

AVALERT

a project proposal, submitted by:



**SAM IANNONE
AUSTIN BALL
CAVIN DOUGHERTY**

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**IG: @avalertco
www.avalert.com**

TABLE OF CONTENTS

abstract	3
i. introduction	4
a. background	5
b. thesis statement	6
ii. scope of work	9
a. overview/srr	10
b. alternative solutions	16
c. evaluation	21
d. decision	23
iii. personnel + organization	25
iv. data + analysis, EDP	32
a. design process	33
b. mathematical + scientific	37
c. data + srr analysis	47
d. results	#
v. budget	#
vi. resumes	#
vii. works cited	#
viii. appendices	#



Avalanche incidents and disasters remain as the biggest and most significant risk in backcountry skiing and snowboarding, where uncertain and rapidly changing conditions and limited real-time data and information leaves these riders vulnerable. As a result, over 160 skiers die in avalanche related disasters every year in the US alone. So, our solution was to provide these users with real-time data analysis for the snow beneath the skiers feet through a handheld device, called AvAlert.

AvAlert is a compact, integrated avalanche-awareness device designed to enhance decision-making and improve situational safety in remote alpine environments. The system combines real-time environmental sensing, including snow depth (ultrasonic sonar), atmospheric pressure, temperature, humidity, and geomagnetic heading, into a single, rugged, portable unit powered by an ESP32-S3 microcontroller and displayed on a high-visibility TFT screen interface.

AvAlert continuously monitors terrain and atmospheric indicators associated with avalanche risk and presents them through an intuitive, color-coded interface that communicates stability trends, depth changes, and directional orientation. The device emphasizes clarity, durability, and low-power performance to ensure reliability in extreme cold and high-altitude conditions. Unlike smartphone-dependent solutions, AvAlert functions as a standalone safety instrument, reducing reliance on cellular connectivity and preserving battery life for emergency communication devices. This combination allows riders to make better decisions in the backcountry, supporting smart risk management in backcountry terrain.

The proposed design meets criteria for portability, environmental resilience, real-time processing, and user-centered interface design. By consolidating critical avalanche-related data into a single dedicated platform, AvAlert aims to empower backcountry travelers with actionable information, supporting safer route selection and informed risk assessment in avalanche-prone terrain.

INTRODUCTION



AvAlert is a compact & handheld avalanche risk assessment device created to provide backcountry snow riders with real-time locational environmental data, such as snow depth and atmospheric conditions, to serve as a first-of-its-kind informational avalanche device. This proposal outlines our design process, mathematical and technical validation, and implementation system for our low-power device that aims to solve avalanche death problems and meet safety and performance criteria all while following an engineering protocol set by our requirements and constraints.

in introduction:
a. background
b. thesis statement

Year after year, an estimated six million skiers venture into the backcountry, at the mercy of Mother Nature and her plethora of dangerous mannerisms. According to ShelterBox.org, 150 of these skiers will be caught and killed in an avalanche; a small percentage, yes, but still one hundred and fifty too many [8]. This also does not include injuries or people put in dangerous, life-threatening situations as a result of these disasters. Each of these skiers will face the unknown, that is, avalanche conditions, without a surefire way of knowing the current dangers they may encounter, except for word of mouth. Adding to the fear, 90 percent of all avalanches are triggered by someone in the victim's party, according to the National Weather Service [2]. During a candid interview with an experienced backcountry snowmobiler and snowboarder, JR Brewer, I received several chilling firsthand anecdotes about the dangers of backcountry riding. While conversing, he elaborated on the uncertainties he feels every time he enters the Rocky Mountain wilderness with aspirations of a fun day in the breathtaking backcountry, he risks life and limb to do the things he loves. During our interview, he told me a bone-chilling story taking place on Rabbit Ears Pass outside of Steamboat Springs, Colorado, during the 2022/2023 season; during a ride day with several friends, they were riding on the south side of the pass above tree line when Mother Nature let her wrath loose. He recollects the frightening experience well, stating that while descending a cornice, he felt a shift below his machine, but it was too late. The powerful slide effortlessly swept him and his sled away into the white abyss, with nothing to do other than hope he was along for the ride. Luckily, he was able to regain control of his body and the machine. He conquered Mother Nature head-on and narrowly rode away from the slide. After this day, he says he will never enter the backcountry without his avalanche safety equipment, but he says that just isn't enough after "coming too close to the edge," as he said. He then went on to say that although most riders, including himself, accept the risks of backcountry riding, they do not do so willingly, but for lack of a viable means to detect avalanches before you are battling one. He ended our conversation with great interest and optimism for the future of avalanche safety, with great fascination in the future of our device.

The problem is this: no current device exists to perfectly warn a skier about the conditions of the snow beneath their feet, and whether or not it is at risk for causing an avalanche. Although things like beacons and receivers exist, neither of these devices comes in handy unless you are already caught in the slide. Clearly, a gap exists in the skiing industry for preventative, early-action avalanche warnings and information. A solution to fill this hole would be an integral part of any skier's routine and a necessary measure to keep our backcountry skiers safe. To back this up, we interviewed John Iannone, an avid backcountry skier from Winter Park, Colorado, who has lived in the area for 30 years. Iannone emphasized that "avalanche prevention measures are currently limited to education and awareness of conditions," a gap that is concerning and an unstable foundation at best. Digging a pit to estimate these conditions, he said, is "time consuming, requires significant physical exertion, and is often overlooked" and even "ignored by backcountry recreation enthusiasts." Something needs to be done about the inefficiency of the current avalanche prevention and the lack of a solution thereof.

Many different factors must be taken into account when studying and predicting avalanche conditions, but perhaps the most important are layer density and snow water equivalent (SWE). Analyzing density and SWE is very important when investigating what snow is prone to sliding and causing an avalanche, especially when doing layer analysis. Avalanches are a direct result of the build-up of layers in snowpack; a weak layer in the snowpack is always a cause for concern, so one must analyze these layers to understand the dangers. Snow stratigraphy, or layer-by-layer density, SWE, and characteristic analysis techniques provide important data on dangerous layers and harsh conditions. Data like this can be graphed, as shown from SnowPilot, and analyzed for density differences; for example, a node taken on Berthoud Pass, CO, on April 27th, 2025, shows a layer of highly dense snow on top of a less dense layer, possibly indicating dangerous layering patterns [7]. However, these metrics require a large pit to be dug and fancy instruments and equipment to be created, something the average skier cannot and will not do before skiing down.

Climate conditions locally can also be heavily attributed to avalanche conditions and the likelihood of a slide. For example, Simon Fraser University lists conditions including heavy snowfall, snowstorms, and wind direction in the top 3 reasons for avalanche disasters [6]. All three of these things are important, especially when considered directly after they happen. Climate and weather changes directly contribute to and correlate with snow water equivalent, layering, grain size, and overall moisture. When put together, climate data along with direct measurements of these qualities are what make a full and complete avalanche analysis and risk assessment. In Colorado alone, the National Weather Service cites that 6 people die each year in these disasters [1].

SWE is directly correlated to the type of avalanches that will happen. Precipitation can cause heavy snow in new storms, and when placed on top of an extremely weak layer of snow, it can create a super dangerous situation and cause the weak layer to collapse. According to OrtoVox's Lab Snow Safety Academy, "A new snow layer often poorly bonds with the old snow layer," and this is the main reason why slab avalanches happen [5]. Consequently, they also cite that 95% of avalanche casualty cases result from the victims triggering their own slab avalanches. That number spikes to 99% when we look at all avalanches caused by recreational skiers, casualty or not. Linking these together, we can identify that the most dangerous avalanche encounters include the factor of wet, new snow drifting over a soft and weak layer. Another important factor to consider when identifying dangerous slopes is slope angles. According to Avalanche Safety, » Identify Terrain, slopes that exist at 30 degrees or more are extremely prone to slab avalanches, and these slope angles exist very commonly in most backcountry areas [4]. Large cornices and backcountry faces have steeper slopes like these, and more common than not, thrill-seeking skiers are looking for the steeper slopes that give them an adrenaline rush.

When it comes to current infrastructure in the avalanche safety world, there are a plethora of solutions, yet "Avalanche hazard prediction remains a crucial task for mountainous regions worldwide," according to the National Library of Medicine [3]. Stationary weather stations and buried radar devices can provide professionals with the data they need to predict and understand current avalanche conditions. Artificial triggering of avalanches using either remote triggering stations or a physical, specialized high-caliber firearm can be used to mitigate problem areas near railroads and roadways. Field researchers can take snow cores to study snowpack and get an understanding of problem layers. Avalanche Zoning can be used to map high-risk areas, typically those near developments and populated areas. And of course, plenty of gear exists for the skiers to use as they venture into the backcountry; beacons, transceivers, avy-packs, and plenty of other gear exist as precautionary measures. Plenty of options exist for protecting people and infrastructure from the destructive forces of avalanches. Amongst all of these solutions, not one of them can be used as a real-time detection device. Even with all of these options, skiers still get caught in avalanches, and according to Brian Pollock (FOBP), "40% had taken an L1 class." L1 being the highest level of professional risk management. Avalanches are unpredictable by nature, so predictions and single-point data can only get skiers so far.

Through our extensive research, we have deduced that there is currently no solution for real-time avalanche detection on the market. A product such as the one we plan to design is essential to keeping backcountry skiers alike safe from the unpredictability of Mother Nature. During our initial research, we have learned the key data markers for safe and unsafe snow, consisting of: snow density, snow water equivalent (SWE), grain size, layer-by-layer topography, and slope angle. In addition to these markers, we studied specific climate data and snowpack records from different areas all over the northern continent to determine various types of snow accumulation patterns using records dating back decades.



SCOPE OF WORK

In our project, we will design, prototype, create, and test AvAlert through integration of environmental sensors and real-time data analysis into a device that is rugged and field ready. Through structured research, evaluation of multiple system configurations and hardware options, and comparison of various alternative solutions through success criterion, we determined our final design and product structure and plan.

◆ in scope of work: ◆

- a. overview/srr
- b. alternative solutions
- c. evaluation
- d. decision

Breaking the AvAlert project down into a year-long scope can be challenging with such daunting of a task. Our scope of work is large, but broken down into a timeline overview and a specific criterion box of 10 specific items, it becomes a bit clearer. Our overview can be seen through the stages of development we will work through, including research, 3D modeling, prototyping, hardware, software, testing, and reiteration. Through our SRR (System Requirements Review) table, we specified exactly what we wanted to give the customer and client, with feasible goal setting and realistic items to accomplish.

* More can be seen on our overview w/ Gantt Chart in Section III.

System Requirements Review (SRR)

Through multiple design reviews, carefully curated research, and a laundry list of items we created, we came up with a 10 criteria System Requirements Review that acted as our rubric for AvAlert. In this rubric contains specifications for functionality, hardware constraints, software constraints, and the minimums and maximums of what we had to do to accomplish them.

RUBRIC

1) The AvAlert Device will allow backcountry skiers and riders to make informed decisions on avalanche conditions and will act as an extra layer of risk assessment when traveling in the variable terrain of the backcountry.

2) The AvAlert Device must be compact and portable to allow skiers and riders to stow it away within their backpacks. Max dimensions 4" by 8"

3) The AvAlert Device must be waterproof and sealed to function in the wet environment, that is the backcountry. It must hold up to snow testing and variable storm conditions. The device will be sealed with o-rings and silicon around any openings.

4) The AvAlert Device will be equipped with a screen interface to provide the user with real-time, visible, and approachable data readings. The danger reading will be shown as a colored bar: stable (green), variable (yellow), unstable (red).

5) As a part of a positive user interface, the device will deliver auditory cues along with its measurement to give the user positive feedback. A single beep will sound during a manual reading followed by a secondary sound (one beep = stable, two beeps = variable, three beeps = unstable). While you ski the device will deliver these cues if and when conditions change to allow you to make informed decisions in avalanche terrain.

6) The AvAlert Device must be able to function in temperatures as cold as -40°F to account for extreme and unpredictable backcountry conditions.

7) AvAlert's AI model within the device's Internal computer will use a variety of measurements from its sensors to predict avalanche danger. Temperature, pressure, depth, humidity, and slope will allow the device to predict snowpack.

8) The Sonar Sensor that the device will be equipped with will feed the model a depth measurement. The Sonar needs to be calibrated and put up against measured values to ensure reliability. Snow pits will help us establish its accuracy during initial setup.

9) The Model will be able to make predictions on SWE using temperature, humidity, depth, and baseline data from past Snow research, utilizing data from the Colorado Avalanche Information Center, and measurements taken during real-life testing in various sites (Berthoud Pass, Rabbit Ears Pass, Loveland Pass)

10) Internal slope angle measurement will allow the device to make predictions within the parameters of reason (snow is only dangerously avalanche-prone between 30 and 45 degrees). Slope angle will be weighted highest in the AI models' calculations as slope angle is the most important variable in avalanche risk assessment.

After reviewing these criteria, it became clearer as to exactly what type of work we were going to have to do. Each of these boxes cover key parts of a solution to a truly easy-to-use risk assessment device that is accurate and reflects industry-standard data analysis and risk rating.

Using the SRR, we came up with distinct design stages to set a rough outline.

1) Device Foundationals

Stage 1 included researching & establishing simple plans for our microelectronics, such as finding the best fit for our device. This included microcontrollers, power systems, displays, and sensors. In stage 1, we also aimed to develop initial SolidWorks models of what hardware components we wanted to include to perform what we wanted.

2) Coding + Hardware Integration

Stage 2 outlines a block for boiling down our research into mathematical equations that we could then turn into code that blended the sensors data together. In addition, during this stage, we aimed to integrate a hardware case for our device, including wiring all of our electronics together for full integration. This stage was the biggest because it included the backend math and also transforming it into a coded User Interface (UI) that gave clear risk assessment. In addition, we had to integrate hardware and software together, which would soon come to be a challenge.

3) Testing + Revision

Stage 3 gives space for all types of testing. This includes simulations of harsh conditions in fabricated situations along with real, gritty backcountry skiing and hands-on device testing. Our 4-step process includes sensor testing, risk-rating testing, simulated testing, and on-site testing where we would give not only the software corrections, but the hardware as well to ensure waterproofing and durability.

4) Implementation + Revision

Stage 4 is the process of taking our findings from testing, and making the actual corrections to AvAlert. This includes sensor reading correction in the code, risk-rating recalibration, and better hardware/waterproofing.

5) Review + Marketing

Stage 5 is polishing details, market analysis for real business large-scale operation, and creating presentations + marketing to promote AvAlert as a viable solution.

ALTERNATIVES

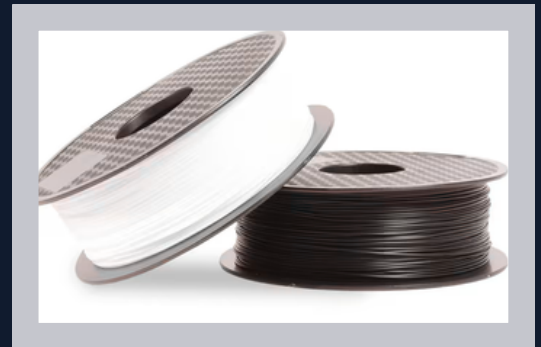
Within our research and requirement definitions, we researched various different ways of accomplishing our SRR in categories like material, electronics, CAD Design, and wiring, using the best from each to ultimately combine each categorical advantage into one device.

MATERIAL

Within our budget and school constraints, we had only a few options of materials to pick from.

3D Printing

PLA: Low-cost, lightweight, but accessible printers are small and PLA is very low strength. In addition, the solids are porous and not very waterproof.



PLA Plastics

Resin: Stronger, solid-body, bigger print plate and reliable printing. However, it costs more and prints take considerably longer time.



Resin Printing (Formlabs)

Molding/Metals

Metal bodies or a plastic mold would have been viable options with a higher budget. In addition, metal would have been too heavy under the size restrictions set in the SRR (see pp. 11, box 2).



Casting

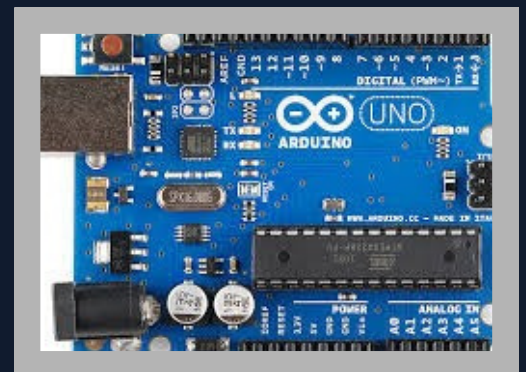
ELECTRONICS

Motherboards

With our small sizing constraints, we needed a small motherboard. However we also needed a motherboard with capability to handle all of our environmental sensors. We compared the Espressif ESP32-S3 DevKit C and the Arduino Uno sets of boards. The Espressif had plenty of pins and capacity to handle all of our sensors, but had a harder interface to code in. The Uno was easier to code, but had less capacity.



ESP32-S3 DevKit C



Arduino UNO

Sensors

There were limited options for depth sensors that could perform the type of acoustic sounding we wanted. We looked at traditional Garmin Fish Finder technology that could perform deep scans, but sizing and cost restraints limited this option. We were able to find a depth sensor from MaxBotix that provides deep scanning while also being well within budget constraints. For angle sensors, compasses, and temp sensors, we looked at a few options. The SparkFun BNO086 Angle sensor was cost-effective and local, as opposed to Bosch alternatives. However, we used a Bosch combined sensor for temperature, pressure, and humidity to knock out a few things in one, and a Bosch magnetometer. We looked at other options, like the Adafruit MCP9808, but it wasn't as cost effective and lacked features.



MaxBotix MB7374



SparkFun BNO086 IMU



Bosch/Adafruit BME280

CAD/HARDWARE

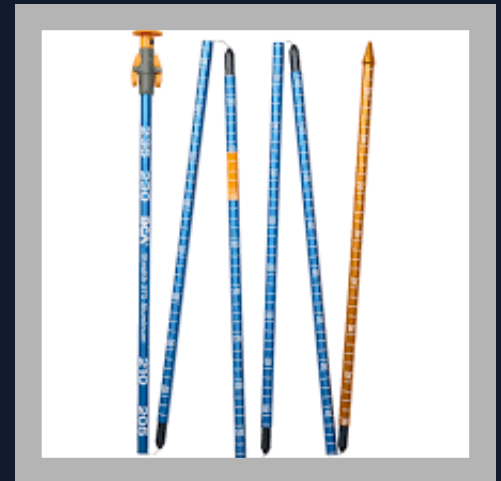
We considered multiple design ideas, including having a smart probe to physically test the snow, a device with no screen that connected to an app, or a handheld like a phone.

Having a probe would allow us to get more accurate SWE data. It directly measures the water content and is a hardware-backed measurement. However, it defeated the purpose of the device being easy to use and really portable. It also violated our sizing constraints in the SRR.

We wanted a friendly, easy to use UI, whether on the device or on an app on a smartphone. However, a physical screen made the data real, and easy to use without worrying about



SolidWorks CAD Software



Smart Avalanche Probe



Probe UI

WIRING

To connect the parts we wanted to use together, we figured that we only had soldering or plug and play wiring options with STEMMA cables or Dupont Wires with male and female connectors.

Soldering would be a viable long term solution, and is the more professional and safe way to ensure the wiring and related harnesses stay intact during the users experience. However, it is time consuming considering the volume of parts that we have.

Dupont cables would allow easy plug and play use, along with STEMMA cables to simply daisy-chain the electronics to the board. However, we would risk the cables slipping and coming undone with no securing methods.



Soldering Microelectronics



STEMMA-QT Cables



Dupont Cables

EVALUATION

When choosing the right parts and ideas to follow to carry out AvAlert, we had to consider many things, including but not limited to: economic, environmental, sustainability, manufacturability, equipment, staffing, resources, budget, and time.

We put the different options head-to-head per category in decision-matrix figures to evaluate which path we should take for the various components of our project.

To view the decision-matrix, please refer to appendix A-1/A-2.

For material, resin scored highest, with its highlights including economics, manufacturability, and SRR compliance for its waterproofing abilities and the printers we have in house. In terms of motherboards, the ESP32-S3 DevKit C came out on top, with the pin availability of the board making it a more viable option over the UNO board. For our depth sensor, MaxBotix's depth sensor proved to be the best option due to its pricepoint being well within budget while also fulfilling SRR depth requirements. The Bosch combined temp sensor won for our other environmental data, due to its cost-effectiveness and ability to condense three stats into one sensor.

For our overall hardware design, we ditched the probe in favor for a case design that has an in-house screen. The probe wasn't feasible for manufacturability and we also didn't have the resources to create a smart probe ourselves. A case design with a screen still fulfilled SRR Requirements while also being manufacturable with the staffing, budget, and time constraints that we had. To connect all of these components, STEMMA wires were the preferred choice for what we could use them on due to their plug and play capability, however all of them scored high on the figure, and therefore we planned on using a combination of soldering, DuPont wires, and STEMMA cables.

To view the decision-matrix, please refer to appendix A-1/A-2.



DECISION

To fully meet our SRR, following our part orders and the evaluation of which components will work the best, we combined our choices into a singular, handheld device that would give accurate risk-assessment for avalanche terrain and snow covered mountains.

We are proud to say that our AvAlert v.3.2 prototype hits ALL 10 major system criteria. For criteria 1 and 2, we successfully created a device that fits within a 4"x8" box, adhering to our compact requirements and the device itself presents analyzed data in a WiFi and Bluetooth-free way that adds as another layer of risk assessment and skier safety. The device provides a smooth user interface that allows the user to make informed decisions about the snow beneath their feet, before they decide to ski it. Hitting criteria 3, the resin printed CASE design is fully watertight and insulated, and all openings are sealed with O-rings and adhesive material. For #4, the device has a clear, go/no-go bar spanning the top of the home screen, making AvAlert's data presentation approachable for all audiences. On criteria #5, we have included a tiny electromagnet speaker that delivers audio cues as outlined in the SRR, as part of a positive user interface.

For criteria #6, we chose and utilized all microelectronics that are rated for super cold temperatures at around -40 degrees Fahrenheit, and insulated the inner workings of AvAlert to add an extra layer of protection allowing it to be skied in and used in the most brutal of winter conditions. On criteria 7 and 8, we included all of the data metrics outlined, and the devices internal AI crafted processing software model uses all of those metrics relevantly. In addition, we have real, high-accurate depth readings coming directly from the sonar sensor that have been calibrated with snowpits, as outlined. Regarding #9 and #10, the code model we implemented directly bases its predictions off of changes in SWE and layer boundaries, using CAIC and other relevant avalanche data as the main driver for how it analyzes the data being fed to the system. In addition, we weighted slope angle as the greatest factor so that AvAlert only makes relevant predictions for snow greater than 30 degrees in slope as listed, due to the lack of avalanches below that threshold.

In summary, our compact device hits all of these criteria, with testing to back up our evaluations. We believe that we created the best product based on our criteria and constraints, and feel that it is accomplishing everything we set out to do: a device that lets skiers be safer.

PERSO NNEL + ORG.



To further refine our project, we set deadlines and met meeting dates with our stakeholders to have certain items done in order to keep on an efficient timeline. We organized this plan through a Gantt Chart and various other dates and deadlines where we had to meet with the shareholders.

We also defined what makes our personnel qualified and what roles we specifically fill in our project. In addition, our personnel structure also helps develop the timeline as we can plan out when our roles need to come into play for more efficient production of AvAlert.

no subsections in personnel/organization

PERSONNEL

To view resumes, please refer to section VI.



SAM IANNONE

Sam is an ambitious engineer and leader with meticulous organizational skills, and a strong communicator who values collaboration and teamwork. His strengths include additive manufacturing, SolidWorks, 3D modeling, and graphic design. Notable achievements include leading roles in a NASA engineering project, public art initiatives, and honors societies.



AUSTIN BALL

Austin is an accomplished SolidWorks Professional and aspiring engineer with a comprehensive mechanical background. His expertise spans multiple industrial fields, and he is a recognized creative contributor within the adaptive manufacturing sector.



CAVIN DOUGHERTY

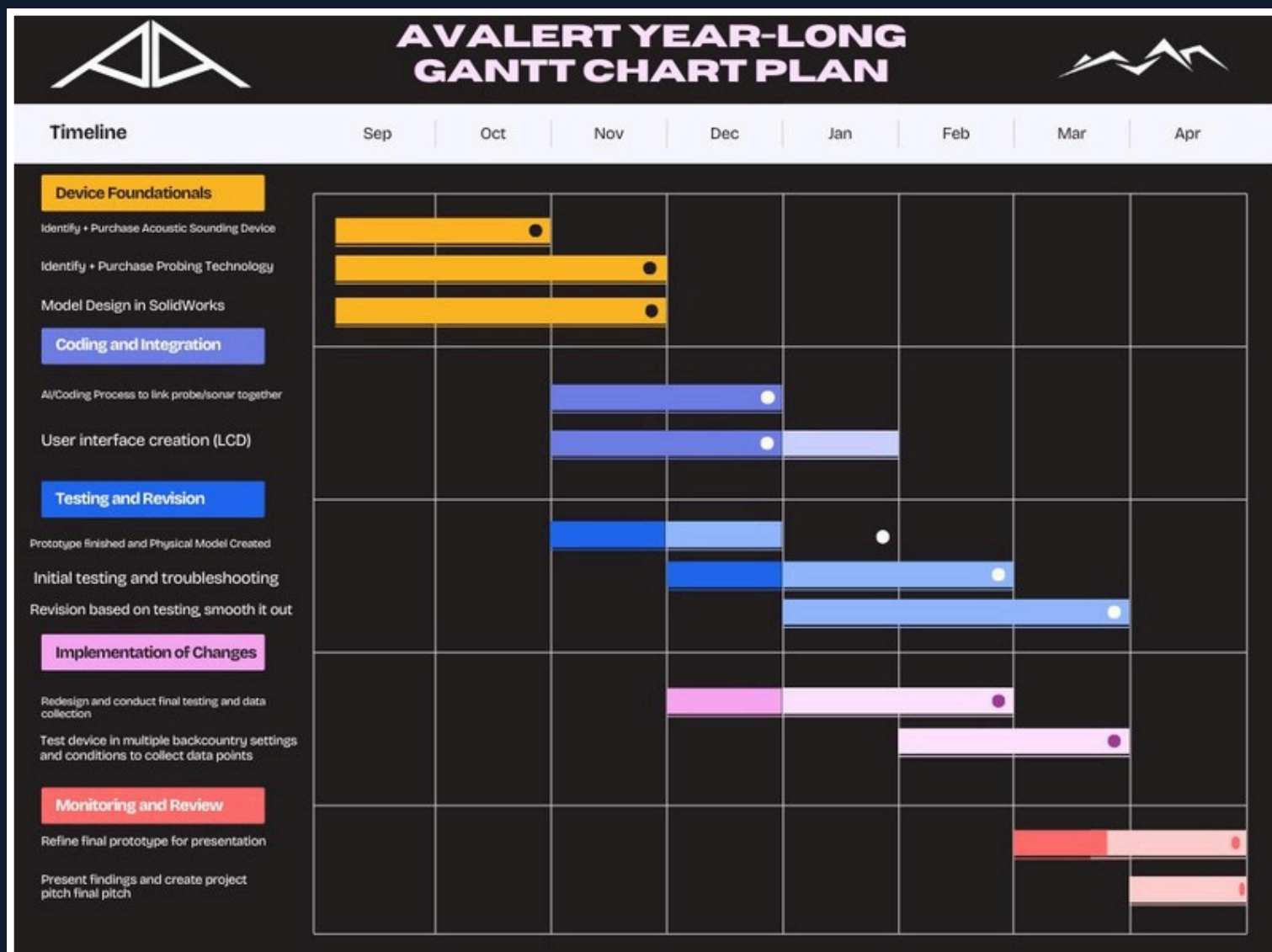
Cavin is an aspiring engineer with a strong interest in the convergence of civil and environmental engineering, driven by a decade-long passion for the mountains, skiing, and the natural world they represent. His technical foundation is robust, evidenced by his certifications as a SolidWorks Associate and SolidWorks Professional.

ORGANIZATION

To manage such a large capacity of tasks throughout the entire year, we had to break it down further into steps where we could meet deadlines. We created a Gantt Chart to keep blocks of time set for certain larger tasks. In addition, meeting with the stakeholders provided a built-in timeline that followed in order to show progress each meeting.

GANTT CHART

To view more in depth, please refer to appendix B-1.



Above is our Gantt Chart year long overview plan from September 2025 to April 2026. By November, we wanted a fulfilled model with all 3D components mapped out and an organizational framework for AvAlert ready to go. We wanted to have a physical model we were proud of done by January, so that we could follow it up with the necessary testing and revision making by March. Then, until the end of the semester would include final touches, marketability, and final testing.

STAKEHOLDER DEADLINES

Along the course of the year, various project meetings and deadline requirements for the STEM capstone itself gave us a rough framework of what items we needed to meet and when we needed to meet them. There were several design reviews, system requirement reviews, and other panel discussions with Darin Spain (3rd party coordinator and stakeholder) and staff of Jeffco STEM departments. Each meeting provided insightful feedback, criticisms, and outside opinions that drove our project forward and ensured that we held accountable to our own requirements while also creating a viable, working product.



DEADLINES ON NEXT PAGE

BACKGROUND RESEARCH PAPER- DUE BY 9/16/25

To view the background research paper, refer to appendix C-1

When initially researching for the Avalert project, we knew it would be paramount to build a baseline understanding of the avalanche climate. We spent the bulk of the time analyzing avalanche research data and understanding why a product such as ours would be a positive addition to the market. In addition, we reviewed what environmental factors trigger avalanches to study those specifically in AvAlert.

INITIAL PROJECT PITCH- 9/16/2025

To view the initial project pitch, refer to appendix C-2

When it came time to pitch the project to our stakeholders for the first time, it was important in the early stages to make sure the problem was clear. Since the solution itself was very early stages, we focused on the "why" behind the concept. We explained the problem that avalanches present in the backcountry, 150 deaths per year, and the dangers that our concept could help solve. We also needed to explain basic avalanche characteristics, such as dry slab vs wet slab, to give the stakeholders a basic understanding of the problems we would need to overcome in product design. Once we, and the stakeholders, had a baseline understanding, we could move on to initial product design.

SYSTEMS REQUIREMENT REVIEW- 10/16/2025

To view the SRR presentation, refer to appendix C-3 or pp. 11-13

The SRR was outlined by a large focus on our success criteria that we had outlined in our initial design. We discussed largely with stakeholder Darin Spain how we could go about updating and refining the criteria we had defined, and how to apply our ideas to the project. We had mostly settled on a rough product design, but needed to focus more on parameters to make sure that, as the design progressed, we understood how we needed to construct it.

PRE-CRITICAL DESIGN REVIEW- 12/18/2025

To view the PRE-CDR, refer to appendix C-4

By the PRE-CDR, we had the first proof-of-concept prototype ready to present. At this point in the project, it was more about outlining future plans as it came to testing. We explained the processes that had gotten us to the point we were at, and the trials and errors that had led to the current design. Once this roadmap had been laid down, we discussed with the stakeholders the next steps. The design was there, and it was solid. We just needed to get out in the field and refine and make changes as we saw necessary with our testing. This meeting made some immediate necessary changes clear and led to us having a very usable product before the next meeting.

CRITICAL DESIGN REVIEW- 02/12/2026

To view the CDR, refer to appendix C-5

When we reached the CDR, we had a product completely ready for testing. Over the last two months, since the PRE-CDR, we had completely changed the case design as we saw fit after discussing the first prototype. After a brief run-through of project history, we outlined the changes to the case and then went on to talk about our plans for testing. This was the most important topic for CDR as was shown during PRE-CDR.

FINAL DESIGN REVIEW- 05/12/2026

By the FDR, we needed to have a final product, project proposal, design portfolios, individual portfolios, and market analysis for real scale production of AvAlert. In addition, we wanted to have every fine detail fully refined, thorough testing, and a real market-ready product. This would be the final venture for the AvAlert in Capstone:STEM before moving outside of the classroom entirely. So, we wanted to make sure what we were presenting as our final run was something that we were truly hoping to be proud of.

DATA + ANALY- SIS, EDP

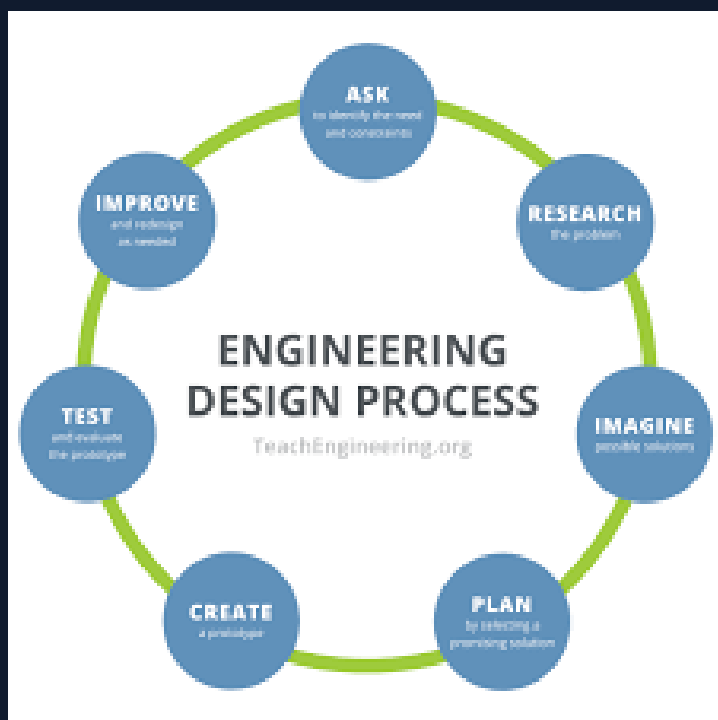
To mathematically prove and refine the metrics that drove AvAlert, various computations and backend iterations changed the way we thought about our snow analysis. In addition, testing gave way for sensor correcting, updated risk ratings, and new mathematical analysis. All of this became a part of our design process, outlined by the Engineering Design Process (EDP) that built the framework for engineering our way to success.

in data+analysis/EDP:

- a. design process
- b. mathematical + scientific
- c. data + srr analysis
- d. results

DESIGN PROCESS OVERVIEW

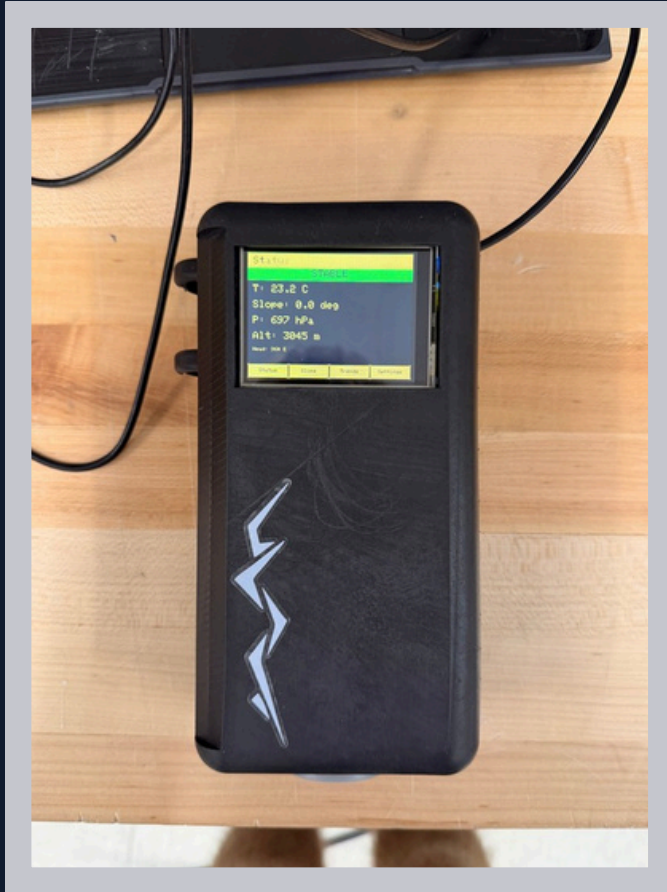
Using our knowledge of the EDP, we used it to create a circular, constantly moving definition on how we wanted to create iterations of our device.



Starting off, since we knew our problem, researched what to do about it, and decided on a series of requirements that we agreed would create a successful product, it was then time to plan out and create the AvAlert. We had chosen on parts and

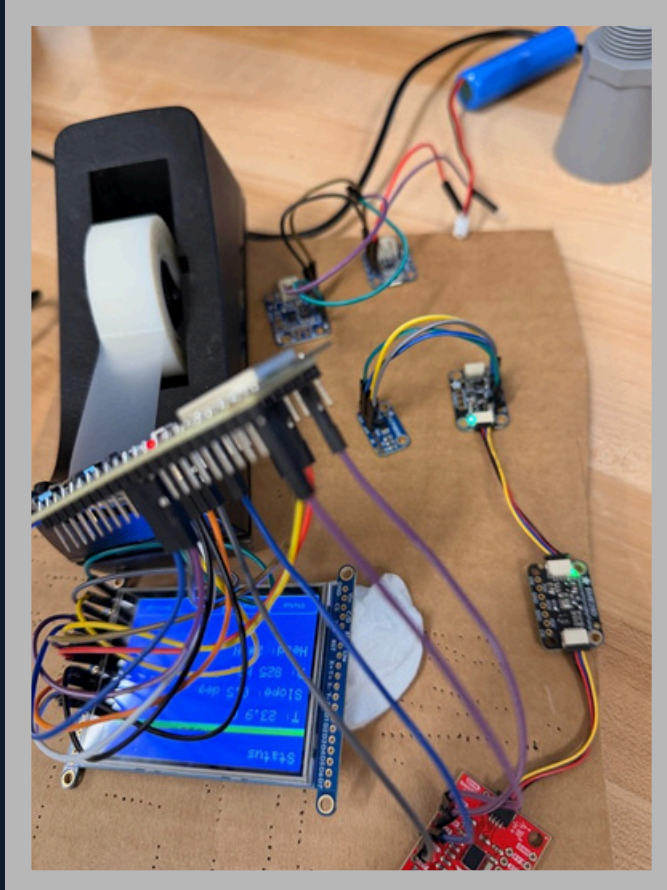
evaluated our different options, and it was time to assemble. We started off with a block case that we carved out a hole for the screen, with no outside features behind the mounting straps on the outside. Visually, it looked like a big box. It was also bifurcated in half, and did not have a way to put it together and lacked any vents for the sensors.

VIEW ON NEXT PAGE



AvAlert v.1.0

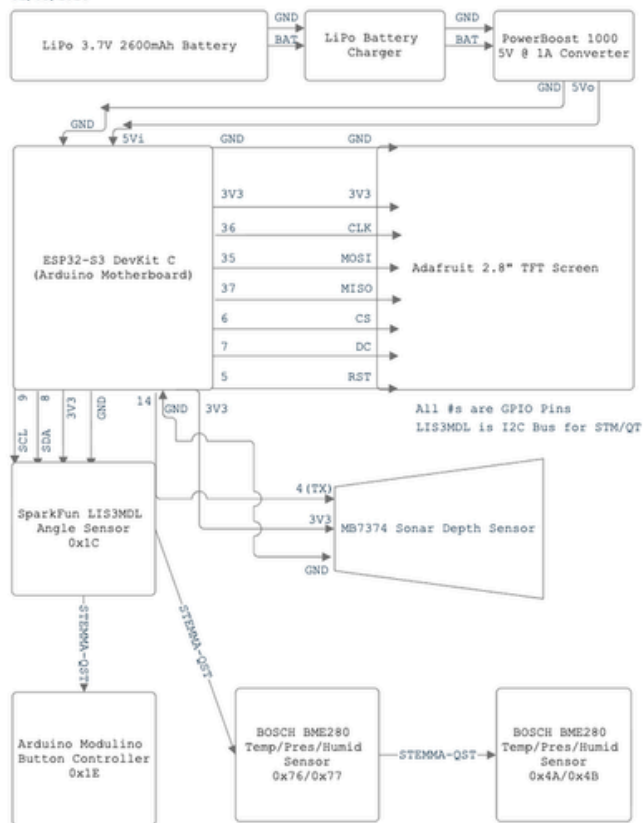
This is how AvAlert v.1.0 was made. We later realized that the screen was not usable without buttons, we needed vents to give outside air to the environmental sensors, and a better way to connect the two halves together. So, that's what we did.



AvAlert v.1.0 Wiring Setup

In terms of the sensors and electronic wiring, we routed the BNO086 Angle Sensor to the motherboard, and created our sensor STEMMA-QT chain off of the angle board. This solution came as a result from checks and tries with different combos, and this one proved to work and feed data directly to the code that actually popped up on the screen. The UI was still rough, but displayed the data accurately.

AvAlert Full Wiring Schematic
02/05/2026



Based on trying different combinations of sensor organizations and seeing if the data would work, we came up with a final wiring schematic. Simply trying led our electronics to working. We also updated and troubleshooted our code using Codex, which helped also analyze our data from our research to create our code criterion for our risk rating.

For our power, we wired our battery into a charger and converter combo that powered our board while making the device rechargeable. As we approached a more final, robust design with the electronics, the case began to follow suit. We added mounting pegs for the screen and angle sensor, and added vents with a subhousing that allowed our temp sensor to get air access, and wiring shelves and mounting areas for the depth sensor and battery (view below). Then, as our code advanced better, we made the UI smoother, added buttons to toggle the screen back and forth and on and off, and made the data easy and readable with a clear risk-rating bar that made for a smooth user experience. Overall, these accomplishments reflect our SRR perfectly, and the trial and error drove our design process forward.



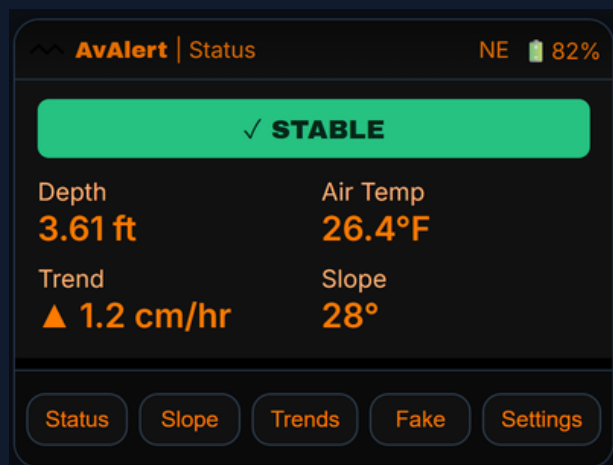
AvAlert v.3.2 CASE Front Side
(Critical Avalanche Sensor
Enclosure)



AvAlert Sensor Housing v.2.1



AvAlert v.3.2 Fully Assembled



AvAlert UI Simulation

AvAlert v.3.2 CASE (Critical
Avalanche Sensor Enclosure)



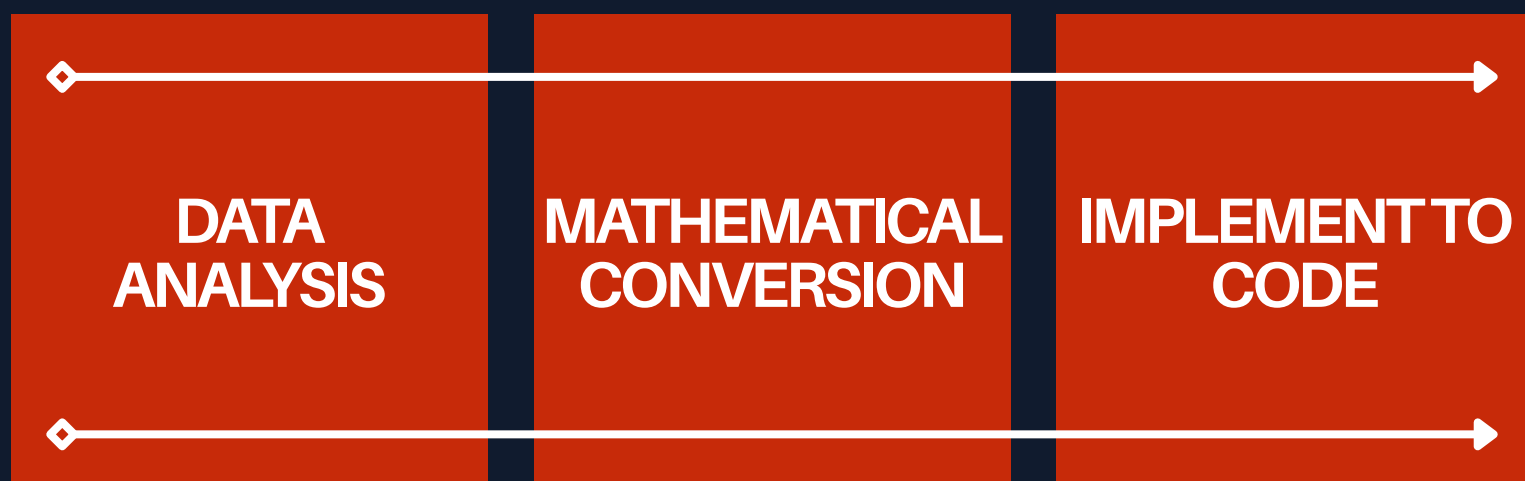
For the rest of the design process documents, please refer to the D appendix.



MATHEMATICAL AND SCIENTIFIC

To view all calculations, please refer to the G appendixes.

Between math that started during our research phase or drove our code into final production, calculations and scientific analysis have driven our entire project. Our three step process of data analysis into math conversion into code implementation allowed for us to clearly develop math that was accurate AND working.

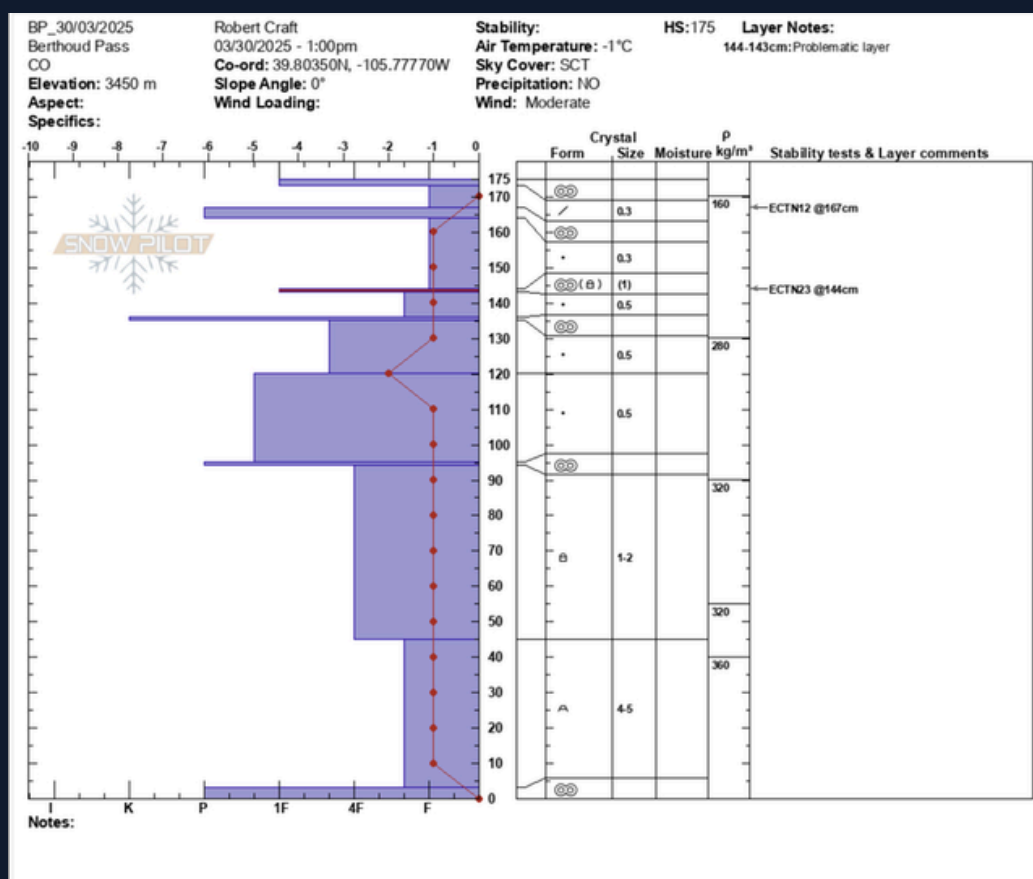


In data analysis, we took CAIC, Open Snow, and other online avalanche data platforms and analyzed it using a ChatGPT model. Through this AI model, we fed it thousands upon thousands of metrics to analyze which factors we needed to understand that proved to be the most impactful in avalanches. Then, using this, we created a risk-rating function with categorical weighting between each environmental data point to combine all of our metrics into one value that could predict relative avalanche likelihood. We then implemented this using Codex, to turn math into software.

DATA ANALYSIS

Like stated earlier, we used various avalanche platforms to gather data and feed to our AI model to analyze. In our research analysis, which can be found in Section 1b on pp. 8, we have learned the key data markers for safe and unsafe snow, consisting of: snow density, snow water equivalent (SWE), grain size, layer-by-layer topography, and slope angle.

We identified that the most important markers to achieve an analysis of these ticket items are slope angle, depth, and temperature trends. In addition, logging the placement of these trends gives us a map for each of these metrics listed above to better predict avalanche likelihood. Below is what these snow sample graphs look like, that allowed us to feed the items into the AI to analyze:



To view the full list of data entries and data sets entered into the AI analysis model, please refer to the E appendixes.

Left:
Source- Robert Craft,
snowpilot.com

MATHEMATICAL CONVERSION

We created a four-step process to our mathematical analysis of snowpack data as follows:

Refreshes Data
Every 1s

Creates Rate
Function From
Data

Interpolates
Rates into Risk
Scores

Combines Risk
Scores into
Composite
Function

Knowing what was important now, we defined our environmental metrics as follows under Step 1:

$D(t) = \text{Snow Depth [cm]}$

$T(t) = \text{Air Temperature [°C]}$

$\theta(t) = \text{Slope Angle [°]}$

$S(t) = \text{Storm Override, if on [cm/hr]}$

Refreshes Data
Every 1s

All of these are functions of time, and refresh at a rate of 1 Hz, or every second. This provides constant data feeding to the model that allows it to make the most accurate predictions.

All of these encase the processes that happen during step 1, or our data collection step. These variables allow us to plug data into other functions.

$$\int \frac{dD}{dt} = D(t) \quad \int \frac{d\theta}{dt} = \theta(t)$$

$$\int \frac{dT}{dt} = T(t)$$

The rate of change functions for each variable are defined as the derivative of the input functions. The input functions are defined as the antiderivative of the rate of change functions, through the fundamental theorem of calculus.

STEP TWO

Creates Rate
Function From Data

We plugged our data points into constantly updating derivatives, letting us see trends in our data that evolve as the skier moves down the hill and become more representative of what is happening as data is added.

Snow Loading Rate:

$$\frac{dD}{dt} = \frac{D(t_2) - D(t_1)}{(t_2 - t_1)}$$

This rate gave us depth trends while the skier was moving down the mountain.

Temperature Trend:

$$\frac{dT}{dt} = \frac{T(t_2) - T(t_1)}{(t_2 - t_1)}$$

This allowed us to see how the temperature was changing during skiing.

Averaging Correction:

$$D(t) = \frac{1}{n} \sum_{i=1}^n D(t_i)$$

This removed any extraneous values from the depth sensor, erasing data from when a skier fell, jolted, or made any sudden movement.

Storm Override Depth:

$$D_s(t) = \frac{dD}{dT} + 0.8(S(t))$$

This fixed depth readings when a snow storm was happening, and would be enabled when the user turned it on.



Interpolates Rates
into Risk Scores

STEP THREE

We then mathematically defined what trend values define each individual data metric as stable, variable, or unstable.

θ : Individual Risk Ratings for Data Functions:

$$\theta(t) < 30^\circ; R(\theta(t)) \text{ SAFE}$$

$$\theta(t) > 40^\circ; R(\theta(t)) = \frac{\theta(t)^2}{2} + 1$$

Snow slopes are only really dangerous above 30 degrees.

D :

$$\frac{dD}{dt} < 1.0 \left[\frac{cm}{hr} \right] \text{ Low Loading}$$

$$1.0 \leq \frac{dD}{dt} \leq 2.5 \left[\frac{cm}{hr} \right] \text{ Medium}$$

$$\frac{dD}{dt} > 2.5 \left[\frac{cm}{hr} \right] \text{ High Risk Loading}$$

Large changes in depth trend indicate shelves that pose high avalanche danger.

T :

$$\frac{dT}{dt} < 0.3 \left[\frac{^\circ C}{hr} \right] \text{ Stable Temperature}$$

$$0.3 \leq \frac{dT}{dt} \leq 0.8 \left[\frac{^\circ C}{hr} \right] \text{ Medium}$$

$$\frac{dT}{dt} > 0.8 \left[\frac{^\circ C}{hr} \right] \text{ Destabilized Temp.}$$

Rapid warming or cooling poses another layer of risk to avalanche danger.

Then, we converted these risk scales into functions that we could plug into the composite function in step 4.

$$f(\theta(t)) \begin{cases} 0; \theta < 30 \\ \frac{\theta - 30}{10}; 30 \leq \theta \leq 40 \\ 1; \theta > 40 \end{cases} \quad [deg]$$

$$f\left(\frac{dD}{dt}\right) \begin{cases} 0; \frac{dD}{dt} < 1.0 \\ \frac{(\frac{dD}{dt} - 1.0)}{1.5}; 1.0 \leq \frac{dD}{dt} \leq 2.5 \\ 1; \frac{dD}{dt} > 2.5 \end{cases} \quad \left[\frac{cm}{hr}\right]$$

$$f\left(\frac{dT}{dt}\right) \begin{cases} 0; \frac{dT}{dt} < 0.3 \\ \frac{(\frac{dT}{dt} - 1.0)}{1.5}; 0.3 \leq \frac{dT}{dt} \leq 0.8 \\ 1; \frac{dT}{dt} > 0.8 \end{cases} \quad \left[\frac{^{\circ}C}{hr}\right]$$



STEP FOUR

Combines Risk
Scores into
Composite Function

To synthesize all of our individual risk weightings for each trend function, we then had to make a composite risk score that combined these functions into a master risk rating that either spit out **stable**, **variable**, or **unstable**.

Composite Risk Function:

$$R(t) = (0.50 f(\theta(t))) + \left(0.3 f\left(\frac{dD}{dt}\right)\right) + \left(0.2 f\left(\frac{dT}{dt}\right)\right)$$

if,

$$R(t) : \begin{cases} R(t) < 0.35 & \text{--Display } \mathbf{stable} \\ 0.35 \leq R(t) \leq 0.75 & \text{--Display } \mathbf{variable} \\ R(t) > 0.75 & \text{--Display } \mathbf{unstable} \end{cases}$$

for all values possible on: $0 \leq R(t) \leq 1$

◆ This composite risk function allows us to compile large volumes of data and their respective trends and boil it down to a risk score. We have angle weighted highest, due to its influence on conditions, followed by depth at second, and temperature at third. ◆

There are also some exceptions to our rules:

EXCEPTIONS

The following all force AvAlert to read unstable:

$$\theta > 40^{\circ}$$

Slopes over 40 degrees pose serious avalanche risk, no matter the other conditions. Friction becomes too low and poses great risk.

$$\frac{dD}{dt} > 2.5 \left[\frac{cm}{hr} \right]$$

Rapid changes in depth indicate high loading that poses dangerous avalanche conditions, that need to be read as unstable.

$$\frac{dT}{dt} > 0.8 \left[\frac{^{\circ}C}{hr} \right]$$

Rapid changes in temperature like these force unstable due to the urgency of freezing or melting that alters snowpack conditions rapidly and in an unstable direction.

$$S(t) > 2.5 \left[\frac{cm}{hr} \right]$$

Storm rating with high loading makes backcountry conditions uncertain, and must force unstable.

This series of equations was AvAlert ready and we could move on to the next step. We took these functions and began implementing them into our code.

CODE IMPLEMENTATION

Using ChatGPT's Codex software, we were able to transform our functions into implementable code.

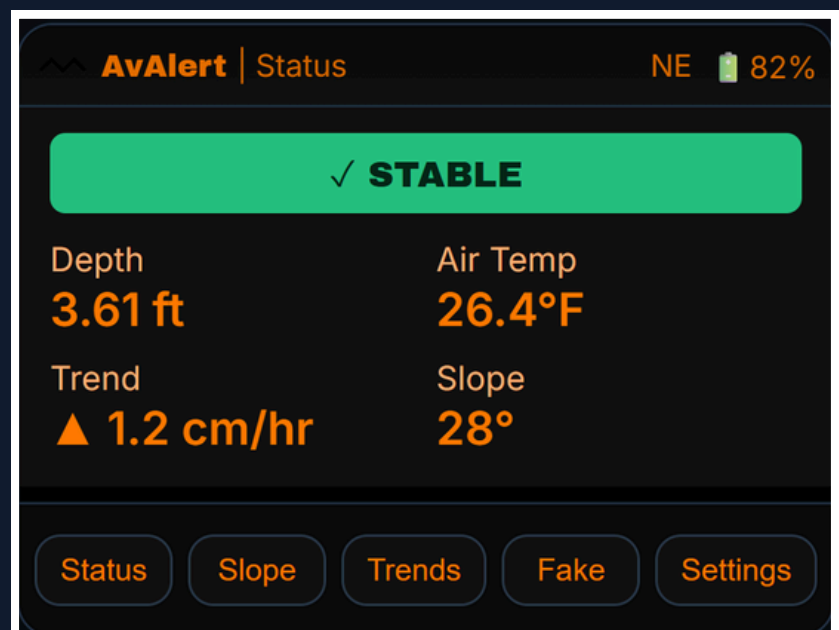
We plugged the math listed above into Codex, and it allowed us to incorporate this algorithm as the driver behind our UI display.



All of this allowed the user to view readable risk ratings in real time that reflected the research, calibration, and mathematical refining thanks to the help of our AI code model.

Behind the scenes, all of this was happening, but the user experience is smoother and does not reveal the inner workings, allowing for simplicity and usability.

Maximizing functionality and ease-of-use, this combination smoothly blends real research with easy experience.



AvAlert UI Simulation

MATH IN TESTING

Our math did not stop at the development stage. Throughout our testing and data analysis, multiple implementations of scientific testing methods influenced how we edited and reiterated AvAlert.

For our sensors, including angle, altitude, temperature, and depth, we field tested and simulation tested their values against real values from independent sensors. We recorded the difference in value, as delta, and summed and averaged all of the recorded values to find how far off AvAlert was reading data from trusted ratings. We then used these numbers to correct the values it outputted in the code by offsetting the values it displays by the average delta value. The math is as follows:

To refer to our testing documents, please refer to the F appendices.

$$\Delta v = |v_{real} - v_{measured}|$$

$$\sum \Delta v = S$$

$$\frac{S}{n_{values}} = Avg\Delta$$

The math is simple, but allows for AvAlert's values to be closer to accepted and true measurements.

DATA + SRR ANALYSIS

Our testing methods went through sensor accuracy, prediction accuracy, simulated testing, and on site testing. So, we analyzed the data that we gathered and used this for corrections and then to compare against SRR and analyze.

To refer to our testing documents, please refer to the F appendices.

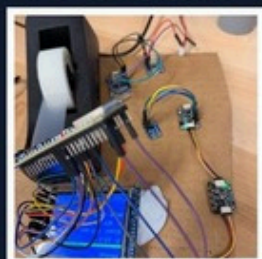
The first phase of our testing included comparing the sensor readings coming from AvAlert and putting them up against measured values. From this, we could account for the difference by code correcting it to make sure the numbers AvAlert was analyzing were as close to real values as possible.



TESTING PLAN



SENSOR ACCURACY



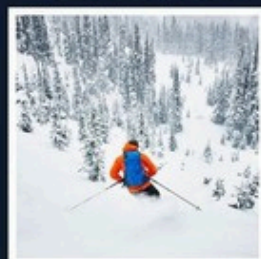
comparing AvAlert's numbers to measured data with external sensors; compare + recalibrate

PREDICTION ACCURACY



based on the numbers, is the risk rating working and outputting what the expected danger level is?

SIMULATED TESTING



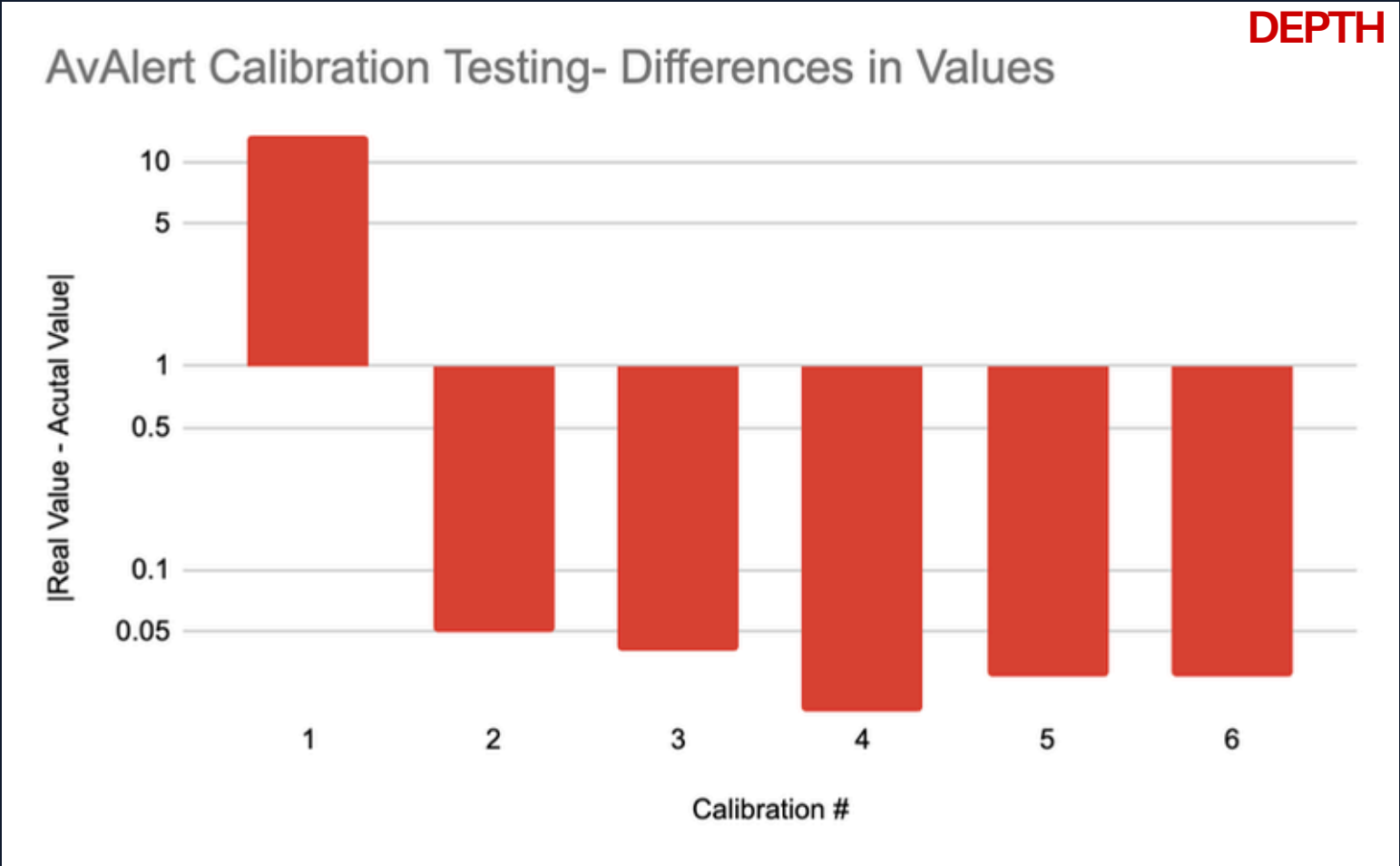
simulate dangerous conditions and compare with AvAlert's risk rating to gauge accuracy

ON-SITE TESTING



take it out into real backcountry terrain and assess usability, battery life, prediction accuracy, & expected results

First, we tested depth by digging real snowpits to compare the depth that AvAlert is reading with the actual pit depth. We performed on-site calibration in order to get reliable values for depth readings, testing at a baseline of 3ft. Within 6 recalibration attempts, we got it so close that our sonar reading was only 0.02 ft away, or 0.6% different than actualized values.



To refer to our testing documents, please refer to the F appendices.

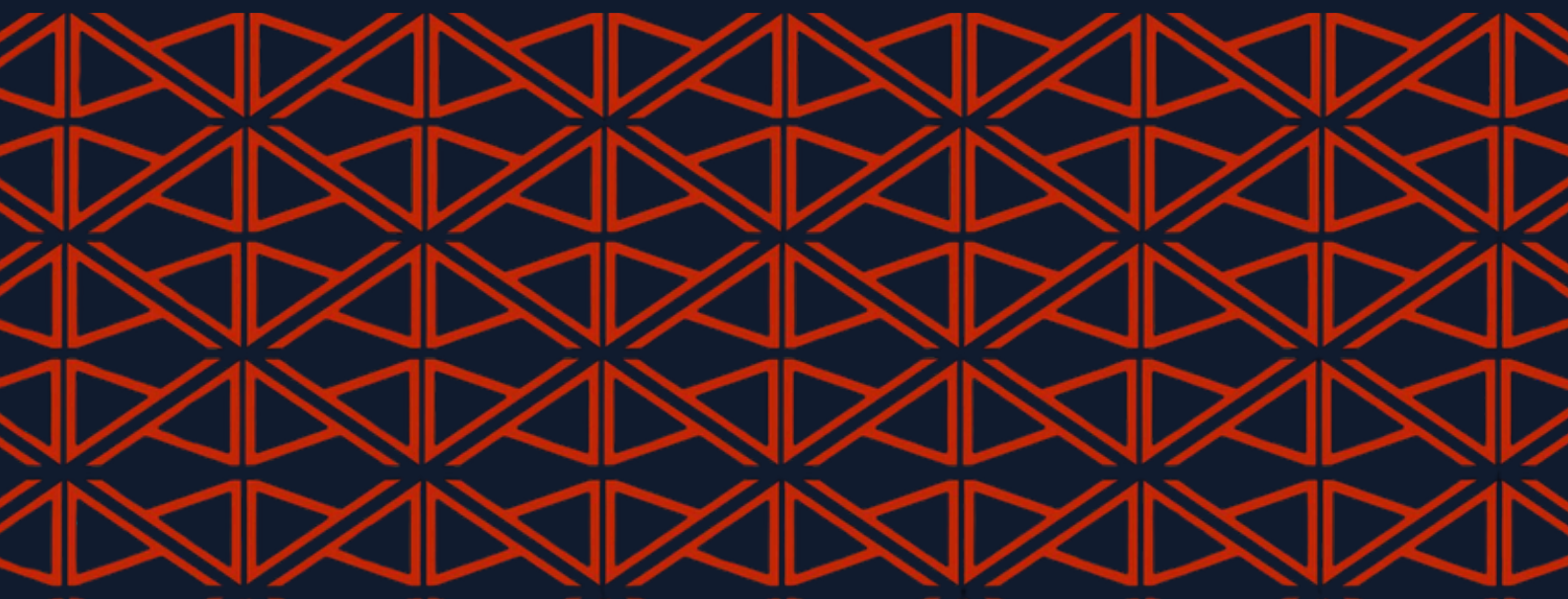
We also found similar success with the accuracy of the other sensors. Temperature was off at most by 0.1 degrees, with an average difference of less than 0.25%. Angle was off by at most 1 degree, which was later code corrected down close to zero. In addition, altitude was off by around 40 feet, which at an altitude around 10-11,000 feet is only around 0.36% off.

In addition, the code was predicting accordingly to the mathematical analysis and equation parameters we created.

On top of quantitative measures, we also saw lots of promising trends in the field. From our expertise, when skiing on more powdery fields with less risk and low slab probability, AvAlert predicted stable accordingly. In addition, when we trekked with AvAlert on steeper and more dangerous slopes, AvAlert also responded accordingly.

We were also able to utilize AvAlert when it was stored inside of a backpack, as the sonar capabilities passed through the fabric in the backpack. Usability seemed highly viable for a skier and rider market, and the data was easily usable in the field.

Overall, we are super happy with how AvAlert performed in the field, and it seems to uphold and adhere to our standards and industry conditions.



RESULTS

Overall, we are highly satisfied with how AvAlert holds up under real testing conditions. Although sources of error we could have encountered includes CASE insulation modifying data and utilizing a prototype for testing, that is missing actual materials that we would use, we believe our code corrections that we have made to account for these gaps in our development account for this.

We believe that this solution is much better than anything on the market because it is preventative, and aims to act as risk assessment before the avalanche itself happens. In addition, the combination of data that it analyzes is extremely powerful, whether or not it is in AvAlert or not. Snow experts, ski patrol, and climate scientists alike can make great use of this data, and these metrics have great implications for safety and climate tracking. This device brings harder to gather data and compacts it into a handheld module, that proves to be a wonderful solution to skier safety and avalanche issues. Furthermore, we are proud to have carried AvAlert out to this stage of testing, and if we had another year, would dive deeper into materials engineering for an easier to make case and refine our testing and code values even further.

BUDGET ANALYSIS

Through our engineering design process, we budgeted under our \$500 Capstone:STEM class limit when building AvAlert, so much so that we were able to create two identical prototypes. Furthermore, we budgeted not only in the class, but we performed real market analysis as well to determine the macroeconomics of AvAlert and real pricing if the product were to go to market with actual margins and cost analysis.

Overall, we will walk you through the class budget and how we stayed under, and run through cost-analysis if we were producing on a mass scale, with updated part prices, etc.

no subsections in budget analysis

ACTUAL BUDGET

Given to us as a part of the Capstone:STEM class, we had \$500 to execute our plan for AvAlert, including all parts and materials that we planned on using. This was a challenge to try and invent a never-seen-before device with this amount of money, especially with the cost of microelectronics and materials needed to test and try different things.

Above all, however, this budget was for the class, and did not include labor or time costs. In addition, tax exemptions were granted due to the educational nature of this project.

Asides from just the goal of staying under \$500 of production costs for prototyping, we had to keep in mind that AvAlert was aimed to be user-friendly and provide a solution to the backcountry skier market. Therefore, maintaining a pricepoint that is cost-effective while also matching the current market prices of other avalanche devices was important to creating a realistic and marketable product.

On the next page, you can view our landed cost for AvAlert, which ended up costing us just shy of \$300. However, most of the project parts were reusable, such as wires and heat shrink, allowing us to create two identical AvAlert prototypes in budget.

LANDED COSTS

Product	Price
Micro lipo batt charger	\$6.95
MaxBotix Sonar Sensor	\$124.65
Lithium Ion power source	\$11.99
2.8" Screen	\$29.95
Compass	\$9.95
Temp Sensor	\$4.95
Pressure Sensor	\$14.95
Motherboard	\$15.00
Bluetooth connector	\$12.50
Angle Sensor	\$34.95
10x WIRES	\$9.50
Male Wire	\$1.95
Screen Protector	\$7.99
Wire	\$0.95
Heat Shrink 2	\$4.95
Female Wire	\$3.95
Male-Female wire	\$3.95
Subtotal:	\$299.08

We also used resin on our FormLabs 3L provided by our school, however factoring in plastics for this project would add around \$10 of realized costs.

MARKET ANALYSIS

In the long run, our goal was to actually send AvAlert to market, to make a real difference and put it out into the world. Accordingly, this meant we had to run a market analysis on the economic viability of AvAlert. In addition, scaling AvAlert to real production meant that the costs of materials would change and labor costs would have to be factored in. Additionally, resin printing is not time-effective enough for scaled production, so silicone injection molding would be the viable option for a real, assembly-line style manufacturing process of AvAlert.

Analyzing the current avalanche technology market, we were working in a product price range of around \$300-\$1500. Beacons and airbags are already essential products that are a part of most, if not all riders setups.

In addition, in consulting with real backcountry riders, we were reassured that AvAlert fills a new niche of avalanche safety necessity not offered by anything else on the market. This gave us a window that allowed us to initially price it enough to encase labor and material costs while also strategically placing it in the price range of other technology.

To view the consultations, please view the F appendixes.

**\$679.99**

unlike forecasts or apps, AvAlert:

- collects on-site data about snowpack
- tracks trend-based stability changes
- translates complex data into clear risk indicators

backcountry participation is at an all time high.

AvAlert gives decision support before the slope fails, not after.

total accesible market:
\$1.5-2.0B GLOBAL MARKET

AvAlert fills an untapped, high-trust, premium niche for ski safety

pricing aligns with airbags and premium safety gear, signaling seriousness and credibility



Product	Typical Price
Beacon	\$300-500
Airbag backpack	\$700-1,500
Touring setup (skis, bindings, boots)	\$1,500-3,000
Full backcountry kit	\$3,000-6,000+

Choosing a retail price of \$679.99 posed AvAlert in a strategic medium between necessary avalanche products like the beacons and high-end premium products like airbags. In addition, full backcountry kits already can run upwards of \$6,000, and with something that carries the safety necessity as high as AvAlert does, it is a small price to pay for peace of mind.



The backcountry ski market is saturated with specialty gear and expensive safety measures. AvAlert targets an untapped niche within a 1.5 - 2 billion dollar industry of gear. Avalanche airbag packs are a basic necessity for big-line backcountry skiing and run anywhere from \$500 for a vest-style bag or upwards of \$1500 for a proper backpack-style bag. A full beacon and receiver kit for avalanche rescue, something that all backcountry skiers and riders must wear at all times, costs around \$400 for a mainstream brand. And of course, once you factor in other basic tools such as shovels, probes, and proper clothing, any rider is most likely thousands of dollars deep. With the actual ski setup easily costing upwards of \$2000 dollars before the rest of the gear, a \$679 device that can help prevent skiers from getting caught in avalanche disasters doesn't sound so expensive. Avalanche gear is expensive, and the market understands that, so a price point of \$679 slots right into expected price ranges, and the market will understand its value in the wake of safety.



RESUMES



Sam Iannone, Austin Ball, Cavin Dougherty

Below are our credentials, qualifications, experiences, and individual skills that make each one of us capable to work on this project.

Together, these skills make for an equipped and balanced team that we believe is essential to our success in engineering, product development, organization, and end-to-end perfection.

This section also serves as our follow-up to the personnel bit in Section III where we briefly summarized the qualifications and resumes of each group member.

no subsections in resumes

SAM IANNONE



SAMUEL IANNONE

🎓 Ralston Valley High School | Arvada, Colorado

📞 (720)-635-9131

✉️ samiannone@icloud.com

🌐 samiannone.com

EXPERIENCE + LEADERSHIP

Int'l Finalist, NASA HUNCH Biomedical and Health Science Program, 2025

- Invited to the NASA HUNCH FDR 2025 as **1 of 30** teams internationally recognized by NASA for helping human research to achieve their goals for Moon and Mars missions.
- Worked with astronauts, lead NASA engineers, and flight surgeons to develop an otoscope, retinoscope, and nasoscope built for space based on academic material and astronaut anecdotes
- Recognized for project created through Iannone-Myers self-founded company for our intuitive and distinctive biomedical device
- Traveled to the Johnson Space Center in Houston TX to present and showcase our design to hundreds of NASA employees and astronauts in front of the Saturn V rocket
- Recognized by FOX31 News / KDVR, Yahoo, World News, Ground News, and Jeffco Public Schools for outstanding accomplishments and contributions to NASA health sciences

NASA-Selected Global Delegate, NASA Human Research Program Workshop, 2025

- Invited to a widely-regarded and highly recognized industry conference in Galveston, TX as **1 of 20** teams internationally for outstanding design achievements and biomedical research projects
- Utilized professional academic research and anecdotes from astronauts, engineers, and project managers across NASA to develop a biomedical device for the International Space Station
- Created a device that allows flight surgeons and astronauts to examine the eyes, ears, and nose of crew to investigate the effects of zero gravity on the fluids in the human body and conduct further studies and research projects aboard the International Space Station
- Recognized by CBS News for accomplishments and work at the NASA Human Research Program Workshop and as a part of a distinctive group of Colorado scholars and student-engineers

Co-Founder, Iannone-Myers, 2024-Present

- Created and ran NASA-contracted engineering business to create biomedical devices for NASA and space-flight, medical, and military applications
- Engineered and invented a otoscope, retinoscope, and nasoscope device intended for the International Space Station and ambulance and military applications
- Led website development, marketing and design, and biomedical engineering platform for our projects in order to successfully develop a biomedical device pitched to and used by NASA flight surgeons, pediatricians and industry professionals
- Created various media (animated videos, photos, 3D renderings) for our device and presentation

Owner / Founder, Sleeper Ski Media, 2024–Present

- Created ski media and clothing company from the ground up, setting up an online store and platform to share videos and sell clothes
- Grew online presence and created several short films and movies across my website and social media accounts as a passion project
- Manufactured and sold items of clothing including hats, T-shirts, jackets, sweaters, and hoodies
- Gained high amounts of experience in marketing, sales, and website development helping contribute to a distinct personal skill set

Owner / Founder, Art by Sam Iannone, 2022–2024

- Successfully set up online store with POS system and portfolio to display artworks and connect with customers with integrated checkout
- Received a showcase at the Jefferson County School District Annual Art Show in 2022 for artwork titled “Kurotoshira”
- Designed and created over 50+ artworks, including on wood-mediums, canvas, and digital artworks showcased on a self-created online gallery
- Recognized by Jeffco in 2022 for Merit for Outstanding Artistic Achievement for artworks created and sold through website and company

Executive Assistant, The Iannone Group Real Estate, 2024–Present

- Coordinated and hosted open houses, managing logistics, preparing marketing materials, and welcoming prospective buyers to enhance client engagement and property visibility.
- Designed and distributed promotional flyers across targeted neighborhoods and digital platforms, contributing to an enhanced range of listings across the Denver, Colorado area.
- Provided technical support, troubleshooting and resolving computer and software issues promptly to ensure uninterrupted office operations.
- Streamlined administrative tasks and aided in housing presentation and marketing through an in-depth knowledge of each listing and home for sale

Varsity Athlete, Ralston Valley Varsity Tennis, 2023–Present

- Tennis Varsity Letter Recipient 2–Years in a row (2023, 2024) competing at the state-level
- Undefeated in doubles match play throughout the 2024 season demonstrating consistent training and a high level of determination
- Recognized for outstanding sportsmanship, leadership and representing team values on and off the court throughout entire high school career
- Tennis upperclassmen leader, assisting new players and other teammates throughout the season to foster new development, increased participation and sportsmanship

Athlete, Apex Tennis Club, 2022–Present

- Competed at a high level in regional club play, demonstrating discipline, strategic thinking, and mental toughness under pressure
- Fostered team cohesion, and mentored younger athletes to improve performance and sportsmanship
- Maintained a rigorous training schedule balancing physical conditioning, technical drills, and match play while managing academic and work responsibilities simultaneously
- Collaborated with coaches to analyze match footage and develop personalized improvement plans, resulting in a consistent increase in match wins
- Competed in high-level independent tournament play, placing 2nd at a regional doubles tournament in 2025 in Parker, CO to train during the off-season

Cashier, BBQ on The Bayou, 2024

- Took hundreds of orders over a tenure of 5 months and ran and communicated effectively with the kitchen staff and other employees
- Greeted and assisted an average of 50 customers daily, receiving positive feedback for providing friendly and timely service
- Trained in POS systems and kitchen management and operations, as well as food safety and assembling food items

Project Manager, Wayne Carle Mural Public Arts Project, 2022

- Dedicated over 30 hours of volunteer work to create 2 room-sized murals and led a team of 7 people that contributed and worked on beautiful artistic installments within my Middle School campus
- Selected by my peers to lead digital design and development of the project, including a lead artist role that allowed me to direct and create the mural
- Utilized a variety of artistic techniques digitally and physically to create two large-scale art installations donated to my school

Designer, Ralston Valley Boys Tennis Apparel, 2025

- Designed team logo kit, including over 10 different designs and styles and rendered onto clothing items
- Set up and managed team store operations, design, and development, working with industry professionals to create an online site with POS reaching hundreds of students, athletes, and community members/parents
- Redesigned logo working with ShirtWorks company to develop products, and school administration to create new designs and styles

Volunteer, 2022-Present

- Ralston Valley Honors Society & Athletics – Volunteer at sporting events, providing event aid and concessions during volleyball events and various other athletic happenings
- Mailed Christmas cards for various seniors, created origami pets for children in the hospital, and contributed over 40+ Hours of community service displaying dedication to my community and to giving back
- Raised over \$800 for victims of the Marshall Fire through gift card and monetary donations as a leader within my Honors Society to help recovering families get back on their feet
- Recognized by InnerView for community service merit and contributions under high standards and a nationally recognized and utilized platform

AWARDS

- Ralston Valley HS Academic Excellence Award Recipient, '23 and '24
- Colorado School of Mines Medal of Achievement, '25
- AP Scholar with Honor Award, '25
- CHSAA Academic All-State First Team Recipient, '23 and '24
- Outstanding Academic Athlete Award, Ralston Valley, '24 and '25
- Academic Varsity Letter Award Winner, '23, '24, '25
- National Honors Society, '24-'25
- Innerview Merit National Community Service Award for 40+ Hours of Community Service and 10 activities, '25
- CollegeBoard School Recognition Award in the National Recognition Program '25

CERTIFICATES

- Solidworks CSW-P Certified (3D Design Professional)
- Solidworks CSW-A Certified (3D Design Associate)
- Solidworks CSW-AM Certified (Additive Manufacturing Associate)
- Jeffco Certificate of Merit for Artistic Achievement 2022

Samuel Iannone

Ralston Valley High School | Arvada, Colorado | samiannone@icloud.com

(720)-635-9131

www.samiannone.com

AUSTIN BALL

Austin Ball

Arvada, CO 80007 | (720) 877-3027

austinball18@icloud.com

WWW: Bold Profile

Dedicated professional with extensive experience as a Snow Plow Operator at SOS Site Services, skilled in heavy equipment operation and conflict resolution. Proven track record in ensuring safe travel through effective snow clearing and vehicle maintenance, while upholding safety standards and fostering team collaboration. Committed to excellence in all tasks.

Skills

- Heavy equipment operation
- GPS navigation
- Snow clearing
- Landscaping maintenance
- Verbal and written communication
- Communication skills
- Written communication
- Adaptability and flexibility
- Equipment inspection
- Conflict resolution techniques
- Vehicle maintenance
- Concrete finishing
- Team collaboration
- Material transportation
- Safety procedures
- Analytical thinking
- Professionalism
- Mechanical aptitude

Work History

Snow Plow Operator

SOS Site Services, Commerce City, CO

November 2024 - Current

- Worked in parking lots and roads to handle needs of businesses and residential customers.
- Upheld safety standards for working in wet, cold and windy conditions.
- Operated snow plow for to support safe travel for local citizens.
- Trained in skid steers, backhoes and ag tractor operation to supplement truck-mounted plow work.

Mechanic

SOS Site Services, Commerce City, CO

May 2023 - Current

- Performed diagnostic and troubleshooting procedures to find and identify root causes of mechanical issues.
- Inspected and tested equipment to locate worn and damaged parts.
- Ordered repair parts quickly to prevent delays in projects and repair work.
- Inspected and tested vehicles and completed preventive maintenance such as engine tune-ups, oil changes, tire rotations, wheel balancing, and filter replacement.
- Disassembled defective parts to make proper repairs.
- Kept equipment in good working order by following operating instructions, troubleshooting breakdowns, and maintaining supplies.

Yard Technician

Arvada Rentals, Arvada, CO

May 2024 - August 2024

- Operated, maintained and repaired ground equipment such as lawn mowers, sweepers, trimmers and snow blowers.
- Completed tasks related to maintenance, upkeep and beautification of grounds by mowing, trimming, pruning, fertilizing and planting.
- Performed snow removal tasks during winter months by shoveling, plowing and sanding.
- Maintained and repaired sidewalks, roadways and parking areas by sweeping and paving.
- Operated equipment while observing standard safety procedures.
- Drove forklifts, pallet jacks and other equipment to move materials.

Education

High School Diploma Expected in May 2026

Ralston Valley Higschool, Arvada, CO

- Completed AP course in U.S history
- 4.1 GPA
- Certifications: Certified solid works associate in additive manufacturing. Certified solid works associates. Certified solid works professional.

CAVIN DOUGHERTY

Cavin Dougherty

Arvada, CO 80005

720-537-1375

sil4films@gmail.com

WWW: Bold Profile

Equipped with strong problem-solving abilities, willingness to learn, and excellent communication skills. Poised to contribute to team success and achieve positive results. Ready to tackle new challenges and advance organizational objectives with dedication and enthusiasm.

Accomplishments

- Ralston Valley High School Senior Team Captain
- Four Year Varsity Letterman

Skills

- Mechanical aptitude
- Teamwork and collaboration
- Reliability
- Responsibility
- Hand tools proficiency
- Detail orientation
- Professionalism

Work History

Shop Technician

Colorado Cycle Dynamics, Arvada, CO

May 2024 - Current

- Help team meet customer service deadlines by working quickly and minimizing errors.
- Work in customer service to maintain positive shop reputation
- Work with customer product and bikes in a neat, orderly, and timely fashion
- Work hands on as a mechanic with all parts of the bicycle
- Double as a sales associate to tailor to customer needs and move product

Courtesy Clerk

King Soopers City Market, Arvada, CO

December 2023 - June 2024

- Helped customers take merchandise out of store and loaded items into vehicles.
- Bagged customer items efficiently using proper techniques to protect delicate items and separate different groups of merchandise.
- Addressed customer complaints in a friendly and helpful manner to restore satisfaction and loyalty.
- Maintained clean and tidy checkout area to optimize service delivery.

Education

University of Colorado Denver at Aurora, CO

Bachelor of Science in Civil Engineering Expected in May 2030

Ralston Valley Senior High School at Arvada, CO

High School Diploma Expected in May 2026

Certifications

- Certified Solidworks Associate - Additive Manufacturing (CSWA-AM)
- Certified Solidworks Associate (CSWA)
- Certified Solidworks Professional (CSWP)

Languages

English

Spanish

WORKS CITED



All of the in text citations, data sources, research citations, and other references made throughout the content of our proposal can be found in this section.

Research paper citations found in Section I are cited using IEEE format, with sources labeled [1]-[8].

Any other source not explicitly referenced or created by ourselves can be found in the appendices, or Section VIII. This includes CAD Drawings, project evolutionary documents, data documents, and other references made too large to include in the body of the proposal.

no subsections in works cited

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Some visuals, graphs, and other omitted sources in works cited are visible in Section VIII, the appendices, where they can be found.

In addition, lots of knowledge has also stemmed from our extensive knowledge of the backcountry, personal experience in the backcountry, and several anecdotal pieces of information and conversations that have been contracted between us and outside sources.



APPENDICES



Any other source not explicitly referenced or created by ourselves can be found in the appendices. This includes CAD Drawings, project evolutionary documents, data documents, and other references made too large to include in the body of the proposal.

Appendices are labeled in letter then number organizational format, and references can be found embedded in the pages throughout this proposal.

All SolidWorks Drawings are .SLDDRW files, SolidWorks VisualEyes renderings have also been included.

no subsections in appendices

A-1

AvAlert Decision Matrix Figure	Category/Product	Economic	Environmental	Sustainability	Manufacturability	Equipment	Staffing	Resources	Budget	Time	SRR EVAL	COMPOSITE / 100	STATUS
Material	PLA	10	4	5	10	10	10	10	10	8	0	77	
	Resin	10	3	8	10	10	10	10	10	7	10	88	WINNER
	Metal	6	5	0	6	0	0	0	5	5	8	35	
	Molding	7	3	2	8	0	0	0	6	3	10	39	
	Category/Product	Economic	Environmental	Sustainability	Manufacturability	Equipment	Staffing	Resources	Budget	Time	SRR EVAL	COMPOSITE / 100	
Motherboards	ESP32-S3 DevKit C	7	8	9	10	10	9	7	9	10	10	89	WINNER
	Arduino UNO	8	8	7	8	9	9	7	10	9	2	77	
	Category/Product	Economic	Environmental	Sustainability	Manufacturability	Equipment	Staffing	Resources	Budget	Time	SRR EVAL	COMPOSITE / 100	
Sensors	Fish Finder	2	7	7	3	6	1	2	2	8	9	47	
	MaxBotix	9	9	8	10	8	3	8	10	7	8	80	WINNER
	Bosch Temp (Comb.)	10	10	9	9	9	8	8	10	9	10	92	WINNER
	Arduino Temp	10	6	7	9	9	8	8	8	7	2	74	
	Category/Product	Economic	Environmental	Sustainability	Manufacturability	Equipment	Staffing	Resources	Budget	Time	SRR EVAL	COMPOSITE / 100	
CAD/Hardware	Probe	5	5	5	2	3	4	3	2	5	5	39	
	No-Screen CASE	9	5	5	10	10	6	6	8	5	0	64	
	CASE w/ Screen	7	5	5	10	10	8	5	6	5	10	71	WINNER
	Category/Product	Economic	Environmental	Sustainability	Manufacturability	Equipment	Staffing	Resources	Budget	Time	SRR EVAL	COMPOSITE / 100	
Wiring	Soldering	7	3	2	10	10	10	10	10	4	9	75	USED
	DuPont	8	10	10	9	8	8	9	8	8	9	87	USED
	STEMMA-QT	10	10	10	9	10	10	9	7	10	6	91	WINNER

A-2

AvAlert Decision Matrix Figure	Category/Product	COMPOSITE / 100	STATUS
Material	PLA	77	
	Resin	88	WINNER
	Metal	35	
	Molding	39	
	Category/Product	COMPOSITE / 100	
Motherboards	ESP32-S3 DevKit C	89	WINNER
	Arduino UNO	77	
	Category/Product	COMPOSITE / 100	
Sensors	Fish Finder	47	
	MaxBotix	80	WINNER
	Bosch Temp (Comb.)	92	WINNER
	Arduino Temp	74	
	Category/Product	COMPOSITE / 100	
CAD/Hardware	Probe	39	
	No-Screen CASE	64	
	CASE w/ Screen	71	WINNER
	Category/Product	COMPOSITE / 100	
Wiring	Soldering	75	USED
	DuPont	87	USED
	STEMMA-QT	91	WINNER

B-1



Device Foundationals

Model Design in SolidWorks

Coding and Integration

User interface creation (LCD)

Testing and Revision

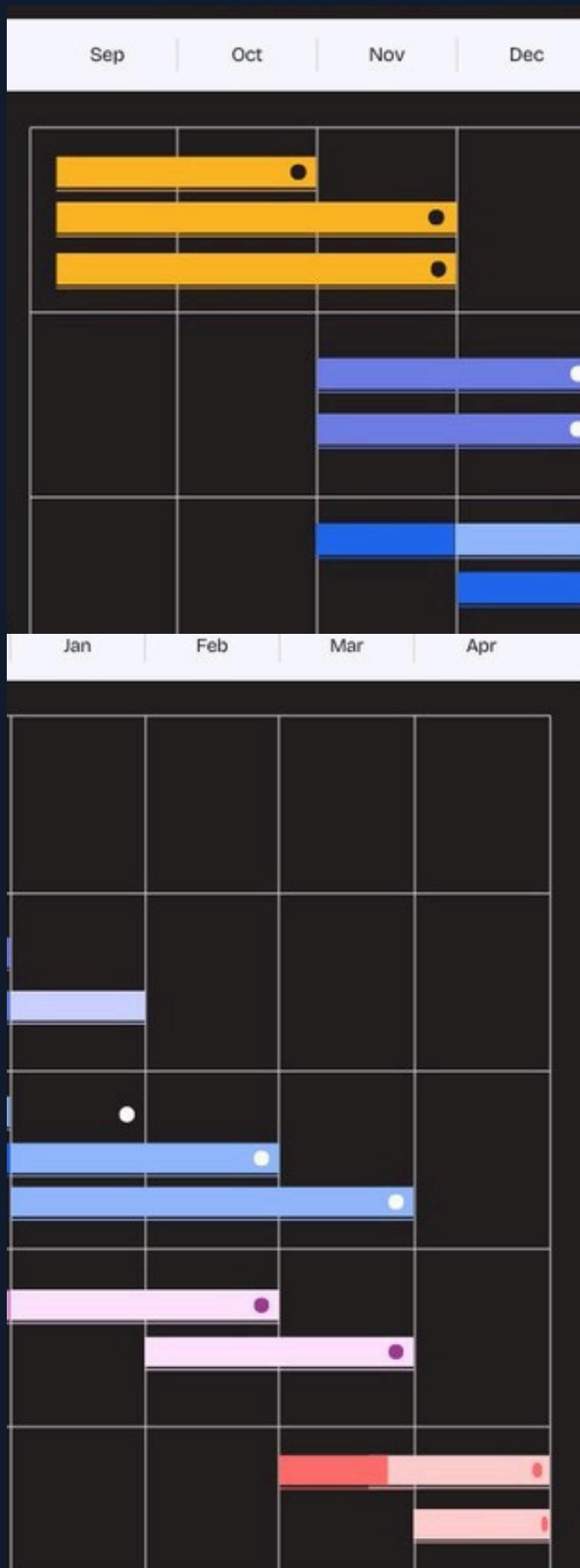
Revision based on testing, smooth it out

Implementation of Changes

Test device in multiple backcountry settings and conditions to collect data points.

Monitoring and Review

Present findings and create project pitch final pitch



C-1

AvAlert Research Paper

Year after year, an estimated six million skiers venture into the backcountry, at the mercy of Mother Nature and her plethora of dangerous mannerisms. According to ShelterBox.org, 150 of these skiers will be caught and killed in an avalanche; a small percentage, yes, but still one hundred and fifty too many [8]. This also does not include injuries or people put in dangerous, life-threatening situations as a result of these disasters. Each of these skiers will face the unknown, that is, avalanche conditions, without a surefire way of knowing the current dangers they may encounter, except for word of mouth. Adding to the fear, 90 percent of all avalanches are triggered by someone in the victim's party, according to the National Weather Service [2]. During a candid interview with an experienced backcountry snowmobiler and snowboarder, JR Brewer, I received several chilling firsthand anecdotes about the dangers of backcountry riding. While conversing, he elaborated on the uncertainties he feels every time he enters the Rocky Mountain wilderness with aspirations of a fun day in the breathtaking backcountry, he risks life and limb to do the things he loves. During our interview, he told me a bone-chilling story taking place on Rabbit Ears Pass outside of Steamboat Springs, Colorado, during the 2022/2023 season; during a ride day with several friends, they were riding on the south side of the pass above tree line when Mother Nature let her wrath loose. He recollects the frightening experience well, stating that while descending a cornice, he felt a shift below his machine, but it was too late. The powerful slide effortlessly swept him and his sled away into the white abyss, with nothing to do other than hope he was along for the ride. Luckily, he was able to regain control of his body and the machine. He conquered Mother Nature head-on and narrowly rode away from the slide. After this day, he says he will never enter the backcountry without his avalanche safety equipment, but he says that just isn't enough after "coming too close to the edge," as he said. He then went on to say that although most riders, including himself, accept the risks of backcountry riding, they do not do so willingly, but for lack of a viable means to detect avalanches before you are battling one. He ended our conversation with great interest and optimism for the future of avalanche safety, with great fascination in the future of our device.

The problem is this: no current device exists to perfectly warn a skier about the conditions of the snow beneath their feet, and whether or not it is at risk for causing an avalanche. Although things like beacons and receivers exist, neither of these devices comes in handy unless you are already caught in the slide. Clearly, a gap exists in the skiing industry for preventative, early-action avalanche warnings and information. A solution to fill this hole would be an integral part of any skier's routine and a necessary measure to keep our backcountry skiers safe. To back this up, we interviewed John Iannone, an avid backcountry skier from Winter Park, Colorado, who has lived in the area for 30 years. Iannone emphasized that "avalanche prevention measures are currently limited to education and awareness of conditions," a gap that is concerning and an unstable foundation at best. Digging a pit to estimate these conditions, he said, is "time consuming, requires significant physical exertion, and is often overlooked" and even "ignored by backcountry recreation

enthusiasts.” Something needs to be done about the inefficiency of the current avalanche prevention and the lack of a solution thereof.

Many different factors must be taken into account when studying and predicting avalanche conditions, but perhaps the most important are layer density and snow water equivalent (SWE). Analyzing density and SWE is very important when investigating what snow is prone to sliding and causing an avalanche, especially when doing layer analysis. Avalanches are a direct result of the build-up of layers in snowpack; a weak layer in the snowpack is always a cause for concern, so one must analyze these layers to understand the dangers. Snow stratigraphy, or layer-by-layer density, SWE, and characteristic analysis techniques provide important data on dangerous layers and harsh conditions. Data like this can be graphed, as shown from SnowPilot, and analyzed for density differences; for example, a node taken on Berthoud Pass, CO, on April 27th, 2025, shows a layer of highly dense snow on top of a less dense layer, possibly indicating dangerous layering patterns [7]. However, these metrics require a large pit to be dug and fancy instruments and equipment to be created, something the average skier cannot and will not do before skiing down.

Climate conditions locally can also be heavily attributed to avalanche conditions and the likelihood of a slide. For example, Simon Fraser University lists conditions including heavy snowfall, snowstorms, and wind direction in the top 3 reasons for avalanche disasters [6]. All three of these things are important, especially when considered directly after they happen. Climate and weather changes directly contribute to and correlate with snow water equivalent, layering, grain size, and overall moisture. When put together, climate data along with direct measurements of these qualities are what make a full and complete avalanche analysis and risk assessment. In Colorado alone, the National Weather Service cites that 6 people die each year in these disasters [1].

SWE is directly correlated to the type of avalanches that will happen. Precipitation can cause heavy snow in new storms, and when placed on top of an extremely weak layer of snow, it can create a super dangerous situation and cause the weak layer to collapse. According to OrtoVox’s Lab Snow Safety Academy, “A new snow layer often poorly bonds with the old snow layer,” and this is the main reason why slab avalanches happen [5]. Consequently, they also cite that 95% of avalanche casualty cases result from the victims triggering their own slab avalanches. That number spikes to 99% when we look at all avalanches caused by recreational skiers, casualty or not. Linking these together, we can identify that the most dangerous avalanche encounters include the factor of wet, new snow drifting over a soft and weak layer. Another important factor to consider when identifying dangerous slopes is slope angles. According to Avalanche Safety,® Identify Terrain, slopes that exist at 30 degrees or more are extremely prone to slab avalanches, and these slope angles exist very commonly in most backcountry areas [4]. Large cornices and backcountry faces have steeper slopes like these, and more common than not, thrill-seeking skiers are looking for the steeper slopes that give them an adrenaline rush.

When it comes to current infrastructure in the avalanche safety world, there are a plethora of solutions, yet “Avalanche hazard prediction remains a crucial task for mountainous regions worldwide,” according to the National Library of Medicine [3]. Stationary weather stations and buried radar devices can provide professionals with the data they need to predict and understand current avalanche conditions. Artificial triggering of avalanches using either remote triggering stations or a physical, specialized high-caliber firearm can be used to mitigate problem areas near railroads and roadways. Field researchers can take snow cores to study snowpack and get an understanding of problem layers. Avalanche Zoning can be used to map high-risk areas, typically

those near developments and populated areas. And of course, plenty of gear exists for the skiers to use as they venture into the backcountry; beacons, transceivers, avy-packs, and plenty of other gear exist as precautionary measures. Plenty of options exist for protecting people and infrastructure from the destructive forces of avalanches. Amongst all of these solutions, not one of them can be used as a real-time detection device. Even with all of these options, skiers still get caught in avalanches, and according to Brian Pollock (FOBP), "40% had taken an L1 class." L1 being the highest level of professional risk management. Avalanches are unpredictable by nature, so predictions and single-point data can only get skiers so far.

Through our extensive research, we have deduced that there is currently no solution for real-time avalanche detection on the market. A product such as the one we plan to design is essential to keeping backcountry skiers alike safe from the unpredictability of Mother Nature. During our initial research, we have learned the key data markers for safe and unsafe snow, consisting of: snow density, snow water equivalent (SWE), grain size, layer-by-layer topography, and slope angle. In addition to these markers, we studied specific climate data and snowpack records from different areas all over the northern continent to determine various types of snow accumulation patterns using records dating back decades.

C-2



▲ SLEEPER // AVALERT

Introducing AvAlert.

Every year, 150 skiers die in avalanches and find themselves trapped with no warning, ending their lives within moments.

Currently, there is no easy, fast, and portable way to know if an avalanche will happen under your feet or not.



▲ SLEEPER // AVALERT



AvAlert is here to help.

AvAlert fills the industry gap of preventative avalanche technology. We aim to combine our years of skiing experience with our engineering, math, and science skills to create something unlike no other.

▲ SLEEPER // AVALERT

Order of Operations

How is this device sending data and using it to provide a safe and predictable experience for the user?



Probe



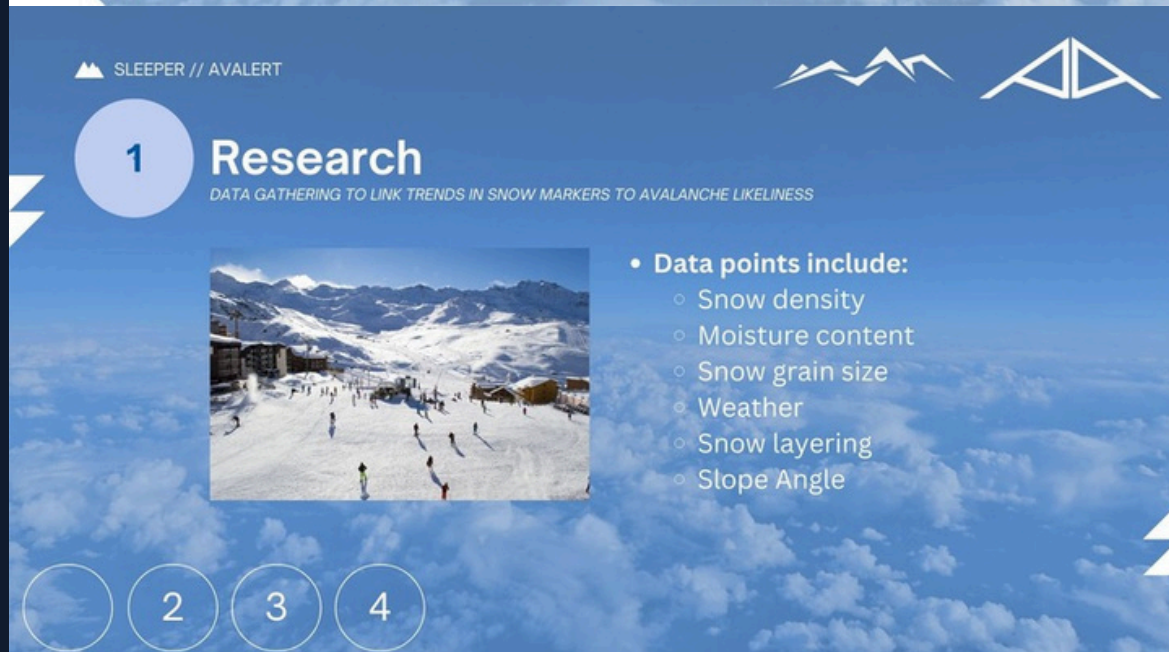
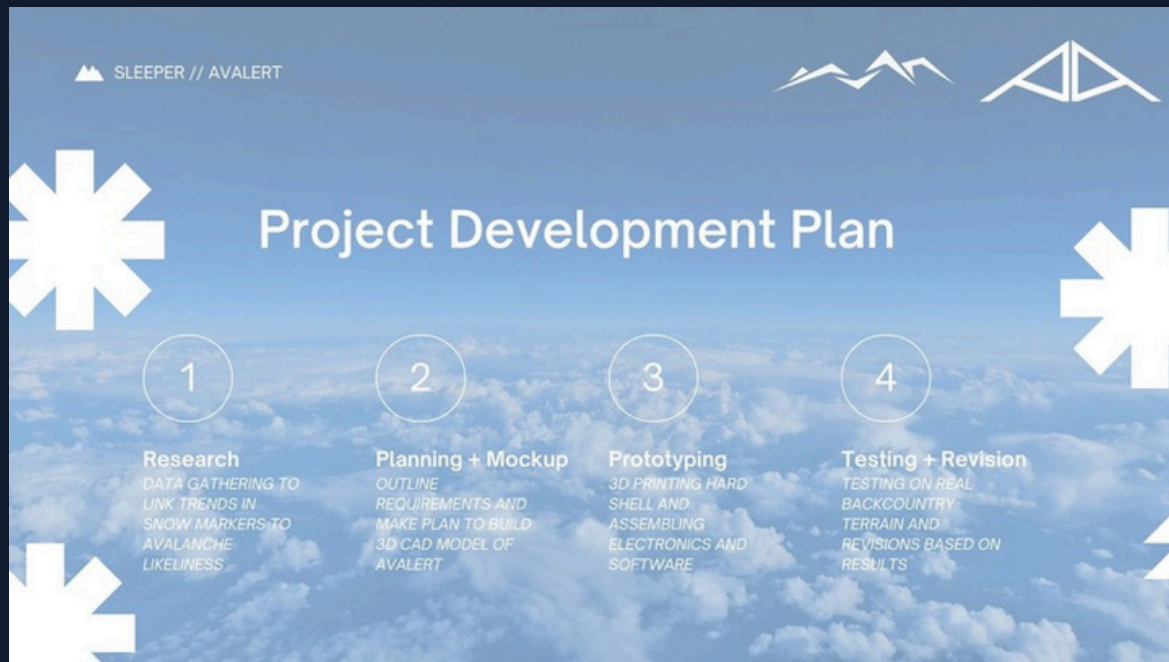
AvAlert



Phone



Server



SLEEPER // AVALERT

3

Prototyping

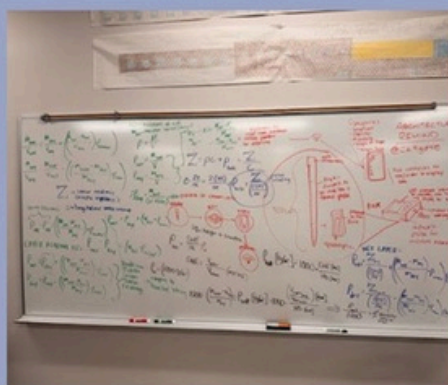
3D PRINTING HARD SHELL - ASSEMBLING ELECTRONICS AND SOFTWARE



- The prototyping process includes:
 - Linking together acoustic sounding, physical probe, computer, and UI
 - Creating a 3D Casing/Shell to hold the device that is durable, weatherproof, and can withstand tough conditions and revising

SLEEPER // AVALERT

Mathematical Analysis



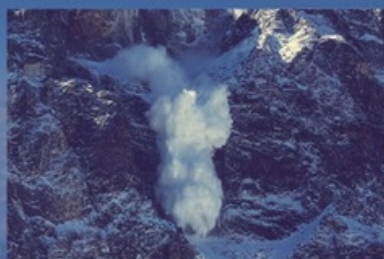
Using a technique called acoustic sounding, we will send an acoustic pulse into the snow and record the echoes. Using a combination of the height of the snowpack measured from our probe and the impulse responses from the snowpack, we can convert the echo time into depth. Using the sound data, spike polarity and size reflect layer changes and a jump in acoustic impedance—in other words, a transition in density to either a harder or softer layer and a weaker or stronger layer. Mapping these changes out, we can see a full layer profile of the snow beneath the skier and highlight concerning patterns of deeper, weaker layers to predict avalanche-prone conditions.

SLEEPER // AVALERT

4

Testing + Revision

TESTING ON REAL BACKCOUNTRY TERRAIN - REVISIONS BASED ON RESULTS

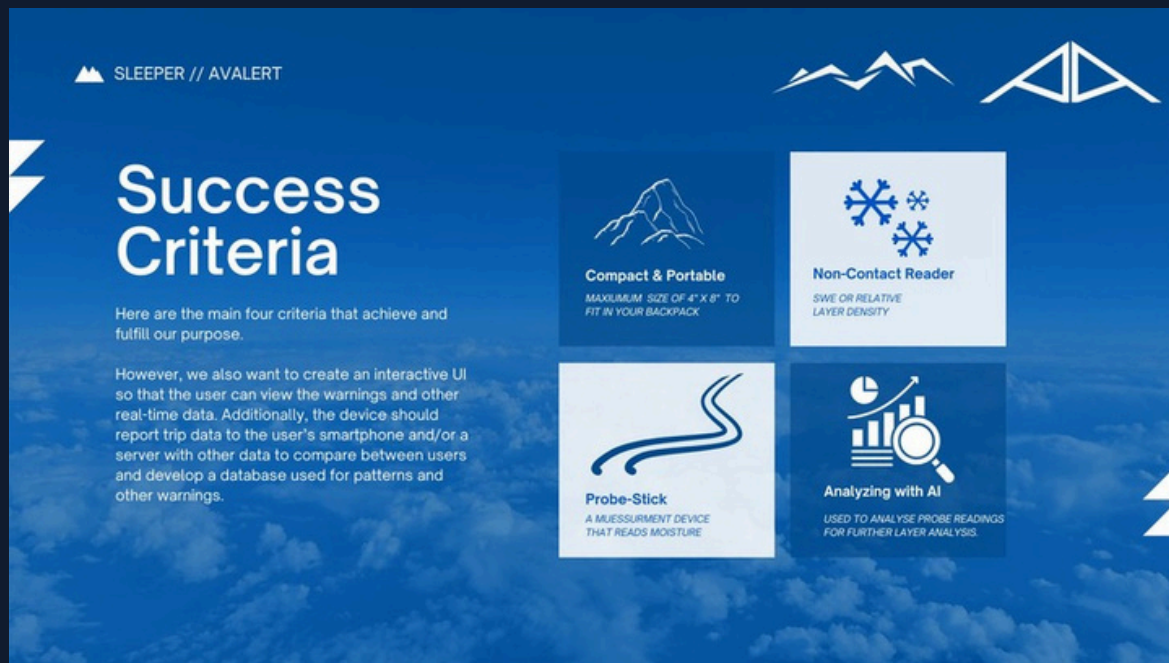


- Testing and revision include:
 - Collecting baseline data using a controlled weather simulation
 - Testing in the backcountry
 - Simulating avalanche conditions and looking for verification between data sets (research/testing)

1

2

3



C-3





Q&A

1. WOULD YOU RECOMMEND ANY FURTHER CHANGES TO OUR CRITERIA?
2. COULD WE IMPLEMENT ANY CHANGES TO THE USER INTERFACE TO CREATE A MORE USER-FRIENDLY DEVICE?
3. DO YOU HAVE ANY IDEAS TO IMPROVE THE PROCESS OF UPLOADING AND EDITING THE SOFTWARE/CODE?
4. HOW WOULD YOU SUGGEST GOING ABOUT CREATING A MARKET PITCH FOR THE PRODUCT AS WE GET FURTHER INTO REAL-WORLD TESTING?
5. AS WE BEGIN TESTING ONCE THE DEVICE IS READY, HOW WOULD YOU SUGGEST WE GO ABOUT MAKING THE CHANGES THAT MAY BE NECESSARY AS IT RELATES TO THE ENGINEERING PROCESS?



RESEARCH CONCLUSIONS

Millions of backcountry skiers face avalanche risk each year, yet most avalanches occur without any real-time warning of unstable snow conditions. Existing safety measures focus on education, rescue, or labor-intensive snowpit analysis, leaving no practical way for skiers to assess avalanche danger. This gap highlights the need for a portable, real-time device that uses snowpack and environmental data to support safer backcountry decision-making.

WORKS CITED LINK TO IS EMBEDDED

- [1] U.S. Department of Commerce, "Avalanche safety," National Weather Service, <https://www.weather.gov/bou/avalanchesafety> (accessed Sep. 8, 2025).
- [2] U.S. Department of Commerce, "Winter Avalanche safety," National Weather Service, <https://www.weather.gov/safety/winter-avalanche> (accessed Sep. 8, 2025).
- [3] N. Denissenov et al., "Real-time Avalanche Hazard Monitoring System based on weather sensors and a laser rangefinder," Sensors (Basel, Switzerland), <https://pmc.ncbi.nlm.nih.gov/articles/PMC12074380/> (accessed Sep. 8, 2025).
- [4] "Identify avalanche terrain," Avalanche Safety, "Identify Terrain," <https://avalanche.org/avalanche-tutorial/avalanche-terrain.php> (accessed Sep. 8, 2025).
- [5] "Chapter 1 - types of avalanches and avalanche dangers Lab snow," Ortovox Lab Snow, <https://www.ortovox.com/en/safety-academy-lab-snow/01-avalanche-basics> (accessed Sep. 8, 2025).
- [6] "What causes an avalanche?", https://www.kulcaz.com/312147/2022/05/04_what-causes-avalanche.html (accessed Sep. 8, 2025).
- [7] R. Craft, "BP, 27/04/2025," Snowpilot Web Application, <https://snowpilot.org/node/75959> (accessed Sep. 8, 2025).
- [8] "Disasters explained: Avalanches - shelterbox," Shelterbox, <https://shelterbox.org/disasters-explained/avalanches/> (accessed Sep. 8, 2025).



OUR PROBLEM

currently, there are no ways to predict when an avalanche is going to happen.

over 160 people every year are killed in the US alone due to avalanche related disasters.

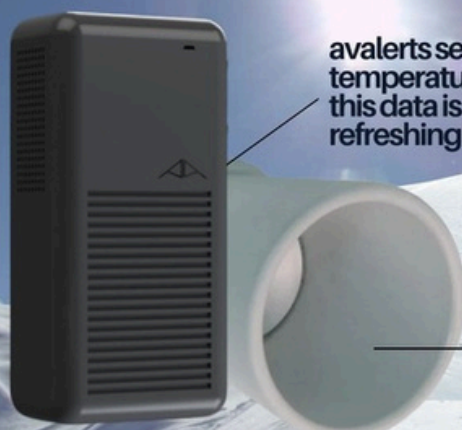
no preventative avalanche technology currently exists.

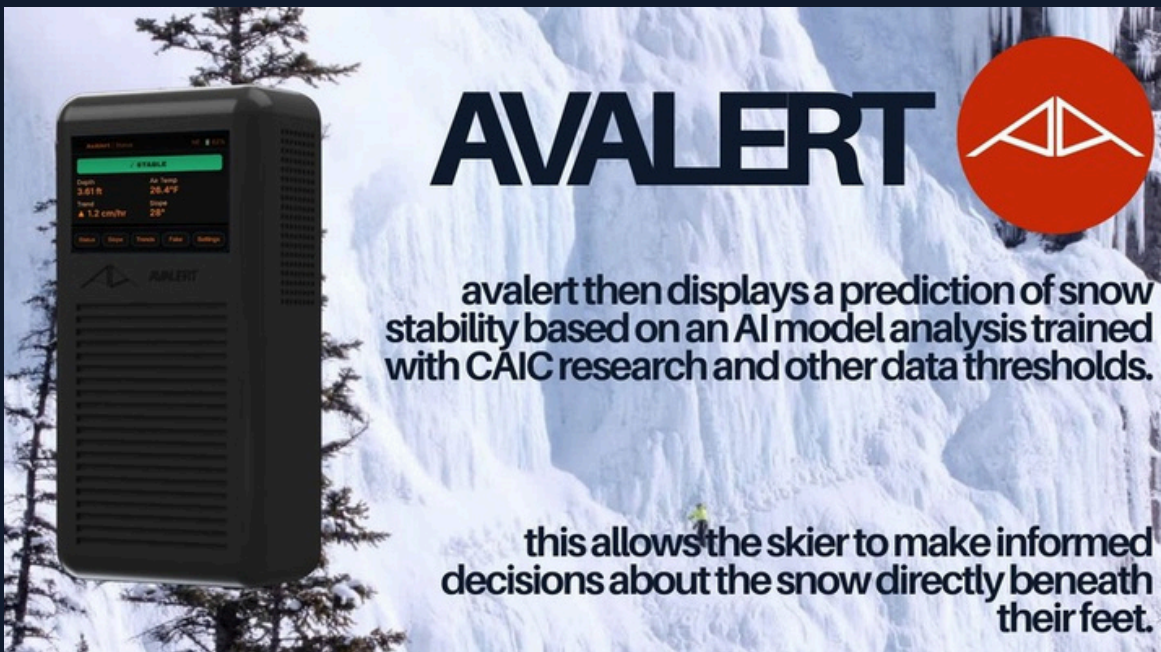
HOW IT WORKS

avalert continuously monitors snow conditions beneath the skiers feet, in real time.

avalerts sensors track snow depth, slope angle, temperature, humidity, pressure, and heading. this data is stored and tracked over time, refreshing every second.

avalert uses sonar technology to perform acoustic sounding to track snow depth.





AVALERT

avalert then displays a prediction of snow stability based on an AI model analysis trained with CAIC research and other data thresholds.

this allows the skier to make informed decisions about the snow directly beneath their feet.

OUR PROCESS

assemble electronics



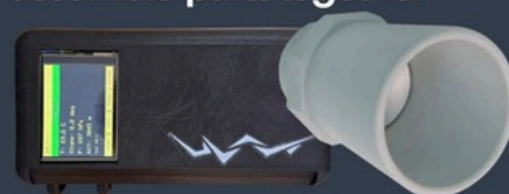
upload code (IDE)



model + print case



assemble parts together



CRITERIA



Requirement	Progress	Requirement	Progress	Requirement	Progress
1. The Avalert Device will allow backcountry skiers and riders to make informed decisions on avalanche conditions and will act as an extra layer of risk assessment when traveling in the variable terrain of the backcountry.	Various sensors provide the concept, and our AI model gets better every day	5. As a part of a positive user interface, the device will deliver auditory cues along with its measurement to give the user positive feedback. A single beep will sound during a measured reading followed by a secondary sound (one beep = stable, two beeps = variable, three beeps = unstable). While you ski the device will deliver these cues if and when conditions change to allow you to make informed decisions in avalanche terrain.		6. The Sensor Sensor that the device will be equipped with will find the model a depth measurement. The sensor needs to be calibrated and put up against measured values to ensure reliability. Snow pits will help establish its accuracy during initial setup.	
2. The Avalert Device must be compact and portable to allow skiers and riders to store it away within their backpacks. Max dimensions 4" by 8"	Initial case design fits the exact dimensions - may be able to go smaller	6. The Avalert Device must be able to function in temperatures as cold as -40°F to account for extreme and unpredictable backcountry conditions.	All of our sensors are equipped to handle this cold, and the device will be insulated to make sure the sensors aren't constantly exposed to unnecessary cold	8. The Model will be able to make predictions on SWE using temperature, humidity, depth, and baseline data from past Snow research, utilizing data from the Colorado Avalanche Information Center, and measurements taken during real-life testing in various sites (Thornton pass, Rabbit ears pass, Loveland pass)	
3. The Avalert Device must be waterproof and sealed to function in the wet environment that is the backcountry. It must hold up to snow testing and variable storm conditions. The device will be sealed with a gasket and silicon around any openings.		7. Avalert's AI model within the device's internal computer will use a variety of measurements from its sensors to predict avalanche danger. Temperature, pressure, humidity, and slope will allow the device to predict snowpack.	All the sensors read and feed the data to the motherboard, and project it on the screen	10. Internal slope angle measurement will allow the device to make predictions within the parameters of reason (snow is only dangerously avalanche-prone between 30 and 45 degrees). Slope angle will be weighted highest in the AI model's calculations as slope angle is the most important variable in avalanche risk assessment.	When the device changes the readings based on the angle at which the device is set in.
4. The Avalert Device will be equipped with a screen interface to provide the user with real-time, visible, and approachable data readings. The danger reading will be shown as a colored bar: stable (green), variable (yellow), unstable (red).	The screen interface reads the data and portrays it to the user as a colored bar, and gives the data readings to back it up				

LINK TO IS EMBEDDED



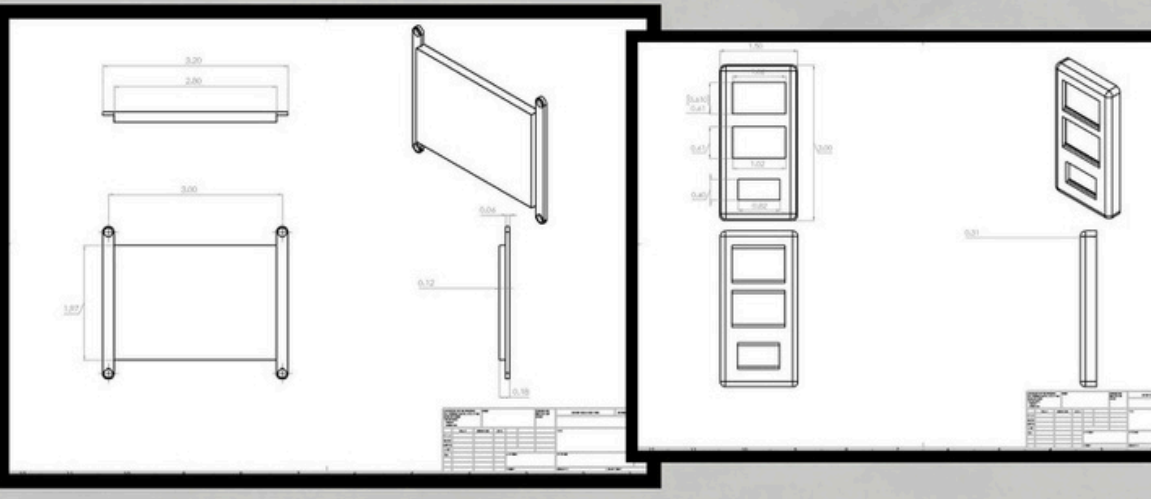
HARDWARE FEATURES



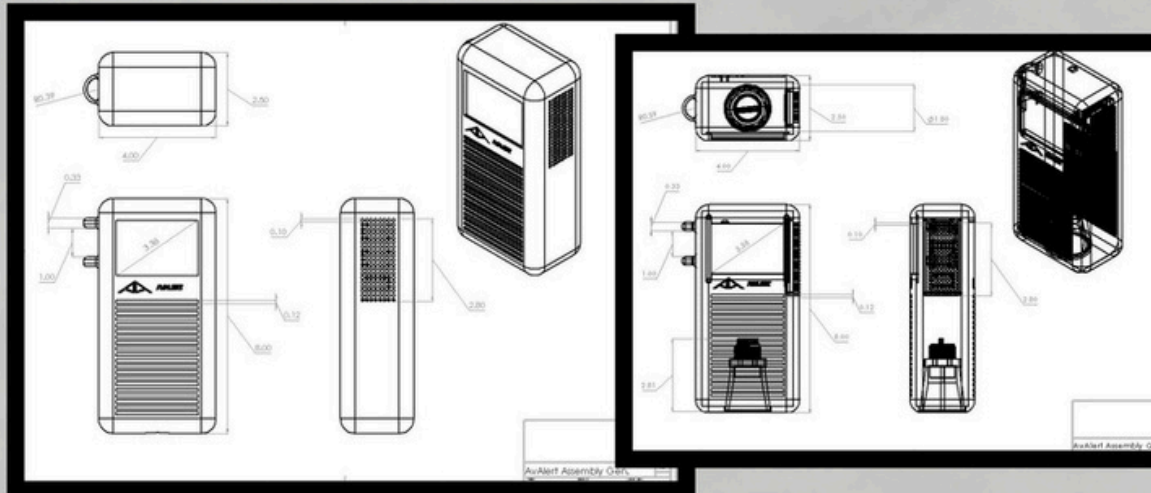
double loops for easy attachment to packs, straps, etc.

textured surface around the case for easy grip

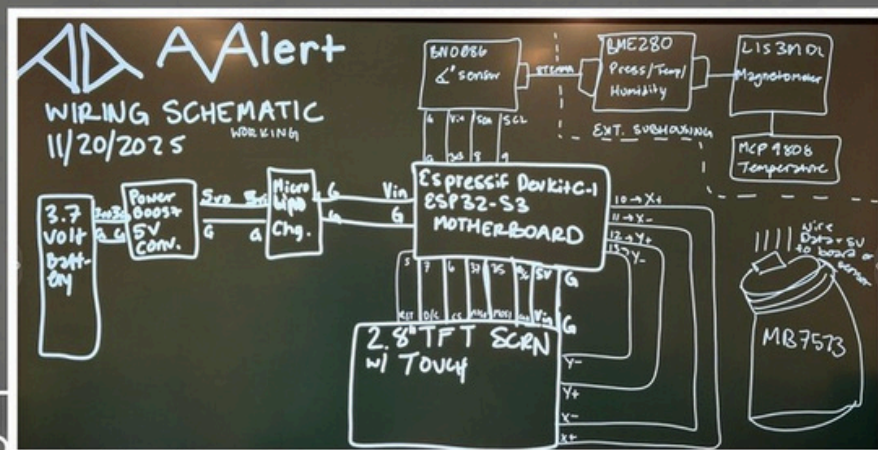
all parts rated for -20 °F or colder



AVALERT HARDWARE SCHEMATICS



AVALERT WIRING SCHEMATICS



MATHEMATICAL ANALYSIS

AvAlert models avalanche hazard by treating snow depth, temperature, and slope angle as time-dependent functions and estimating their rates of change using finite differences and moving averages. These derivatives are normalized against known avalanche thresholds and combined with weighted terms to produce a dimensionless instability score.

* AVALERT OS

status screen

Utilizing metrics gathered from onboard sensors, AvAlert makes a prediction based on data thresholds, stressing emphasis on slope angle. Based on this, AvAlert assigns one of three stability levels: stable, variable, unstable. **This risk rating appears as a large colored bar across the screen.**

* AVALERT OS

slope screen

A clear needle will point to the current slope angle, indicating danger based on each correspondent number. The resistive touchscreen lets the user navigate AvAlert. **All pages update automatically in real time accordingly.**

* AVALERT OS

trends screen

AvAlert stores temperature, slope, and pressure readings over the last several minutes and displays them in trend graphs. Sudden pattern changes like warming or rapid slope shifts can indicate rising avalanche risk and AvAlert will respond accordingly.



*** AVALERT OS**

settings menu

AvAlert has customizable themes, metric and imperial units, a PRO Mode for more acclimated climate data collectors, and a storm mode that updates risk factors accordingly.

AvAlert is adaptable and suitable for all types of users.

NEXT STEPS

- testing with avalanche simulations and real field experiments
- calibration of sensors to match measured metrics
- implement new case design with full insulation and fully installed parts

AVALERT VERSION ONE

WHERE WE ARE

- ✓ fully deployable software complete
- ✓ code uploaded + sensors operational
- ✓ hardware model and prototype finished



AVALERT C.A.S.E.

V3.2



CRITICAL AVALANCHE SENSOR ENCLOSURE

AVALERT C.A.S.E.



- micro-USB charging port for compatibility
- bifurcated to the backplate for maximum insulation
- sealed O-ring track makes AvAlert waterproof
- screw placeholders

BACKPLATE

AVALERT C.A.S.E.



- insulated sensor box for open-air sensor readings
- safe & easy one-click installation
- small + compact microelectronics
- no wifi or bluetooth connectivity required

SENSORS + ELECTRONICS

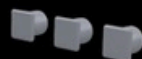
AVALERT C.A.S.E.



2.8" LCD screen
with fully
interactive UI

silicone + O-ring dual
insulated

SCREEN + OPERATION



easy to use buttons
with gloves on +
tactical response

scroll through
screens, operate
settings, etc.

AVALERT C.A.S.E.



3.7V 2600mAh
battery- cold
resistant

52 hour consistent
runtime*

BATTERY + DEPTH



sonar acoustic
sounding depth
sensor

hard wired into
system, fail-proof

*estimate based off of theoretical, calculated values

SOFTWARE

AVALERT HAS FULL CODE IMPLEMENTATION



(CLICK TO OPEN SIM)

BUTTON SYSTEM

LEFT PAGE

SELECT ON/OFF

RIGHT PAGE

easier to use with gloves and in cold weather with limited tactile ability

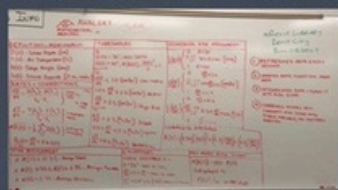


AI USAGE & IMPLEMENTATION



using ChatGPT's Codex software, we transformed our math into code.

using thousands of entries of CAIC research, Codex created this weight scale.



Codex



$R(t) = (0.50f(\theta(t))) + (0.3f(dD/dt)) + (0.2f(dT/dt))$
 if : $R(t) < 0.35$ **stable**
 if : $0.35 < R(t) < 0.75$ **variable**
 if : $R(t) > 0.75$ **unstable**
risk assessment equation
 *theta is angle, D is depth, T is temperature, and t is time. R(t) is the composite risk score from 0-1

Codex takes our sets of equations and changes it into readable code that allows AvAlert to make a trend-based prediction

the user can then see readable, easy to understand risk assessment levels.

 **\$679.99**

unlike forecasts or apps, AvAlert:
 -collects on-site data about snowpack
 -tracks trend-based stability changes
 -translates complex data into clear risk indicators

backcountry participation is at an all time high.

AvAlert gives decision support before the slope fails, not after.

total accesible market:
\$1.5-2.0B GLOBAL MARKET

AvAlert fills an untapped, high-trust, premium niche for ski safety

pricing aligns with airbags and premium safety gear, signaling seriousness and credibility



Product	Typical Price
Beacon	\$300-500
Airbag backpack	\$700-1,500
Touring setup (skis, bindings, boots)	\$1,500-3,000
Full backcountry kit	\$3,000-6,000+

TESTING PLAN

SENSOR ACCURACY	PREDICTION ACCURACY	SIMULATED TESTING	ON-SITE TESTING
			
comparing AvAlert's numbers to measured data with external sensors; compare + recalibrate	based on the numbers, is the risk rating working and outputting what the expected danger level is?	simulate dangerous conditions and compare with AvAlert's risk rating to gauge accuracy	take it out into real backcountry terrain and assess usability, battery life, prediction accuracy, & expected results

AS AN AVID BACKCOUNTRY SNOWBOARDER, THIS IS A LIMINAL NICHE OF NECESSITY THAT WILL BENEFIT TONS OF RIDERS.

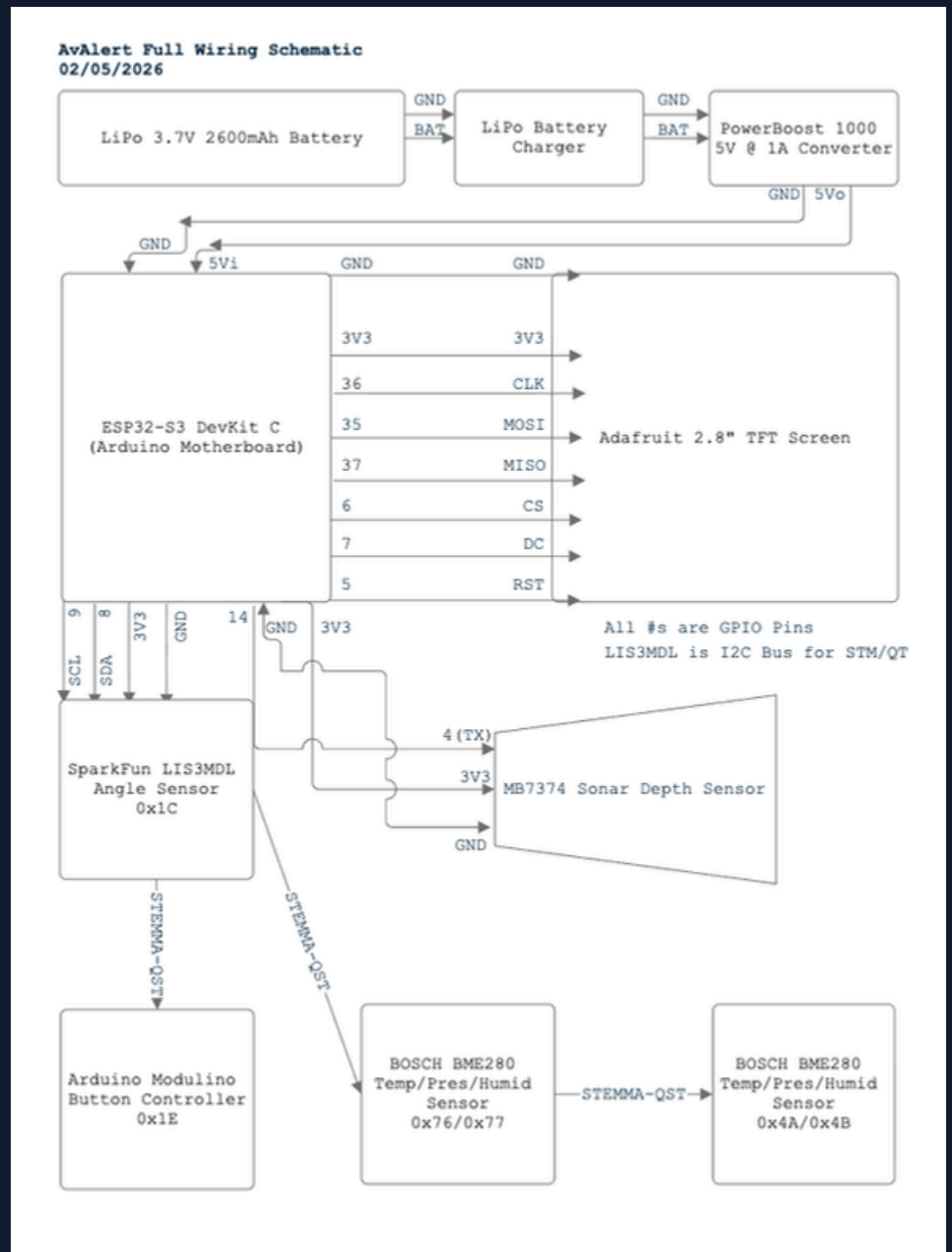
-Conner Baldwin
backcountry snowboarder

THERE IS CURRENTLY NO TECHNOLOGY OR PRODUCT ON THE MARKET THAT PROVIDES SIMPLE AND EFFECTIVE PERSONAL AVALANCHE PREVENTION.

SKIERS AND SNOWBOARDERS, SNOWMOBILERS, HIKERS, SKI PATROL, AND SKI RESORT PERSONNEL WILL ALL FIND AVALERT A WELCOME ADDITION TO THEIR WINTER SAFETY KITS.

-John Iannone
backcountry skier

AvAlert Final Wiring Schematic



AvAlert Screen
Mounting Plate



AvAlert CASE Rear Side

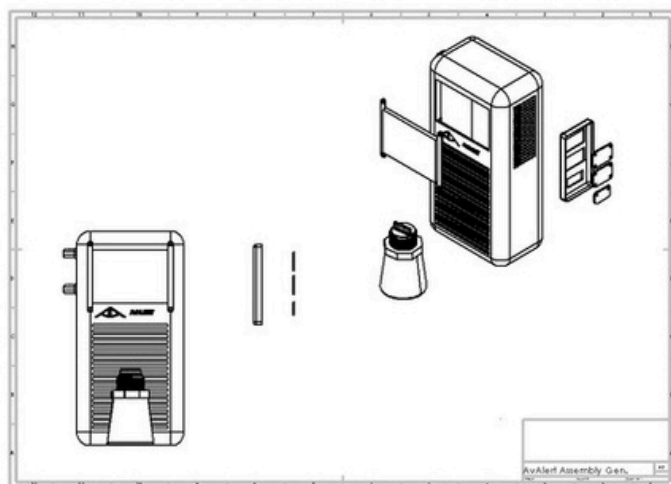


AvAlert CASE Front Side

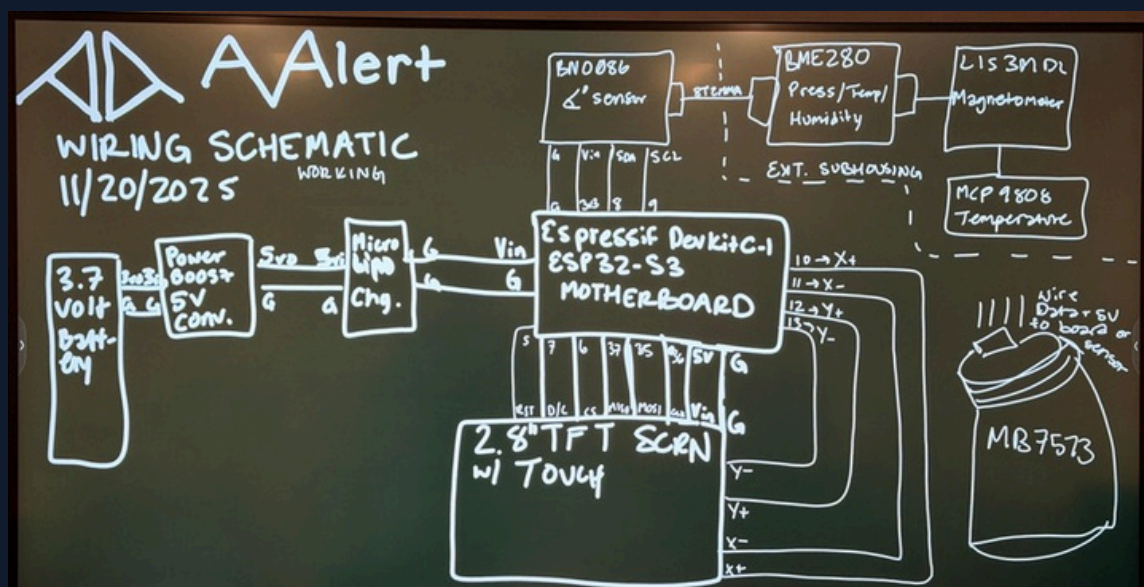


AvAlert CASE Resin Printing





AvAlert Full SolidWorks
Exploded Assembly
Drawing



Early AvAlert Wiring
Schematic Plan



AvAlert CASE
Render

E

Climate-

Northern ranges may have more stable snowpack due to more consistent storms. Southern ranges could have more complex layering, with greater avalanche potential, especially on shaded aspects.

The slow start followed by a sudden mid-January storm likely created buried weak layers (facets or surface hoar) that can persist and be reactive weeks or months later.

-Facet: Large, angular, "sugary" snow grains that form a weak, poorly bonded layer within the snowpack due to strong temperature gradients, causing water vapor to sublimate and deposit from warmer to colder areas.

-Surface Hoar: fragile, feathery ice crystals that form on the snow's surface during clear, cold, calm nights by the deposition of water vapor from the air onto the snow. These delicate crystals are harmless on the surface but can become a dangerous, persistent weak layer within the snowpack if buried by subsequent snowfall.

[How Climate Change Impacts Avalanche Conditions - Protect Our Winters](#)

Increased climate variability causes increasingly hard-to-predict avalanche forecasts

Change in types of avalanches during unusual times of the year because of warming temps

Past avalanche data is no longer indicative of the future, as weather becomes increasingly unpredictable and variable

Density markers-

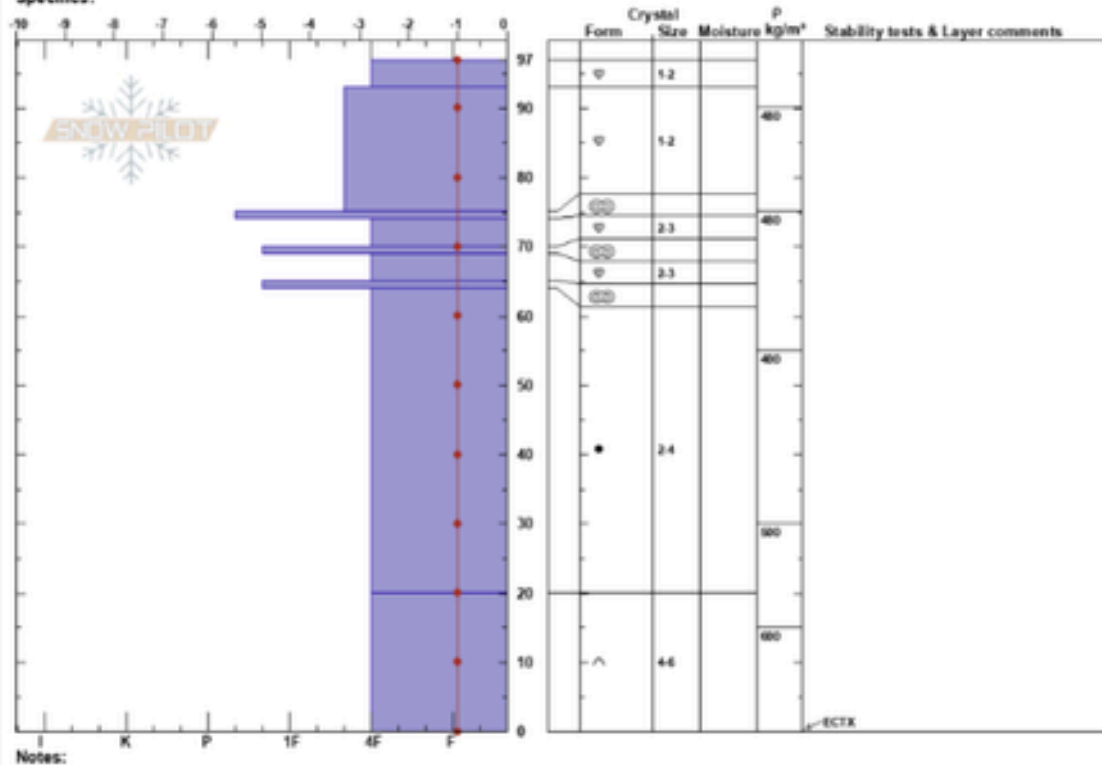
Snow stratigraphy and layer markers- [SnowEx20 Time Series Snow Pit Measurements, Version 2 | National Snow and Ice Data Center](#)

BP_24/05/2025
Berthoud Pass
CO
Elevation: 3450 m
Aspect:
Specifics:

Robert Craft
05/24/2025 - 10:00am
Co-ord: 39.80350N, -105.77770W
Slope Angle: 0°
Wind Loading:

Stability:
Air Temperature: 14°C
Sky Cover: CLR
Precipitation: NO
Wind: Calm

HS:97 Layer Notes:
75-74cm Problematic layer

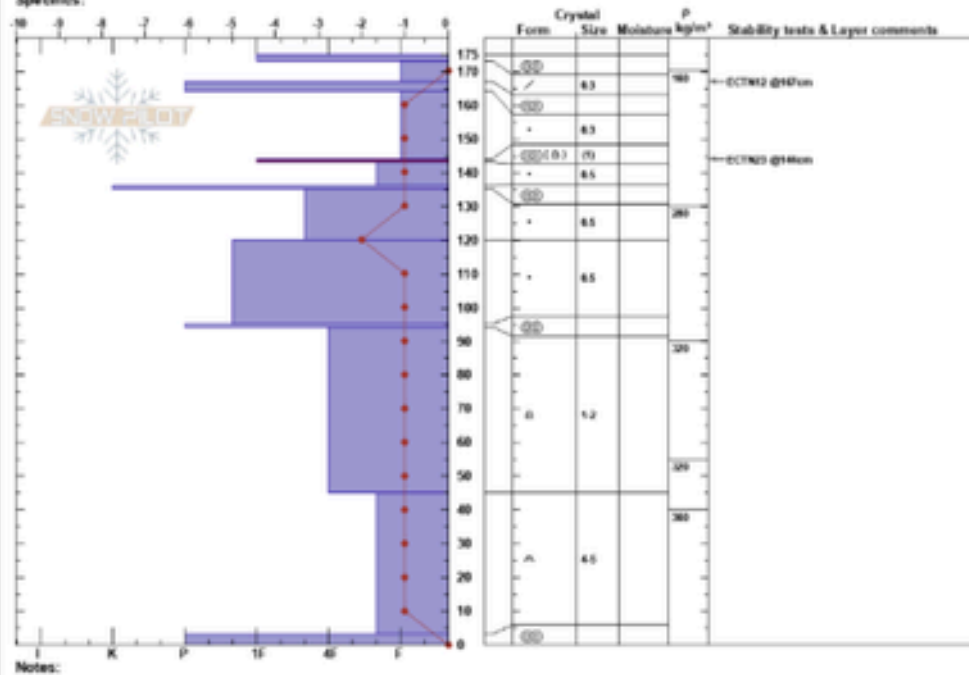


BP_30/03/2025
Berthoud Pass
CO
Elevation: 3450 m
Aspect:
Specifics:

Robert Craft
03/30/2025 - 1:00pm
Co-ord: 39.80350N, -105.77770W
Slope Angle: 0°
Wind Loading:

Stability:
Air Temperature: -1°C
Sky Cover: SCT
Precipitation: NO
Wind: Moderate

HS:175 Layer Notes:
144-140cm Problematic layer



- Mid-January storm cycle: Major increase in SWE, especially impactful due to weak early season layers.
- February: A steady stream of storms with regional variation (north vs. south). These patterns often result in **persistent weak layers** in the snowpack—especially when heavy snow rapidly follows a dry early season—which **increases avalanche risk**.

Geographic snowpack variability-

- Statewide Snow Water Equivalent (SWE) is 97% of the 1991-2020 median.
- Northern mountains are slightly above average (e.g., Yampa-White Basin at 104%).
- Southern mountains are below average (e.g., Rio Grande headwaters at 88%)

Avalanche conditions-

March could bring **more snow (El Niño influence)**, potentially **loading existing weak layers**. **Warming trends** in spring could **rapidly destabilize snowpacks**, triggering **wet avalanches**.

Dry slab avalanche - Slope angle above 30 degrees - 35 to 45 sweetspot. A dense cohesive slab breaking away on top of a weak, less-cohesive layer, reaching speeds of up to 200 mph, accounts for most of the avalanche deaths in North America. Usually, a direct result of high wind activity is depositing dense layers of snow on old snowfall, or heavy snowfall creates a new dense layer. Weak layers can be created by warming or by cold temperatures crystallizing the top layer

Drought and its effects - Long periods of no precipitation can cause the exposed layer of snow to sublime (losing its moisture content to windy conditions or evaporation, usually happening in colder conditions), creating grainy weak layers, or melting that causes moisture to percolate into and weaken the layers beneath it. When new layers are deposited on top of these, extreme instability can occur.

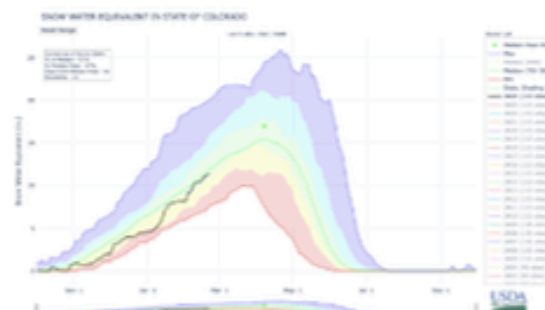
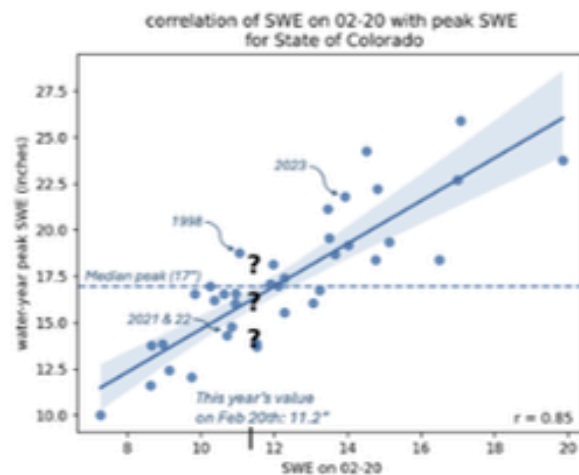
Wet slab avalanche - These occur when warming and melting occur, causing moisture to percolate into the different layers of snow and weaken it. These typically happen later in

Berthoud Pass Snow Pilot Data for Density of weekly sample pits - BP_24/05/2025 | Snowpilot
[Web Application](#)
[NWCC iMap](#)

Moisture-

[Colorado mountain snowpack in 2024 so far: decent, fine, ok](#)

SWE: Snow Water Equivalent, is a measurement of the amount of liquid water contained within a snowpack, essentially determining how much water you would have if the snow melted completely.



Snowpack-

Snowpack is a direct byproduct of weather patterns: wind, temperature, drought, and heavy snowfall can all increase risk. Yet predicting this is not easy and can only provide a prediction, not real-time data

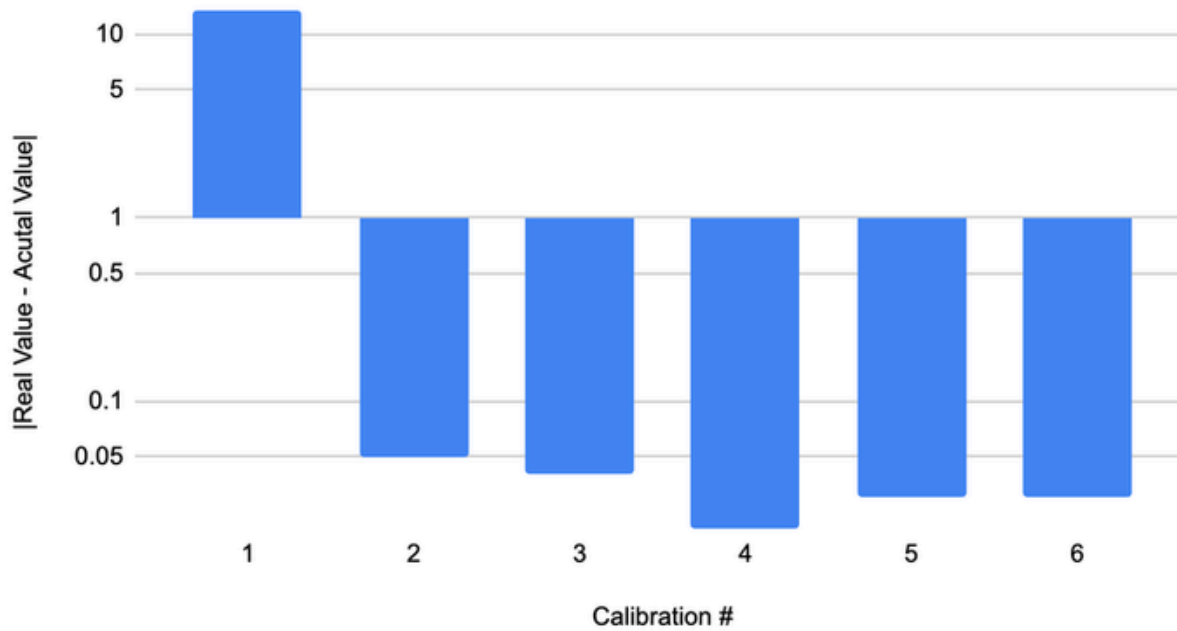
Seasonal Snowpack Trends-

- Early winter (through early Jan): Very low snowpack; some areas near record lows.

[illegible]

	AvAlert Software Correctioning			
	Angle	Temperature	Altitude	Depth
AVG Delta (Actual-Real)				
Correctioning				

AvAlert Calibration Testing- Differences in Values



Depth Sensor Calibration Testing

Angle Sensor Data 03/12/2026 [deg]

Actual	AvAlerts	Delta
0	2	2
7	9	2
9	10	1
18	20	2
30	32	2
38	40	2
48	46	2

Temp Sensor Data 03/12/2026 (F)

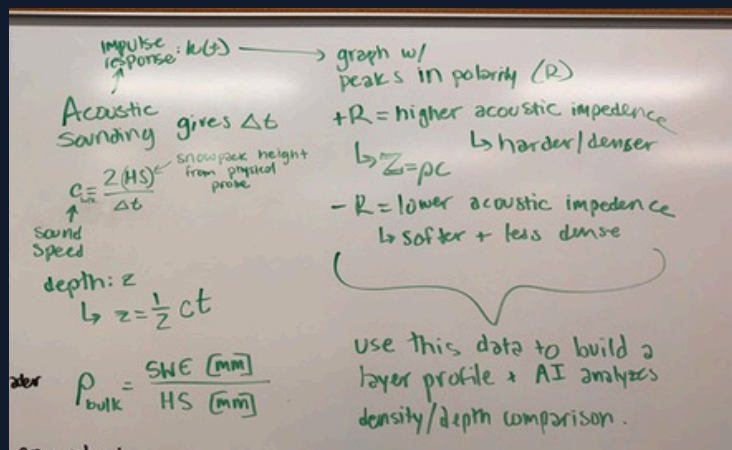
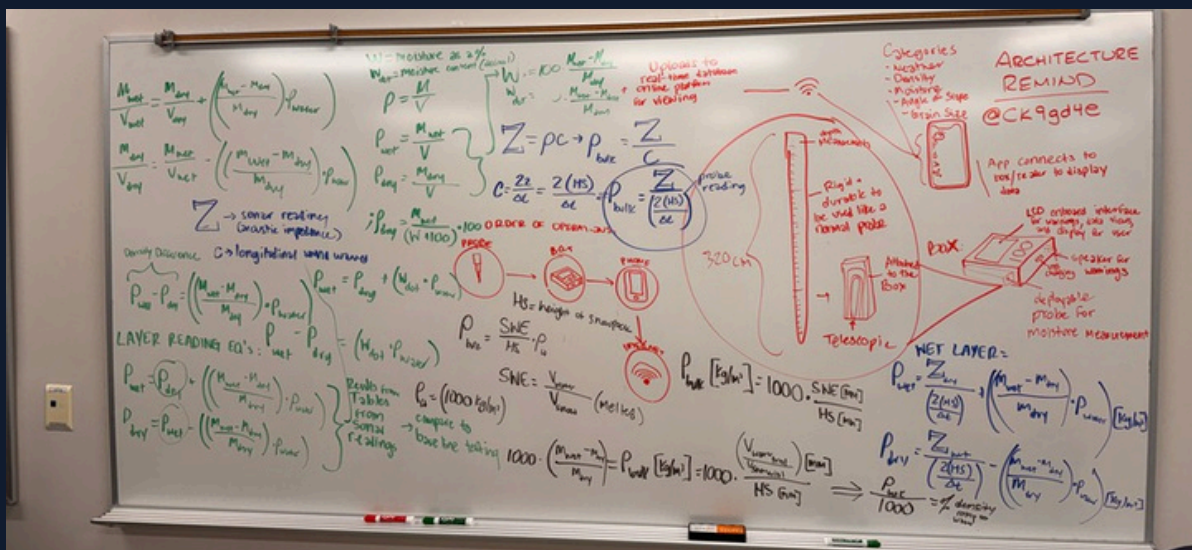
Actual Number	AvAlerts Number	Delta
40	39.9	0.1
41	40.4	0.6
41	40.5	0.5
41	40.8	0.2

CLUB INFO		
WE SA		
 AVALERT MATHEMATICAL ANALYSIS		
DEFINITIONS + MEASURABLES	THRESHOLDS	NUMERICAL RISK ASSIGNMENT
$D(t)$ - Snow Depth [cm] $T(t)$ - Air Temperature [°C] $\theta(t)$ - Slope Angle [deg] $S(t)$ - Storm Override [if on, cm/hr]	θ : $\theta(t) < 30^\circ$; $R(t)$ SAFE $\theta(t) > 40^\circ$; $R(\theta(t)) = \frac{\theta(t)^2}{2} - 1$ D : $\frac{dD}{dt} < 1.0$ [cm/hr] - Low Loading $1.0 \leq \frac{dD}{dt} \leq 2.5$ [cm/hr] - Medium $\frac{dD}{dt} > 2.5$ [cm/hr] - High Risk T : $\frac{dT}{dt} < 0.3$ [°C/hr] - Stable $0.3 \leq \frac{dT}{dt} \leq 0.8$ [°C/hr] - Medium $\frac{dT}{dt} > 0.8$ [°C/hr] - Destabilized	$f(\theta(t))$ $\begin{cases} 0 & \theta < 30 \\ \frac{\theta - 30}{10} & 30 \leq \theta \leq 40 \text{ [deg]} \\ 1 & \theta > 40 \end{cases}$ $f\left(\frac{dD}{dt}\right)$ $\begin{cases} 0 & \frac{dD}{dt} < 1.0 \\ \frac{\frac{dD}{dt} - 1.0}{1.5} & 1.0 \leq \frac{dD}{dt} \leq 2.5 \text{ [cm/hr]} \\ 1 & \frac{dD}{dt} > 2.5 \end{cases}$ $f\left(\frac{dT}{dt}\right)$ $\begin{cases} 0 & \frac{dT}{dt} < 0.3 \\ \frac{\frac{dT}{dt} - 0.3}{0.5} & 0.3 \leq \frac{dT}{dt} \leq 0.8 \text{ [°C/hr]} \\ 1 & \frac{dT}{dt} > 0.8 \end{cases}$
RATES + CORRECTIONS		
$\frac{dD}{dt} = \frac{D(t_2) - D(t_1)}{t_2 - t_1}$ } snow loading rate $\frac{dT}{dt} = \frac{T(t_2) - T(t_1)}{t_2 - t_1}$ } temperature trend $\overline{D(t)} = \frac{1}{n} \sum_{i=1}^n D(t_i)$ } averaging correction $D_s(t) = \frac{dD}{dt} + 0.8 S(t)$ (if on)		
RISK ASSIGNMENT	EXCEPTIONS	PRO MODE RISK SCORE:
if $R(t) < 0.35$ - Assign Stable if $R(t) 0.35 \leq R(t) < 0.75$ - Assign Variable if $R(t) > 0.75$ - Assign Unstable	FORCE UNSTABLE if - $\theta > 35^\circ$ - refer to rates $\frac{dD}{dt} > 2.5 \frac{\text{cm}}{\text{hr}}$ - refer to rates $\frac{dT}{dt} > 0.8 \frac{^\circ\text{C}}{\text{hr}}$ $S(t)$ comp. $> 2.5 \text{ cm/hr}$	$P(R(t)) = 100 \cdot R(t)$ $\hookrightarrow$ displayed as $P(R(t))/100$ in PRO Mode
		COMPOSITE AVERAGE $R(t) = (0.50f(\theta(t)) + (0.3f\left(\frac{dD}{dt}\right) + (0.2f\left(\frac{dT}{dt}\right)))$

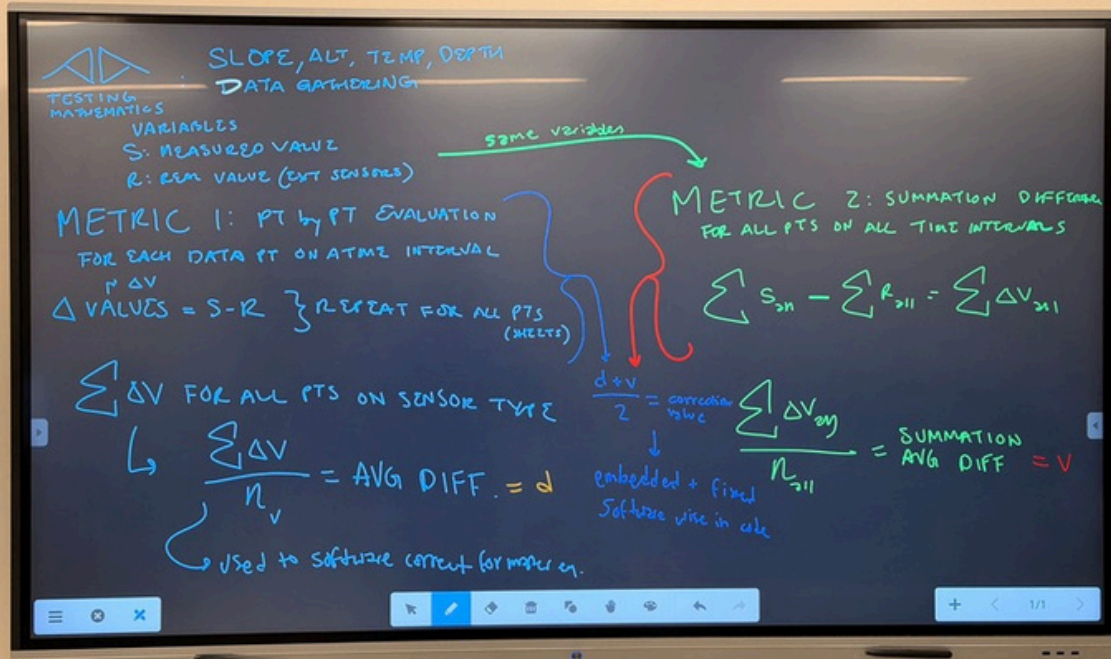
Definitions: $S(t)$ - acoustic signal $r(t)$ - reading/recorded value $h(t)$ - impulse response from acoustic reader $n(t)$ - extra noise $r(t) = [S(t) \cdot h(t)] + n(t)$ $\Delta y = \frac{2HS}{\Delta t_g}$; $z(t) = \frac{\Delta y_{\text{bulk}} \cdot t_g}{2}$ $P_{\text{bulk}} = \frac{1000 \text{ SNE [mm]}}{HS \text{ [mm]}}$ Attenuation correction (not required): $A(z, f) \approx A_0(f) e^{-\alpha(f)z}$ Wentz: $\Delta \alpha = \alpha(f_{hi}) - \alpha(f_{lo})$ α linear fit for $\ln A$; map for lower density Reflectivity @ layer boundaries (layer profile) $Z = \rho c$; $R_i = \frac{Z_{i+1} - Z_i}{Z_{i+1} + Z_i}$; $R_i > 0$ {harder, denser, steeper} $R_i < 0$ {softer, less dense, shallower} Relative Density change: $\frac{\Delta Z}{Z} = \frac{\Delta \rho}{\rho} + \frac{\Delta c}{c}$; $ R \approx \frac{1}{2} \left \frac{\Delta Z}{Z} \right $ $Z(t) = \rho c$; $Z(t) = \frac{1}{2} c(t) \cdot t$ $[\frac{1}{2} c(t) \cdot t]$ $\rho = \frac{Z}{c}$; $\rho c = \frac{1}{2} c(t) \cdot t \Rightarrow$

Code Order of operations Math

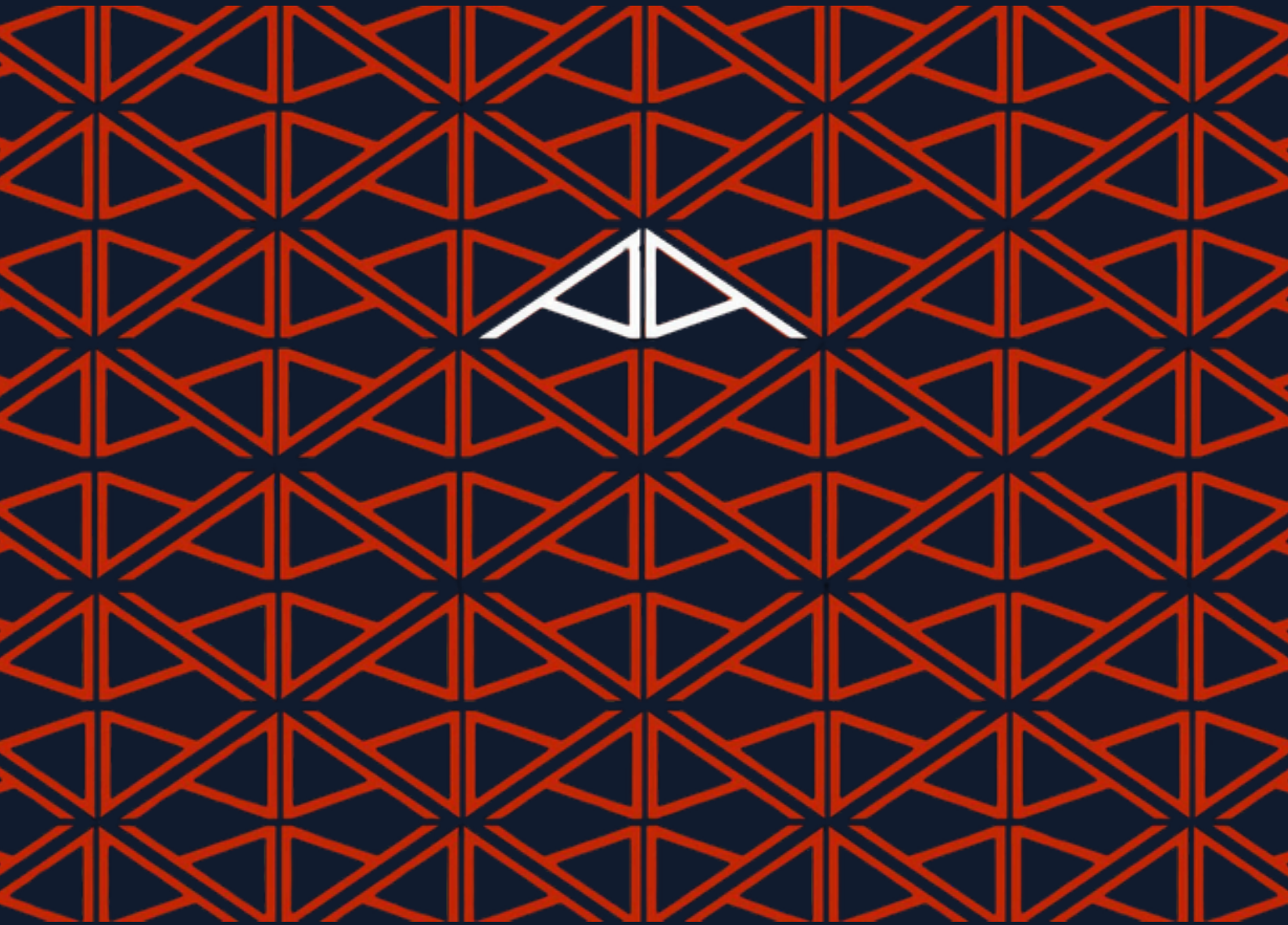
Sonar Proofs/Backend Calculations



Early AvAlert methodical calculations



AvAlert Testing Mathematical Backend Calculations



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