TIRED TECHIES

Project Proposal

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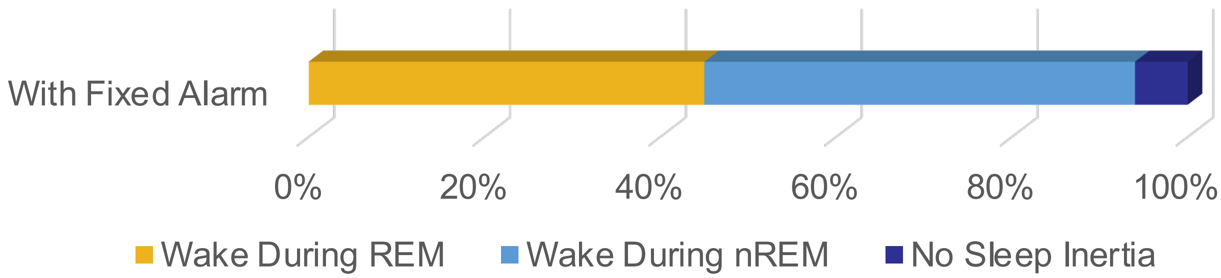
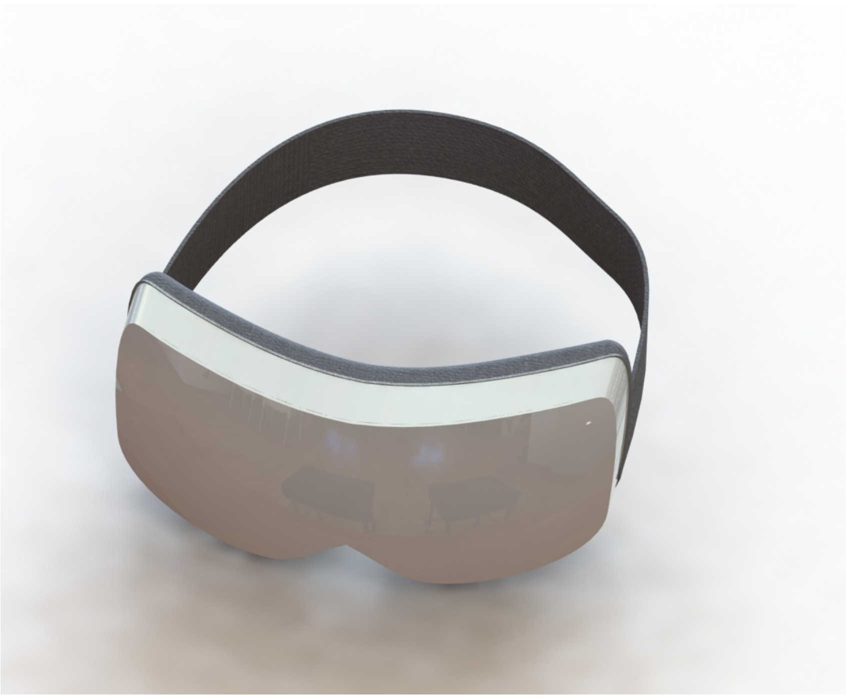
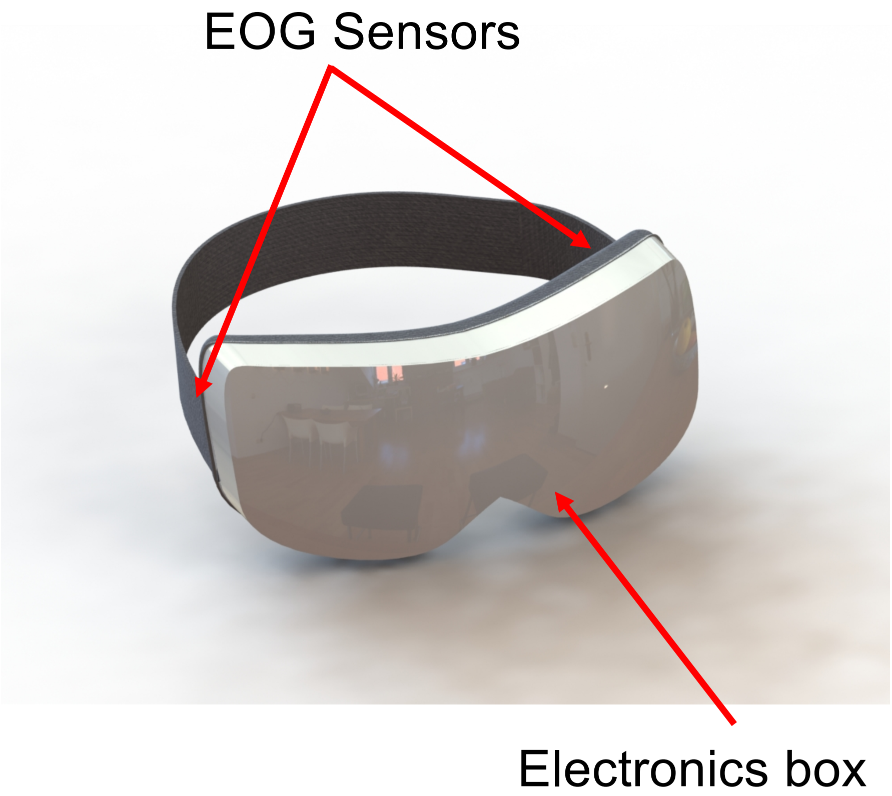
Problem

- Alarm clocks always wake users at a fixed time
- Being awakened during REM sleep can cause grogginess, formally known as "sleep inertia“



- Existing online "Sleep Calculators" that try to combat sleep inertia are very ineffective
  - Generalize that all sleep cycles average 90 minutes
- The problem is: when is the *healthiest* time for ***me*** to wake up?





Ready Every Morning Mask

Solution

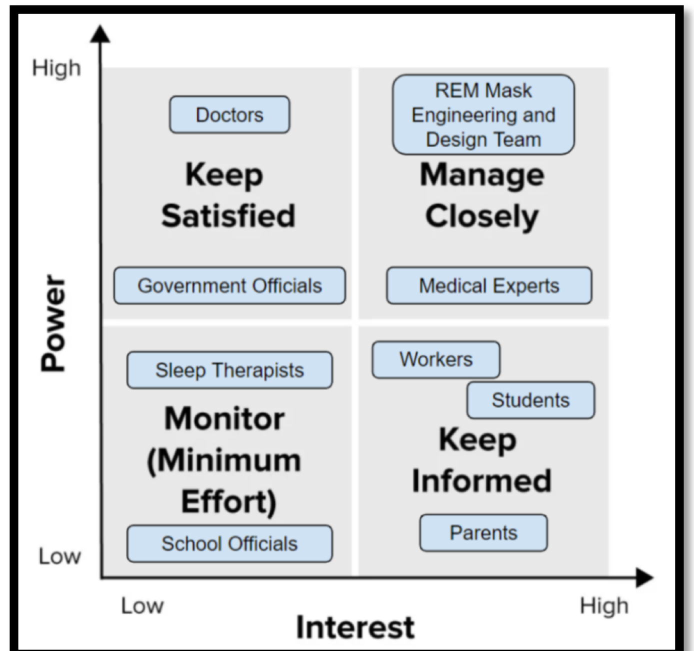
- Current wearables:
  - ***Indirect*** method with heart rates, movement data, and machine learning
  - Estimation of sleep stages (~70% accurate)
- Our solution:
  - ***Direct*** method of measuring REM stages with eye movement during sleep; very accurate
  - Goal: wake users up on time, without compromising sleep quality
- We are unique in **TWO** key ways:
  - Can more accurately identify sleep stages, end of REM
  - Help users benefit from this data with "better" sleep!

Project Description

- Product Overview:

Mask gathers EOG sleep data → Data transmitted to mobile phone → Phone sounds the alarm

- Customer Requirements:
  - Fashionable, comfortable, affordable, reliable, intuitive
- Engineering Requirements:
  - Battery life at least 10 hours, max. charge time of 2 hours



Proof of Function and Scope

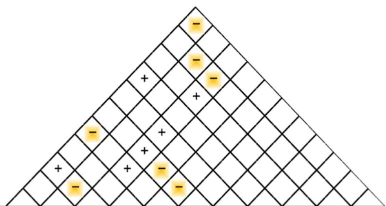
- Proof of Function:
  1. Prove the device can accurately record EOG data.
  2. Prove the integrated software can recognize REM sleep from EOG data.
  3. Prove via *customer surveys* that the device fulfills its goal of maximizing quality of sleep.
- Scope:
  - Target any and all individuals who need to wake up at a specific time but also want to prioritize their sleep
  - Provide users with a product that maximizes the quality of their sleep without jeopardizing the timeliness of their waking up
  - Serve as a product that can be worn to sleep every night

Technical Specification

Correlations	
Positive	+
Negative	−
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

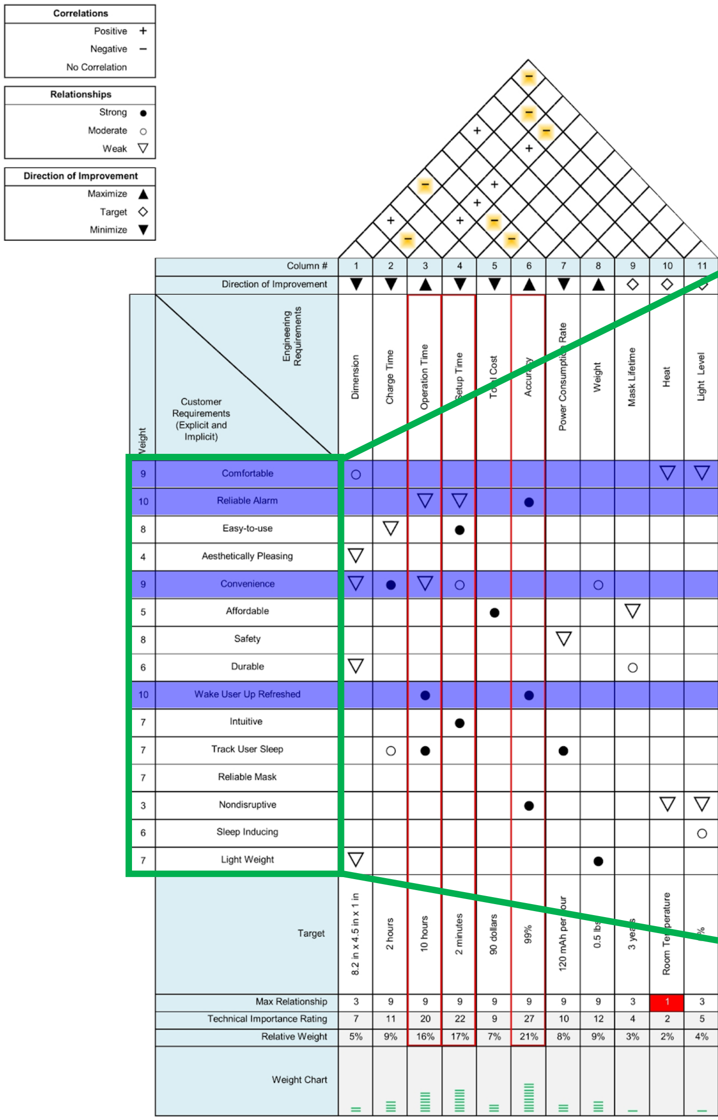
Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



Weight	Column #	1	2	3	4	5	6	7	8	9	10	11
	Direction of Improvement	▼	▼	▲	▼	▼	▲	▼	▲	◇	◇	◇
Weight	Customer Requirements (Explicit and Implicit) / Engineering Requirements	Dimension	Charge Time	Operation Time	Setup Time	Total Cost	Accuracy	Power Consumption Rate	Weight	Mask Lifetime	Heat	Light Level
9	Comfortable	○									▽	▽
10	Reliable Alarm			▽	▽		●					
8	Easy-to-use		▽		●							
4	Aesthetically Pleasing	▽										
9	Convenience	▽	●	▽	○				○			
5	Affordable					●				▽		
8	Safety							▽				
6	Durable	▽								○		
10	Wake User Up Refreshed			●			●					
7	Intuitive				●							
7	Track User Sleep		○	●				●				
7	Reliable Mask											
3	Nondisruptive						●				▽	▽
6	Sleep Inducing											○
7	Light Weight	▽							●			
	Target	8.2 in x 4.5 in x 1 in	2 hours	10 hours	2 minutes	90 dollars	99%	120 mAh per hour	0.5 lbs	3 years	Room Temperature	0%
	Max Relationship	3	9	9	9	9	9	9	9	3	1	3
	Technical Importance Rating	7	11	20	22	9	27	10	12	4	2	5
	Relative Weight	5%	9%	16%	17%	7%	21%	8%	9%	3%	2%	4%
	Weight Chart											

House of Quality

Technical Specification



Weight | Customer Requirement

9	Comfortable
10	Reliable Alarm
8	Easy-to-use
4	Aesthetically Pleasing
9	Convenience
5	Affordable
8	Safety
6	Durable
10	Wake User Up Refreshed
7	Intuitive
7	Track User Sleep
7	Reliable Mask
3	Nondisruptive
6	Sleep Inducing
7	Light Weight

Customer Requirements

Technical Specification

Correlations	
Positive	+
Negative	−
No Correlation	

Relationships	
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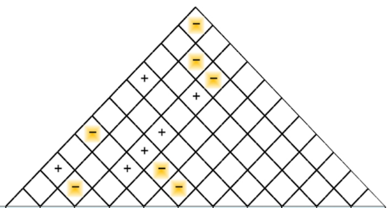
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



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4	Aesthetically Pleasing	▽										
9	Convenience	▽	●	▽	○				○			
5	Affordable					●				▽		
8	Safety							▽				
6	Durable	▽								○		
10	Wake User Up Refreshed			●			●					
7	Intuitive				●							
7	Track User Sleep		○	●				●				
7	Reliable Mask											
3	Nondisruptive						●				▽	▽
6	Sleep Inducing											○
7	Light Weight	▽							●			
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	Weight Chart											

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Weight Chart											

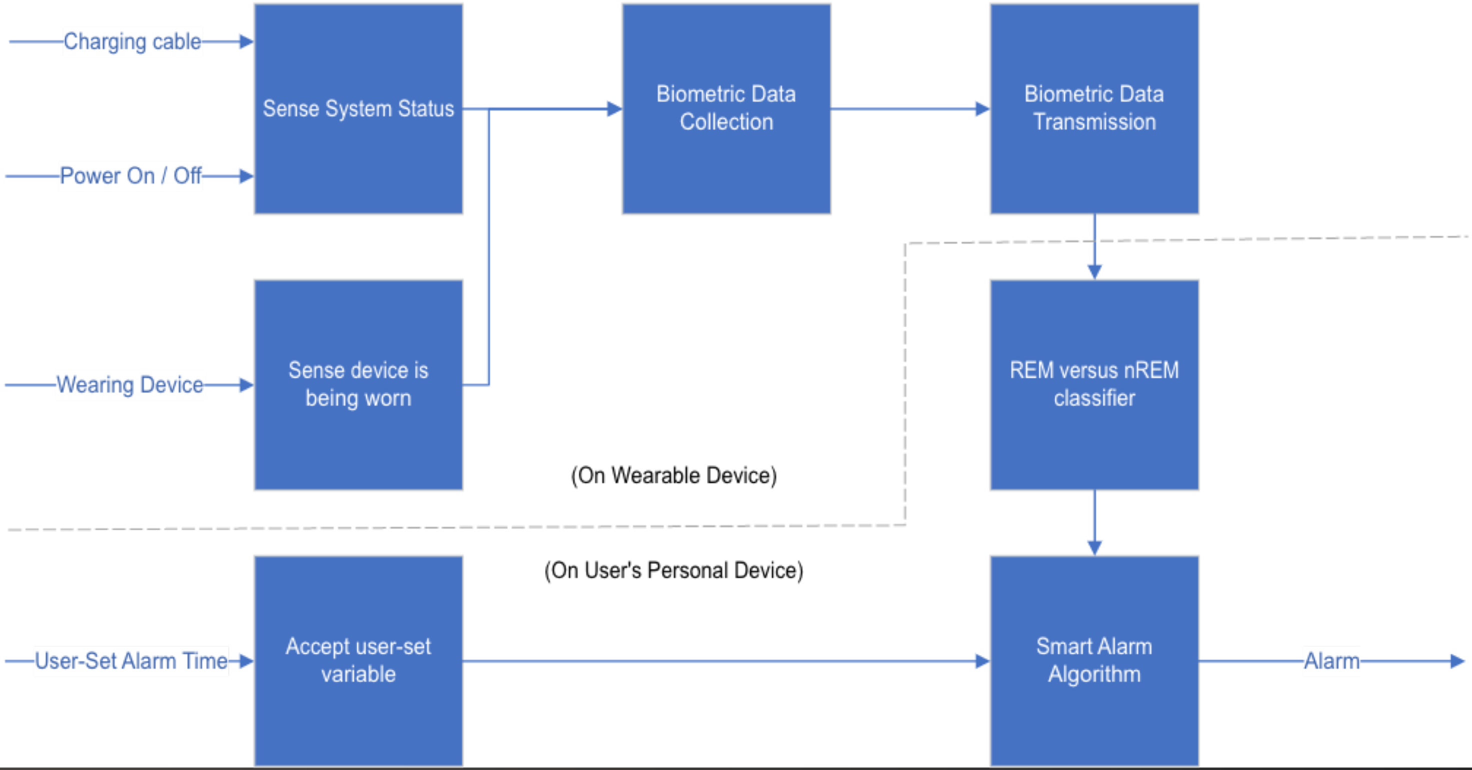
Engineering Requirements Weight

Technical Specification

Changes	D/W	Requirement	Responsibility	Source
2/1/22	W	Wake User Up at the Most Optimal Time	Team	Team
		Geometry		
2/1/22	W	Prefered Dimensions: 8.2 in x 4.5 in x 1 in	Kai	Team - min form factor for comfort/convience
2/1/22	W	Min Head Circumference: 21.5 in	Kai	Average mininum size for one size fit all hats
2/1/22	W	Max Head Circumference: 23 in	Kai	Average maximum size for one size fit all hats
		Energy		
2/1/22	D	Battery Capacity: 1200 mAh	Nabid	Battery- For a night of sleep
2/1/22	W	Product Temperature: Room Temp	Nabid	Team - Low power components
		Software		
2/1/22	D	Min Data Collection Rate: 100 Hz	Andrew	Based on eye movement rate.
2/1/22	W	Data Collection Rate: 200 Hz	Andrew	Team - higher collection rate for accuracy
2/1/22	D	Min Accuracy: 70%	Ananth	Based on Competitors
2/1/22	W	Preferred Accuracy: 90%	Ananth	Team
2/1/22	W	Sleep Classication Algorithm: 30 Seconds	Andrew	Team
		Safety		
2/1/22	D	Number of Loose Parts: 0	Kai	Team
2/1/22	D	Voltage Outside Of Mask: 0 V	Kai	Team
		Sustanability		
2/1/22	W	Product Lifetime: 3 years	Kai	Team
		Operation		
2/1/22	W	Max Operational Time: 10 Hours	Nabid	Team - For a night of sleep
2/1/22	W	Max Set-up Time: 2 Minutes	Nabid	Team - Try to reduce for convenience
2/1/22	W	Max Charge Time: 2 Hours	Nabid	Team - Try to reduce for convenience
		Cost		
2/1/22	W	Max Cost of System: $90	Andrew	Team
		Materials		
2/1/22	W	Max EOG Sensors: 2	Nabid	Team
2/1/22	W	Max Temperature Sensor: 1	Nabid	Team
2/1/22	W	Max Mircotroller: 1	Nabid	Team
2/1/22	W	Max Number of Batteries: 1	Nabid	Team
		Ergonomics		
2/1/22	W	Wires Contained: 100%	Samin	Team
2/1/22	W	Aesthetic Appearance Jury: 95% concensus	Samin	Team
		Production		
2/1/22	W	Total Prototype Time: 10 hours	Kai	Team
		Schedule		
2/1/22	D	Prenstation and Project Proposal: 02/09/22	Team	Project Requirement
2/1/22	D	Presentation and Report #2: 03/16/22	Team	Project Requirement
2/1/22	D	Final Presentation: 04/20/22	Team	Project Requirement
2/1/22	D	Final Report: 4/29/22	Team	Project Requirement

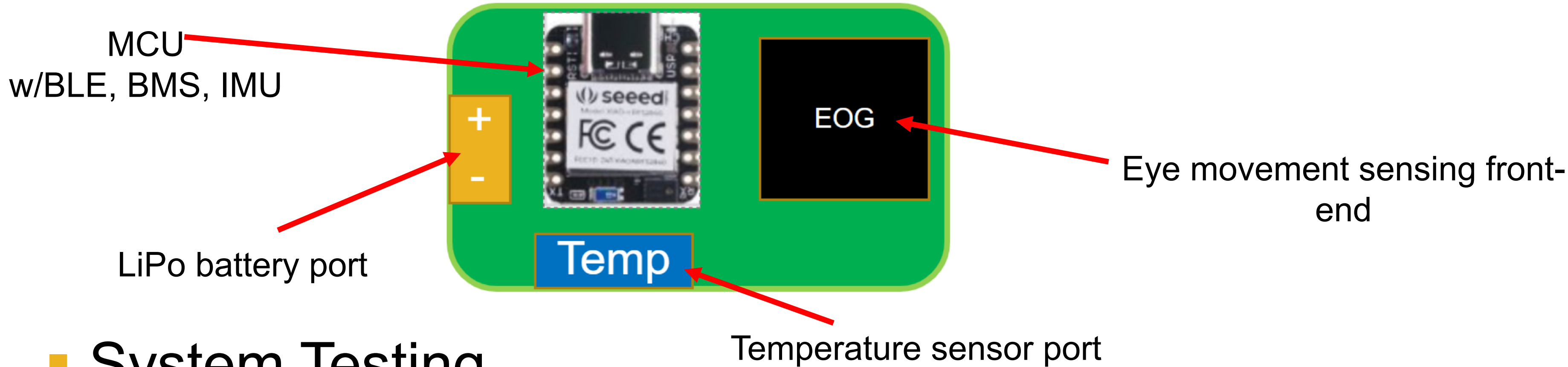
Design Approach and Details

- Input the user's set alarm time and biometric data and dynamically schedule their alarm clock.
- Two-part system
- Specific constraints in a wearable device



Design Approach and Details

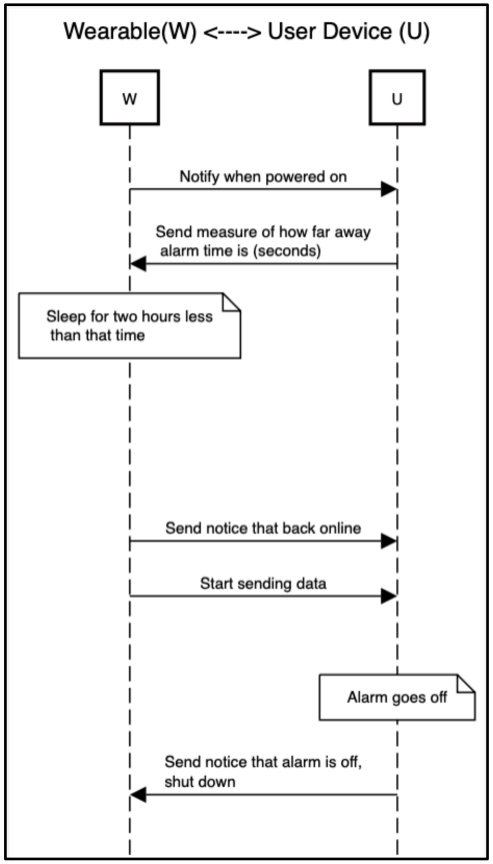
- Small form factor PCB controller:

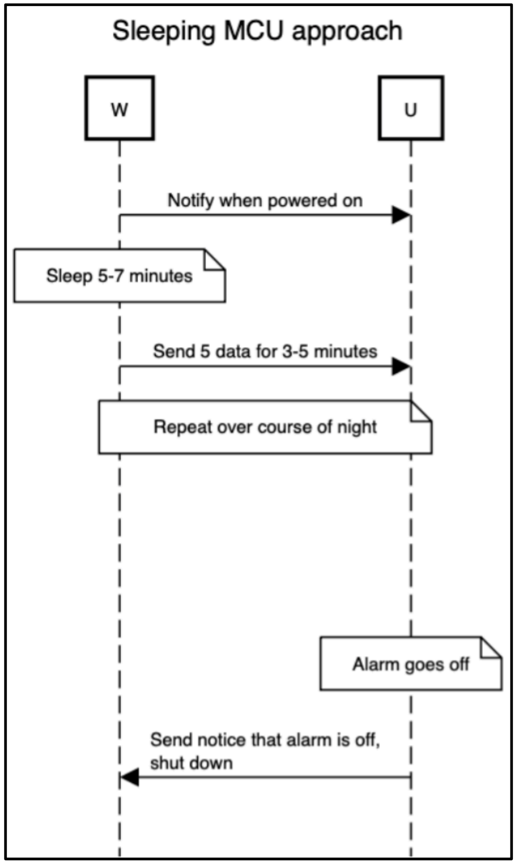


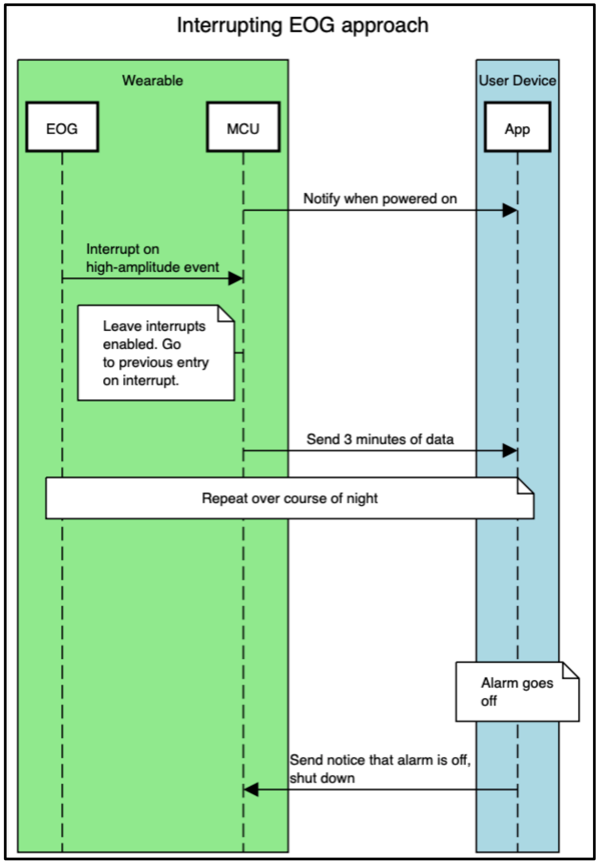
- System Testing
  - Battery – power worst-case analysis, runtime test
  - BLE – transmission test
  - EOG – scope measurement
  - IMU/Temperature – serial data breadboard test

Design Approach and Details

- Specific design detail – when does the MCU sample and transmit data throughout the night?

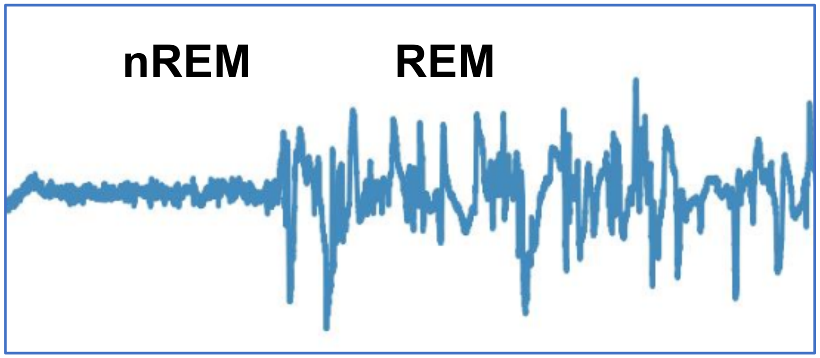






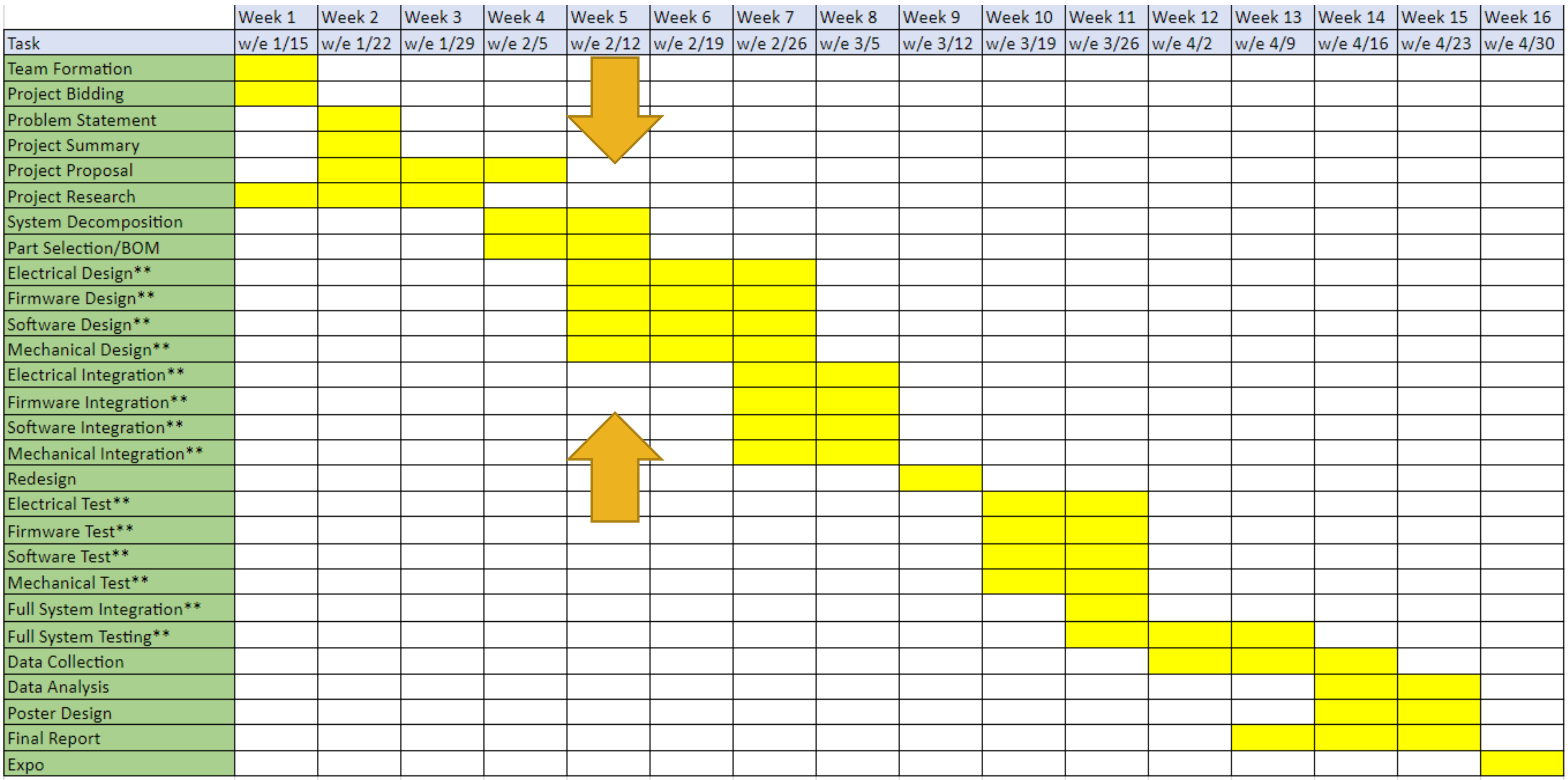
Project Demonstration

- Recorded and classified data will be used to validate project idea
- Biometric data evaluation to demonstrate proof of function
  - Validate temperature sensor and accelerometer functionality overnight
  - Utilizing electrodes on temples to simulate an EOG waveform as shown below (nREM to REM)



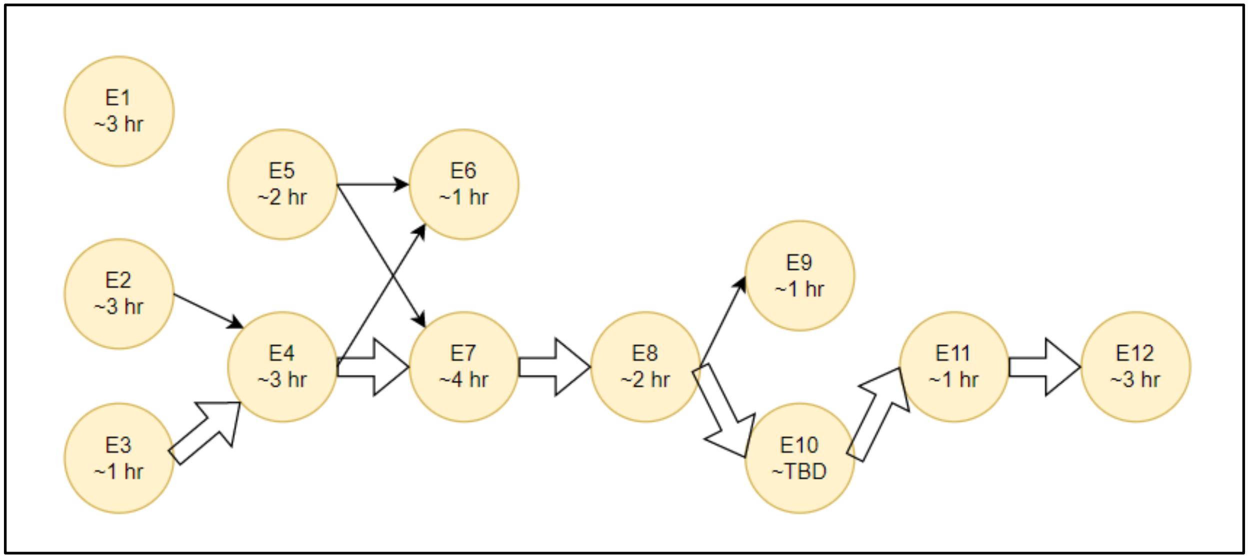
- Live demonstration: demonstrate EOG sensor functionality
  - Smart controls
  - Live waveform recording

Schedule, Tasks, and Milestones



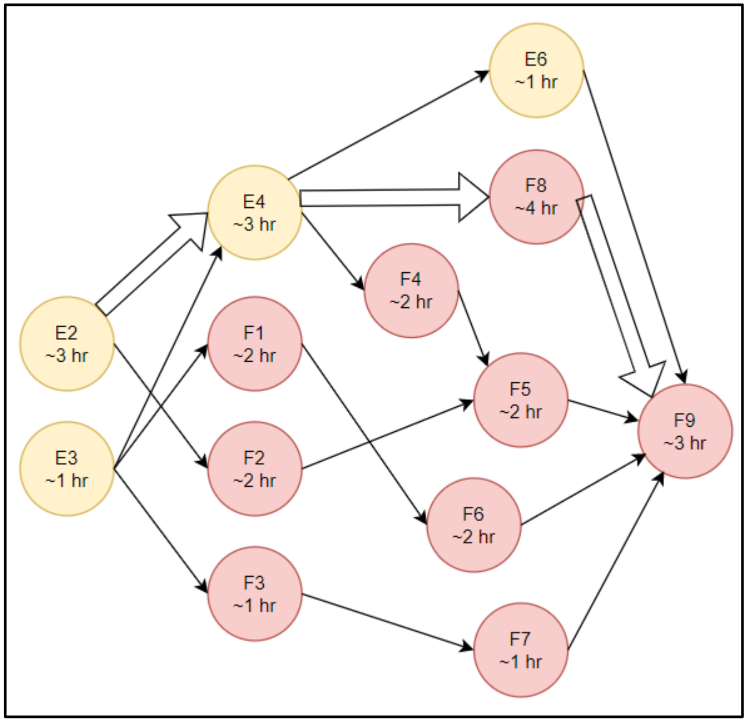
Electrical Tasks

Task #	Task	Relative Importance, Level of Importance	Predecessors	Members involved
E1	Simulate discrete EOG circuit backup	7, 7	--	Nabid
E2	Assemble and test EOG AFE chip	10, 6	--	Nabid
E3	Wire temperature, IMU, SD card	5, 2	--	Nabid
E4	Full breadboard sensing test (EOG, temp, IMU, SD)	10, 5	E2, E3	Nabid, Syed
E5	Battery charge circuit test	7, 4	--	Nabid
E6	Power analysis/measurement	8, 3	E4, E5	Syed
E7	PCB schematic design	9, 9	E4, E5	Nabid
E8	PCB board layout and ordering	10, 2	E7	Nabid
E9	PCB pinout test	7, 4	E8	Syed
E10	PCB fabrication	7, --	E8	Nabid
E11	PCB power-on test	8, 4	E10	Nabid
E12	Full PCB sensor test	10, 6	E11	Nabid



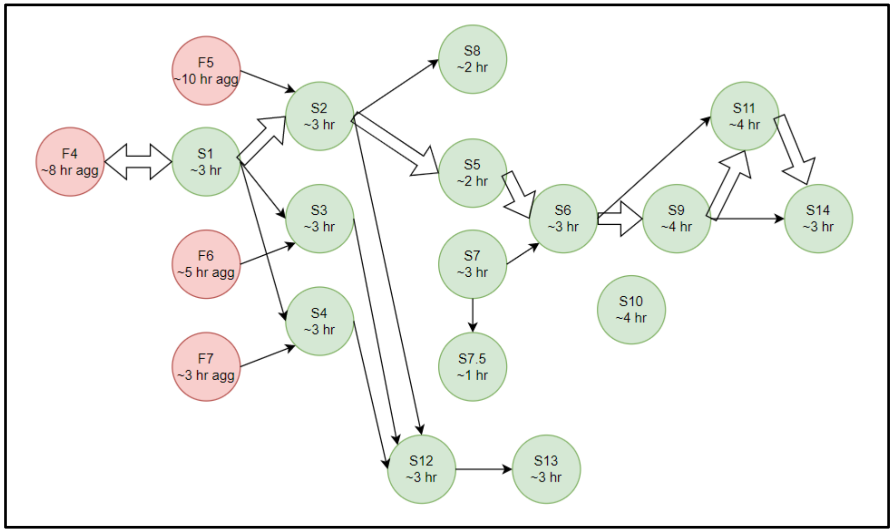
Firmware Tasks

Task #	Task	Relative Importance, Level of difficulty	Predecessors	Members involved
F1	Read IMU data	7, 4	E3	Andrew
F2	Read EOG data over SPI and buffer it	10, 5	E2	Andrew
F3	Read temperature sensors	4, 3	E3	Andrew
F4	Establish a BLE connection – wearable side	10, 5	E4	Andrew, Syed
F5	Send EOG data over BLE	10, 5	F2, F4	Andrew
F6	Send IMU data over BLE	7, 5	F1	Andrew
F7	Send temperature data over BLE	4, 5	F3	Andrew
F8	User interface development and integration	8, 8	E4	Andrew
F9	Refactor to minimize power consumption	8, 8	E6, F5, F6,F7, F8	Andrew, Nabid



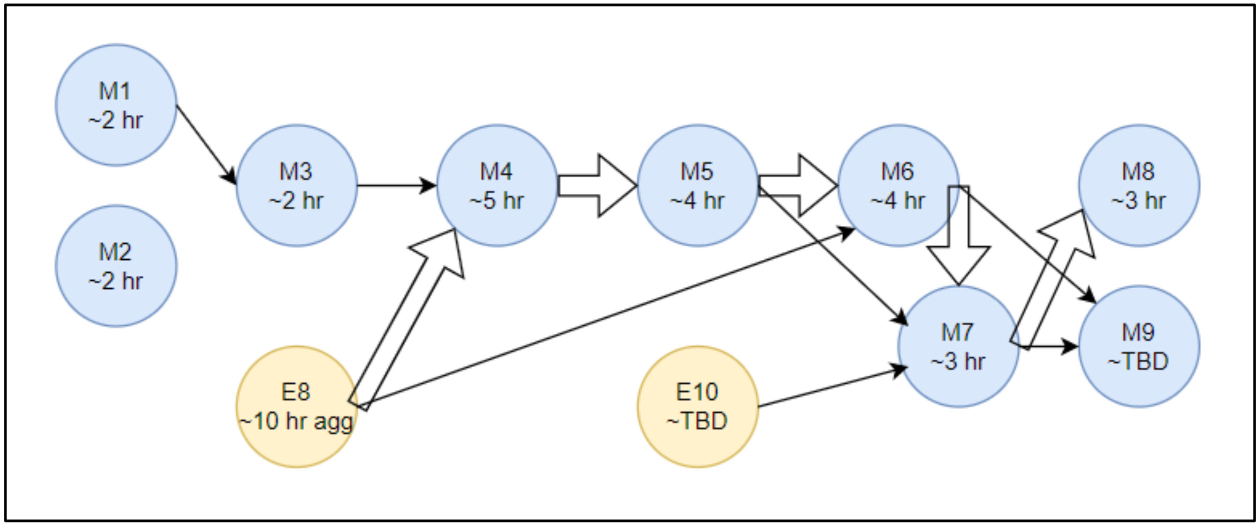
Software Tasks

Task #	Task	Relative Importance, Level of difficulty	Predecessors	Members involved
S1	Establish a BLE connection – application side	10, 7	F4 (concurrent)	Syed
S2	Parse EOG data from BLE	10, 5	S1, F5	Ananth, Syed
S3	Parse IMU data from BLE	7, 5	S1, F6	Ananth, Syed
S4	Parse temperature data from BLE	4, 4	S1, F7	Ananth, Syed
S5	Subdivide EOG data and extract features	10, 5	S2	Ananth, Andrew
S6	Classify REM versus nREM using data	10, 6	S5, S7	Ananth, Andrew
S7	Create a model which classifies REM vs nREM sleep	10, 6	--	Syed, Ananth
S7.5	Make the classification model loadable, not created every time the application is launched	4, 5	S7	Ananth
S8	Create visualization tools to aid debugging and demonstration	4, 5	S2	Ananth
S9	Smart Alarm Algorithm	4, 8	S6	Ananth
S10	Mobile Application – User Interface	8, 6	--	Syed
S11	Mobile Application – Integrate algorithm and sleeping data with user interface	8, 7	S6, S9	Ananth
S12	Mobile Application – Implement Bluetooth module fo data transfer between phone and mask	10, 6	S2, S3, S4	Syed
S13	Mobile Application – Integrate data classifier in backend of application	10, 6	S12	Ananth
S14	Mobile Application – Develop easily-customizable alarm that will "go off" at time determined by algorithm	10, 5	S9, S11	Ananth



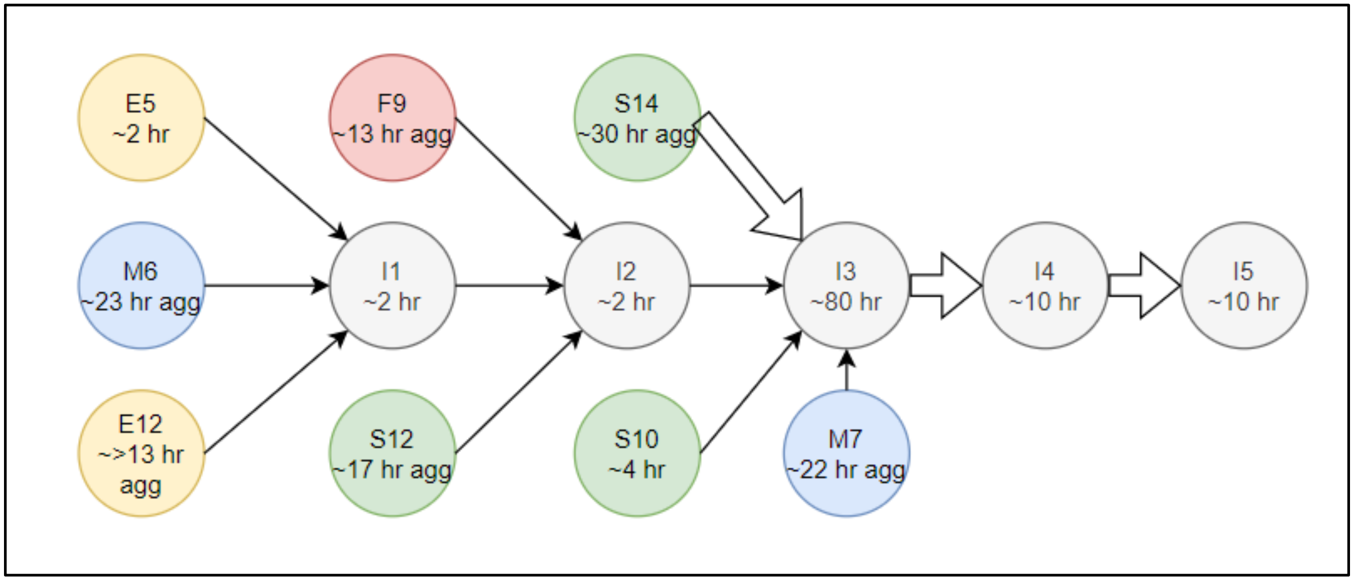
Mechanical Tasks

Task #	Task	Relative Importance, Level of difficulty	Predecessors	Members involved
M1	BOM for mask	6, 2	--	Kai, Nabid
M2	Create General Layout	6, 4	--	Kai
M3	Material Selection (EDUPACK)	7, 4	M1	Kai
M4	CAD Design	6, 8	E8, M3	Kai
M5	3D Printing/Resin Printing	6, 5	M4	Kai
M6	Prototyping Form Factor	8, 7	E8, M5	Kai
M7	Prototyping Wearable Mask	8, 10	E10, M5, M6	Kai
M8	Obtain Customer Feedback for Mask	9, 2	M7	Team
M9	Iterate Design/Aesthetic adjustments (repeat M1 to M8 as necessary)	10, 8	M6, M7	Kai



Integration of Full System Tasks

Task #	Task	Relative Importance, Level of difficulty	Predecessors	Members involved
I1	Ensure electronics fit the form factor	9, 4	M6, E5, E12,	Kai, Nabid
I2	Confirm connection between wearable and app	9, 5	I1, F9, S12	Syed
I3	Full System testing	9, 8	M7, S10, S14, I2	Team
I4	Full System debugging	9, 9	I3	Team
I5	Final System Integration	10, 9	I4	Team



Marketing and Cost Analysis

Revenue	
Timeline (years)	5
Serviceable Obtainable Market Size	4,804,082
- Total addressable US Market (US residents who use an alarm clock)	226,746,586
- Fraction of market which would consider wearing a sleep mask	53.60%
- Fraction of those people that would tradeoff less sleep for a better wake up	73.20%
- Fraction of those people that would use a sleep-tracking wearable	5.40%
Unit price	$150.00
Total revenue over period	$3,603,061,299

Marketing and Cost Analysis

COST ANALYSIS FOR THE SEMESTER (PRODUCT DEVELOPMENT)	
- Total Engineering Hours	750
- Team Members	5
- Weekly Hours Worked	10
- Project Duration (weeks)	15
- Hourly Engineering Rate ($)	$40.00
- Employee Benefits	$5,000.00
- Reimbursed Expenses	$2,500.00
TOTAL LABOR COST	$37,500.00
TOTAL PROTOTYPING COSTS	$270.08
- Anticipated Number of Prototypes	4
- Total Prototype Cost	$67.52
- Sensing Subsystem	$25.19
- Computing / Transmission Subsystem	$20.00
- User Interface Subsystem	$0.50
- Power subsystem	$21.83
TOTAL SEMESTER COST	$37,770.08

Marketing and Cost Analysis

MANUFACTURING COSTS	
MANUFACTURING ENGINEER COSTS	$260,000
- Yearly Salary	$52,000
- Manufacturing Timeline (years)	5
TOTAL PRODUCTION COST FOR ALL UNITS	$2,420,488,540
- Parts Pricing	$60.77
- Manufacturing labor cost for one unit	$40.00
- Total Expected Units Sold	24,020,408.66
- Yearly Expected Units Sold	4,804,081.73
- Product sales timeline (years)	5
OVERHEAD COST	$4,250,000
- Facility cost	$2,750,000
- Amortized Machine Cost over 5 years	$1,500,000
- Total machinery cost	$3,000,000
- Average machine lifespan (years)	10
Total Manufacturing Costs	$2,424,998,540

Marketing and Cost Analysis

PROFIT	
Product Sale Revenue	$3,603,061,299
Engineering Cost	($37,500.00)
Manufacturing Cost	($2,424,998,540)
TOTAL PROFIT	$1,178,025,259
PROFIT PER UNIT	$49.04

Current Status

✅ Completed:

- Sleep and EOG research (ongoing)
- Project Proposal

🚧 In progress:

- Breadboarding the EOG circuit (~15%)
- Hardware design (~65%)
- Firmware design (~60%)
- Software design (~25%)
- REM vs nREM classifier using third-party datasets (~15%)