MindWave Mobile: User Guide

February 11, 2012

NeuroSky
Brain-Computer Interface Technologies

The NeuroSky® product families consist of hardware and software components for simple integration of this biosensor technology into consumer and industrial end-applications. All products are designed and manufactured to meet consumer thresholds for quality, pricing, and feature sets. NeuroSky sets itself apart by providing building block component solutions that offer friendly synergies with related and complementary technological solutions.

Contents

Introduction to the MindWave Mobile

Thank you for purchasing NeuroSky's MindWave™ Mobile. This Brain-Computer Interface (BCI) device turns your brainwaves into actions, unlocking new worlds of interactivity. The MindWave Mobile reports the wearer's mental state in the form of NeuroSky's proprietary Attention and Meditation eSense™ algorithms, along with raw wave and information about the brainwave frequency bands. The NeuroSky MindWave Mobile can be used with supported video games, research software, or a number of other applications for an enhanced user experience.

For any technical information updates and additional support questions not answered by this document please register at the NeuroSky support website at http://support.neurosky.com. We also recommend you join our email list by filling out the form on http://www.neurosky.com to receive general information about NeuroSky, new products announcements, and any technical information updates.

MindWave Mobile Product Contents

- MindWave Mobile headset
- MindWave Mobile Quick Start
- User Guide (this document)
- MindWave Mobile DVD:
    - Windows Frameworks, Connectors, and Utilities for MindWave Mobile
    - PC installation Executables
    - Bundled PC Apps
    - OS X Frameworks, Connectors, and Utilities for MindWave Mobile
    - Mac installation executables
    - Bundled Mac Apps

MindWave Mobile headset

Adjustable Head Band

Power Switch

Sensor Tip/Arm

Battery Area

Flexible Ear Arm

Ear Clip
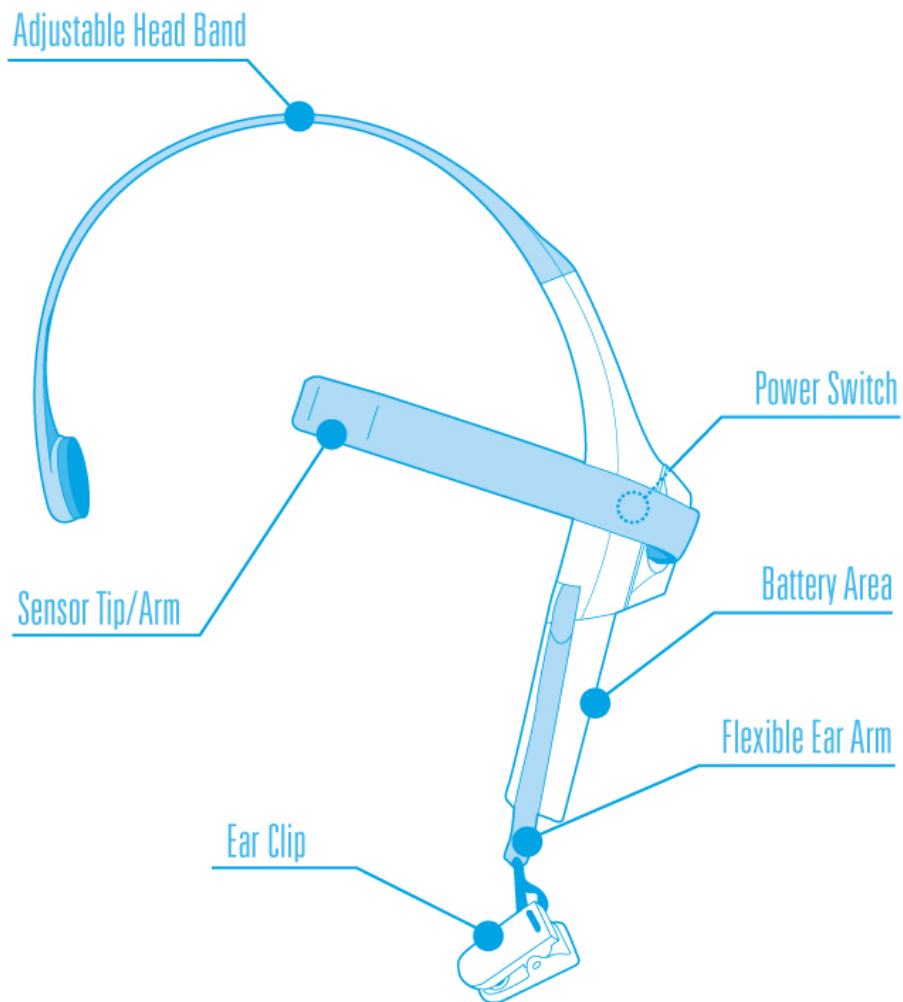
Setting Up Your MindWave Mobile

Minimum System Requirements for PC/Mac

	PC (Windows)	Mac
Operating system	XP/Vista/7	Mac OS X 10.5.8 or later
Processor	Intel Core Duo or equivalent	
Memory	1GB or more	
Video	DirectX 9.0 or greater	Intel GMA900 or greater
Hard disk	2.5GB free disk space	2GB free disk space
Wireless	Bluetooth Version 2.1 w/ EDR	
Optical drive	DVD-ROM	

Important: On 32-bit Windows 7 systems, the system must have at least Windows 7 Service Pack 1 (SP1) applied.

Minimum System Requirements for iOS/Android

	iOS	Android
Operating system	iOS 4.3.3 or later	Android 2.2 or later
Hardware	at least iPhone, iPad, or iPod Touch 3 (3rd gen 32GB or later)	Compatible Android phone or tablet
Wireless	Bluetooth	

Replacing The Battery

The MindWave Mobile headset requires 1 AAA battery to operate, which provides 8 hours of run time. To install or replace the battery, slide open the battery cover. Remove any existing battery within and replace with a new AAA battery.
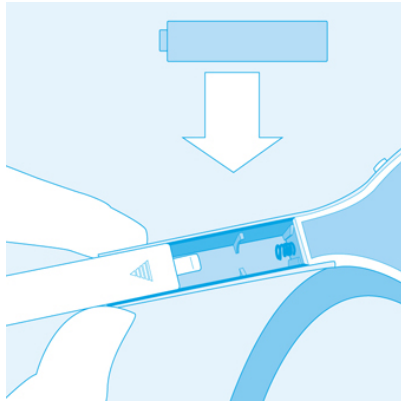
Power

To power on the MindWave Mobile headset, slide the switch to the ON (middle) position. When held past the ON position for 3 seconds and then released, the headset will enter Bluetooth pairing mode. If instead the switch is held past the ON position for 6 seconds, the headset's pairing memory will be cleared.

While the MindWave Mobile headset is powered on, the LED light on the side of the headset will be turned on. If the MindWave has a low battery, the LED light will flash to indicate low battery status.

To turn the MindWave Mobile off, slide the switch back to the OFF position.

Figure 2.1:

LED Light

The MindWave Mobile's LED light has has two colors: red and blue. Refer to the chart to see what state the MindWave is in.

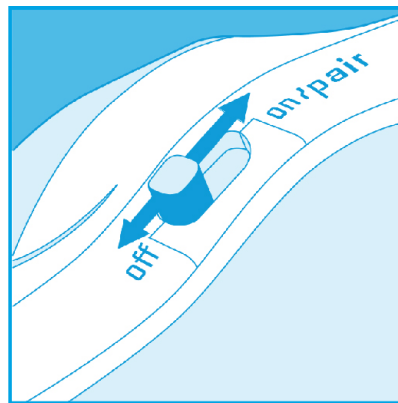| Light	MindWave State	Meaning
Off	Powered off	MindWave is turned off or has no battery
Double Blinking Blue	Pairing Mode	MindWave is ready to be paired to a device
Solid Red	Unpaired	MindWave needs to be paired to a device
Single Blinking Blue	Ready	MindWave is waiting for a paired device to connect
Solid Blue	Connected	MindWave is communicating with a paired device
Double Blinking Red	Low Battery	Need to replace the MindWave battery

Bluetooth Pairing

"Pairing" is when your computer/tablet/phone remembers your MindWave Mobile headset, and your MindWave Mobile headset allows that computer/tablet/phone to connect to it. Note that this is different from "connecting", which is when the computer/tablet/phone is actively sending or receiving data and information.

You must first pair each of your computers/tablets/phones to your MindWave Mobile headset in order for them to connect to each other. To do so:

1. Put the MindWave Mobile headset into "Pairing Mode" by holding the On/Off switch past the "On" position for 3 seconds.

    - Important: Release the switch when the light starts flashing blue. If you continue holding for more than 6 seconds, the MindWave Mobile headset will clear all previously remembered pairings.

2. Refer to the Bluetooth pairing instructions that came with your iOS, Android, PC, or Mac device to search for and pair to the MindWave Mobile headset.

    - If prompted, enter **"0000"** for the authentication key.

Your MindWave Mobile headset can "pair/remember" up to 3 computers/tablets/phones at the same time.

Bluetooth Connection

Depending on your computer/tablet/phone, it may automatically connect to the headset whenever an application needs to use the headset. If your Bluetooth software does not automatically connect when an app is started, please refer to the Bluetooth connecting instructions that came with your iOS, Android, PC, or Mac device to manually connect to the headset before running your apps.

Serial/COM Port Name or Number

Some games and applications will ask for you to enter the serial COM port name or number for the game or application to connect to the headset. Use the Bluetooth software on your computer/tablet/-phone to determine the COM port name or number that your MindWave Mobile has been assigned to.

Wireless Connection Troubleshooting

Problem	Cause	Solution
Unable to find or connect to Mind-Wave Mobile headset, or headset disconnects unexpectedly	Low battery	Replace the AAA battery in the MindWave Mobile with a new battery
	MindWave is not turned on	Turn the MindWave on
	MindWave is not paired to this computer	Make sure that you use your computer/device's Bluetooth software to pair the headset
	MindWave headset is too far from the Wireless USB Adapter	Check that your headset stays within 10 feet of the Wireless Adapter
	ThinkGear Connector is not running	Make sure the ThinkGear Connector is running and enabled.
		Make sure you have the latest version of the ThinkGear Connector or app.
Light on MindWave headset does not turn from red to blue	Bluetooth is not enabled on your computer/device	Make sure you have Bluetooth enabled and turned on in your computer/device
Other	Strong radio interference	Move the headset closer to the Bluetooth on your computer/device, or move the Bluetooth of your computer/device closer to the headset using a USB extension cable (not included)

Note: If problems still persist, re-run the MindWave Mobile Application Disc setup to download the latest version of the software, or visit http://support.neurosky.com or email support@neurosky.com

Using Your MindWave

This chapter walks you through fitting the MindWave and installation of the included MindWave software on your computer. Be sure to first connect and pair the headset as described in the previous chapter first.

Fitting the MindWave Mobile

The MindWave Mobile is more than your average headset. It has the ability to use your brainwaves for exciting new applications.

Important: In order to take full advantage of these functions and features of the MindWave Mobile, it must first be properly worn.

1. Orient the MindWave with the forehead Sensor Arm on your left hand side. Rotate the Sensor Arm from its base by about 90 degrees. It can be rotated slightly more if necessary to get proper fit and comfort.
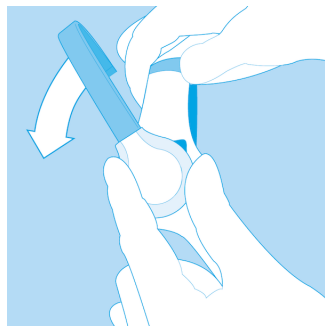
2. The overhead band of the MindWave is adjustable and can be extended to fit various sizes. Put on the MindWave. If the sensor does not make contact with the forehead or if the fit is not comfortable, remove the MindWave to readjust the overhead band and the forehead Sensor Arm. The forehead Sensor Arm is flexible and should arch inwards.
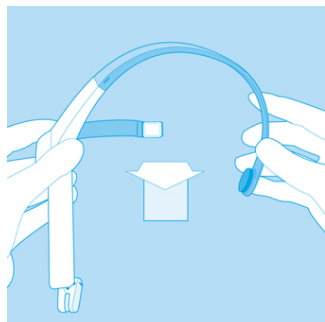
3. Allow the rubber ear hoop to rest behind your left ear, and then clip the earclip onto your earlobe.

4. **Make sure the two metal contacts on the inside of both sides of the earclip make skin-contact with your earlobe or ear**. Move any hair or obstructions (such as jewelry) out of the way. Readjust the earclip as necessary to make proper contact with the skin of your ear. You may need to squeeze the ear clip against your ear for a few seconds.
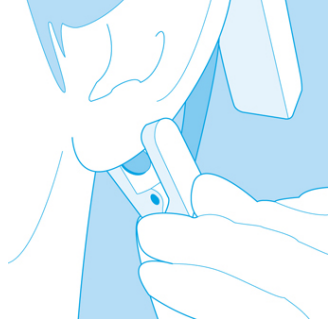
5. Adjust the forehead Sensor Arm of the headset so that the Sensor Tip makes contact with the skin of your forehead. This Sensor Tip must maintain steady skin contact in order to properly measure your brainwaves, it will not work through hair. The Sensor Tip should be comfortable, yet stay firmly in position. Keep hair away from the sensor – **the sensor must be able to directly contact the skin at all times**. Make up, dead skin, or debris can interfere with the connection. Scratch or wipe the obstruction away if you have trouble obtaining a clean signal.

6. This is how the MindWave should look when properly worn. During usage, if you are not receiving a signal, repeat the steps above to make minor adjustments to ensure the sensor and contacts have proper **skin contact**.
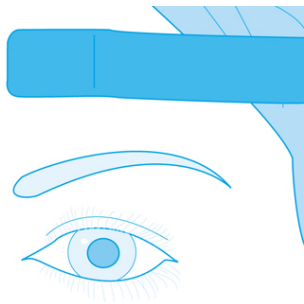
Note: If you are having a problems with the signal quality, carefully recheck all the instructions above, and then try sitting still for a few seconds. Note that talking can sometimes interfere with the signal quality as well. If this does not work, check that your head is not within a few feet of a strong electrical device (like a laptop adapter or an electrical outlet).

NeuroSky Technology Overview

Brainwaves

The last century of neuroscience research has greatly increased our knowledge about the brain and particularly, the electrical signals emitted by neurons firing in the brain. The patterns and frequencies of these electrical signals can be measured by placing a sensor on the scalp. The MindTools line of headset products contain NeuroSky ThinkGear™ technology, which measures the analog electrical signals, commonly referred to as brainwaves, and processes them into digital signals. The ThinkGear technology then makes those measurements and signals available to games and applications. The table below gives a general synopsis of some of the commonly-recognized frequencies that tend to be generated by different types of activity in the brain:

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed (but not drowsy) tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

ThinkGear

ThinkGear is the technology inside every NeuroSky product or partner product that enables a device to interface with the wearers' brainwaves. It includes the sensor that touches the forehead, the contact and reference points located in the ear clip, and the on-board chip that processes all of the data. Both the raw brainwaves and the eSense Meters (Attention and Meditation) are calculated on the ThinkGear chip.

eSense

eSense™ is a NeuroSky's proprietary algorithm for characterizing mental states. To calculate eSense, the NeuroSky ThinkGear technology amplifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in the interpreted eSense meter values. Please note that eSense meter values do not describe an exact number, but instead describe ranges of activity.

eSense Meter - General Information

The eSense meters are a way to show how effectively the user is engaging Attention (similar to concentration) or Meditation (similar to relaxation).

Like exercising an unfamiliar muscle, it may take some time to gain full proficiency with each of the eSense™ meters. In many cases, people tend to be better at one eSense than the other when they first begin. We recommend trying different tactics until you are successful with one. Once you see a reaction on the screen from your efforts, you will be able to duplicate the action more easily with additional practice.

Generally, Attention can be controlled through a visual focus. Focus on a singular idea. Try to "funnel" your concentration and focus your train of thought towards pushing up the meter. Other suggestions include picking a point on the screen to stare at or imagining the action you are trying to accomplish happening. For example, look at the Attention eSense meter and imagine the dial moving towards higher numbers.

For Meditation, it typically helps to try to relax yourself. Connect to a sense of peace and calm by clearing your mind of thoughts and distractions. If you are having difficulty engaging Meditation, close your eyes, wait a number of seconds, and then open your eyes to see how the meter has responded.

If you have trouble at first in controlling your eSense meter levels, be patient. Try different techniques and practice. Also be sure to read and try to understand the Technical Description in order to get a better idea about how eSense actually works under the hood.

eSense Meter - Technical Description

For each different type of eSense (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. On this scale, a value between 40 to 60 at any given moment in time is considered "neutral" and is similar in notion to "baselines" that are established in conventional brainwave measurement techniques (though the method for determining a ThinkGear baseline is proprietary and may differ from other methods).

A value from 60 to 80 is considered "slightly elevated", and may be interpreted as levels tending to be higher than normal (levels of Attention or Meditation that may be higher than normal for a given person). Values from 80 to 100 are considered "elevated", meaning they are strongly indicative of heightened levels of that eSense.

Similarly, on the other end of the scale, a value between 20 to 40 indicates "reduced" levels of the eSense, while a value between 1 to 20 indicates "strongly lowered" levels of the eSense. These levels may indicate states of distraction, agitation, or abnormality, according to the opposite of each eSense.

The reason for the somewhat wide ranges for each interpretation is that some parts of the eSense algorithm are dynamically learning and at times employ some "slow-adaptive" algorithms to adjust to natural fluctuations and trends of each user, accounting for and compensating for the fact that brainwaves in the human brain are subject to normal ranges of variance and fluctuation. This is part of the reason why ThinkGear sensors are able to operate on a wide range of individuals under an extremely wide range of personal and environmental conditions, while still giving good accuracy and reliability.

ATTENTION eSense

The eSense Attention meter indicates the intensity of a user's level of mental "focus" or "attention", such as that which occurs during intense concentration and directed (but stable) mental activity. Its value ranges from 0 to 100. Distractions, wandering thoughts, lack of focus, or anxiety may lower the Attention meter level. See eSense Meter - General Information for more details about interpreting eSense levels.

MEDITATION eSense

The eSense Meditation meter indicates the level of a user's mental "calmness" or "relaxation". Its value ranges from 0 to 100. Note that Meditation is a measure of a person's mental states, not physical levels, so simply relaxing all the muscles of the body may not immediately result in a heightened Meditation level. However, for most people in most normal circumstances, relaxing the body often helps the mind to relax as well. Meditation is related to reduced activity by the active mental processes in the brain. It has long been an observed effect that closing one's eyes turns off the mental activities which process images from the eyes. So closing the eyes is often an effective method for increasing the Meditation meter level. Distractions, wandering thoughts, anxiety, agitation, and sensory stimuli may lower the Meditation meter levels. See eSense Meter - General Information for details about interpreting eSense levels in general.

Additional Products

To find new and exciting ways to unlock the full potential of you MindWave, visit the NeuroSky Store for additional software and applications: http://store.neurosky.com

Development Tools 3 (DT3)

The NeuroSky MindSet Development Tools 3 (DT3) is a collection of drivers, sample code, and documentation describing how to develop applications for several software platforms, including PC, Flash, and even lower level platforms such as microcontrollers like the Arduino™. The DT3 is available for free from the NeuroSky Store, and provides all the tools and resources necessary to create and publish games and applications capable of taking advantage of the exciting new Brain-Computer Interface (BCI) technology of NeuroSky's MindSet or MindWave headset.

Languages directly supported include C/C++, C#, Java (through JNI), and J2ME. In addition, the Development Tools provide the ThinkGear Connector (TGC), a daemon-like software that runs on Windows or Mac OS X, and opens a TCP port on the user's local computer so that applications can connect to it and retrieve MindSet or MindWave data. As long as the TGC is running on one of the supported platforms and connected to a MindSet, then any application written in any language that can communicate through TCP sockets (such as Flash's ActionScript3 and scripting languages in general) can connect to the TGC to read data from the MindSet.

Create exciting new games that challenge people to use the power of their mind or retrofit your existing games with a new dimension of brainwave control.

The DT3 is available for *free* and can be downloaded from the NeuroSky Store at http://store.neurosky.com.

Research Tools

The NeuroSky Research Tools bundle is a collection of two data collection and viewing applications. The Research Tools enable researchers to use the MindSet, MindWave, or MindWave Mobile as a data collection device. Using the cost-effective and user-friendly features of MindWave Mobile in conjunction with the Research Tools allows researchers to broaden the scope of their research and to make efficient use of resources.

The Research Tools bundle includes the NeuroView software, which make it easy to connect, graph, view, and record MindSet, MindWave, or MindWave Mobile data in real time. The Research Tools bundle also includes the more advanced NeuroSkyLab MATLAB module, which adds the ability to define custom MATLAB scripts and functions for customized processing and analysis of MindSet, MindWave, or MindWave Mobile data.

For more information on the uses and capabilities of the Research Tools, please visit: http://store.neurosky.com/.

Maintenance

- Clean the MindWave's sensor and ear contacts with alcohol or a damp cloth periodically to ensure the best signal quality. Use a soft cloth to clean the MindWave casing.
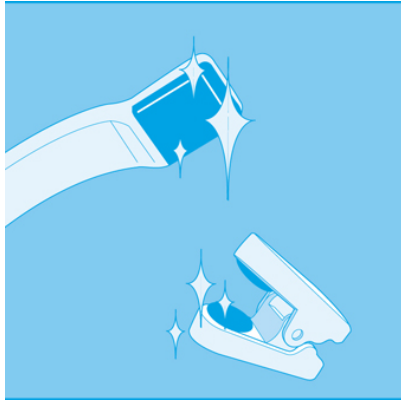
- For travel and storage, gently push the sensor arm up until it is aligned with the top of the headset. Be careful not to overextend the maximum range of the boom by adjusting it beyond the natural stopping point.
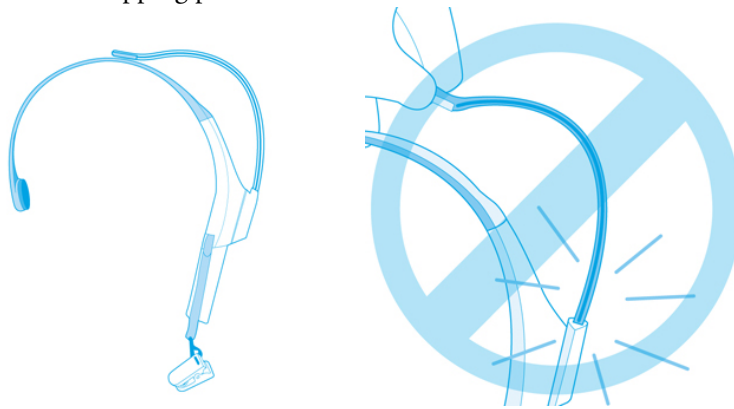
- Do not expose the MindWave to temperatures above 140°F (60°C)

- Dropping or throwing the MindWave may cause damage to the MindWave.

- Remove the battery from the MindWave when not in use for extended periods of time.

Troubleshooting and Support

The MindWave does not turn on.
The battery might be low. Please try replacing the battery and try again.

The signal quality status is consistently poor (fewer than three bars).
Check that the forehead sensor and each clip contacts are making good contact with the skin. Make sure to remove all obstructions including hair and jewelry.

It usually takes three or four seconds for the headset to validate the signal after holding still. Also make certain to keep the sensor and contacts clean.

The eSense meters do not move.
Be sure to allow several moments for the eSense meters to go through some self-calibration and initialization before troubleshooting. If the meters still do not move after 10 seconds, make sure the sensor rests on the skin of the forehead and the contacts are on the skin of the left ear. The sensor and contacts must always make firm and consistent contact with your skin.

I don't seem to be able to control the eSense™ meters.
Like exercising an unfamiliar muscle, it may take some time to gain full proficiency with the eSense™ meters. First, be sure you understand how the eSense meters work and what they are measuring. Generally, we recommend engaging Attention by concentrating and Meditation by relaxing. Most importantly, be sure you have read the detailed explanation of eSense previously described in the eSense sections.

I still have a problem, or my problem is not covered by this Troubleshooting section.
For further technical support, please contact NeuroSky Support at http://support.neurosky.com or email support@neurosky.com.

Safety and Regulations

Operating Conditions

- Operating temperature: 0-35C
- Headset: 1.5V / 95mA maximum average current

Safety

- Batteries should not be exposed to excessive heat such as sunshine, fire, or similar conditions.

ISO/IEC

ISO/IEC Guide 37 [17].

- No naked flame sources, such as lighted candles, should be placed on the apparatus;
- Battery disposal: This product requires the use of an AAA battery. AAA batteries commonly available in the market contains hazardous waste and should be properly disposed of. Contact your local government for disposal or recycling practices in your area.

FCC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NCC

The use of this device must comply with the following NCC requirements:

經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變 更頻、加大功率或變更原設計之特性及功能。

低功率射頻電機之使用不行影響飛航安全及干擾合法通信；經發現有干擾現象　　時，應立即停用，並改善至無干擾時方時繼續使用。

前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通　信或工業、科學及醫療用電波輻射性電機設備之干擾。