BikeBuddy

Team A3 - Johnny Tian, Jack Wang, Jason Lu

https://www.seekpng.com/ipng/u2w7t4y3y3y3u2w7_green-bike-clip-art-at-clker-bike-symbol/

Use Case

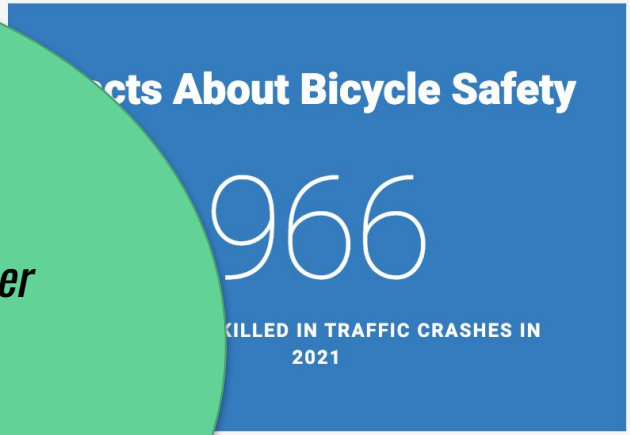
11-year-old bicyclist suffers li
in southwest valley crash

by Matthew Seeman & George Acosta | Tue, January 30th 2024

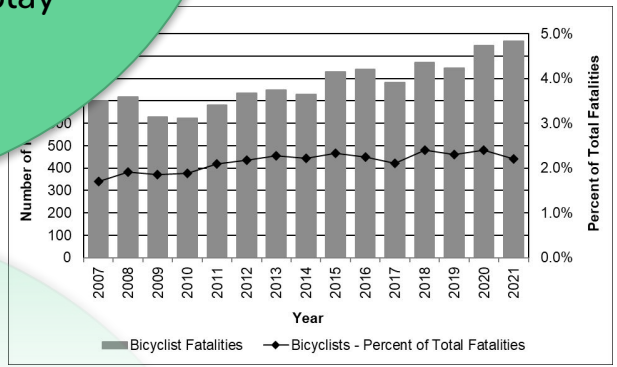
Bike Buddy

Your Commute Safety Partner

- Blind Spot Detection
- Collision Alerts
- Turn Signals
- Centralized Warning Display



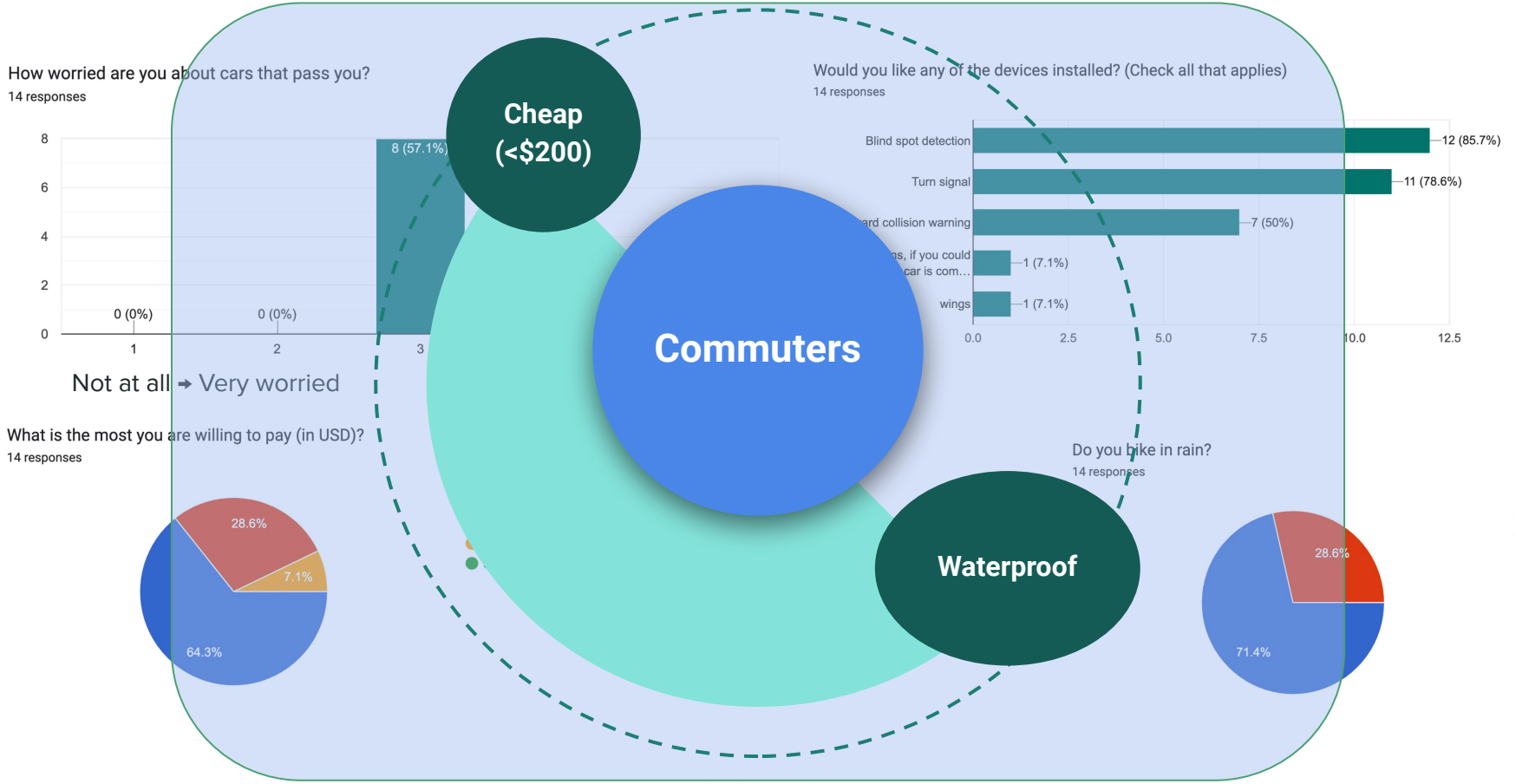
sa.gov/road-safety/bicycle-safety



https://www.nhtsa.gov/book/countermeasures-that-work/bicycle-safety

ECE areas: Software Systems, Circuits, Signals and Systems

Use-Case Requirements



Use-Case Requirements

- Power consumption >= 2 hrs endurance
  - Average commute distance in the U.S. is 8.3 miles (ca. 13 km)[1]
  - Assume biking speed of 15 mph (ca. 24 km/h) ➔ ~1.1 hrs round trip time + buffer time

- Detection range – 10 m
  - Ford does 4 m under normal residential area speed (25 – 30 mph)[2]
  - Human response time: 100 – 300 ms
  - Assume speed differential of 15 mph (ca. 24 km/h) + 1.5 s response time from detection to possible collision[3]

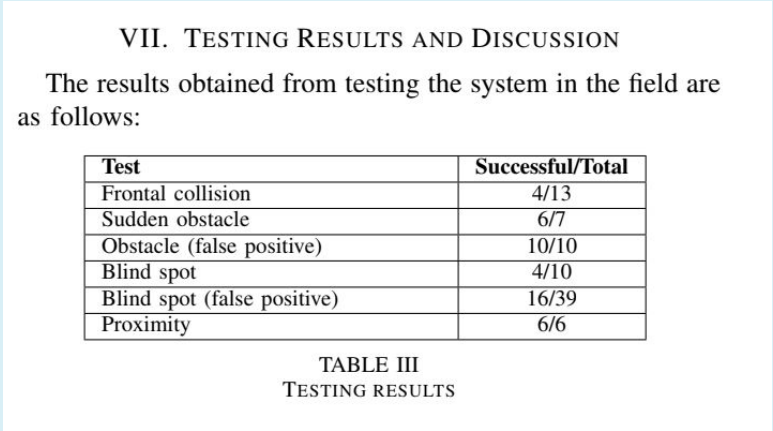
[1] https://velo.outsideonline.com/road/road-racing/strava-end-year-insights-live-fastest-state/
[2] https://www.fordservicecontent.com/Ford_Content/vdirsnet/OwnerManual/Home/Content?variantid=7506&languageCode=en&countryCode=USA&Uid=G2029928&ProcUid=G2029836&userMarket=usa&div=f&vFilteringEnabled=False&buildtype=web
[3] https://news.mit.edu/2019/how-fast-humans-react-car-hazards-0807

Use-Case Requirements

- Uptime >= 99.999%
  - “5 nines uptime” rule
  - People want a reliable system

- Confusion Matrix
  - <= 40% False Negatives
  - <= 30% False Positives

Table III from 2019 CycleSafe Project:



VII. Testing Results and Discussion

The results obtained from testing the system in the field are as follows:

Test	Successful/Total
Frontal collision	4/13
Sudden obstacle	6/7
Obstacle (false positive)	10/10
Blind spot	4/10
Blind spot (false positive)	16/39
Proximity	6/6

TABLE III
Testing Results

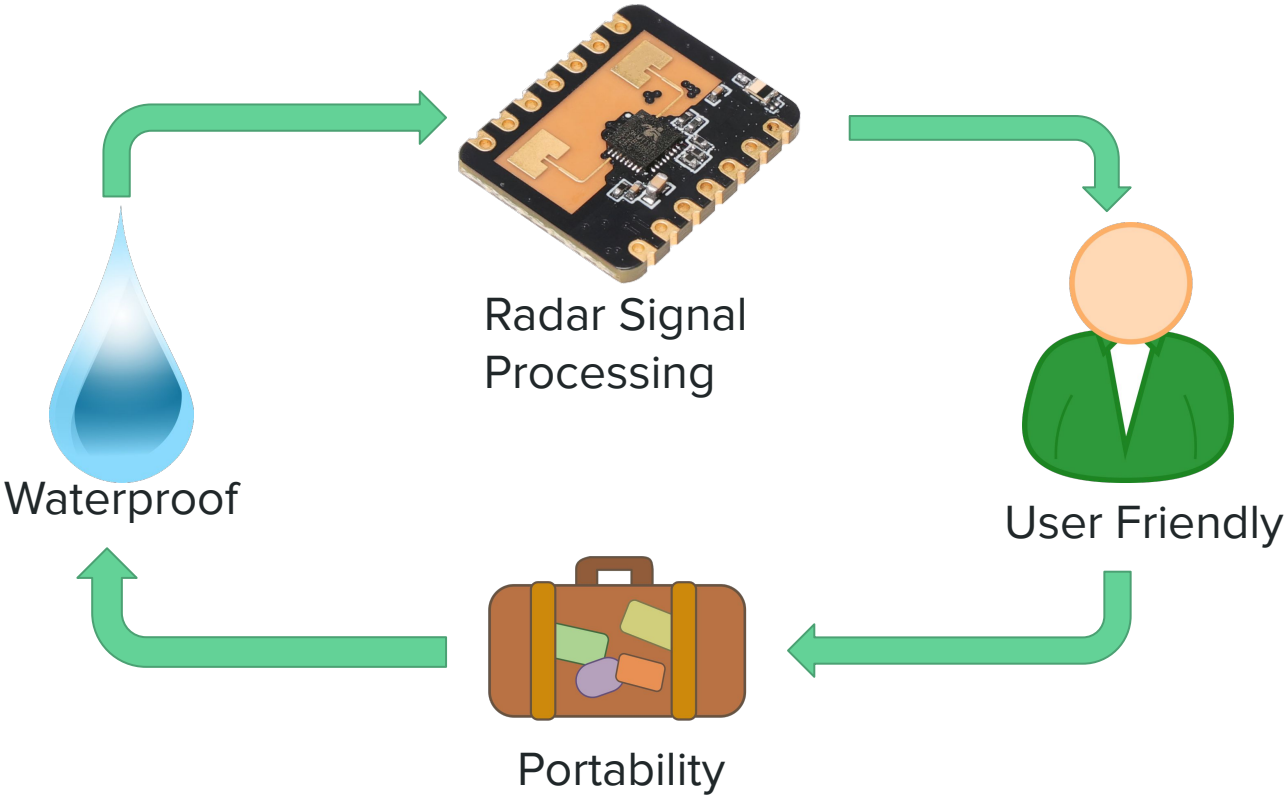
https://course.ece.cmu.edu/~ece500/projects/s19-teama1/final-report/

Use-Case Requirements

- Ruggedness — IPX4
  - For commuters to ride in rain
- Information Display — Screen
  - ~43% of surveyed prefer some sort of screen display
- Ease of Use — Modular
  - Easy to attach and remove
  - Easy to swap batteries

Level	Protection against
0	None
1	Dripping water
2	Dripping water when tilted at 15°
3	Spraying water
4	Splashing of water
5	Water jets
6	Powerful water jets
7	Immersion, up to 1 meter (3 ft 3 in) depth
8	Immersion, 1 meter (3 ft 3 in) or more depth
9	Powerful high-temperature water jets

Technical Challenges



https://wiki.seeedstudio.com/mmwave_for_xiao_arduino/ - From Seeed Studio under CC BY-SA 4.0
https://openclipart.org/detail/238217/water-drop
https://openclipart.org/detail/320342/suitcase-with-travel-stickers
https://openclipart.org/detail/171433/user-2

Embedded System Choice

Embedded Choices:

1. Odroid N2: No built-in Wi-Fi/Bluetooth[1]
2. RPi 5[2] / Orin[3]: Higher Power Consumption
3. Asus Tinker
4. Jetson Nano
5. **RPi 4 (most common)**

N2

https://wiki.odroid.com/_media/odroid-n2/n2_shat.jpg.

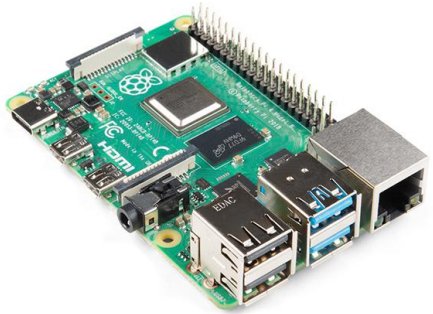
"N2_shat.jpg" from ODROID Wiki under CC BY-SA 4.0

Jetson Orin

https://www.sparkfun.com/products/22098

RPI 5

https://www.sparkfun.com/products/23550



RPI 4

https://www.sparkfun.com/products/15447

Jetson Nano

https://www.sparkfun.com/products/17283

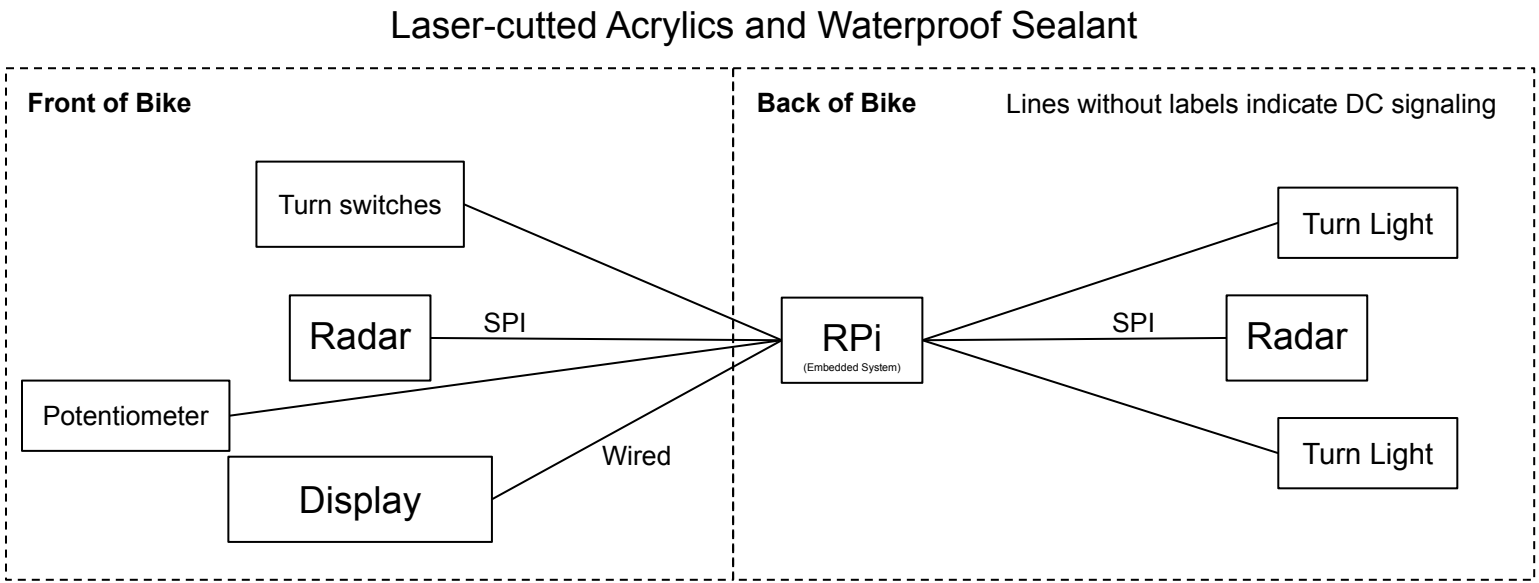
Asus Tinker

https://en.wikipedia.org/wiki/Asus_Tinker_Board#/media/File:Tinker-board.jpg

"MiniPC Tinker-Board" by Gabriele.romano under CC BY-SA 4.0

Sparkfun images are under CC BY 2.0. [1]https://wiki.odroid.com/odroid-n2/odroid-n2. [2]https://www.raspberrypi.com/news/introducing-raspberry-pi-5/. [3]https://forums.developer.nvidia.com/t/agx-orin-power-consumption/223580

Solution Approach



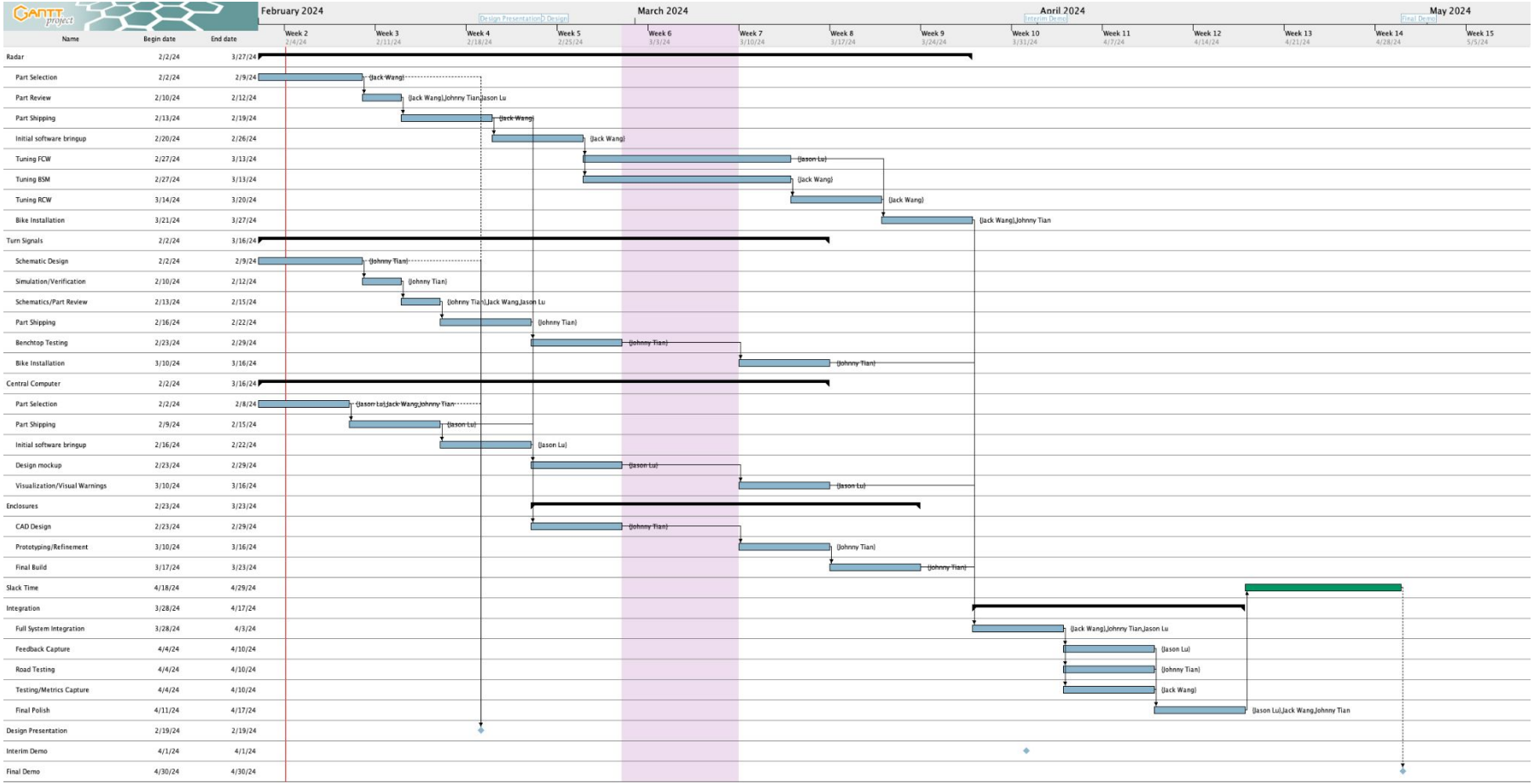
Testing, Verification and Metrics

Metric	Test Plan
Cost	● Add up the final BOM for final deployment materials
Uptime	● Measure the total time that the system is available during each use
Confusion Matrix	● Static testing on false positives and negatives ● Real world testing on false positives and negatives
Power Consumption	● Measure current draw of the total system and extrapolate ● Record the running time of the system under normal use
Detection Range	● Static testing on the detection range of the radar ● Real word testing on actual detection lead time when moving
Ruggedness	● Verify the waterproof case complies with IPX4 standard ● Test the final product in the case to make sure its functionality
Ease of Use	● Ask 5+ bike riders to try the product and gather their opinions

Tasks and Division of Labor

Name	Task
Johnny	● Device installation ● Enclosure design + manufacture ● Turning signals
Jason	● Central computer software implementation ● Display UI ● PCB design if needed
Jack	● Radar setup, tuning, and testing ● Radar data processing and forwarding ● System integration

Schedule


GANTT project
February 2024
March 2024
April 2024
May 2024
Design Presentation
Design Review
Interim Demo
Final Demo
Week 2 2/4/24
Week 3 2/11/24
Week 4 2/18/24
Week 5 2/25/24
Week 6 3/3/24
Week 7 3/10/24
Week 8 3/17/24
Week 9 3/24/24
Week 10 3/31/24
Week 11 4/7/24
Week 12 4/14/24
Week 13 4/21/24
Week 14 4/28/24
Week 15 5/5/24
Name | Begin date | End date
Radar | 2/2/24 | 3/27/24
Part Selection | 2/2/24 | 2/9/24 | [Jack Wang]
Part Review | 2/10/24 | 2/12/24 | [Jack Wang],[Johnny Tian],Jason Lu
Part Shipping | 2/13/24 | 2/19/24 | [Jack Wang]
Initial software bringup | 2/20/24 | 2/26/24 | [Jack Wang]
Tuning FCW | 2/27/24 | 3/13/24 | [Jason Lu]
Tuning BSM | 2/27/24 | 3/13/24 | [Jack Wang]
Tuning RCW | 3/14/24 | 3/20/24 | [Jack Wang]
Bike Installation | 3/21/24 | 3/27/24 | [Jack Wang],[Johnny Tian]
Turn Signals | 2/2/24 | 3/16/24
Schematic Design | 2/2/24 | 2/9/24 | [Johnny Tian]
Simulation/Verification | 2/10/24 | 2/12/24 | [Johnny Tian]
Schematics/Part Review | 2/13/24 | 2/15/24 | [Johnny Tian],Jack Wang,Jason Lu
Part Shipping | 2/16/24 | 2/22/24 | [Johnny Tian]
Benchtop Testing | 2/23/24 | 2/29/24 | [Johnny Tian]
Bike Installation | 3/10/24 | 3/16/24 | [Johnny Tian]
Central Computer | 2/2/24 | 3/16/24
Part Selection | 2/2/24 | 2/8/24 | [Jason Lu],Jack Wang,Johnny Tian
Part Shipping | 2/9/24 | 2/15/24 | [Jason Lu]
Initial software bringup | 2/16/24 | 2/22/24 | [Jason Lu]
Design mockup | 2/23/24 | 2/29/24 | [Jason Lu]
Visualization/Visual Warnings | 3/10/24 | 3/16/24 | [Jason Lu]
Enclosures | 2/23/24 | 3/23/24
CAD Design | 2/23/24 | 2/29/24 | [Johnny Tian]
Prototyping/Refinement | 3/10/24 | 3/16/24 | [Johnny Tian]
Final Build | 3/17/24 | 3/23/24 | [Johnny Tian]
Slack Time | 4/18/24 | 4/29/24
Integration | 3/28/24 | 4/17/24
Full System Integration | 3/28/24 | 4/3/24 | [Jack Wang],[Johnny Tian],Jason Lu
Feedback Capture | 4/4/24 | 4/10/24 | [Jason Lu]
Road Testing | 4/4/24 | 4/10/24 | [Johnny Tian]
Testing/Metrics Capture | 4/4/24 | 4/10/24 | [Jack Wang]
Final Polish | 4/11/24 | 4/17/24 | [Jason Lu],Jack Wang,Johnny Tian
Design Presentation | 2/19/24 | 2/19/24
Interim Demo | 4/1/24 | 4/1/24
Final Demo | 4/30/24 | 4/30/24