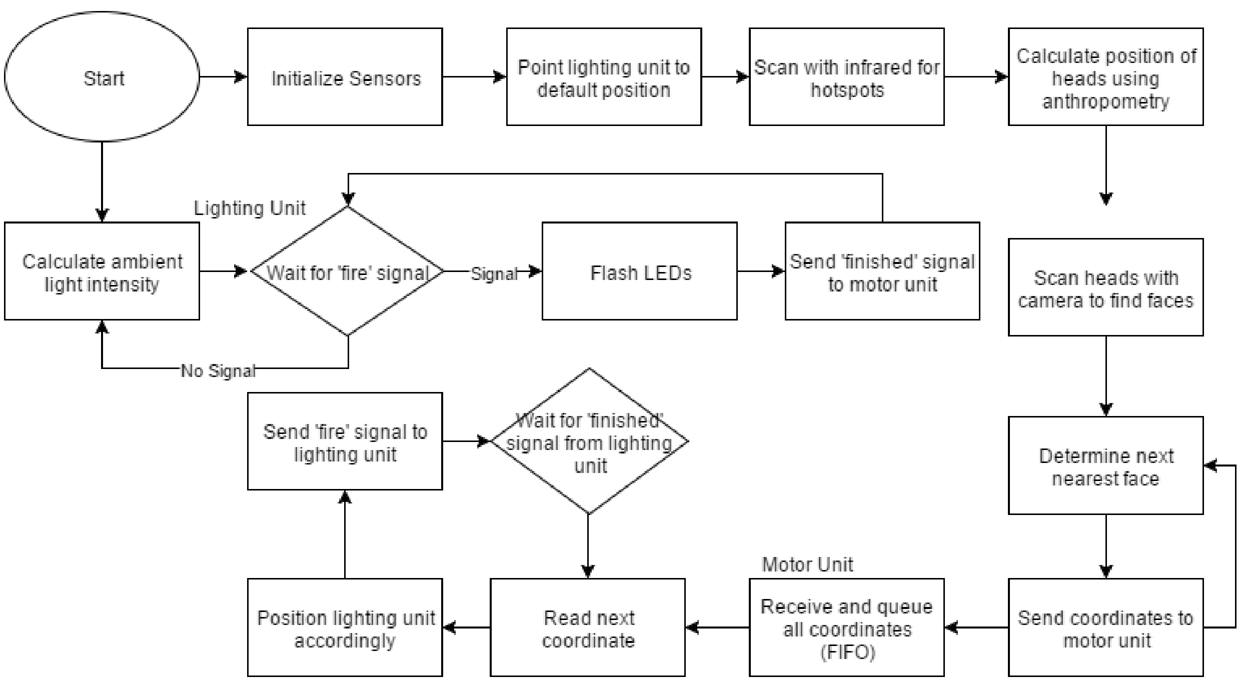

Figure 2 System Overview of the DISCo LASER

3. General Requirements

In this section and in the following sections, the functional requirements for the DISCo LASER will be described in detail. These requirements will be used to strictly design the final prototype, as well as to envision the final manufactured version. The general, system-level requirements are specified in Table 1.

Table 1: General Requirements

Section / Requirement ID	Requirement Definition
FR3.1 - 1	The total cost of the system shall be less than $1400.
FR3.2 - 2	The system shall be able to selectively identify human targets within 10 meters of the sensor module.
FR3.3 - 1	The system shall be able to identify human targets within a 50 degree scan range.
FR3.4 - 1	The system shall be able to identify and lock-on to up to 6 targets each second.
FR3.5 - 2	The system shall employ an error of no more than 0.5 degrees when moving the motor unit per the coordinates given by the sensor module.
FR3.6 - 1	The system shall move the motor unit to the final targeting position no more than 1/6th of a second after the coordinates have been received from the sensor module.
FR3.7 - 3	The system shall be able to be used and deployed in all weather scenarios without damage to the equipment.
FR3.8 - 1	The system shall operate on battery power for the duration of its use.
FR3.9 - 1	The system shall effectively stun, nauseate, or otherwise disorient its targets without causing permanent damage

4. Hardware Requirements

4.1 Infrared Camera

The infrared camera is part of the sensor module and is used to capture infrared radiation input in its nominal response wavelength band (from approximately 8 to 14 microns) and output a uniform thermal image within 0.5 seconds of scanning for data. This will be employed in order to capture infrared radiation emitted from individuals within range of the sensor module, at least 10 meters, depending on weather and visibility conditions--in weather conditions that affect visibility, such as heavy precipitation, wind, or fog, the maximum range of the infrared sensor will decrease. The camera will feature a sensor with a 50-degree field of view that has an optimum operating temperature range of at least -10 to 65 degrees Celsius, which is optimal for identifying human individuals in most weather conditions. In order to minimize outside signal processing for human-identification, the sensor will feature integrated thermal image processing functions. Further, in order to limit the power consumption of our sensor module, the camera will consume a low operating power of nominally 150mW. The physical and electrical requirements for the infrared camera are specified in Tables 2 and 3.

Table 2: Infrared Camera Physical Requirements

Requirement ID	Requirement Definition
FR4.1.1 - 1	The system shall be able to identify target heat signatures within a 50-degree field of view from the eye of the infrared camera.
FR4.1.2 - 2	The system shall be able to differentiate between living and inanimate objects through the use of heat-signatures.
FR4.1.3 - 3	The system shall be able to identify heat signatures in all weather conditions.
FR4.1.4 - 2	The system shall be able to selectively identify targets within 10 meters of the sensor module.
FR4.1.5 - 2	The system shall be able to identify a heat signature with enough resolution to be able to employ the principles of anthropometry to locate the head.
FR4.1.6 - 1	The system shall have an optimum operating temperature range of -10 to +65 degrees Celsius.
FR4.1.7 - 1	The system shall support a longwave infrared spectral range of 8 to 14 micrometers.
FR4.1.8 - 1	The system shall be capable of producing an image within 0.5 seconds of receiving the infrared radiation data.
FR4.1.9 - 1	The system shall support integrated digital thermal image processing functions, including automatic thermal environment compensation, noise filters, non-uniformity correction, and gain control.

Table 3: Infrared Camera Electrical Requirements

Requirement ID	Requirement Definition
FR4.1.10 - 1	The system shall be operated within low operating power conditions, nominally 150mW.

4.2 Camera

The camera is part of the sensor module and is used in tandem with the infrared camera in order to perform facial recognition on individuals once a human heat signature is identified. Through use of the infrared camera, we will obtain the infrared image of a human shape before utilizing the principles of anthropometry in order to obtain the position of the head. Once the head has been identified, we will use the camera in order to find the position of the eyes through utilizing image processing techniques for facial recognition. The camera will feature a sensor with a 50-degree field of view, to match that of the infrared camera, and will have an optimum operating temperature range similar to the infrared camera of at least -10 to 65 degrees Celsius. The physical and electrical requirements for the camera are specified in Tables 4 and 5.

Table 4: Camera Physical Requirements

Requirement ID	Requirement Definition
FR4.2.1 - 1	The system shall be able to identify a target within a 50-degree field of view from the eye of the camera.

FR4.2.2 - 2	The system shall be able to identify objects in all but the most extreme weather conditions.
FR4.2.3 - 2	The system shall be able to employ accurate facial recognition using coordinates provided by anthropometry to identify the eyes of the individual.
FR4.2.4 - 2	The system shall be able to identify when a target is facing away or facing towards the device through the use of facial recognition.
FR4.2.5 - 2	The system shall have high enough resolution to be able to employ facial recognition on targets within 10 meters of the sensor module.
FR4.2.6 - 2	The system shall receive the coordinates given by anthropometry no more than 0.1 seconds after they have been identified by the infrared camera.
FR4.2.7 - 1	The system shall have an optimum operating temperature range of at least -10 to +65 degrees Celsius.
FR4.2.8 - 1	The system shall implement internal image processing functions, including exposure control, gain control, automatic white balancing, automatic band filtering, automatic black-level calibration, colour saturation, hue control, gamma, edge enhancement, anti-blooming, noise reduction, and defect correction.

Table 5: Camera Electrical Requirements

Requirement ID	Requirement Definition
FR4.2.9 - 1	The system shall operate within the normal power conditions of approximately 1.7V to 3.0V.

4.3 Microcontroller

The microcontroller will be employed to control and link all of the system's modules: sensors, motors, and lighting. In order to be able to link all of the required modules, it will feature at least 14 pins, and will operate with a low voltage of approximately 5V. In order to account for all different weather conditions, the microcontroller will have an optimal operating temperature range of at least -10 to +65 degrees Celsius, to match that of the infrared and regular cameras. The physical and electrical requirements for the microcontroller are specified in Tables 6 and 7.

Table 6: Microcontroller Physical Requirements

Requirement ID	Requirement Definition
FR4.3.1 - 1	The system shall be able actively control the sensor module, motor unit, and lighting unit.
FR4.3.2 - 1	The system shall have enough pins in order to connect the sensor, motor, and lighting units.
FR4.3.3 - 1	The system shall be able to relay information throughout the modules with a delay of no more than 0.1 seconds.
FR4.3.4 - 1	The system shall have an optimum operating temperature range of at least -10 to +65 degrees Celsius.

FR4.3.5 - 1	The system shall contain 2 levels of processing in parallel: the sensor processing which generates a queue of target coordinates; and the motor processor which reads coordinates and controls timing of the lighting unit.
FR4.3.6 - 3	The processing for the lighting unit shall control intensity relative to ambient brightness and ensure the LEDs flash only once a target has been targeted.

Table 7: Microcontroller Electrical Requirements

Requirement ID	Requirement Definition
FR4.3.7 - 1	The system shall operate within the normal power conditions of approximately 5V.
FR4.3.8 – 3	The system shall operate at a maximum clock speed to ensure sensors and servos can conform to general requirements.

4.4 LEDs

The LEDs will be a part of the lighting module, and will function in place of the lasers in the proof-of-concept system. In the system's operation, the lighting module will be activated once a target has been identified by the sensor module and the motor unit has moved the unit to those coordinates, so we wish to employ a minimal delay time. Since we desire the lighting unit to be operational in nearly all weather conditions, the optimal operating temperatures should match that of the sensor module, at least -10 to +65 degrees Celsius. In addition to this, since the angle of our cameras will be approximately 50 degrees, our lighting unit should employ a 50 degree viewing angle to match. Further, in order to prevent glasses that filter out particular wavelengths, we wish to employ a lighting unit that has the ability to emit multiple wavelengths. The physical and electrical requirements for the LEDs are specified in Tables 8 and 9.

Table 8: LED Physical Requirements

Requirement ID	Requirement Definition
FR4.4.1 - 1	The system shall be able to turn on the LEDs with a delay of no more than 50 milliseconds after activation is signalled by the sensor module.
FR4.4.2 - 1	The system shall employ a uniform output intensity through the width and length of the beam.
FR4.4.3 - 1	The system shall employ varying output wavelengths or a wide spectrum of wavelengths.
FR4.4.4 - 1	The system shall have an optimum operating temperature range of at least -10 to +65 degrees Celsius.
FR4.4.5 - 1	The system shall employ a viewing angle that matches that of the sensor module, 50 degrees.

Table 9: LED Electrical Requirements

Requirement ID	Requirement Definition
FR4.4.6 - 1	Due to the high powered nature of the lighting unit, the LEDs may use a higher voltage according to their specifications

4.5 Lasers

The lasers will be a part of the lighting module in the final production system. In the system's operation, the lighting module will be activated once a target has been identified by the sensor module, so we wish to employ a minimal delay time with a high firing rate to quickly neutralize targets. Since we desire the lighting unit to be operational in nearly all weather conditions, the optimal operating temperatures should match that of the sensor module, at least -10 to +65 degrees Celsius. In addition to this, since the angle of our cameras will be approximately 50 degrees, our lighting unit should employ a 50 degree viewing angle to match, and should emit lasers with a beam diameter of no more than 1 cm for no more than 0.25 s in order to ensure the beam is focused on the individual's' eyes and will not cause lasting damage. Further, in order to prevent glasses that filter out particular wavelengths, we wish to employ a lighting unit that has the ability to emit multiple wavelengths. The physical and electrical requirements for the lasers are specified in Tables 10 and 11.

Table 10: Laser Physical Requirements

Requirement ID	Requirement Definition
FR4.5.1 - 3	The system shall be able to turn on the lasers with no significant delay once the motor unit has fixed to a target.
FR4.5.2 - 3	The system shall employ a uniform output intensity.
FR4.5.3 - 3	The system shall employ varying output wavelengths or a wide spectrum of wavelengths.
FR4.5.4 - 3	The system shall have an optimum operating temperature range of at least -10 to +65 degrees Celsius.
FR4.5.5 - 3	The system shall employ a viewing angle that matches that of the sensor module, 50 degrees.
FR4.5.6 - 3	The system shall emit a pulse width of no more than 0.25 seconds to avoid permanent damage to the eyes.
FR4.5.7 - 3	The system shall emit a beam diameter of no more than 1 cm.

Table 11: Laser Electrical Requirements

Requirement ID	Requirement Definition
FR4.5.8 - 3	The system shall operate within the normal power conditions of approximately 5mW.

4.6 Motors

The motors will operate as part of the motor unit and will function to move the lighting unit to the required position once the sensor module has identified a target. In order to limit the power consumption of our sensor module, the motors will consume a low operating power of nominally 350mA, with a drive voltage of 10V. Since we desire the motor unit to be operational in nearly all weather conditions, the optimal operating temperatures should match that of the sensor module, at least -10 to +65 degrees Celsius. In order to move the lighting unit both horizontally and vertically in the proof-of-concept system, two servo motors will be employed and attached in order to account for both horizontal and vertical movement. In the final production system, a motor with the capability to move in all angles will be desired. The physical and electrical requirements for the motors are specified in Tables 12 and 13.

Table 12: Motor Physical Requirements

Requirement ID	Requirement Definition
FR4.6.1 - 2	The system shall be able to position the lighting unit to the required position with a delay small enough to allow a total time-to-target of less than 1/6th of a second
FR4.6.2 - 2	The system shall have an optimum operating temperature range of at least -10 to +65 degrees Celsius.
FR4.6.3 - 1	The system shall be able to move both horizontally and vertically at the same time.
FR4.6.4 - 3	The system shall be able to move in all directions and angles within the field of view of the camera in order to reach the desired coordinates.
FR4.6.5 – 1	The motors must provide sufficient torque to accelerate and stop motion of the lighting unit.
FR4.6.6 – 1	Horizontal and vertical rotation must occur around the same axis.

Table 13: Motor Electrical Requirements

Requirement ID	Requirement Definition
FR4.6.7 - 1	The system shall operate within the normal power conditions of approximately 350mA, with a drive voltage of 10V.

5 Mechanical Requirements

5.1 Arduino Enclosure / Base of Device

The physical requirements of the Arduino enclosure are specified in Table 14.

Table 14: Arduino Enclosure Physical Requirements

Section / Requirement ID	Requirement Definition
FR5.1.1 - 1	The base of the enclosure must support the entire weight of the enclosure
FR5.1.2 - 1	The base must provide sufficient friction with an external surface such that it remains stationary as the lighting unit rotates
FR5.1.3 - 1	The enclosure for the Arduino and electronic components must be weather-proof for all on-earth environments
FR5.1.4 - 1	The enclosure must allow users to access the Arduino and the connections between each unit.

FR5.1.5 - 3	The system shall be small enough to be considered portable, and provide features for mounting

5.2 Lighting Unit

The physical requirements of the lighting unit are specified in Table 15.

Table 15: Lighting Unit Physical Requirements

Section / Requirement ID	Requirement Definition
FR5.2.1 - 1	The lighting unit shall emit a parallel (collimated) beam of light such that light intensity does not significantly diminish with distance.
FR5.2.2 - 2	Emitted light cannot be filtered by passive filters potentially used by the targets.
FR5.2.3 - 2	The emitted beam of light must be wide enough to tolerate small errors in the precision of the targeting system. A beam width of 10cm over a 10m range is sufficient for a targeting precision of 0.3 degrees.
FR5.2.4 - 2	There is to be no UV light present in the emitted light
FR5.2.5 - 2	The movement of the lighting unit shall not cause disturbances in the positioning of the device

5.3 Motor Unit

The physical requirements of the lighting unit are specified in Table 16.

Table 16: Motor Unit Physical Requirements

Section / Requirement ID	Requirement Definition
FR5.3.1 - 2	Two servomotors shall be used to provide both horizontal and vertical rotation, respectively, to the lighting unit.
FR5.3.2 - 2	The lighting unit will be secured to the motors in such a way that a minimal amount of torque is required for rotation. This shall be achieved by minimizing the moment of inertia of each moving part relative to the axis of rotation; by bringing the centers of mass very close to the axis
FR5.3.3 - 2	The motor unit must be powerful enough to position the entire lighting unit up to 6 times per second, so one complete maneuver must take less than 1/6th of a second
FR5.3.4 - 2	The axis of rotation for both vertical and horizontal rotation should be at the same point

5.4 Sensor Unit

The physical requirements of the sensor unit are specified in Table 17.

Table 17: Sensor Unit Physical Requirements

Section / Requirement ID	Requirement Definition
FR5.4.1 - 2	The sensor position must be completely fixed with respect to the lighting unit and known to the processor precisely
FR5.4.2 - 2	The processor may calibrate sensor positions upon start-up

5.5 Reliability

Some physical requirements related to product reliability are specified in Table 18.

Table 18: Reliability Physical Requirements

Section / Requirement ID	Requirement Definition
FR5.5.1 - 2	The enclosure shall be water and dust resistant
FR5.5.2 - 2	The enclosure must not allow direct sunlight to degrade electronic components
FR5.5.3 - 2	The system shall be fully functional within all requirements for a lifespan of 2 years
FR5.5.4 - 2	All materials must be selected to avoid corrosion and deformation
FR5.5.3 - 3	The system must successfully target and stun 99% of all targets

6. Software Requirements

The software employed will utilize Arduino-interfacing between our hardware components, the sensor module, motor, and lighting units in order to selectively identify, track, and lock onto targets. The sensor module, composed of infrared and regular cameras, will first scan for and identify a human heat signature. Utilizing anthropometry, the head of the individual will be identified, and then facial recognition techniques will be employed to locate the eyes. Once a target has been acquired, the motor unit will move according to coordinates provided by the sensor module in order to position the lighting unit towards the target's position. From here, the lighting unit will be activated and fired, neutralizing the target. In order to optimize the produced software, it will be written and debugged according to IEEE standards.

6.1 - Sensor Module

The function of the sensor module's software will be to identify a target from the infrared camera's data using image processing techniques, apply the principles of anthropometry to identify the head of the individual, then utilize the camera to identify if the individual is facing the sensor module, and if so, the coordinates of their eyes. Finally, these coordinates will be passed to the motor unit so that it can move the lighting unit to the correct position. Software requirements for the sensor module are specified in Table 19.

Table 19: Sensor Module Software Requirements

Requirement ID	Requirement Definition
FR6.1.1 - 2	The software shall be able to selectively identify a target from the data obtained from the infrared camera.
FR6.1.2 - 2	The software shall be able to selectively identify the head of an individual utilizing the principles of anthropometry from the data obtained from the infrared camera.
FR6.1.3 - 2	The software shall be able to selectively identify whether an individual is facing the sensor module through the use of facial recognition principles and data obtained from the camera.
FR6.1.4 - 2	The software shall be able to selectively identify the eyes of an individual through the use of facial recognition principles and data obtained from the camera.
FR6.1.5 - 2	The software shall be able to pass the coordinates of the eyes of an individual to the motor unit.

6.2 - Motor Unit

The function of the motor unit's software in the proof-of -concept system will be to selectively move the horizontal and vertical servo motors to the location specified and sent by the sensor module. In the final production system, a motor with the capability to move in all angles will be utilized, so it will not have to selectively move the separate horizontal and vertical motors. Once the lighting unit has reached the required position, the software should activate the lighting unit in order to fire at the target. Software requirements for the motor unit are specified in Table 20.

Table 20: Motor Unit Software Requirements

Requirement ID	Requirement Definition
FR6.2.1 - 2	The software shall be able receive the coordinates for the eyes from the sensor module.
FR6.2.2 - 2	The software shall be able to move the lighting unit to coordinates specified by the sensor module.
FR6.2.3 - 1	The software shall be able to selectively move the horizontal and vertical servo motors separately in order to reach the appropriate position.
FR6.2.4 - 3	The software shall be able to move the motor at any angle in order to reach the appropriate position.
FR6.2.5 - 2	The software shall be able to identify when the lighting unit is in the appropriate position and signal the lighting unit to fire when it is reached.

6.3 - Lighting Unit

The function of the lighting unit's software will selectively fire once it has been sent an activation signal by the motor unit. The lighting unit should be able to selectively fire at a high repetition rate in order to maximally neutralize targets and should be able to alternate the wavelengths of the LEDs (in the proof-of-concept system) and the lasers (in the final production system) in order to avoid filtering. Software requirements for the lighting unit are specified in Table 21.

Table 21: Lighting Unit Software Requirements

Requirement ID	Requirement Definition
FR6.3.1 - 2	The software shall be able receive the activation from the motor unit when it has reached the correct position for firing.
FR6.3.2 - 2	The software shall be able to selectively fire the lighting unit only when signalled from the motor unit.
FR6.3.3 - 1	The software shall be able to selectively fire the lighting unit at a repetition rate of at least 10 Hz.
FR6.3.4 - 3	The software shall be able to alternate the wavelengths of the lasers fired.
FR6.3.5 - 1	The software shall be able to alternate the wavelengths of the LEDs fired.

7. Engineering Standards

7.1 Electrical Safety

The following two standards are in regard to safety with electrical equipment. As our device uses electrical equipment, it is important we follow these standards to avoid electric shocks for nearby people. Also, these standards cover safety issues for protection from moisture damage to electrical circuits. Since the DISCo LASER can be deployed in many scenarios such as rain or tropical areas, it is important that moisture is not a concern.

UL 61010-1 – Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements [1]

UL 60950-1 – Information Technology Equipment – Safety – Part 1: General Requirements [2]

Since our device is a video electronic apparatus that will go into areas of public, the safety standards outlined in the following standard should be followed.

IEC 60065:2014 – Audio, video and similar electronic apparatus – safety requirements [3]

Based on the following two standards, our device must have safety protocols that will initiate in the event of misbehaviour. Having these redundancies will allow our device to safely resolve possible failures.

IEC 61508 – Functional Safety [4]

IEC 62061:2005 - Safety of machinery: Functional safety of electrical, electronic and programmable electronic control systems [5]

7.2 Mechanical Safety

In order to avoid injury for people who may be maintaining these devices for routine check-ups, the following two standards should be followed.

> *ISO 13854:1996 - Safety of machinery – Minimum gaps to avoid crushing of parts of the human body* [6]

> *ISO 12100:2010 - Safety of machinery – general principles for design – risk assessment and risk reduction* [7]

7.3 Environmental

DISCo Tech does not want to impact the environment negatively and does want to support recycling, so we should adhere to the following requirements to ensure that the DISCo LASER and its components do not have a negative impact on the environment.

> *ISO 17422:2002 – Plastics – Environmental aspects – General guidelines for their inclusion in standards* [8]

> *ISO 14040:2006 – Environmental management – Life Cycle assessment – principles and framework* [9]

> *ISO 14044:2006 - Environmental management - Life cycle assessment - Requirements and guidelines* [10]

> *ISO 14046:2014 - Environmental management - Water footprint - Principles, requirements and guidelines* [11]

7.4 Light Safety

The following standards used for ophthalmic instruments are considered in our situation as we do not wish to cause lasting eye damages. The ANSI standards for general safe use of the lasers are also implemented to ensure no lasting harm on the receiving end.

> *ANSI Z136.1 – Safe use of Lasers*

> *ANSI Z136.6 – Safe Use of Lasers Outdoors* [12]

> *ISO 15004-1:2006 - Ophthalmic instruments - Fundamental requirements and test methods - Part 1: General requirements applicable to all ophthalmic instruments* [13]

> *ISO 15004-2:2007 - Ophthalmic instruments - Fundamental requirements and test methods - Part 2: Light hazard protection* [14]

We want to make sure we follow the standard guidelines for components in our device. Following this standard will make repairs easier due to standard parts being used, as well as better sustainability.

ISO 11151-1:2015 - Lasers and laser-related equipment - Standard optical components - Part 1: Components for the UV, visible and near-infrared spectral ranges [15]

The following standard is in regard to the reliability of our own equipment. We require the laser not to damage its own enclosure or nearby circuitry as it is functioning.

ISO 10110-17:2004 - Optics and photonics - Preparation of drawings for optical elements and systems - Part 17: Laser irradiation damage threshold [16]

7.5 Security

This standard is required since we will process facial images while performing facial recognition and eye-locating.

ISO 22311:2012 - Societal security -- Video-surveillance -- Export interoperability [17]

7.6 Imaging and Processing

These standards will help our team in providing the correct vocabulary use in documentation. It will also provide guidelines ensuring we are appropriately performing and understanding readings in the thermal images.

ISO 6781-3:2015 - Performance of buildings - Detection of heat, air and moisture irregularities in buildings by infrared methods - Part 3: Qualifications of equipment operators, data analysts and report writers [18]

ISO 10878:2013 - Non-destructive testing -- Infrared thermography – Vocabulary [19]

Since our device will rely upon facial recognition before implementing eye-locating for the stunning of individuals, we should meet the following facial recognition standards for efficiency.

ISO/IEC 19794-5:2011 - Information technology - Biometric data interchange formats - Part 5: Face image data [20]

7.7 Functionality

Since the DISCo LASER is going to be deployed in a military setting, we should meet the following requirements for bullet-proofing.

EN 1063 – Security Glazing [21]

8. Sustainability and Safety

There are many materials hazardous to the environment that may cause lasting damage if they are used and disposed of. To prevent our product from having a detrimental effect on the environment, the parts used for the product are specifically selected to be RoHS compliant. RoHS restricts the use of harmful materials including the following [22]:

- Lead (Pb)
- Mercury (Hg)
- Cadmium (Cd)
- Hexavalent chromium (CrVI)
- Polybrominated biphenyls (PBB)
- Polybrominated diphenyl ethers (PBDE)
- Selected Phthalates (DEHP, BBP, BBP, DIBP)

Restrictions of the above substances also ensure safer disposal of the parts used if needed.

Furthermore, due to the simple way of assembling our product, the parts used within the product can also be easily reused in other projects. For example, when disassembling the project, the regular and infrared cameras used can simply be unplugged from the Arduino board and the wires and lighting units detached just as easily.

In addition to the above sustainability and environmental concerns, there are also certain safety requirements the product will meet for each part:

8.1 Lighting Unit

- Intensity of the light shall be regulated so there will be no permanent damage to the eyes
- Alterations between different wavelengths shall take more than 0.2 seconds to avoid inducing seizures [23]
- When the light sources are lasers:
    - the power shall not exceed 5mW with 25W/m^2 (classified as class 3A)
    - the duration must be less than 0.25sec to avoid permanent eye damage [24]
    - Nd:Yag/ruby lasers shall be used to prevent thermal skin damage [25]

8.2 Actuators

- Moving junction shall be covered (casing or molding) to avoid physical injuries such as the pinching of a finger

8.3 Arduino Board and Wires

- Wires and board shall be properly insulated and grounded to prevent shocks and electrical fires

8.4 Outer Casing

- Outer surface shall be smooth to prevent accidental physical damage on the casing
- Casing should be durable against bullets and other weaponry

8.5 Other Considerations

- Device should be non-flammable, non-explosive, and easily transported
- There should be password or fail safe protection in the case that the device falls into the wrong hands [26]

9. Conclusion

The DISCo LASER is a full security system for the next generation of *safety.* By using coupled light and thermal sensors, the disco laser will first find any and all faces of those who may complicate non-combat missions. With this information the sensors will quickly store their coordinates in a queue. The system then rapidly reads through the queue, targeting and firing a concentrated blast of photons, rendering the targets stunned for a significant amount of time. Within seconds, most targets will be stunned and incapacitated. All targets which have not been stunned will be severely hindered, since the moment they look towards the soldiers, they will be stunned too.

This device has applications reaching much further than the military. Any situation in which a squad of officials needs to incapacitate a group of people is ideal for the DISCo LASER. These situations may include riots, bank heists, and police busts. In every situation, the incapacitation ensures that the number of victims of violence from either side of the conflict is significantly reduced. This device is a functional alternative to dangerous, imprecise non-lethal weapons such as stun grenades or rubber bullets. It also allows the squadron to move more freely, as it is fully automated and can be mounted on nearly any surface or vehicle. The DISCo LASER is the future of security.

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