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October 13, 2011

Dr. Andrew Rawicz  
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Re: ENSC 440 Functional Specification for an Avatar 3G

Dear Dr. Rawicz:

The documentation, *Functional Specification for an Avatar 3G*, describes the requirements for Elysian Innovations' current project. Our goal is to design, build, and program a remote controlled device that allows the user to navigate using a 3G network through a mobile phone.

We have a set of high standards and requirements for the project's concept and production development as described in the attached document. Our group of engineers will use this document as a guide throughout the research and development process.

*Elysian Innovations* is innovative, creative, and aspires to go beyond the limit. This company consists of five young engineers filled with passion and motivation. They are Leo Chan, Anthony DiNicolo, Simon Mai, Celestine Poon, and Sherman Tse. If any questions arise about our functional specifications, please contact our CCO, Celestine Poon, through email at [ccp2@sfu.ca](mailto:ccp2@sfu.ca).

Sincerely,

*Sherman Tse*

Sherman Tse  
President and CEO  
Elysian Innovations

Enclosure: *Functional Specification for Avatar 3G*



# Functional Specification for an Avatar 3G

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## Executive Summary

Smartphones are rapidly becoming the dominant method of communication between people. People everywhere are demonstrating their need for Smartphones and depend on their mobile communication functions continuously. However, a major drawback of phone-to-phone communication is the inability to interact with and explore the environment remotely. Elysian Innovations has found an efficient and affordable solution to this problem, allowing people to be in two places at once through the use of the Avatar 3G. The Avatar 3G gives users control of a compact remote device that will allow them to communicate, explore, and interact with the environment remotely -- controlled entirely by a Smartphone. The Avatar 3G includes the following functions:

- Communication via 3G network
- Two way audio communication
- Full pan and tilt control of mounted video camera
- Full motor control of robot movement
- Easy to use interface allowing access to all features through Smartphone

At Elysian Innovations, we believe that the Avatar 3G is the next level in mobile communication, allowing users to explore and interact with their environment remotely. The Avatar 3G is designed to be an affordable solution to telepresence communication, allowing a much wider range of people to benefit from this technology than previously available. Similar products have been seen to sell for as much as \$19,000 while Elysian Innovations will be attempting to construct the Avatar 3G prototype for under \$800, and mass production costs planned to be under \$350. This significant price drop for a device with nearly identical features will open up a market in mobile communications that was previously inaccessible for the average customer.

The proposed development cycle for the Avatar 3G has been established as four months long, with targeted completion set for mid-December 2011. At the end of this cycle, Avatar 3G will be fully operational with complete control via an Android smartphone, independence from wires through the use of a single rechargeable battery for power, and a sleek and finished outer design. Once these main features have been completed, there are endless luxury features that Elysian Innovations have designed that could be added onto existing Avatar 3G devices. These additional features demonstrate the vast range of functions that the Avatar 3G can possess and its seemingly limitless expansion into more functionality.

Expand your horizons. Go anywhere with Avatar 3G.

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## Glossary

<b>3G</b>	3rd generation mobile telecommunications; a generation of standards for mobile communications
<b>3G Modem</b>	3G modulator-demodulator; used for communication through 3G standards.
<b>3G Router</b>	Device that forwards data packets between 3G modem and other devices.
<b>Android</b>	Operating system for mobile devices developed by Google Inc.
<b>ANSI</b>	American National Standards Institute
<b>Application</b>	The downloadable program for the Smartphone that controls the Avatar 3G.
<b>Arduino Uno</b>	The microcontroller for the Avatar 3G.
<b>CE</b>	European Commission
<b>dB</b>	Decibel; It is used to in measuring the volume of sound.
<b>Feedback</b>	The return of an output signal.
<b>GUI</b>	Graphical User Interface; It is the user interface for the user to interact with the device.
<b>Km/h</b>	Kilometer per hour; It is used in speed measurement.
<b>lb</b>	Pound; It is used as a weight measuring unit.
<b>Multi-Touch</b>	The interface which allows the user to have multiple points of movement for control.
<b>RoSta</b>	Robot Standards and Reference Architectures
<b>Shields</b>	An add-on for the Arduino board for controlling specific parts of the Avatar 3G (eg. Motors)
<b>SIM card</b>	Subscriber Identity Module; It is used for cellphones.
<b>TCP/IP</b>	Transmission Control Protocol/ Internet Protocol
<b>Treads</b>	The conveyor belt like tires of the Avatar 3G.
<b>USB</b>	Universal Serial Bus; industry standard for cables, connectors, and protocols for device communication
<b>Webcam</b>	Video camera that feeds images to a computer.
<b>Wi-Fi</b>	Mechanism for communicating wirelessly via the IEEE 802.11 family of standards.

## 1. Introduction

The Avatar 3G is a robotic device that allows the user to operate a small remote vehicle via an Android application with an Android Smartphone. Through the use of a 3G network, users can operate the device anywhere at any time as long as there is network coverage. This functional specification will provide the requirements for the Avatar 3G as proposed by Elysian Innovations.

### 1.1 Scope

The following document will specify all the functional requirements for the prototype of the Avatar 3G proposed by Elysian Innovations. This document will also provide a system test plan.

### 1.2 Intended Audience

The team members of Elysian Innovations will use this document as a guideline during the development of the product. The team leader will refer to this document as a guideline for the progress of the overall design process. The mechanical engineers will refer to this document for the mechanical requirements for the design of the product. The software engineers will use this document for the instructions and demands of the Android application used to operate the device. The electrical engineers will design and develop the electrical components following the guideline listed in this document. The test engineers will test the product under the requirements and conditions listed in this document.

### 1.3 Classification

The following convention will be used to indicate the functional requirements of the Avatar 3G throughout the document:

[R-p] – A functional requirement

Where **p** represents the priority of the functional requirement, one of:

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

## 2. System Requirements

General requirements regarding the Avatar 3G are listed in this section.

### 2.1 System Overview

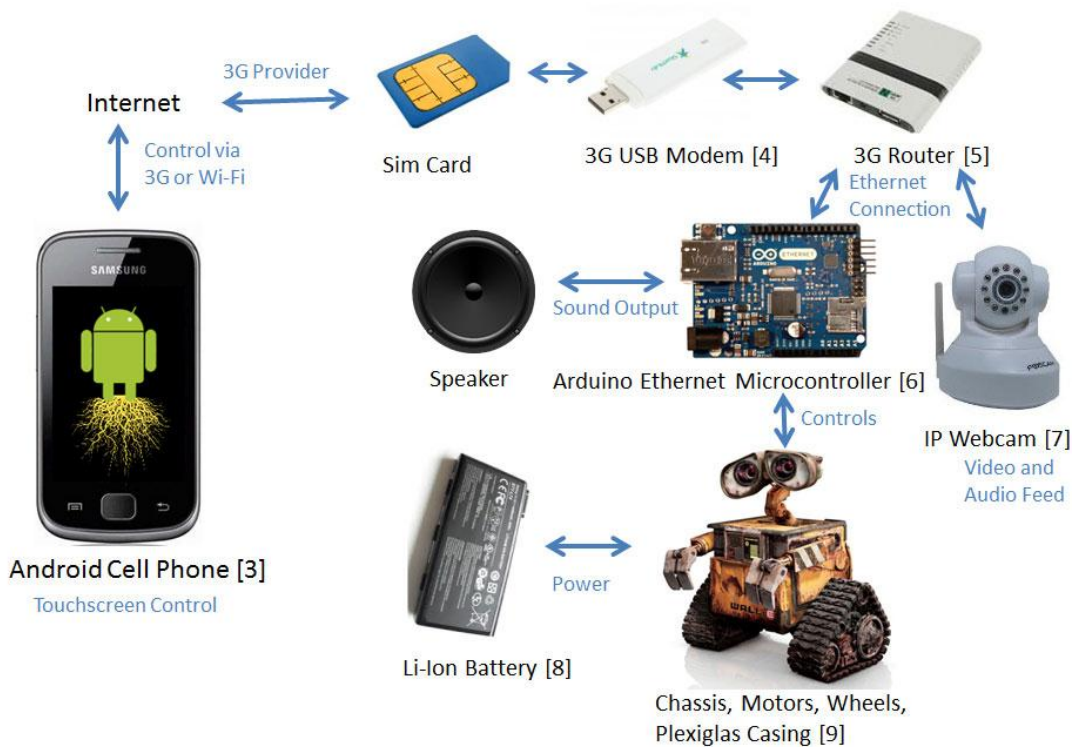
Control of the Avatar 3G is accomplished through an application running on a mobile Smartphone with the Android Operating system. The graphical user interface, as shown in figure 1, will display the video feed from the webcam built into the Avatar 3G, while broadcasting the audio feed on the phone's speakers. With the phone in the horizontal orientation, two control areas will be present for each thumb. The left area will be used to move the Avatar 3G forwards, backwards, left, and right, while the right area will be used to pan and tilt the camera. Input from the phone's microphone can also be sent to the Avatar 3G to be broadcasted through built in speakers.



**Figure 1: GUI Overview**

The Android application will connect to the internet, either using 3G or Wi-Fi. Using a SIM card, 3G USB modem, and 3G router, the Avatar 3G will be able to communicate with the Android application through TCP/IP. An Arduino Uno microcontroller board, along with applicable shields, will run a simple web server that allows the application to connect and control the movement of the Avatar 3G. The application will also receive a video and audio feed from the IP webcam, as well as the ability to control the pan and tilt. The overall structure of how components are connected is shown in figure 2.





**Figure 2: System Overview**

## 2.2 General Requirements

[R1-II] Moving parts shall be locked when at an idle state.

[R2-III] The Avatar 3G shall have a maximum retail price of \$350.

## 2.3 Physical Requirements

[R3-II] The dimensions of the Avatar 3G shall not exceed 30cm x 20cm x 50cm (width x length x height).

[R4-II] The Avatar 3G shall have an attractive appearance to all ages.

## 2.4 Electrical Requirements

[R5-II] The Avatar 3G shall not interfere with other devices.

[R6-II] The Avatar 3G shall not be interfered with by other devices.

[R7-II] The Avatar 3G shall perform all required tasks simultaneously while powered by a single rechargeable battery.

[R8-II] The power adapter shall be compatible with typical North American wall outlets.

[R9-II] The power adapter shall be easily inserted into the battery for charging.

[R10-II] The Avatar 3G shall be operational while power adapter is attached.

## 2.5 Mechanical Requirements

- [R11-II] All moving parts are controlled using the Android Application by the user.
- [R12-II] All non-moving parts are tightly secured using proper tools.
- [R13-II] All non-waterproof components are securely encased to prevent rusting and mold to collect.
- [R14-II] Treads and casing are made of non-rust materials.

## 2.6 Environment Requirements

- [R15-III] The Avatar 3G shall operate normally under typical Canadian temperatures (-33 – 27°C). [1]
- [R16-II] The Avatar 3G shall function properly under sun and rain.
- [R17-I] The Avatar 3G is not for operation in snow.
- [R18-II] The Avatar 3G shall be silent when inactive.
- [R19-II] Noise generated by the Avatar 3G while idle shall be minimized.
- [R20-II] Noise generated by the Avatar 3G during operation shall be minimal.

## 2.7 Standards

- [R21-III] The Avatar 3G shall obey RoSta standards. [11]
- [R22-III] The Avatar 3G shall obey ANSI standards. [13]
- [R23-III] The Avatar 3G shall obey CE standards. [12]

## 2.8 Reliability & Durability

- [R24-II] The Avatar 3G shall be able to withstand normal daily uses.
- [R25-II] The Avatar 3G shall be able to work under dry and wet conditions.
- [R26-II] The Avatar 3G shall be able to withstand water spilling on the device without any physical or electrical damage.
- [R27-III] The Avatar 3G shall be serviceable by any trained mechanics.
- [R28-III] The Avatar 3G shall be able to operate for four hours continuously.
- [R29-II] The Avatar 3G shall be able to operate and communicate anywhere within the mobile phone network coverage.
- [R30-III] The Avatar 3G shall be able to hold 10lbs of grocery products without any physical or electrical damage.
- [R31-III] Regular service interval shall be at least once every year.

## 2.9 Safety Requirements

- [R32-II] The Avatar 3G shall not overheat and explode.
- [R33-II] The electronic component and the circuitry shall be enclosed.
- [R34-II] The Avatar 3G shall not exceed 10km/h.
- [R-II] The speaker's volume shall not exceed 90dB.

[R35-II] The Avatar 3G shall not collapse when the maximum weight load is exceeded.

[R36-II] There shall not be a power leakage.

[R37-III] The Avatar 3G shall have a panic button used as a security system incase theft occurs.

[R38-III] The Avatar 3G shall have sensors to prevent the device from crashing into people and objects within a range of 10cm from the edge of the device.

## 2.10 Performance Requirements

[R39-II] The Avatar 3G shall not have a response delay more than one second.

[R40-II] The Avatar 3G shall not have a feedback delay more than one second.

[R41-II] The Avatar 3G shall be able to start up immediately when turned on.

## 2.11 Usability Requirements

[R42-II]The Avatar 3G shall automatically connect to phone control.

[R43-II]The Avatar 3G shall self-reach to user (without user moving).

[R44-II]The Avatar 3G shall stop all operations and keep reconnect terminal when connection is lost.

[R45-II]The Avatar 3G shall send out warning signal when 10% of battery life remains.

[R46-II]The Avatar 3G can reach to charging dock by itself.

## 2.12 Luxury Functions

[R47-III] The Avatar 3G shall have a secondary camera for 360° view.

[R48-III] The Avatar 3G shall have a robotic arm for pressing buttons or lifting objects.

[R49-III] The Avatar 3G shall have brake lights when the brakes are applied.

[R50-III] The Avatar 3G shall have head lights when it is operating in the dark.

[R51-III] The Avatar 3G shall have an emergency braking system.

[R52-III] The Avatar 3G shall be able to detect any obstacles on its way and warn the user.

[R53-II] The Avatar 3G shall have a burglar alarm.

[R54-III] The Avatar 3G shall notify the user if the maximum weight load is exceeded.

[R55-II] The Avatar 3G shall notify the user if the battery level is below 10%.

[R56-II] The Avatar 3G shall have an auto-charging dock.

### 3. Battery

The power supply is a very important part of the Avatar 3G for the following reasons since it powers each of the main components of the Avatar 3G. Great attention must be paid to the battery since its failure can result in a complete system failure. Therefore lengthy tests must be performed to make sure the battery meets all standards and reliability qualifications.

#### 3.1 General Requirements

- [R57-II] The battery must be rechargeable to provide multiple uses of the Avatar 3G.
- [R58-II] The battery must take no more than three hours to recover full charge when charging.
- [R59-II] The battery must have high security and reliability
- [R60-II] The battery must provide simultaneous power to each component attached to the Avatar 3G
- [R61-II] The battery must be easily removable for replacement if necessary

#### 3.2 Electrical Requirements

- [R62-II] The battery must have sufficient capacity to power all components for no less than one hour.
- [R63-II] The battery must have efficient energy conversion to avoid wasted power.
- [R64-II] The battery must be charged by a power adapter compatible with typical North American outlets.
- [R65-II] Built-in protection must prevent over-charge, over-discharge, and over-current of battery.
- [R66-II] Short circuit protection must be built into the battery.

#### 3.3 Physical Requirements

- [R67-II] The weight of the battery shall be low enough to prevent wasting power to carry battery.
- [R68-II] The dimensions of the battery shall be small enough to fit inside casing of the Avatar 3G.

### 4. Motor & Treads

The primary function of the motor and treads is to mobilize the Avatar 3G. The motors are controlled using the Android Application remotely. By opposing the direction the left and right treads are turning, the Avatar 3G turns left and right.

#### 4.1 General Requirements

- [R69-II] The Treads have to be waterproof and non-slip under rainy weather.
- [R70-III] The motors and treads have to be able to carry the weight of the Avatar 3G plus up to an extra 10 lbs.

## 4.2 Mechanical Requirements

[R71-III] The motors shall not overheat due to heavy load or weather temperature.

[R72-II] The motors and treads must be durable for long term usage.

[R73-II] In the event that the motors or treads become damaged, they must be easily replaceable.

## 4.3 Physical Requirements

[R74-III] The size of the treads must lift the casing a significant distance from the ground to prevent the case from hitting a ramp prior to the upward climb.

# 5. Camera & Speaker

The camera and speaker are used by the user to communicate with the device and its surroundings. The camera will provide a real time video feedback to the android application so the user can operate the device remotely and the speaker will provide a two way communication between the user and the device's ambiance.

## 5.1 General Requirements

[R75-II] Both the camera and speaker have to be waterproof.

[R76-III] The camera must have a 270° horizontal pan and a 90° vertical tilt.

[R77-II] The speaker must have a maximum volume of 90dB.

## 5.2 Electrical Requirements

[R78-II] The circuitry of the camera and speaker must be enclosed by the casing to prevent any damage or interference.

[R79-II] The power supply of the whole system must be regulated to prevent any damage to the device and the user.

## 5.3 Physical Requirements

[R80-II] Both the camera and speaker must be able to fit on top of the device.

[R81-II] There must be no components obstructing the camera's view

[R82-I] The exterior of the camera and speaker must be aesthetic.

## 6. 3G Communication

A 3G modem with a SIM card is needed to allow communication and control of the Avatar 3G. The 3G modem and 3G router will work together to stream video, two-way audio, and instructions between the Avatar 3G and the user's mobile device.

### 6.1 General Requirements

[R83-II] The 3G modem must be able to connect to the subscribed mobile network of choice in areas with reception.

[R84-II] The 3G modem must be configurable to allow compatibility with mobile network setups.

[R85-II] The 3G modem must acquire necessary information about the mobile network provider from the SIM card.

[R86-I] The 3G modem must be able to communicate with the 3G Router via USB.

[R87-II] The 3G modem must be able to handle data rates sufficient for live video streaming, two way audio, and navigation control input.

[R89-I] The 3G router must be able to connect to the internet via USB on the 3G modem and route TCP/IP traffic to at least two different targets.

[R90-II] The 3G router must be able to handle data traffic that results from video streaming, two-way audio, and navigation without crashing.

### 6.2 Electrical Requirements

[R91-I] The 3G modem must operate on 5V DC or less and draw no more than 900 mA.

[R92-I] The 3G router must operate on 9V DC or less and draw no more than 1000 mA.

### 6.3 Physical Requirements

[R93-I] The 3G modem dimensions must be under 10 cm by 5cm by 2 cm.

[R94-I] The 3G modem weight will not exceed 30 grams.

[R95-I] The 3G router dimensions must be under 20 cm by 15 cm by 5 cm.

[R96-I] The 3G router weight will not exceed 300 grams.

## 7. Android Application

The Android application functions as a control terminal of the Avatar 3G. By pressing the control button on the phone screen, it can send out command and audio signals to control the motion of Avatar 3G and communicate with the surrounding environment. Meanwhile, it can also collect video and audio signals from the Avatar 3G in real-time, providing two way communication between user and robot.

### 7.1 General Requirements

[R97-I] Application only performs under Android operating system.

[R98-II] Application operates on “Android 2.1 Platform” or higher version. [2]

[R99-II] 3G network must be provided in order to access the Avatar 3G.

[R100-III] Application size shall be optimized to fewer than 50MB. [10]

### 7.2 Usability Requirements

[R101-II] User interface shall be simple and clear (modeled after a gamepad control).

[R102-III] By pressing the help button, a list of operation instructions shall be provided.

[R103-II] Video image shall refresh quickly, giving users immediate feedback.

### 7.3 Physical Requirements

[R104-II] The Android Application must interface properly with phone hardware, such as the microphone, speakers, touchscreen, and physical buttons.

## 8. User Documentation

The Avatar 3G is an interactive device controlled by the user. Product information will be available to the user through a user manual.

### 8.1 General Requirements

[R105-II] The user manual will be written in English.

[R106-III] The user manual shall be available in French, Spanish, German, Traditional Chinese, Simplified Chinese, Japanese and Korean to satisfy international markets.

[R107-II] The user manual shall be written for an audience with minimum knowledge of robotics and smartphone technologies.

[R108-III] A detailed start-up guide shall be available to users and vendors for quick installations.

[R109-III] The start-up guide shall be written in English but available in other languages for international needs.

## 9. System Test Plan

This section contains the test plan for the Avatar 3G proof of concept prototype. Each main component will be tested individually to identify any limiting factors on our project. Usability and acceptance testing will be performed using participants outside of our group in order to acquire unbiased feedback and expectations of the average user. Safety and reliability testing will be used to indicate our compliance with standards and overall quality of our product.

### Performance of 3G communication

- Determine the maximum and minimum data transfer rate in areas with good reception.
- Determine the number of dropped connections per hour of use.
- Check that the minimum data rate is sufficient for video streaming, two way audio, and instruction sending.
- Determine the latency between the 3G modem and a local server.
- Determine the latency between issuing command and signal being received by 3G modem.
- Stream video through the 3G modem and router for several days to test for stability.

### Performance of Camera and speakers

- Determine the range of lighting conditions that camera can operate under
- Determine maximum volume of speakers
- Determine speed of camera pan and rotation

### Motor Performance

- Determine the maximum and minimum speeds that Avatar 3G can move.
- Determine the maximum weight of objects that can be moved by Avatar 3G.
- Determine whether the Avatar 3G can move up inclined surfaces such as wheelchair ramps.
- Determine the mobility and movement speeds on different ground material, such as pavement, asphalt, dirt, and grass.

### Power Consumption and Battery Performance

- Measure the power consumption of 3G modem, 3G router, motors, speakers, and camera under normal use.
- Measure the maximum battery life of a full charge under normal use.

### Android Application

- Determine whether or not there are memory leaks in the program
- Determine whether the application can run on different Android handsets that meet the OS version requirements.



### **Usability and Acceptance**

- Determine whether the GUI, responsiveness, and navigation of the Android Application is intuitive and easy to use for the average user by having people unfamiliar with our project test it.
- Determine whether the latency between the video feed and instruction sending is acceptable for the average user.
- Determine whether the image quality of the camera feed is acceptable for the average user.
- Determine whether audio communication is acceptable between user and participants in range of the Avatar 3G.

### **Safety**

- Determine that no harmful electric shocks result from physical contact with any external part of the Avatar 3G.
- Determine whether the Avatar 3G complies with Canadian Radio Frequency Interference Requirements (ICES-003).
- Determine whether the Avatar 3G falls under the category of Class B digital apparatus.
- Determine the maximum amount of force that can be exerted by the Avatar 3G travelling full speed.

### **Reliability**

- Measure the maximum operational length of the Avatar 3G under normal use, and determine whether function has stopped due to depleted battery, or unexpected failures.
- Determine whether the Android application is stable under regular use.
- Determine the average uptime of the 3G modem, 3G router, and Arduino board.
- Determine whether the Avatar 3G will be functional after minor collisions.

## **10. Conclusion**

The functional specifications have clearly defined the functional requirements of the Avatar 3G. The team has already started the development of the proof-of-concept design model and is expecting to finish it with the functional requirements (those marked with I or II) by December, 2011. After completion of the functional prototype, the team will move on to work on the requirements listed in the luxury functions section and plan the final production system to be used in the future.

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