Project Interim Report

Acoustic- Collision Detection Smart Watch Feature for Pedestrians Operating Smartphones

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PROBLEM IDENTIFICATION

The increasing popularity and prominence of smartphones have not only benefited users in innumerable ways, but the years have also witnessed a series of dangerous incidents with distracted pedestrians and drivers operating cell phones that need to be mitigated for users. While technology is developed for the benefit of its users, it is mandatory that it be put to the correct use at the correct time.

Firstly, vehicle commutes are one of the most popular means of travel, aside from which public transport is also being necessitated by governments for several reasons. This means there will be a growing number of pedestrians commuting by foot to bus stops and workplaces. As the number of passengers on foot has multiplied, a recent trend in the number of pedestrian accidents within Silicon Valley has gained prominence. Smartphones are becoming a major safety concern for pedestrians who commute daily to nearby hospitals, offices, universities, and other workplaces.

Secondly, travelers commuting on foot are consistently engaged in activities like texting, calling, video watching, surfing the internet, or playing games. Moreover, commuters on foot have been sighted bumping into objects like trees, trash bins, traffic lights, or vehicle traffic. Since 2009, the city has witnessed critical pedestrian injuries like sprains, concussions, fractures, and even immediate death. This trend is quickly advancing due to an increase in inattentive and distracted smartphone users.

Thirdly, a CBS Bay Area news article reported an incident at Greentree, San Jose, where a juvenile male driver speeding in a stolen Hyundai struck a pedestrian after which the car continued to move northbound and damaged a tree. The pedestrian was declared deceased. This was the 33rd fatal crash and the 19th pedestrian death of 2023. Injuries related to mobile phone distractions have increased from 0.58% in 2004 to 3.67% in 2010. State councils are taking measures by imposing fines on smartphone users for their distracted walking behaviors and drivers for violating the speed limits (CBS Bay Area, 2023).

Lastly, an important mitigation measure that will be the subject of discussion in the main report is a recent innovation in which product developers are working to enhance the sensing capabilities of smartphones and watches to alert pedestrians of an approaching object and assist blind pedestrians to follow an easy commute.

ANTICIPATED CUSTOMER WANTS AND NEEDS

For regular pedestrians use the Active outdoor mode of the smartwatch.

Customer Needs:

1. Collision alerts and a simplified user interface.
2. Customized ringtones to differentiate critical alerts.
3. Warning indications must be issued at sufficient proximity from the approaching obstacle to support the user's reaction time.
4. Waterproof feature to protect from unexpected rain.
5. Immediate emergency outreach (SOS) on collision detection.
6. Extended battery life to avoid frequent recharges and shutdowns.
7. Internet and 5G connectivity for enhanced user experience.
8. Affordability to purchase the product with ease.
9. Touch screen technology with advanced displays.

Customer Wants:

1. Display of an AI-generated satellite image of an approaching object.
2. Obstacle categorization to recognize the type of obstacle.
3. Temperature sensors
4. Sleep tracking system

5. Pulse detection
6. Pedestrians using “Blind Mode” of smartwatch.

Customer Needs (Additional features):

1. Virtual Assistant for Navigation: Guidance on Terrain (Curb, Side Walks, Trees, and Shrubs) and Against Approaching Vehicles
2. Consistent alerts on the number of steps and movements
3. Embedded offline GPS integration.
4. High-performance RAM

Customer Wants:

1. Tactile feedback: vibrating wristbands when an obstruction is detected.
2. Multiple Language

Validation Process

Overview: Acoustic Collision Detection Smart Watch Feature is a cutting-edge technology that improves the safety of pedestrians. It is designed for people who use their smartphones while walking or crossing streets. This function detects probable collisions with adjacent objects or vehicles using acoustic sensors and real-time processing and informs the user via the smartwatch. The objective is to prioritize safety, accuracy, use, and personalization while improving battery efficiency and cost-effectiveness.

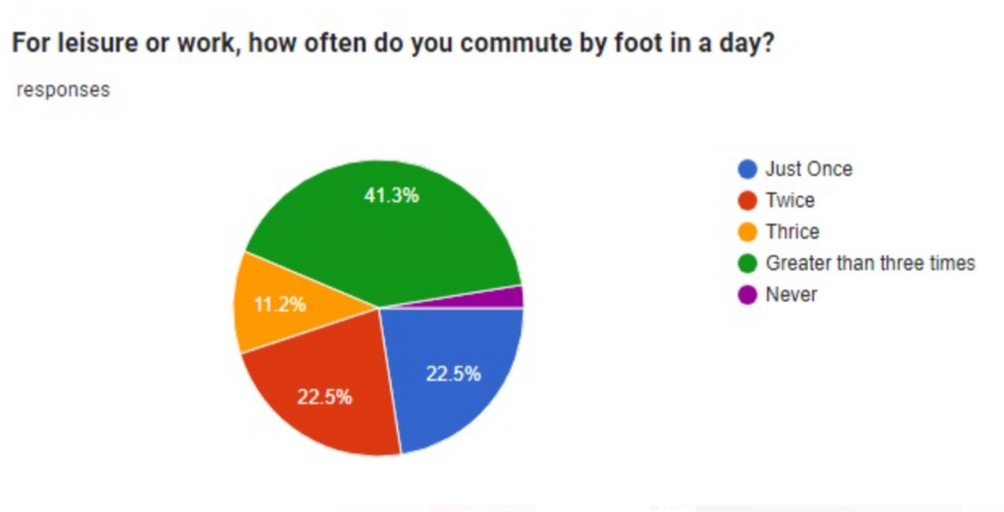
To validate the customer needs and wants a customer survey analysis was conducted, to collect responses from 80 participants and the survey contained a total of 11 questions listed below

VALIDATION PROCESS RESULTS

Analysis of the survey data provides valuable insights into the potential adoption of a smartwatch with an enhanced intelligence system for collision detection and obstacle alerts among pedestrians. Here are the key findings and observations:

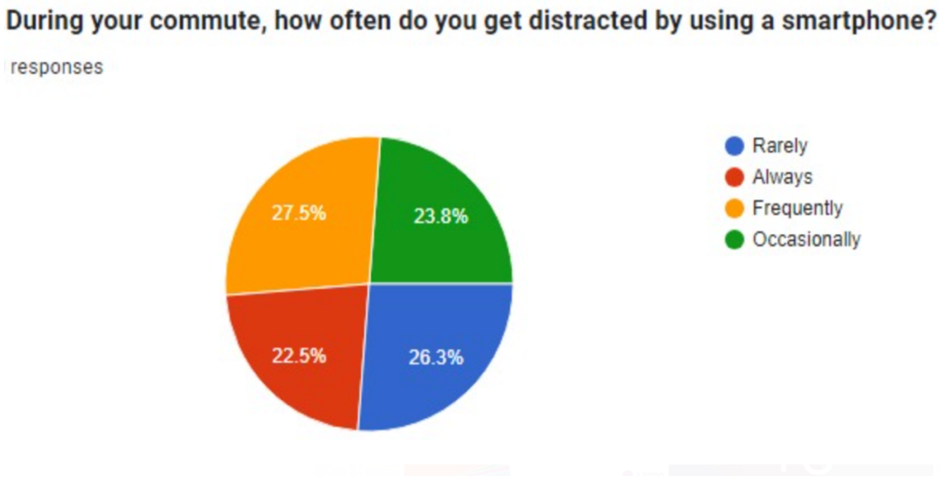
Commute Frequency: Over 40% of respondents commute by foot more than three times a day, indicating a significant portion of the sample engages in regular pedestrian activities.

Figure 1-Graphical analysis for Question 1



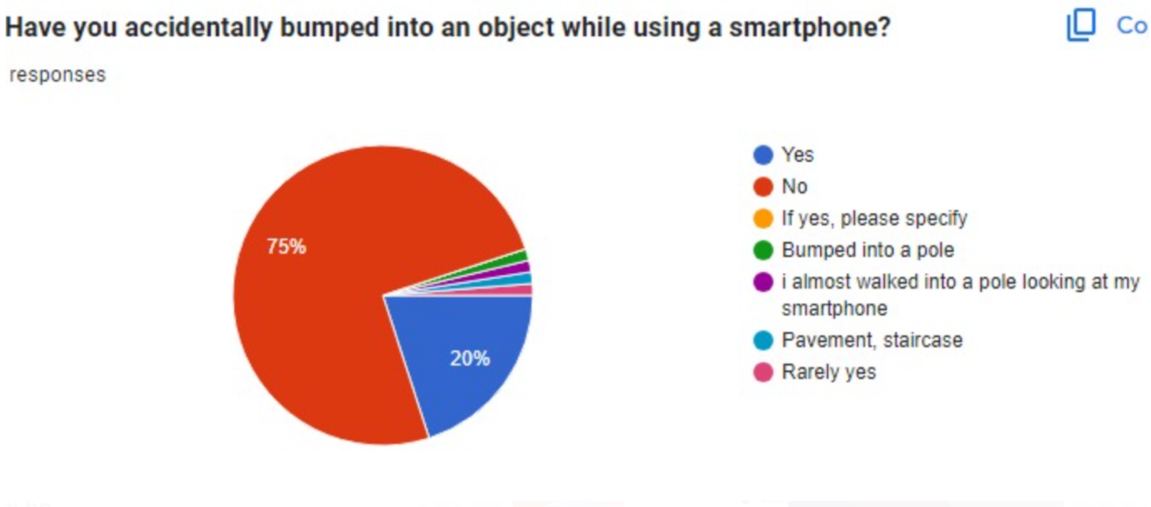
Smartphone Distraction: While 75% claim they are not distracted by smartphones during their commute, the 20% who admit to distraction highlight an opportunity for technology solutions that enhance safety.

Figure 2-Graphical analysis for Question 2



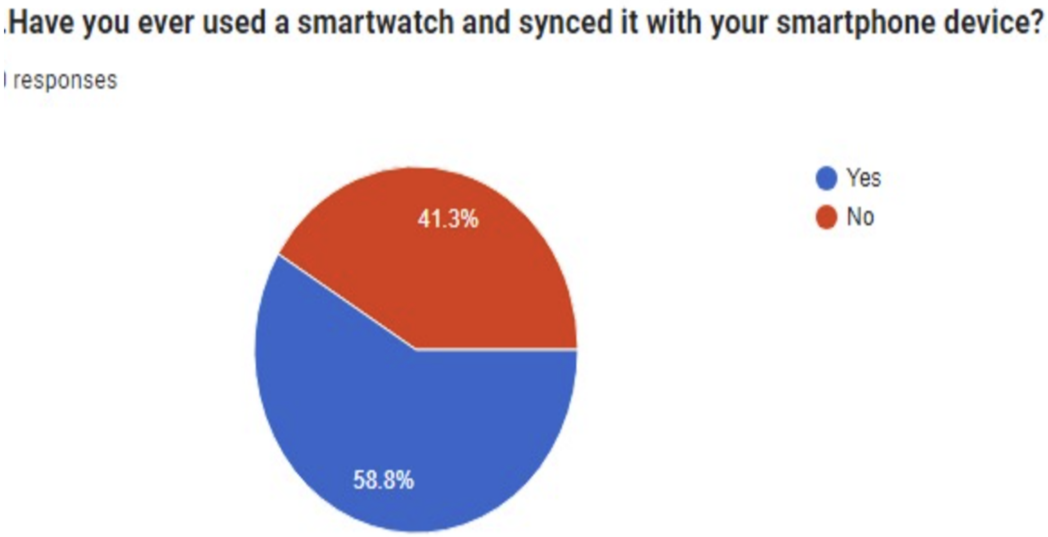
Smartwatch Usage: Most respondents (58.8%) have experience using a smartwatch, suggesting a familiarity with wearable technology.

Figure 3-Graphical analysis for Question 3



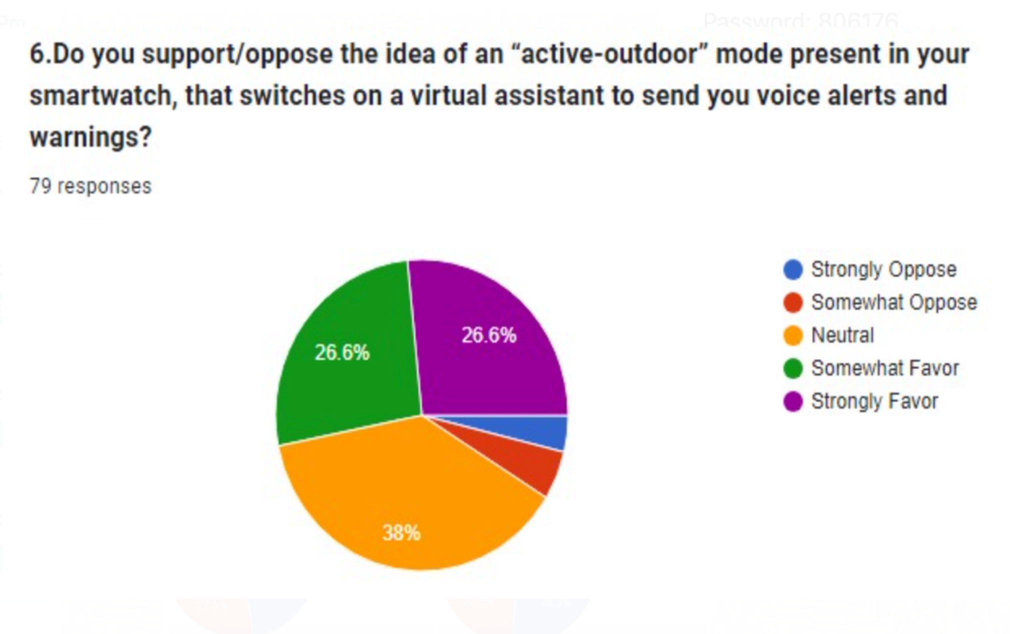
Interest in Collision Detection Smartwatch: Approximately 70% of respondents express a likelihood of purchasing a smartwatch with enhanced collision detection features, demonstrating a strong market interest in such devices.

Figure 4-Graphical analysis for Question 4



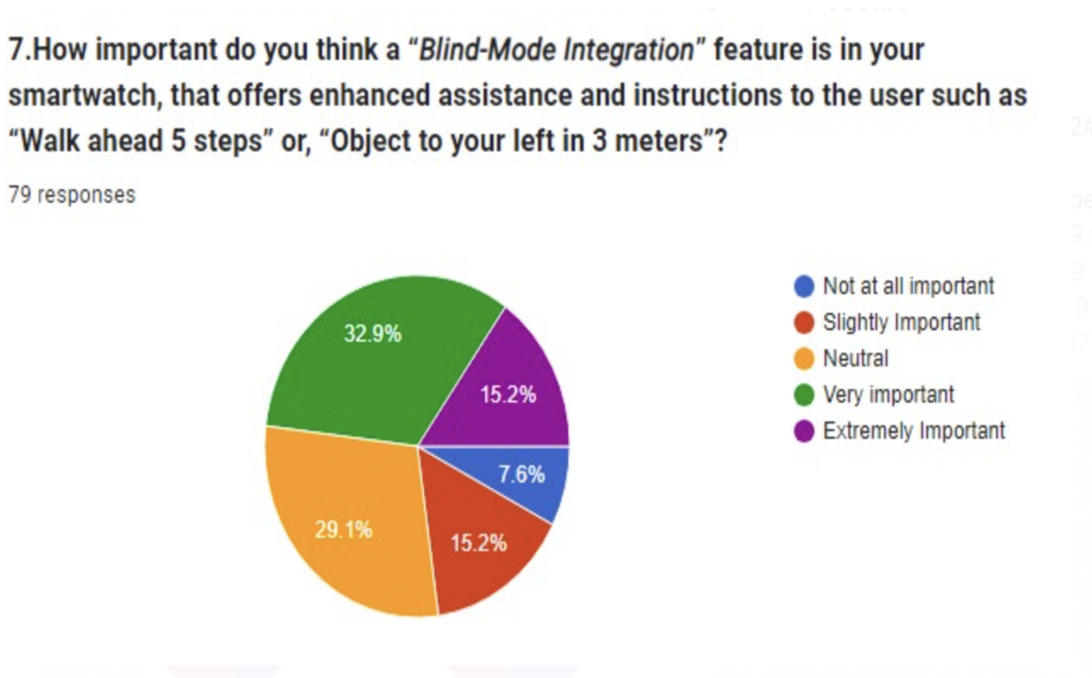
Active-**Outdoor Mode:** A considerable percentage (53.2%) either strongly or somewhat favors the idea of an "active-outdoor" mode in smartwatches, indicating user interest in voice alerts and warnings during outdoor activities.

Figure 5-Graphical analysis for Question 6



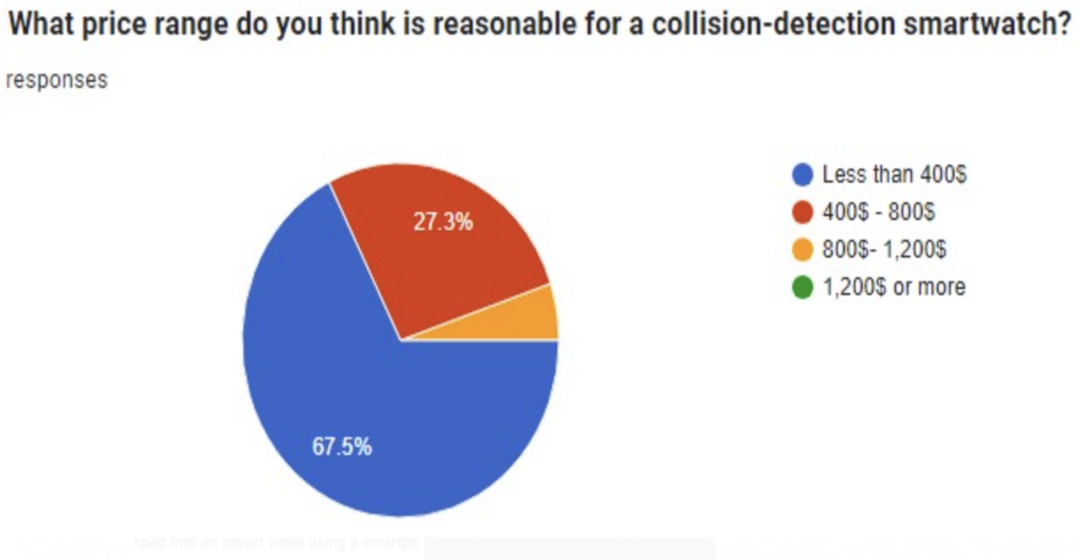
Blind-Mode **Integration:** Respondents consider the "Blind-Mode Integration" feature important, with 48.1% finding it slightly to extremely important, underscoring the need for enhanced assistance and instructions in smartwatches.

Figure 6-Graphical analysis for Question 7



Price Expectations: The majority (67.5%) expect a reasonable price range for a collision-detection smartwatch to be less than $400, signaling price sensitivity among potential customers.

Figure 7-Graphical analysis for Question 8

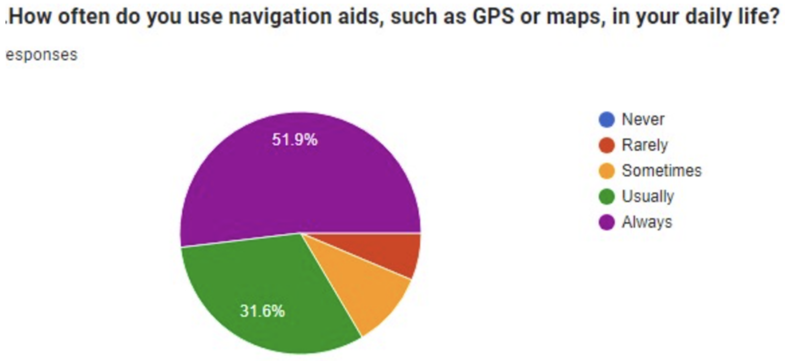


Satisfaction with Current Watches: Over 70% of respondents express satisfaction levels of 3 or higher (on a scale of 1 to 5) with their current watch products, indicating a generally content customer base.

Figure 8-Graphical analysis for Question 9

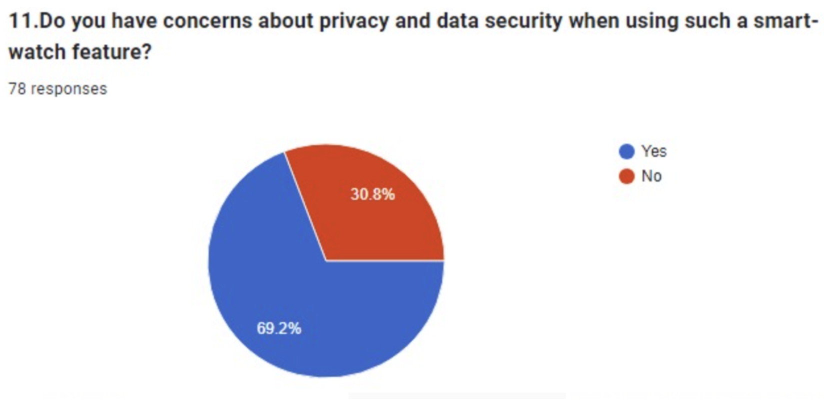
Navigation Aid Usage: A large portion (82.5%) report using navigation aids, such as GPS or maps, frequently, suggesting an active user base that could benefit from added safety features.

Figure 9-Graphical analysis for Question 8



Privacy Concerns: The data reveals that privacy and data security are significant concerns for the majority (69.2%) of respondents, highlighting the need for robust privacy controls in smartwatch technology.

Figure 10-Graphical analysis for Question 11



In conclusion, the survey data indicates a strong market potential for collision-detection smartwatches among pedestrians. Respondents are open to such devices, provided they offer value in terms of safety features, pricing, and privacy protections. Manufacturers should take note of the significant demand for intelligent safety solutions in the wearable technology market.

Actual customer wants/needs list

This list was shortlisted after customer validation of 80 responses for a total of 11 Survey questions.

Table 1-Customer Needs and Wants with Importance Rating determined using Customer Survey

Customer Requirements	Need/Want	%weightage	Importance Rating
Customization of Blind Mode Integration	Need	14.29	9
Compatibility of Active Outdoor Mode	Need	11.11	7
Accuracy of Alerts	Want	12.70	8
Efficient Battery system	Need	12.70	8
Cost Effectiveness	Need	11.11	7
Privacy of User Data	Need	12.70	8
User-friendliness	Want	11.11	7
Safety	Need	14.29	9

SURVEY ANALYSIS OF QUESTIONNAIRE

In analyzing the survey data, several key insights emerge regarding the potential adoption and preferences related to the Acoustic Collision Detection Smart Watch Feature for pedestrians. Firstly, a notable majority of respondents (41.3%) report commuting by foot more than three times a day. This finding indicates a significant demand for solutions that enhance safety and awareness during pedestrian activities. Furthermore, over half of the respondents (58.8%) have previous experience using a smartwatch, suggesting a level of familiarity with wearable technology.

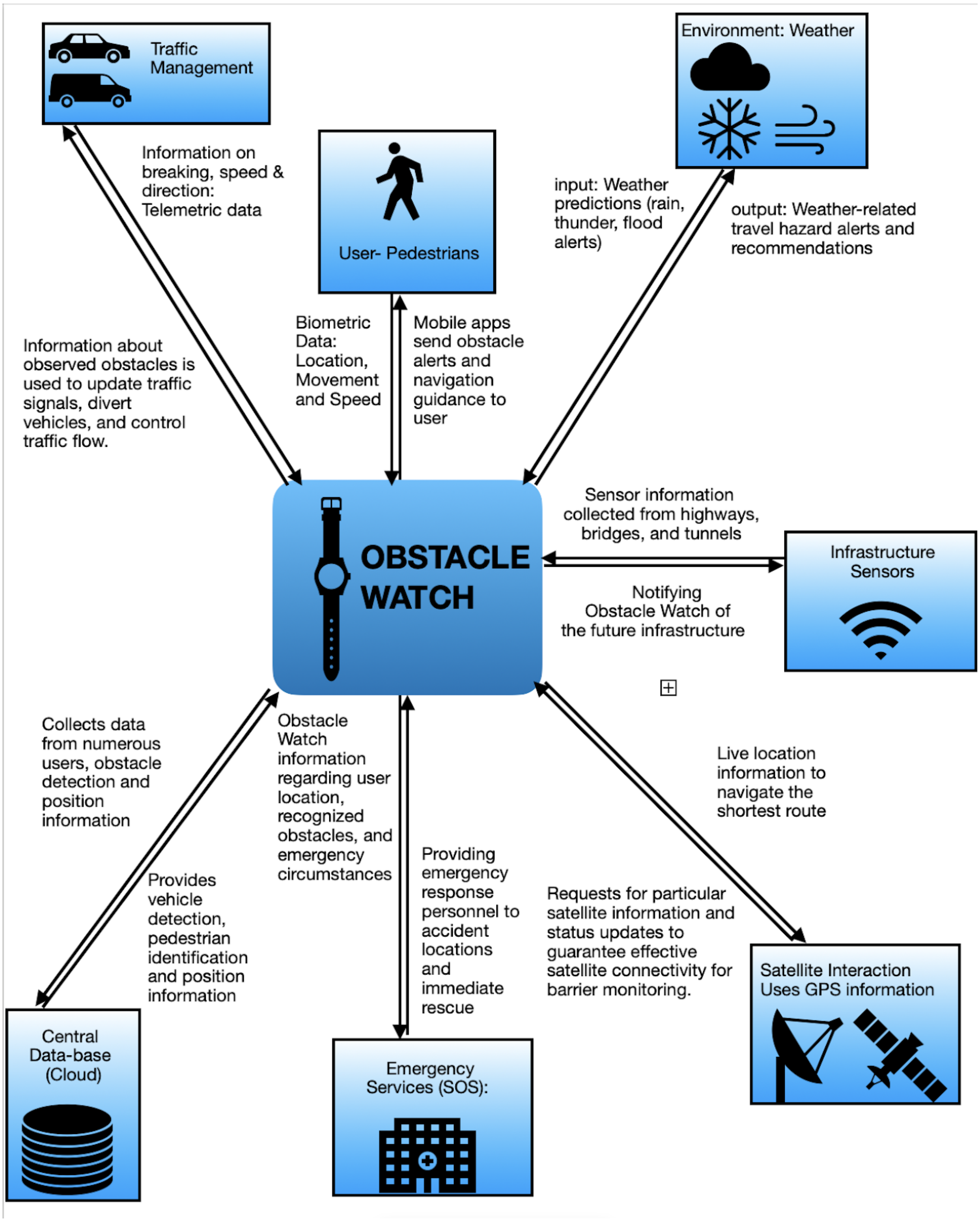
Secondly, the survey indicates a substantial willingness among respondents to embrace innovative features. Nearly 70% of participants expressed interest in purchasing a smartwatch equipped with enhanced intelligence for collision detection and obstacle alerts. Moreover, the majority (75%) report that they rarely get distracted by their smartphones during their commutes, which suggests that users may appreciate a complementary technology that augments their awareness without causing distractions.

Lastly, the survey highlights concerns related to privacy and data security. A significant majority (69.2%) express apprehension about privacy when using such smartwatch features, emphasizing the importance of robust privacy controls and data security measures in the development of this technology. Overall, the survey data underscores a substantial market for collision-detection smartwatches, given the demand for safety-enhancing features and the existing interest in smartwatch technology. To succeed in this market, manufacturers must prioritize user privacy and data security, and ensure that their products align with user preferences and commuter habits.

In summary, the survey data reveals a promising market for smartwatches equipped with collision-detection features, with most respondents expressing interest in purchasing such devices. This interest is fueled by the desire for enhanced safety during pedestrian activities and an evident familiarity with smartwatch technology. However, data security and privacy concerns must be addressed to gain users' trust. Overall, these findings provide valuable insights for the development and marketing of Acoustic Collision Detection Smart Watch Features and similar wearable technologies.

CONTEXT DIAGRAM

Figure 11-Context Diagram for Acoustic- Collision Detection Smart Watch


Traffic Management
Information on breaking, speed & direction: Telemetric data
Information about observed obstacles is used to update traffic signals, divert vehicles, and control traffic flow.
User- Pedestrians
Biometric Data: Location, Movement and Speed
Mobile apps send obstacle alerts and navigation guidance to user
Environment: Weather
input: Weather predictions (rain, thunder, flood alerts)
output: Weather-related travel hazard alerts and recommendations
OBSTACLE WATCH
Sensor information collected from highways, bridges, and tunnels
Infrastructure Sensors
Notifying Obstacle Watch of the future infrastructure
Collects data from numerous users, obstacle detection and position information
Provides vehicle detection, pedestrian identification and position information
Central Data-base (Cloud)
Obstacle Watch information regarding user location, recognized obstacles, and emergency circumstances
Providing emergency response personnel to accident locations and immediate rescue
Emergency Services (SOS):
Live location information to navigate the shortest route
Requests for particular satellite information and status updates to guarantee effective satellite connectivity for barrier monitoring.
Satellite Interaction Uses GPS information

INTERFACES

Table 2-Interfaces for Acoustic- Collision Detection Smart Watch

Interface	Input/Output	Type	Description
Infrastructure sensors	Input: Output:	Hardware	Sensors to capture ambient sounds, motions to detect potential hazards like horns or fast approach
Bluetooth/Wi-Fi Module	Input: Output:	Hardware	Communicate with the paired smartphone and receive/send data.
Sensor Analysis software	Input: Output:	Software	Analyze data to determine user motion direction and sound.
Smartphone Interfacing App	Input: Output:	Software	Communicate between the smartwatch and smartphone, relay alerts, and possibly pause distractions.
User Profile & Preferences	Input & Output	Software	Store and provide customization settings like alert sensitivity, notification preferences, etc.
Haptic Feedback Algorithm	Input & Output	Software	Determine vibration patterns based on the level of threat and user settings.
History Log	Output	User Interface	Display past alerts with timestamps for user review.
Tutorials & Guides	Output	User Interface	Provide guidance on how to use the watch effectively.
Vibration Patterns	Output	Alert	Different patterns to signify the level of threat, e.g., single vs. repeated vibrations.

Visual Alerts	Output	Alert	Color-coded warnings on the watch display indicating the threat level.
Audible Alerts	Output	Alert	Beeps or voice warnings for hazards, played through earphones or the phone's speakers.
Battery & System Health	Output	Safety Protocol	Check system health and warn users if the battery is low or a malfunction is detected.

SCOPE OF THE SYSTEM UNDER CONSIDERATION

Physical Boundaries:

In a smartwatch, physical boundaries are associated with tangible components and constraints proposed by Hardware Components, Accessibility Features, and Battery life. Hardware components refer to the physical components of a smartwatch such as sensors, displays, buttons, and haptic feedback mechanisms.

Enclosures refer to the durable and seamless titanium alloy casing or housing of the smartwatch that is designed for durability.

Accessibility features are created to elevate the experience of users who are visually impaired. These features are tactile buttons and voice dictation. A virtual assistant is activated by using the Blind Mode Feature for directional assistance. For automatic activation and deactivation, the feature has an integrated calendar setting. A visually impaired user can take advantage of the virtual assistant to dictate his outdoor schedule. Operation is similar for an athlete who uses an active outdoor mode.

Battery Life is the power source of the smartwatch which supports the required functionality.

Business Boundaries:

These boundaries encompass various aspects of the business ecosystem associated with the smartwatch which includes Market Segments, Distribution, Partnerships, Pricing strategies, and Regulatory compliance.

Market segments represent the target market of consumers, who prefer the bind mode integration such as the elderly aged 55+ or the visually impaired. Another category that desires the Active outdoor mode is teens aged 14-19 years and 20+

Regulatory Compliance would mean adhering to disability regulations and standards.

Distribution refers to retailing the product to customers directly firsthand or distributing to 3rd party vendors and wholesalers' cross-country.

Partnerships are directed to organizational collaborations that offer technological solutions for the visually impaired.

Pricing Strategy is set on the features and customer requirements and expectations of such a product. Previously a customer survey conducted through this report highlights the preferred price range of consumers.

Process Boundaries

In a smartwatch with blind mode integration relates to functional and operational aspects of a device's lifecycle.

Design and Development: The Blind mode Integration is defined such that it is only accessible to people with visual impairment. Other users might not require the level of detailed instructions from a virtual assistant.

Quality assurance: Testing and quality control ensures that the Blind mode functions as intended. Types of testing may include usability, performance, compatibility, security, integration, privacy (UAT) User Acceptance and (UI) user interface testing. Quality control measures for the blind mode must be an ongoing process to ensure the blind mode and active outdoor mode are reliable, accessible and meet the needs of the visually impaired.

User training and support: This area is critical for Blind mode users. A specific support system must dedicate specialized training to help the Visually impaired take advantage of this feature. An on call support can always be accessed by voice dictation to the Virtual Assistant. The virtual assistant is active at all times. The training and support is not limited to the visually impaired but on call assistance is also available to users operating the Active outdoor mode.

Software Updates: Updates are attributed to every feature, display and app embedded within the watch.

Accessibility Testing: To refine and enhance user experience of the visually impaired usability and accessibility testing is required.

Information Boundaries

Concentrate on the data and information managed by the smartwatch system with active outdoor and blind mode integrations. This culminates user data, accessibility settings, health, alert filtering, virtual assistant, obstacle detection, and network data.

Personal user preferences regarding virtual assistant guidance, alerts, and notifications must have a privacy lock.

Accessibility settings on the configuration and customization of the smartwatch must be shielded.

The Machine learning algorithm is constructed such that it creates prediction models and analyzes live data gathered from radars (LIDAR, SONAR) and transmits the result to the Microcontroller to issue the alert.

OPERATIONAL REQUIREMENTS AND TECHNICAL PERFORMANCE MEASURES

Table 3-Operational Requirements and Technical Requirements for Acoustic- Collision Detection Smart Watch

Operational Requirement	TPM	Unit	Target Value
Sensor Technology: Aims to detect obstacles within a certain range	Range for Accuracy	Meters	2-5 meters
Auditory feedback from a virtual Assistant for Navigation	Clarity and Sound Quality	THD (Total Harmonic Distortion)	>1% is Excellent
Real-Time Processing: To analyze data as quickly as possible	Latency	Milliseconds	< 100 milliseconds
Machine Learning Algorithms: For better decision-making and Predictions	Measures how well the model fits the data	R^2	0-1, If >1 Better fit of data

Smartwatch Battery Optimization: To ensure an elevated performance	Battery Life	Hours	2-3 days
Bluetooth Connectivity: Ensures synced devices.	Data Transfer Speed	Megabits per second	≥ 2 Mbps
App Integration: To communicate and share data from watch to phone	Compatibility	None	iOS and Android compatibility
Privacy Controls: To ensure encryption of sensitive data	User Consent	None	Clear and informed consent
Alert Filtering: Categorization of sound haptics based on severity of a predicted collision.	Precision	Percentage	≥ 90%
Cost Management	Budget Adherence	Currency (e.g., USD)	Within specified budget

R^2 (square): It is a measure of how best the Model fits the data.

Latency: The time it takes for the data to flow through the processing pipeline. Latency is critical in this scenario which works on minimizing the delay between data processing and arrival.

Total harmonic distortion (THD): A metric used to measure the harmonic content introduced by a system. Lower THD values indicate better sound quality.

HOUSE OF QUALITY

Procedure for House of Quality:

1. Determine the consumer attributes and engineering characteristics that are required.

2. Ascertain relationships between customer attributes and engineering characteristics (weak, moderate, strong).

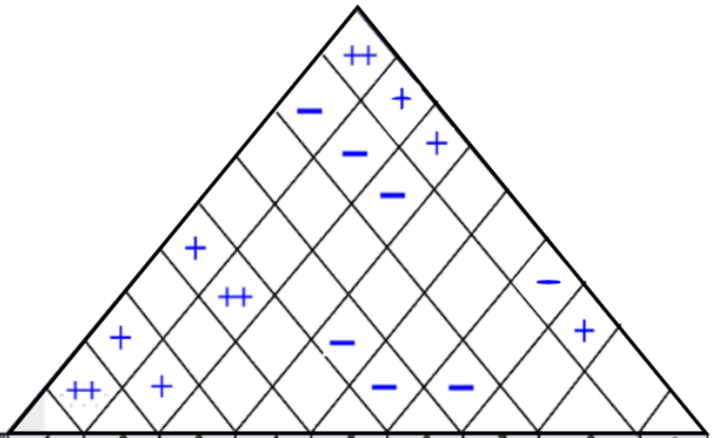
3. Based on importance, assign relative weights to consumer attributes.

4. Calculate the impact scores and prioritize the engineering characteristics.

5. The QFD matrix can be used to direct product development and quality improvement activities.

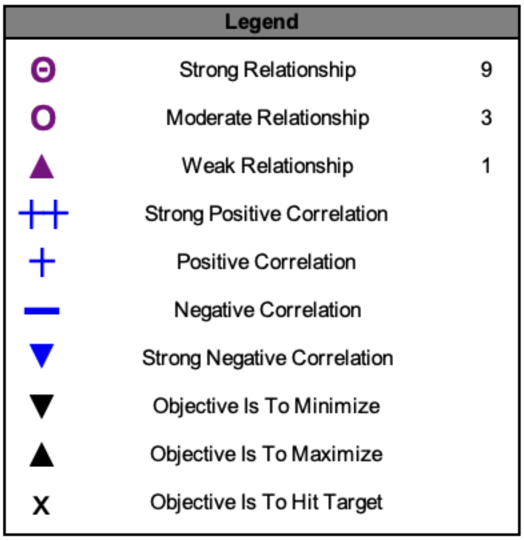
Customers - Pedestrians and Smartphone Users, Parents and Guardians, Elderly Population, Commuters and City Dwellers, Smartwatch Manufacturers, Insurance Companies, Health and Fitness Enthusiasts, Government and Municipal Authorities, Safety Advocacy Groups, Businesses and Corporations

Figure 12 -House of Quality



Row #	Relative Weight	Weight / Importance	Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") / Demanded Quality (a.k.a. "Customer Requirements" or "Whats")	1 sensor Technology	2 Machine Learning Algorithms(Heptic Feedback Algorthim)	3 Smartwatch Battery optimization	4 Bluetooth connectivity	5 APP Integration(smartphone Interfacing APP)	6 Privacy Controls	7 Alert Filtering	8 Cost Management	9 Active Audio Feedback (Virtual assistance)
1	14.3	9.0	Safety	Θ	O	O	O	▲	Θ	Θ	▲	O
2	12.7	8.0	Alert Accuracy	Θ	Θ	▲	▲	▲	Θ	▲	▲	Θ
3	11.1	7.0	User-Friendliness	O	O	O	O	▲	Θ	Θ	▲	Θ
4	14.3	9.0	Customization(Blind mode integration)	Θ	Θ	▲	▲	Θ	O	▲	▲	O
5	12.7	8.0	Battery Efficiency	▲	O	Θ	O	O	▲	O	▲	▲
6	11.1	7.0	Compatibility(active outdoor mode)	▲	▲	O	Θ	Θ	▲	▲	▲	Θ
7	12.7	8.0	Privacy	▲	▲	▲	Θ	Θ	O	O	▲	O
8	11.1	7.0	Cost-Effectiveness	O	▲	O	▲	Θ	O	▲	O	▲
			Target Values	Range Accuaracy (2-5 meters)	Processing Efficiency (4 Quad)	Extended Battery Life (2-3 days)	Data Transfer Speed(≥ 2 Mbps)	Seamless Compatibility(iOS and Android compatibility)	User Consent(Clear and informed consent)	Low False Positives(≥ 90%)	Efficient Resource Use(Within specified budget)	Clarity and sound quality
			Weight / Importance	474.6	392.1	296.8	366.7	519.0	481.0	354.0	122.2	461.905
			Relative Weight	13.7	11.3	8.6	10.6	15.0	13.9	10.2	3.5	13.32

Figure13 - Legend for attributes in House of Quality



PRIORITIZATION OF OPERATIONAL REQUIREMENTS

Result: Operational requirements have been prioritized in Figure 12 . Operational requirements Importance ratings were calculated by forming a relationship matrix between Customer Importance ratings and operational requirements relevance ratings. The result summarizes that Seamless compatibility (rated: 541.3) is extremely critical for app integrations, and data transmissions from a smartwatch to a phone. If interfaces are incompatible the system is dysfunctional since the visibility of alerts will be canceled.

The second in line is the user consent with an overall rating of 449.2. User consent during user ID setup on the device is necessary to activate "Blind mode/Active Outdoor mode" or to receive any navigation guidance from a virtual assistant or alerts, and notifications. This section also includes user preferences and customizations. The 3rd on the list is "Range Accuracy" at 338.1. This operational requirement states that an alert, vibration, or instructions from a virtual assistant must be extremely accurate in its timing. It must occur within the safest clearance (2-5 meters) between an approaching obstacle and the user to ensure safety. For which SONAR and LIDAR sensors must be highly responsive. Range Accuracy is followed by Low false positives, which determines the possibility of an error and processing efficiency.

MAINTENANCE CONCEPT

Figure 14-Maintenance Flow Diagram

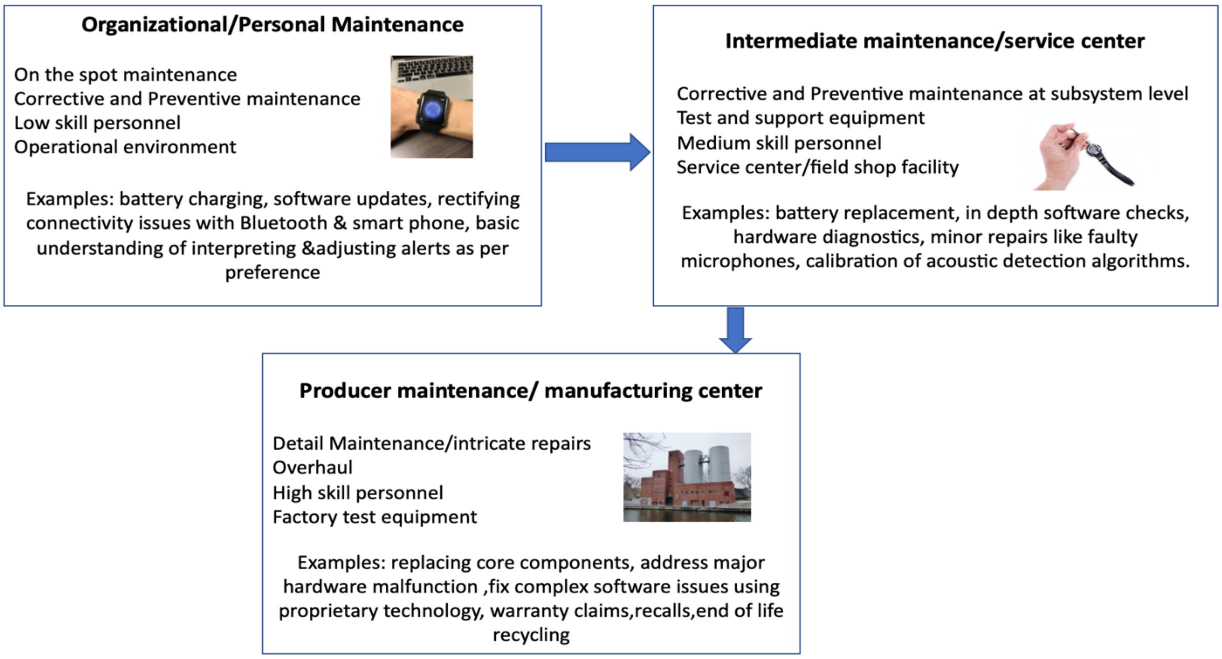
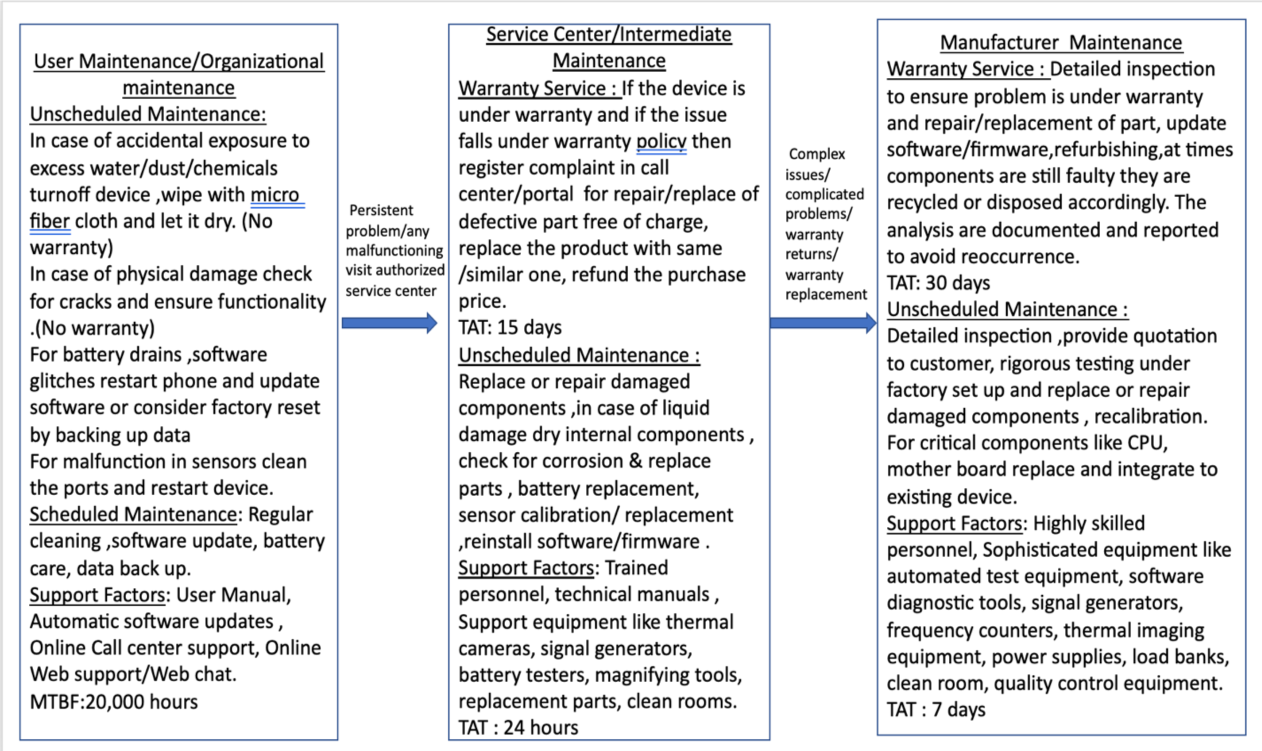


Figure 15 -Repair Policies



WARRANTY POLICY

The Acoustic-Collision Detection Smart Watch is covered by a limited warranty and covers a duration of 12 months from the date of purchase. The warranty is originally valid for the purchaser and is non-transferable.

A standard warranty covers defects in materials and workmanship of the product, malfunction of sensors due to manufacturing defects, reduced battery capacity or failure under normal use, and software or firmware malfunction.

The warranty does not cover damage resulting from shipment, misuse, poor storage, not adhering to product instructions, unauthorized modifications or repairs, physical damages due to accident, excess exposure to water or chemicals, issues related to the app not being installed by the company, situations beyond the control of the manufacturer.

If a purchaser’s claim fits the standard requirements of warranty coverage, the company will either replace the item with a new or refurbished item or repair it using new or refurbished parts. Components, craftsmanship, and freight for the return will all be paid for by the manufacturer. To claim the warranty, file a complaint with the call center or portal, get the issued ticket number, and follow the instructions in the email that was provided to the registered email address.

Table 4-*Maintenance Details on Visual Displays*

	Level of maintenance	1	2	3,4
Components of smart watch	Criteria	Organizational maintenance	Intermediate Maintenance	Manufacturer/Depot maintenance
	Done where			

Electronic visual displays using Liquid Crystal Displays		Done at the operational site	Done at the authorized service center/store	Done at the factory/manufacturing set up with test facility
	Done by whom	Done by users themselves with minimum skills	Done by service technicians with medium skills	Done by service experts with high level of skills
	On whose equipment	Users smart watch	Users smart watch	Users smart watch
	Type of work accomplished	Visual inspection with cleaning using a microfiber with a screen cleaning solution. External adjustments such as turning off the display when not in use for extended periods. Avoiding static	Detailed inspection and system checkout for software or firmware updates. Backlight replacement. Specialized equipment can be used to attempt to revive stuck pixels. Diagnosis and replacement of faulty	Complicated factory adjustments and advanced calibrations to ensure uniformity and accuracy in screens, major hardware overhaul for components of display, addressing other systemic issues related to display.

		images for extended periods to avoid burn in from image persistence. Operational check on brightness & contrast as extremely high settings can lead to quicker wear.	capacitors that cause power issues.	

Table 5-*Maintenance Details on Battery*

Rechargeable Lithium-ion Battery for smart watch	Done where	Done at the operational site	Done at the authorized service center/store	Done at the factory/manufacturing set up with test facility
	Done by whom	Done by users themselves with minimum skills	Done by service technicians with medium skills	Done by service experts with high level of skills

	On whose equipment	Users smart watch	Users smart watch	Users smart watch
	Type of work accomplished	Visual inspection to ensure periodic partial charging rather than drain out or 100% always charge. Always use the recommended charger. External adjustments such as avoiding extreme temperatures	Detailed inspection and safety check for swelling, leakage, or visible signs of damage to battery. Firmware updates for smart battery management systems. Diagnostic test and battery replacement if necessary.	Complicated factory adjustments and advanced calibrations for smart battery management system. Overhaul and rebuild battery as per standards.

		for extended battery life and efficiency.		

Table 6-*Maintenance Details on Sensors for crash detection*

Sensors used by smart watch for obstacle detection	Done where	Done at the operational site	Done at the authorized service center/store	Done at the factory/manufacturing set up with test facility
	Done by whom	Done by users themselves with minimum skills	Done by service technicians with medium skills	Done by service experts with high level of skills
	On whose equipment	Users smart watch	Users smart watch	Users smart watch
	Type of work accomplished	Software updates as some updates may include	Detailed inspection and diagnostic	Complicated factory adjustments to inspect damages and

		calibration or improvements for sensors. Users are suggested to avoid physical damage as it could damage sensors. Operational checkout by restarting the device if there are issues. Visual inspection by cleaning ports regularly.	check to ensure sensors functioning and to make sure there are no residues on sensors. Calibration of sensors or replacement of sensors. Software and firmware updates.	corrosion to replace or perform advanced calibrations to ensure sensors are functioning as intended. For example, accelerometers are calibrated to ensure precision in motion sensing. High level of expertise and care are equipped to identify problems to perform complex equipment repair and modifications. Software and firmware update at factory test setup.

Table 7-*Maintenance Details on the Central Processing Unit*

Central Processing unit- CPU	Done where	Done at the operational site	Done at the authorized service center/store	Done at the factory/manufacturing set up with test facility
	Done by whom	Done by users themselves with minimum skills	Done by service technicians with medium skills	Done by service experts with high level of skills
	On whose equipment	Users smart watch	Users smart watch	Users smart watch
	Type of work accomplished	Regular software updates to fix bugs and optimize CPU performance, avoiding overloading of apps simultaneously, periodic restarting	Detailed inspection and diagnostic test to ensure CPU's condition and replace if necessary. Inspect the check for overheating.	Complicated factory adjustments and advanced diagnostics to check deep rooted issues such as overheating, lagging, processing errors which are not visible at service center.

		can clear software glitches.	Complicated adjustments and repairs on CPU. Update firmware to optimize CPU.	Firmware is reinstalled. Surrounding components are tested for malfunction. If issues are found and if parts are defective entire motherboard or main circuit is replaced.

FUNCTIONAL ANALYSIS AND REQUIREMENT ALLOCATION

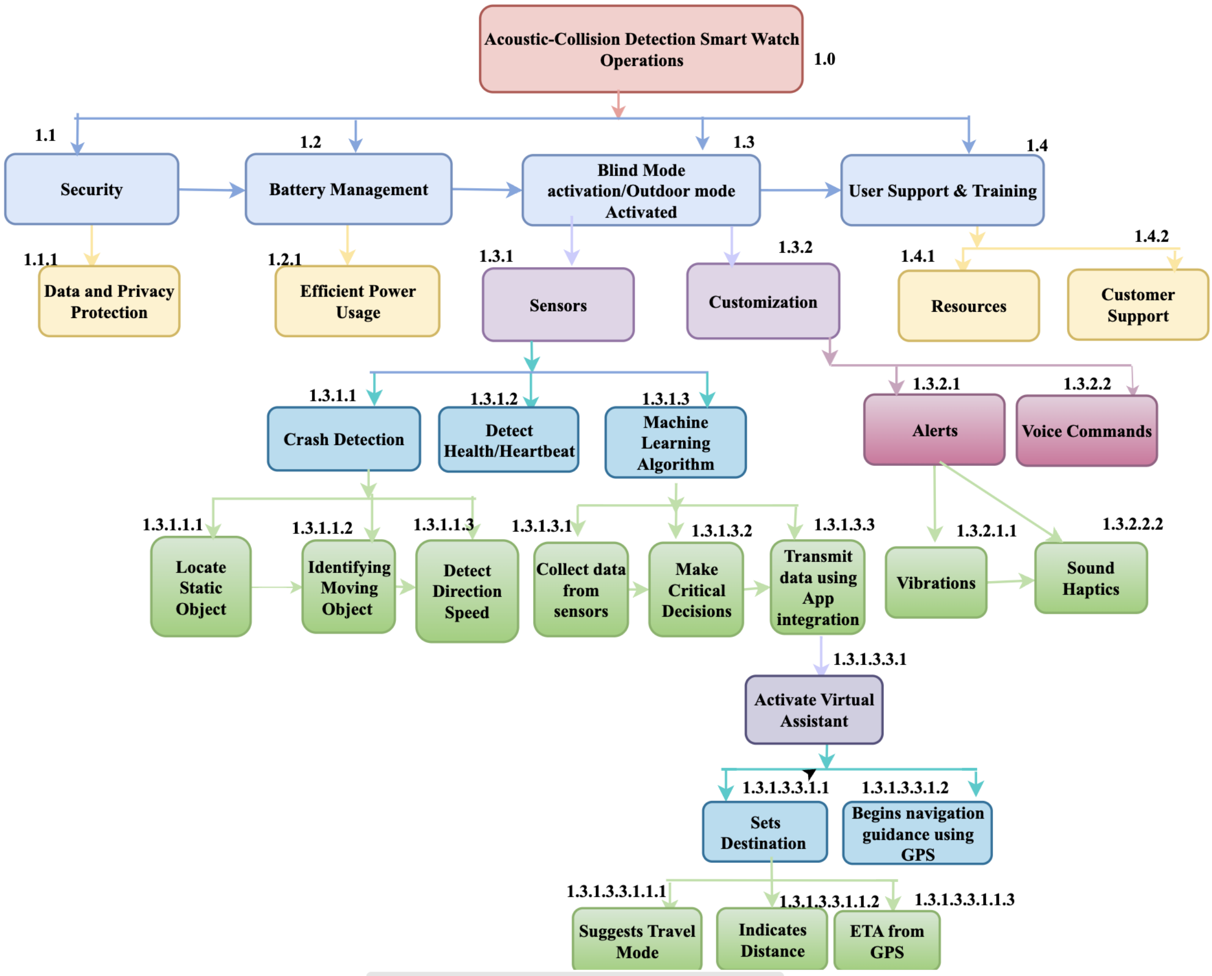
Description: The functional analysis diagram in Figure 16 aims to highlight all the functions taking place in the hardware and software operations of the smart watch. This diagram does not focus on the manufacturing of the watch, rather it focuses on its compatibility with the interfacing systems and functionality of components within the casing. The diagram indicates sequence and hierarchy of each action performed. Followed by this will be the functional requirements which display the TPM (technical performance measures attributed to each node) . Operation of the Blind Mode feature is most critical in Figure 16. It is followed by Sensors and Customization by user, since sensors detect and gather information, and customization filters unnecessary information relayed to the user.

Table 8-*Requirement Analysis for Functional Diagram*

Operational Requirement	Nodes	TPM	Target values
Sensor Technology	1.3.1	Range	Range b/w 2-3 meters
Crash Detection	1.3.1.1		
Machine Learning Algorithm	1.3.1.3	R^2	0-1,if >1 Better fit of data
Alerts	1.3.2.1	THD	
Sound Haptics	1.3.2.2.2	THD	
Real -Time Processing	1.3.1.3	milliseconds	<100 milliseconds
Battery Optimization	1.2	Hours	2-3 days
Efficient Power Usage	1.2.1		
Privacy Controls	1.1.	% Acceptance	>50%
Data and Privacy	1.1.1		

Protection		
Cost Management	1.3	Budget
Customization	1.3.2	

Figure 16-*Functional Analysis for Acoustic Collision Detection Smart Watch Operation*



LIFE CYCLE COSTING

Life cycle costing is made up of the CBS (Cost break-down structure) shown below which gives a general outline of cost categories associated with developing and manufacturing a technologically advanced acoustic-collision detection smartwatch system. It collectively points out every dollar associated with design, development, manufacturing, and distribution that decides the cost of a collision detection Smartwatch.

Below is a Cost Breakdown structure of all the phases and Sub-phases. It quantifies all the costs that will be added to the Life cycle costing. (COST ESTIMATING , March 2020)

Table 9 -*Cost BreakDown for Miscellaneous Costs*

Miscellaneous Costs	Amount ($) (per year)
Warranty and returns	$100,000
Legal and Compliance	$200,000
Contingency	$500,000
Total Miscellaneous Costs	**$8,00,000.00**

Table 10-*Cost Breakdown for Project Management and Contingency Cost:*

Project Management and Contingency Cost	**Amount ($) (per year)**
Project Management and Oversight	$300,000
Project Contingency	$500,000
Total Project Management and Contingency Cost	**$800,000**

Table 11-*Cost Breakdown for Manufacturing and Production Cost*

Manufacturing and Production Cost	**Amount ($) (per year)**
Manufacturing Setup	$3,000,000
Tooling and Molds	$500,000
Production Run	$10,000,000
Total Manufacturing and Production Cost	**$13,500,000**

Table 12 -*Cost Breakdown for Software Development and Integration Cost*

Software Development and Integration Cost	**Amount ($) (per year)**
Operating System	$300,000
App Development	$500,000
Software Updates	$200,000
Total Software Development and Integration Cost	**$1,00,000**

Table 13-*Cost Breakdown for Marketing and Sales Cost*

Marketing and Sales Cost	**Amount ($) (per year)**
Marketing and Advertising	$2,000,000
Sales and Distribution	$3,000,000
Retailer Commissions	$1,000,000
Customer Support	$500,000
Sales and Marketing Collateral	$100,000

Total Marketing and Sales Cost	**$6,600,000**

Table 14-*Cost Breakdown for Overhead and Administrative Costs*

Overhead and Administrative Costs	Amount ($) (per year)
Office Space and Utilities	$500,000
Employee Salaries and Benefits	$1,200,000
Research and Development	$300,000
General and Administrative	$150,000
Total Overhead and Administrative Costs	**$2,150,000**

Table 15-*Interest rate & Present Value specification*

Interest Rate	10%
Used excel Financial Formula to estimate PV	
(Present Value)	=POWER (1+Discount rate, Years) *Total cost (for 5yrs)

Figure 17-*Shows the life cycle costs over a 5-year period and estimates the Net Present worth*

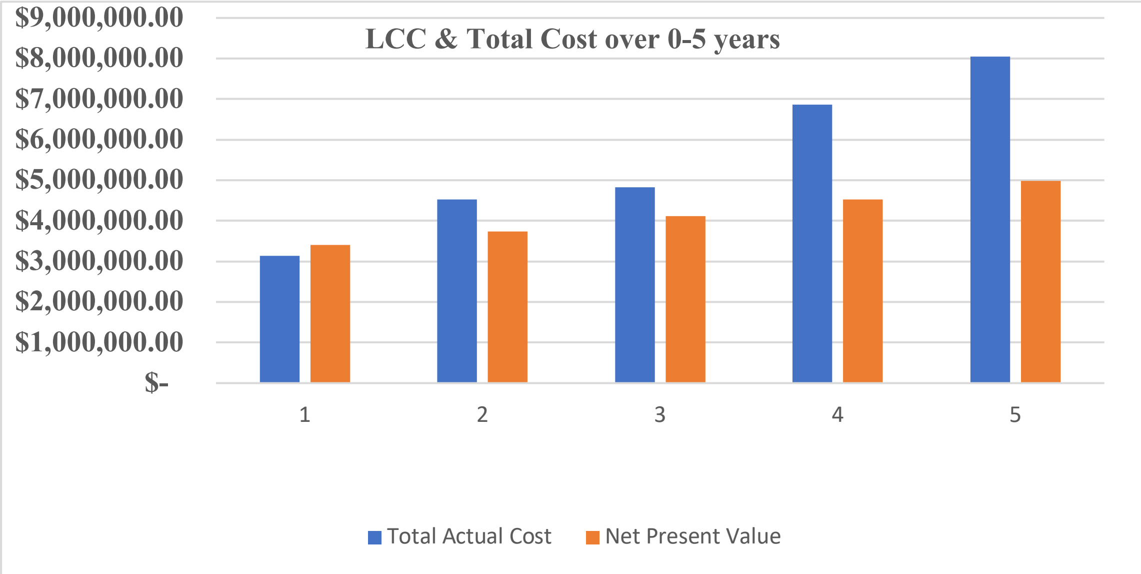
Project Phase	Cost Category	Years	2024	2025	2026	2027	2028	Total Actual Costs
Phase 1	Designation		1	2	3	4	5	
Research and Devlopment	Cr	Market Research And Analysis	$ 50,000.00					$ 50,000.00
		Feasibility Studies	$ 20,000.00					$ 20,000.00
		Concept Development	$ 80,000.00					$ 80,000.00
		Business Case Development	$ 30,000.00					$ 30,000.00
Phase 2								
Design and Manufacturing Setup	Cd	Designing and Prototyping	$300,000.00	$350,000.00	$400,000.00	$500,000.00	600,000	$2,150,000.00
		Intellectual Property	$50,000.00	$60,000.00	$70,000.00	$90,000.00	110,000	$ 380,000.00
		Engineering and Development	$500,000.00	$600,000.00	$700,000.00	$900,000.00	1,100,000	$ 3,800,000.00
		Regulatory Compliance	$60,000.00	$75,000.00	$90,000.00	$120,000.00	150,000	$ 495,000.00
Phase 3								
Production and construction	Cp	Materials and Components	$200,000.00	$220,000.00	$240,000.00	$280,000.00	320,000	$ 1,260,000.00
		Manufacturing and Production	$500,000.00	$1,600,000.00	1,320,000	$2,730,000.00	$3,040,000.00	$ 9,190,000.00
		Software Development and Integration	$100,000.00	$190,000.00	$270,000.00	$290,000.00	350,000	$ 1,200,000.00
Phase 4								$ -
Operations and Support	Co	Marketing and Sales	$660,000.00	$777,000.00	$945,000.00	$1,091,000.00	1,450,000	$ 4,923,000.00
		Overhead and adminitrative Expenses	$430,000.00	$ 458,000.00	$559,000.00	$ 572,000.00	$602,000.00	$ 2,621,000.00
		Miscellaneous Costs	$80,000.00	$96,000.00	$120,000.00	$144,000.00	160,000	$ 600,000.00
		Project Management and Contingency	$80,000.00	$96,000.00	$120,000.00	$144,000.00	160,000	$ 600,000.00
		Total Actual Cost	$ 3,140,000.00	$ 4,522,000.00	$ 4,834,000.00	$ 6,861,000.00	$ 8,042,000.00	$ 27,399,000.00
		Total Present Value of Cost	$17,012,623.33	$18,713,885.66	$20,585,274.23	$22,643,801.65	$24,908,181.82	
		Income (20% of Actual Costs)	$3,768,000.00	$5,426,400.00	$5,800,800.00	$8,233,200.00	$9,650,400.00	$32,878,800.00
		Total Present Value of Income	$20,415,148.00	$22,456,662.80	$24,702,329.08	$27,172,561.98	$29,889,818.18	
		Net Present Value	$3,402,524.67	$3,742,777.13	$4,117,054.85	$4,528,760.33	$4,981,636.36	

Note:

Net Present value= Total Present Value of Income – Total Present Value of Cost

Income was estimated at a 20 percent profit over the actual costs.

Figure 18-*The bar plot shows the relationship between total actual cost and net present value.*



Description: From the above plot depicted in Figure 18 it can be summarized that the Actual costs are greater than the net present value, which is a concern for the firm. It must analyze and optimize the budgets more precisely. The net present value could improve if the income made exceeds 20%. Furthermore, it is necessary that the product sells at its actual value and consistently maintains demand with upcoming features. For an escalated demand of the product to take shape, it holds mandatory to analyze customer feedback when a product is released to its target market. If the response is highly positive, the profit margins will widen, i.e., the income level shall rise and as a result the Net present values will escalate.

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APPENDIX

Validation Process Details

This section depicts a customer-specific survey that was added to prioritize and quantify the attributes of customer requirements. There was a requirement added to fill out the survey, whose intention was to track the target market. Below the survey is listed with a total of 11 questions.

Hello customers, below is a quick survey to fill out, please answer only if you are a smartphone and a smartwatch user.

1.For leisure or work, how often do you commute by foot in a day?

Just once

Twice

Thrice

Greater than three times

Never

During your commute, how often do you get distracted by using a smartphone?

Rarely

Occasionally

Frequently

Always

Have you accidentally bumped into an object while using a smartphone?

Yes

No

If yes, please specify……………………………………………

Have you ever used a smartwatch and synced it with your smartphone device?

Yes

No

How likely are you to buy a smartwatch with an enhanced intelligence system that alerts you of approaching obstacles?

Very Likely

Strongly Likely

Less Likely

Not Likely

Do you support/oppose the idea of an "active-outdoor" mode present in your smartwatch, that switches on a virtual assistant to send you voice alerts and warnings?

Strongly Oppose

Somewhat Oppose

Neutral

Somewhat Favor

Strongly Favor

How important do you think a "*Blind-Mode Integration*" feature is in your smartwatch, that offers enhanced assistance and instructions to the user such as "Walk ahead 5 steps" or, "Object to your left in 3 meters"?

Not at all important

Slightly Important

Neutral

Very important

Extremely Important

What price range do you think is reasonable for a collision-detection smartwatch?

Less than 400$

400$ - 800$

800$- 1,200$

1,200$ or more

On a scale of 1 to 5, how satisfied are you with your current watch product (if applicable)?

1 - Very Dissatisfied

2-3 - Dissatisfied

3-4 - Satisfied

5 - Very Satisfied

How often do you use navigation aids, such as GPS or maps, in your daily life?

Never

Rarely

Sometimes

Usually

Always

What concerns, if any, do you have about privacy and data security when using such a smart-watch feature?

…………………………………………………………