LUMIN

CLIENT DELIVERABLE 1

Jake Runzer	CEO
Zev Isert	Toolsmith
Claire Champernowne	Documentation
Dylan Golden	Analyst

Summary

The Ember Applications functional specification and management plan for Lumin has been reviewed and some changes have been annotated. The document requirements and management aligned with our requirements, with the exception of some minor changes. Overall, we are satisfied with the direction Lumin is heading.

Findings

An overview of our findings are outlined below. Small edits to the proposal are not shown.

- ## Accelerometer

  The document mentioned that the user's phone could potentially be used as the accelerometer. This is technically possible but does not meet the requirement that Lumin will track your sleep and trigger the alarm without a mobile device nearby, and it is also potentially dangerous to your device.

- ## Speaker

  It was mentioned that the alarm sound quality does not matter. The final production version of Lumin should have a speaker comparable to one you would use to listen to music with. A good quality speaker is not a minimal requirement for EOT.

- ## Wake up Time

  The alarm lighting should not turn on at the soft wake time. If there is a large difference between soft and hard wake time, this could be very annoying to the user. The lamp should turn on at the best possible time, with the sound turning on after a small delay. If the alarm is triggered at the hard wake time, both should turn on immediately.

- ## Colour Wheel

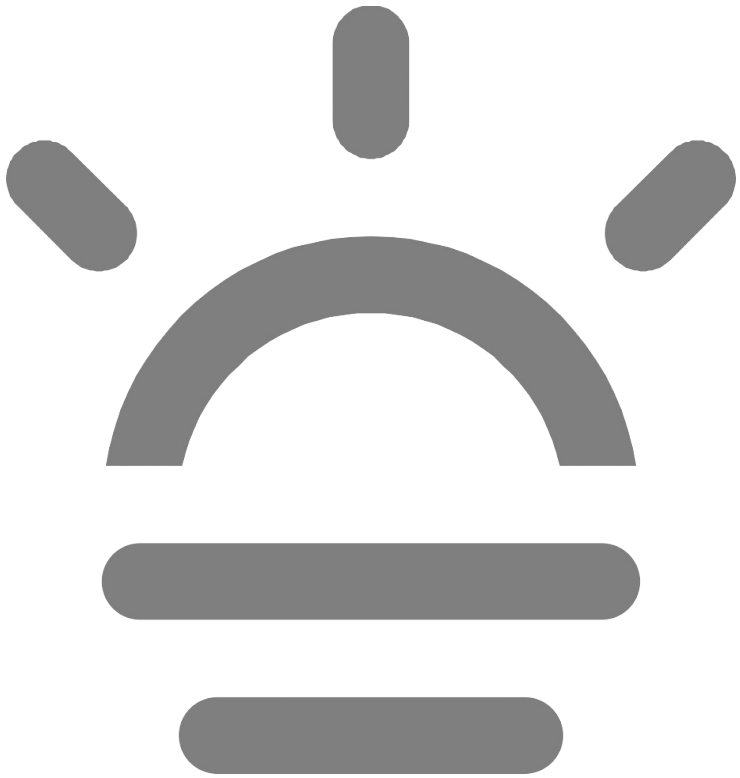
  The colour wheel in the final system should have both RGB and HSV sliders, instead of just RGB. HSV allows much more control when choosing a colour, allowing changing hue, saturation, and luminance separately.

- ## Outside Connectivity

  The document made no mention to allowing users to connect to Lumin from outside the local network. This is a difficult and time consuming feature to add and does not need to be in the minimally required system. The final production version of Lumin should allow users to create alarms from outside their local Wi-Fi network and on mobile data.

Change/Fix

Addition/Small note



Lumin

By Ember Applications

Authored by:

Brian Pattie

Cameron Long

Chenchen Guo

Thinh Nguyen

With consultation from:

Jake Runzer

Zev Isert

Claire Champernowne

Dylan Golden

1.0 Executive Summary

The Lumin project tackles the pain of using typical sound alarms. The Lumin will instead wake users gradually using a slowly rising light, and play a sound alarm during the lightest part of the user's sleep cycle, determined by an accelerometer attached to the bed. The colour of light used to wake is highly customizable, and can use local weather data to mimic the days natural light. It also provides dynamic RGB lighting for general use. The user can specify sequences of colours that will rotate until turned off.

Connectivity between Lumin and a mobile device using Bluetooth/WiFi will allow the user to control the hardware from a mobile application, and facilitates features like the weather lighting. This lets the user-system interactions take place on a fine tuned GUI, and reduces the hardware costs of the device itself. The GUI will mostly comprise of a system of menus, with most input taking the form of button presses. Colours will be selected from a colour wheel, and RGB sliders for fine tuning the colour. Alarms settings will comprise of a name, a soft and hard wake up time, days of the week, a light colour setting, and a sound. Dismissing alarms and the Snooze button will be done through buttons on the hardware.

The hardware will comprise of a small microcontroller that can control the light functions. Several possible controllers have been made note of, including the Raspberry Pi, the Onion Omega, the Arduino Mega 2560, and the ARPI600. The sleep tracking accelerometer may take two possible forms:

The users phone should not be considered as an accelerometer

1. The accelerometer on the user's mobile phone
2. A special Lumin accelerometer designed to be unobtrusive to the sleeper

The minimal prototype for completion by the end of March will cover, at the very least, the following 3 features:

1. RGB Lighting Control
2. Combination Light/Sound based alarms
3. WiFi or Bluetooth connectivity with the mobile device

These are the core features that define the Lumin.

2.0 Functional Specifications

The Lumin Project will address the common pain of waking up in the morning. Traditional alarms are sudden and jarring, taking the user from deep sleep to consciousness over the course of a few painful seconds. These alarms often leave users feeling groggy and resentful of morning's arrival. It's no surprise that many users abuse the the snooze button to try to get a few extra minutes of sleep. Lumin will solve this by providing a far gentler waking experience.

The Lumin is a bedside solution that combines the features of a colour changing bedside lamp, an alarm clock, and a sleep monitoring system. Instead of using only harsh sounds or music to rouse the subject, Lumin will use a variety of techniques to wake the user gradually and comfortably. Long before the sound alarm fires, the light will turn on and slowly increase in intensity. By tracking the user's sleep cycles, the Lumin will wait for the best moment to fire off a sound alarm to bring the user to full consciousness. The system will be useful to anyone who regularly needs to wake up early in the morning, and will be particularly handy for those that struggle to drag themselves out of bed.

2.1 Important Features

2.1.1 Customizable Lighting

The most noticeable feature of the Lumin will be the dynamic lighting. While it's primary purpose is an alarm, it will also provide a customizable lighting experience for use while awake. By using dynamic RGB lights, it will provide a broad spectrum of possible colours, which can be chained together in sequences. A sequence will rotate through a set of chosen colours. One could be a chain of soft, warm, sunset colours for an evening wind down, and another could rapidly change between bright, solid colours to make a high energy party sequence.

2.1.2 Sleep Tracking

Over the course of the night, a person goes through numerous sleep cycles. Some parts of this cycle are more pleasant to wake up from than others. By measuring the certain body movements, its possible to determine what stage of sleep a person is in. Typically people do more tossing and turning during the lighter stages of sleep, which is the better time to wake. The Lumin will track the user's sleep cycle using an an external sensor attached to the bed. This allows the Lumin to choose the best moment to fully wake the user with a sound alarm.

2.1.3 Connectivity and Control

The Lumin will have some controls as part of the hardware, but most of the controls will be done through a mobile application. From the app, alarms can be set, colours can be chosen, and lighting sequences can be specified. The two devices will most likely communicate via Bluetooth or WiFi. The night's sleep tracking data will also be sent here for storage and review.

2.1.4 Hardware

The product will make use of 6 main hardware components:

1. A microcontroller will control the functionality of the Lumin. It must be capable of interacting with the user's mobile device through either Bluetooth or WiFi, and ideally support USB as a back up. It will need to have enough memory to store the users alarm and light configurations.
2. An RGB light that can provide a variety of colours and brightness levels, and transitions smoothly between them. It must not flicker noticeably during any part of these processes.
3. A speaker loud enough to wake a deep sleeper. The sound quality is not a major concern, as it's purpose is to wake the user, not fill the role of a sound system.
4. An accelerometer for movement tracking. I needs to be small and unobtrusive such that it doesn't interfere with the user's sleep, but must be sensitive to pick up movement transferred through the bed from subtle body movements.
5. External casing for both structure and aesthetic value. The form must be attractive enough that a user would want it clearly visible in their bedroom. This will not be present on the prototype.
6. A digital clock face to display the current time. The brightness must be adjustable, or at least able to be turned off to prevent sleep interference. This won't likely be present in the prototype due to time constraints.

3*. The speaker sound quality should not be poor. It should be good enough to comfortably and enjoyably listen to music with. Prototyping with a low quality speaker is adequate and the final sound system is not a minimal requirement that needs to be completed by end-of-term.

3.0 User Interaction

When interacting with the Lumin, the user will use one of two interfaces. First are the controls built directly into the Lumin's hardware. Here, only the most basic of interactions will be carried out. This includes turning the light on and off, hitting the snooze button, and dismissing an actively ringing alarm. Depending on the final implementation, it may also have a button to turn the digital clock face on and off. The rest of the operations will be carried out through the mobile application, a choice which has the added benefit of reducing production costs. Many of the interactions, such as colour selection, require a much more fine tuned interface, which would require a GUI on the device itself. Instead, these controls will be located on a mobile device that most customers will already have access to.

Through the mobile application, the user will carry out most of the Lumin's interactions:

- setting alarm soft and hard wake up times
- setting waking colours and alarm sounds
- changing the active colour of the light
- creating colour sequences
- reviewing sleep tracking data

From the main menu, the user will be presented with a 4 options:

1. Toggle the light on and off immediately
2. Alarms
3. Light
4. Sleep History

Almost every interaction with the system will begin at this menu.

3.1 Interaction Dialogues

3.1.1 Setting the alarm

The user, Janine, wants to set a routine alarm that wakes her up at 6:30am every weekday for work.

From the main menu, Janine presses the Alarms button

This takes her to a list of existing alarms. Each one takes the entire width of the screen, displaying the time, and days of the week that it fires. It also shows an icon representing the light colour/sequence and sound associated with the alarm. To the right of each one is a checkbox that toggles the alarm between active and inactive. The user can see more alarms by swiping her finger up or down. At the top of the list is a wide button with the text *New*

The soft wake up time should not be the exact time the light turns on. There is a chance the user is a light sleeper and the light will always wake them at the soft time. The light should turn on at the best possible time between soft and hard wake ups, and the alarm sound should follow after a small delay.

Alarm.

Janine presses New Alarm.

Janine is presented with the Alarm Configuration Menu. In the top right corner are the Save and Delete buttons. The next row has a text field for the alarm's name. In the row below, she sees two times. The first of these is the *soft wake up* time. This determines the earliest possible time for the alarm to wake the user, and is used to calculate when the light will turn on. The second is the *hard wake up* time. Through sleep cycle tracking, the Lumin will try to wake the user at the best possible time between the soft and hard wake up times. If the user never enters the light portion of their sleep cycle, then the alarm will fire at the hard wake up time.

Janine enters the name "Work" into the text field. Next she presses on the soft wake up time and is presented with a typical time selection screen. She enters 6:00am, then repeats for the hard wake up time, for which she selects 6:30am.

Default should be to set the alarm off once at the next possible time. Showing a list of days may be confusing if that isn't the intended action. Consider a submenu (tap Repeat->show list of days)

Under the alarm times, the days of the week are listed horizontally. The alarm will fire on highlighted days, and this is toggled by tapping on the day. Immediately underneath is a checkbox that says *repeat.* If checked, the alarm will continue to fire on those days even after the first weekly cycle.

Other alarm apps will repeat the alarm each week on a day if it is highlighted in a list. Requirin the user to tap an additional box to repeat weekly may confuse users.

Janine taps every day from Monday to Friday and checks the repeat checkbox. She scrolls down to see more options.

Under the weekday selection are two more icons: a colour wheel and a speaker representing light colour selection and sound selection respectively.

Janine taps the colour wheel icon.

The user is presented with 4 options:

1. Choose Colour – Allows the user to choose a single colour of their choice
2. Presets – Leads to a list of preset colours
3. Sequences – Allows Janine to choose from any of the preset, or user defined sequences that she made herself
4. Weather – The colour of the alarm light will reflect the current weather in Janine's region

Janine presses Presets.

She is presented with a list of options. On the left is the title of the colour, and on the right is a circle filled with the colour itself. The first 3 items on the list are Sunrise, Forest, and Dark Sky. (Subject to change)

Janine presses Sunrise, a soft light blue colour.

The menu darkens, and a dialogue window opens with 3 options on it:

1. Confirm – Selects the colour for the new alarm
2. Demo – Turns the lamp onto the selected colour so that the user can sample it before making a decision
3. Cancel – Dismisses the dialogue window, returning the user to the list of preset colours

Janine presses Demo. The dialogue window stays open, and her Lumin turns a pale blue colour. Liking her choice, she presses Confirm.

She is returned to the Alarm Configuration Menu. The only remaining task is to choose a sound.

Janine taps on the speaker icon.

A new menu opens, listing every available alarm sound by title.

There should be an option to choose sound from music on device

Janine presses wolf howl.

She is presented with the same dialogue menu as when she pressed Sunrise during colour selection. The options are still Confirm, Demo and Cancel. When Demo is pressed, the sound plays on the mobile device.

Janine presses Demo, listens to the sound, then presses Confirm. Her alarm is now fully configured. After being returned to the Alarm Configuration Menu, she presses Save.

The user's alarm has been saved, and she is returned to the Alarms Menu. She can now exit the app knowing her alarm is set.

3.1.2 Setting a Colour and a Colour Sequence

The user, Brock, wants to set a colour to read to.

From the Main Menu, Brock presses the Light button.

Brock is taken to the Light Menu, which has 3 buttons, Colour, Brightness, and Sequences. The first two buttons control the current light colour and level, which will remain as a solid, unchanging colour. Sequences will take the user to a new menu to turn on and edit sequences.

Brock taps the Colour button.

The user is presented with a colour wheel like such as in *Figure 1*.

Consider changing RGB sliders to HSV or have an option to switch between them. With HSV it is much easier for user to select a colour with colour wheel or hue and saturation sliders, then adjust the strength of the colour using the luminance slider. This gives greater control and flexibility over the colour and sequences.

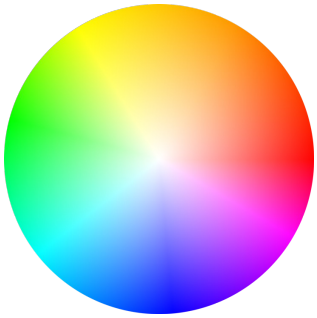


Figure 1: Colour Wheel

Beneath the wheel are 3 numerical values, one each for red, green, and blue. Each can be adjusted by swiping them up and down. The user can press on the colour wheel to get close to the colour he wants, then fine tune the individual colours to get precisely the colour he wants.

> *Brock taps somewhere on the green section of the colour wheel. He likes the colour, but decides to reduce the level of blue by swiping down on the blue value.*

Under the colour selection controls are the Demo and Confirm buttons. Demo will put the currently selected colour on the lamp without overwriting your previous setting, whereas Confirm will apply the colour and return the user to the Light Menu. Above the colour selection, in the top right corner, is a save button. Pressing this will prompt the user to type in a name for the newly selected colour.

> *Brock presses the Demo button and looks at his room lit up with green. Happy with what he see's, Brock presses the save button and enters the name "Forest Green" into the new text field. Next he is presses Confirm to apply the colour now. He is returned to the Light Menu. From here he turns up the light level using the brightness slider. Next he wants to create a rotating colour sequence, so he presses the Sequences button.*

Brock is now looking at the Sequences Menu. Here all the sequences are listed, both the presets and the user defined. Each sequence shows a row of circles containing the colours in the order that the sequence displays them. A New button sits at the top of the list.

> *Brock presses the New button.*

Brock is taken to a new menu with two options, Start Fresh, and Base Off Existing. Both will take the user to the sequence editor, but the Base Off Existing button will populate the editor with the colours a sequence you select.

> *Brock presses the Base Off Existing button. He is show the same list of sequences as before, and selects one that has 4 colours: purple, orange, green, and red, all of them bright.*

The editor opens, showing a list of colours. On the left is a circle containing the colour, and on the right is an X button that deletes the colour. The order can be changed by holding your finger on a colour, then dragging it to where you want the colour to be. At the bottom, a New button creates a new colour slot when pressed. In the top right corner are the Save and Delete buttons for the entire sequence.

> *Brock decides to remove purple because it doesn't quite fit with the others. He moves green to the top of the sequence. Brock presses the New button. A new colour is added to the sequence, a default white. He tabs on the new white colour.*

Tapping on any of the colours in the sequence opens up a new menu with 3 options: Colour, Brightness and Duration. The brightness option is a simple slider. Pressing Colour opens the same colour selection window that Brock used to make “Forest Green.” Pressing Duration lets him choose how long the sequence will spend on that colour. You can adjust the time in hours, minutes, or seconds.

> *Brock leaves the colour and brightness of the new white colour alone, but changes the duration to last 5 minutes. He goes back to the other colours in the sequence and changes all of their durations to 5 seconds. Brock now has a sequence that rotates quickly through green, orange, and red, then relaxes with 5 minutes of white light. Happy with his new sequence, he presses save, and closes the app.*

There should be an option to change the duration of all/multiple colours.

3.1.3 Sleep History

The last Main Menu option, Sleep History, takes the user to a page listing all the nights for which the sleep tracker has gathered data. Each night is listed as a line graph, who's up and down waves represent your sleep cycles. This gives the user an idea of how restless their sleep was. By scrolling, you can see the graphs from previous days.

3.1.4 Dismissing Alarms

When an alarm fires, it can be dismissed by pressing a large button on the hardware. A separate, but equally large button acts as Snooze, giving the user 5 minutes before the sound alarm will fire again. Snooze and Dismiss may be operable from the mobile application as well, but this is undecided.

The snooze time should be configurable through the mobile app, regardless if the mobile app can actually snooze the alarm.

4.0 Management Plan

4.1 Features

The feature set of the Lumin will be split between the hardware system and the mobile application. Each play an important role in delivering the feature set that FixCode requires for this product.

4.1.1 Physical System

The physical Lumin device will be a small microcontroller that is capable of controlling the light functions. So far, the micro computer's capabilities require it to have WiFi and Bluetooth connections, as well as a USB port. The more minimal the features, the lower the cost to the user when purchasing the finished product. To control the light functions, it will be able to take commands from the user via the smartphone application. This will allow the user to set different color and brightness schemes for separate alarms, or for idling at different parts of the day. The Lumin will also include some presets out of the box. In order to provide the best lighting experience, the Lumin will have the lights behind a diffuser, to better spread the outgoing light more easily and provide a softer look. The main premise is to help the user to wake up refreshed, and harsh light will not do.

Each alarm can be set with it’s own sound and volume settings, set again from the integrated smartphone app. It may have the ability to use the user's’ smartphone music, through the Bluetooth, WiFi, or USB connection.

Lumin will also have an included accelerometer attachment, to monitor the user's’ sleep cycle, and wake the user up in the lightest part of the sleep cycle. The system will sync this data to provide historic data for the user via the app. ~~Ideally the system can just use a smartphone accelerometer for this purpose, but an accelerometer attachment is many people want to charge their phones in during the night.~~

4.1.2 Smartphone App

The smartphone app will be available for the Android and iPhone platforms. The functionality will be the same across both. If the user base demands it, a Windows Phone app could also be considered for development. The app will have access to the user’s calendar and sync alarms accordingly. The user can set automatic alarms based on mornings or inputted commute or wake up data.

The app will also have complete control over the base station’s features using simple sliders and settings. The app will have a demo mode to test out various alarm and color schemes, as well as to be able to adjust the settings in real-time.

This app will communicate to the station via WiFi and Bluetooth. To ensure no one else on the network can mess with your Lumin's settings, a simple password system will be introduced between the app and the Lumin base station.

4.2 Possible Implementations

The choice of implementation rests a lot on the choice of microcontroller to run the system. As stated above, the important features of the system are the WiFi/Bluetooth, USB and lighting systems. The trade-off will be needed to balance features and cost. Upping the computer's feature set usually results in excess ones, that are not a part of Lumin's use cases. Finding that balance will be important. That said, the Lumin team have looked at a few different microcontrollers that have been earmarked for possible selection. The Raspberry Pi, Onion Omega, Arduino Mega 2560 and ARPI600 microcontrollers will be evaluated for this project based on this criteria.

Another large divergence in implementation will be the integration of the sleep tracking accelerometer, as it can come in several forms. ~~Firstly, the user can allow the app to access to accelerometer on their smartphone, and transfer the data to the base station while they are sleeping, provided their phone is in a position to record the relevant data.~~ However, this implementation may hinder the ability to comfortably charge the phone overnight, and drain battery. The Lumin could include its own accelerometer, and be attached in a wireless or wired fashion to the base station, and placed underneath or on top of the mattress. This would provide the most consistent data, but increase the cost of the system. It also does not provide the user with choice of whether or not they wish to use the feature in the first place. The wireless strategy would be more convenient, with the exception of when the batteries die. Promised longevity would be key to the success with this device.

The lighting systems are robust in terms of color depth. A decision will have to made on how many colors is a reasonable amount before becoming too cumbersome or expensive for the average user. Most RGB lights can display over sixteen million colors, but some are capable of sixty-eight million different colors.

4.3 Minimal System by End of March

The system that will be delivered by month's end will at least cover the three key functions, RGB control, WiFi connectivity and alarms. However, the smartphone application will be bare bones at best, as it is expected the smartphone app development and sleep tracking will consume most of the timeline.

In terms of building the physical system, a fully functional engineering sample is completely possible by the end of term. Once a microcontroller has been selected with its peripherals, construction of the Lumin and the programming of the related embedded software is expected

to take around a month. However, the construction will be very basic and not indicative of the final product's look or build quality. It is meant to be a platform to present to FixCode for feedback and criticism.

After basic functionality is completed, and the product is presented to FixCode before the deadline, we can begin to add a number of improvements and functions, as well as FixCode's design changes. On the long-term road map for this product is further development of the smartphone app, as well as its sleep tracking and waking functionality. Sleep tracking is expected to have a high testing overhead, along with a selection phase for the implementation of the sensor. The waking functionality is also expected to have a large testing phase. As it is tied to the app and requires synchronization of data, it could take a significant amount of time to iron out problems that take away from the user experience. This large time constraint is why these features are not guaranteed for March.

Later along the timeline will be the calendar, weather and related synchronization features. This functionality is not deemed as integral to the Lumin's functionality, and is considered as 'nice-to-have'. Other nice-to-have features include the USB connectivity for music and radio features of the clock. Delivery of these features would be considered above and beyond on this timeline.

In the FixCode's request for RFP, it is stated a mock website is acceptable to simulate the features of the app. This will be considered from a time-saving perspective in order to focus resources on the delivery of the physical system.

4.4 Summary

The implementation of all the proposed features in the Lumin product will create something that has never been done before in this field of electronics. Most products struggle with connectivity or lighting features, or are not to be used as bedside sleep solutions at all. The first iteration of the Lumin is expected to be delivered by March 31st, 2016, covering all the fundamental features of the system. The are future plans to add more functionality and have rigorous testing of the sleep cycle and waking features. There is also plenty of time allotted for feedback from FixCode.

The Lumin design team consists of four skilled engineers: Brian Pattie, Chenchen Guo, Cameron Long and Thinh Nguyen. The project will be split as follows:

Group Member	Responsibilities
Chenchen Guo	Hardware design/implementation, and website management
Cameron Long	Documentation, mobile application/hardware interaction
Thinh Nguyen	Interface design and implementation for the mobile application
Brian Pattie	Group coordination, documentation, minor website management, and interface design

5.0 Glossary

Accelerometer	A sensor that detects motion in 3 dimensions.
API	Stands for Application Program Interface. This is the set of protocols through which a system is interacted with.
GUI	Graphical User Interface
Hard Wake Up	The latest point at which the Lumin will wake up the user
RGB	Red Blue Green, the three colours of light that are combined to form the rest of the colour palette
Soft Wake Up	The earliest point at which the Lumin will wake up the user