SafeLink //

Secure ID and Alert System for Dementia Care

Team Danger // ENP 161

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Prepared for Professor James Intriligator and Neil Haigler

Summer Peterson

Joey Marmo

Fatima Tahir

Nancy Yang

Iris Guzman De Leon

Introduction and Background

Client Summary

Our client is Neil Haigler, a Tufts alum who has an implant from the body modification company *Dangerous Things*. *Dangerous Things* specializes in implantable body modifications that go beyond aesthetics, offering functional technologies such as bioluminescent implants, wirelessly powered LED implants, and NFC/RFID chips capable of storing and transmitting data.

Dangerous Things has inspired Neil to seek fresh, creative, and practical implant applications since current demonstrations feel underwhelming. Although interested and open to pursuing additional implants, Neil acknowledges the associated risks and assumes full responsibility for them. In cases where implants are not feasible due to personal or institutional limitations, wearable alternatives may be used, though they are considered less compelling. He looks forward to implants that take a creative approach.

Project Objective

Our team's project explores how implantable technologies can improve the safety and independence of individuals with dementia and their caregivers. Originally, our concept focused on medical ID implants for general users. However, through early feedback and expert interviews, particularly with Amal Graafstra (CEO of Dangerous Things), we realized that adoption of such devices is most successful when aimed at specific, high-need user groups. We therefore pivoted to designing an implant system specifically for at-home dementia care. The system integrates NFC chip technology with a digital network that helps caregivers identify and safely reunite wandering individuals when they leave a safe zone.

Background Research and Problem Statement

To narrow our project scope and identify a clear problem statement, we first conducted high-level background research on fields with potential for RFID/NFC-driven solutions. Our early research confirmed a clear market need for home security systems specialized for dementia patients and their families. Below are some key statistics highlighting the problem area we identified:

- There are an estimated 57 million dementia patients globally, with nearly 10 million cases each year (World Health Organization)
- 6 out of 10 dementia patients wander at least once (Alzheimer's Association)
- Patients who are unfound for over 24 hours risk a 50% chance of injury or death (Cleveland Clinic)

Problem Statement

Current home-safety options for dementia often feel restrictive or unreliable. Patients need dignity and independence, and families need clear, continuous assurance that their loved one is protected. To address this issue, we propose a home security system that leverages NFC technology to create a "safe zone" for patients, alerting caregivers whenever a patient leaves.

Expectations and Task Challenges

Expectations, Goals, and Objectives

Our objective for this project was to research and design the three primary components of our product. We aimed to produce the following deliverables:

- A detailed system design defining integration of real-world components with a digital platform, and addressing edge cases and errors
- Finished CAD prototype of a wearable NFC storing device
- High-fidelity interactive prototype of a digital app

Hypothesis

Going into our initial user research, we hypothesized that caregivers and family members would report a consistent desire for real-time alerts and transparent communication above all. Based on our background research, we also believed that users from both home and care facility contexts would report similar needs. We also anticipated concerns regarding the NFC implant component of the system, and began exploring the possibility of a wearable alternative from early on in the product development process.

Challenges

One of our team's biggest challenges came very early in the design process. We had initially aimed to create a generalized NFC medical ID implant, which would allow users to store medical information on their bodies for instant access by first responders. However, early expert interviews, specifically with *Dangerous Things* CEO Amal Graafstra, helped us realize that we needed to reimagine our approach. Through Amal, we learned that our initial concept had already been explored by the company VeriChip in 2004, but had ultimately failed due to a lack of practicality: The time it took to check each patient for an implant came at a high cost compared to the number of patients who actually had one. Additionally, we learned that first responders rarely utilize medical information in emergencies, focusing on patient stabilization and transport rather than treatment. As a result, we decided to pivot our concept to an entirely new NFC application. The decision to rapidly change directions challenged us to rework our timeline, and some aspects of our project had to be restarted from scratch. However, we ultimately came away with a clearer vision and a stronger product.

Another challenge that caused a significant change to our project was the high adoption barrier of implantable technologies in everyday contexts. We found that while implants present a compelling solution for patients who are prone to removing clothing and jewelry, many of the users we interviewed also had concerns about the health and safety risks of an implanted chip. We also observed that social perception surrounding implants is largely negative, shaped by false narratives about location tracking and privacy violation. For this reason, we decided to shift our focus from an implantable solution to a wearable device, while still maintaining the implant as an option for high-risk patients.

Methods

Research Methodology

We conducted qualitative research using semi-structured one-on-one interviews with caregivers and expert consultations to explore both technical feasibility and user experience.

Participant Overview

Type	Participants	Purpose	Method

Expert Interview 1 (twice)	Amal Graafstra (CEO of Dangerous Things and Vivokey)	Feasibility of implants, security standards, type of implant, and system design	Google Meet Interview
Expert Interview 2	Dr. Daniel Hannon (Tufts University)	System design and usability insights	In-person meeting
Caregiver Interview	Yuli Guzman (CNA/Private Care)	Real-world pain points and emotional impact	Zoom Interview
Older Adult At Risk of Dementia Interview	Louis Pamblanco	Attitudes toward autonomy, comfort, and technology	Zoom Interview
Caregiver of Patient with Dementia Interview	Nancy Yang	Understand the needs of caregivers	In-person Interview

Data Collection

- 6 Semi-structured interviews (ranging from 30 to 60 minutes each)
- Conducted virtual or in-person interviews with consent to remain identifiable
- Focus on daily routines, safety challenges, emotional reassurance, and attitudes toward wearable/implantable technology
- Appendix includes full question sets and transcripts.

Caregiver interviewers

Professional Caregiver — Yuli Guzman

Focus: Workflow needs, patient safety, and system usability.

The interview with the caregiver consisted of questions regarding their workflow, systems currently in place, and recommendations for a new system that would benefit caregivers.

The interview revealed many safety concerns and insight regarding dementia patients and how an implant could be effective:

1. Safety as the Primary Concern

- Caregivers prioritize immediate awareness of patients leaving safe areas, particularly for those who may become confused, disoriented, or aggressive.

2. Simplicity and Reliability in Technology

- Staff prefer tools that are easy to use, with clear, immediate, and persistent alerts.
- Alerts should integrate seamlessly into daily routines and workflows, minimizing disruption while maximizing effectiveness.
- Features such as group notifications ensure that all caregivers are informed and can respond quickly.

3. Emotional Relief and Confidence for Caregivers

- Knowing a patient's exact location reduces stress and provides reassurance, allowing caregivers to focus on quality care.
- Efficient communication tools (e.g., notifications across staff) further alleviate anxiety and improve coordinated responses.

4. Patient Comfort and Compliance

- Wearable devices are preferred over implants to respect patient comfort and autonomy.
- Placement should prevent removal by patients while remaining out of sight.

Key Needs and Requirements:

Functional Needs:

- Information on real-time last-seen location.
- Immediate, loud, and persistent alerts when a patient leaves a designated area.
- Group notifications to all relevant caregivers.
- Ability to temporarily disable alerts for planned outings, with reminders to reactivate.
- Display of key patient information (name, age, relevant medical details)

Usability Requirements:

- Intuitive interface requiring minimal training
- Alerts that are noticeable but manageable, integrating smoothly with existing workflows
- Minimal setup and maintenance to reduce caregiver burden
- Prioritizing wearables over implants for patient comfort

- Facilitate clear communication among staff to reduce stress and improve coordination

Family Caregiver — Nancy Yang

Focus: understanding the experiences, challenges, and emotional needs of a caregiver responsible for two grandparents with dementia.

The discussion explored how families manage daily safety, handle wandering incidents, and perceive implantable or wearable technologies as part of caregiving. The caregiver's insights shed light on the tension between ensuring safety and maintaining the autonomy and comfort of loved ones with cognitive decline.

The conversation revealed the following key perspectives and emotional themes relevant to designing a respectful safety system:

1. **Safety Anxiety and Emotional Reassurance**
    - The caregiver described constant fear of her grandparents leaving the house unattended and the stress caused by past incidents where police had to intervene.
    - The caregiver emphasized the need for a system that provides reassurance and peace of mind, especially when family members are not home.
2. **Preference for Proactive, Automated Systems**
    - Family members are extremely busy and favor a proactive alert system that automatically notifies caregivers when the patient leaves the home.
3. **Trust and Medical Endorsement**
    - The caregiver emphasized that medical recommendations or endorsements from a healthcare provider would strongly influence family adoption.
    - Trust in the technology depends on professional validation and clear safety assurances.
4. **Simplicity and Accessibility for Older Caregivers**
    - The caregiver noted that most family members assisting in care are in their 50s and 60s and are not tech-savvy.
    - She stressed that the interface must be clear, intuitive, and easy to manage, with direct alerts and minimal setup requirements.
5. **Comfort and Non-Invasiveness**
    - She expressed her preference for a small, minimally invasive implant over a wearable device, which her grandparents might remove or find irritating.

Key Needs and Requirements

Functional Needs:

- A proactive alert system that automatically detects when a dementia patient leaves a defined safe zone.
- RFID or NFC detection network around the building to monitor presence and trigger alerts only when necessary.
- Medical endorsements to build family trust and legitimacy.
- Escalation of the stakes if no caregiver acknowledges the alert within a set time frame.

Usability Requirements:

- Simple, easy-to-read mobile interface suitable for older caregivers.
- Low-maintenance hardware that requires no daily input or charging.
- Multi-user caregiver access, allowing family members to communicate and share updates.
- Comfortable, minimally invasive implant to ensure user compliance and long-term wearability.

Older Adult at Risk of Dementia

Early-Stage Dementia Patient Interview — Louis Pamblanco

Focus: Autonomy, comfort, and attitudes toward safety devices.

The interview focused on understanding the daily routines, feelings surrounding independence, past experiences with disorientation, and attitudes toward safety technology for older adults at risk of dementia. The participant shared insights that helped us explore how safety systems can protect users while still respecting their autonomy and privacy.

The conversation revealed the following key perspectives and emotional themes relevant to designing a respectful safety system:

1. **Independence and Self-Confidence**
    - The participant values being able to move freely and make his own decisions.

- There was an emphasis on the importance of maintaining control to feel safe and respected.

2. **Family Connection and Reassurance**
    - He has daily check-ins with his oldest daughter.
    - He described his family's concern as usual for someone his age and supportive.
    - Systems built around family networks are likely to be trusted and accepted.

3. **Technology Simplicity and Comfort**
    - He avoids using his phone unless necessary.
    - He dislikes wearing accessories such as watches or rings.
    - He expressed openness to a safety device if it was small, comfortable, and required no upkeep.
    - He is open to the idea of an implant, as long as there are no health risks. He has a pacemaker and is concerned it could be affected.

4. **Trust and Privacy Preferences**
    - He is comfortable with limited location sharing through tools like Life360, provided information is only shared with close family.
    - He prefers to have personal control over when and how the system is active.

5. **Balance Between Safety and Surveillance**
    - While recognizing the value of safety technology, he is concerned about feeling constantly tracked.
    - He prefers a system that alerts caregivers only during emergencies or confusion events rather than continuous monitoring.

Key Needs and Requirements

Functional Needs:

- Event-based alerts that activate only when disorientation or wandering occurs.
- Tiered caregiver notification system (spouse first, then primary family contact).
- Limited data sharing (time, duration, and general location only).
- Automatic caregiver notifications when the patient changes settings.
- Implementing an integrated cognitive check before the patient makes any system changes.

Usability Requirements:

- Simple and intuitive interface with clear, friendly language.
- Passive, low-maintenance hardware with no daily management required.
- Ability for the patient to independently control or disable the system.
- Positive, non-restrictive feedback, such as "Let's review this together," when prompting cognitive checks to keep patient autonomy in place.
- Create a caregiver and patient dashboard.

Expert interviews

Expert Interview - Dr. Daniel Hannon

Focus: Human–machine system design and usability logic.

Our team member Nancy Yang met with Dr. Daniel Hannon, Professor of the Practice in Mechanical Engineering at Tufts University, for an expert review and to discuss the human–machine system design for our project.

We shared our plan to use RFID detectors installed around the building to monitor whether patients with dementia remain within a defined safe zone. If the system detects that the patient has moved outside the detection radius, it will automatically send an alert to caregivers through our mobile app.

Dr. Hannon stressed the importance of balancing false alarms and missed alerts, noting that missed alerts are more critical. He suggested a tiered caregiver notification system to ensure someone always responds. Caregivers should also be able to "check in" before outings to reduce unnecessary alerts.

He highlighted that system simplicity and reliability are essential for caregivers managing multiple patients.

Key Takeaways:

- Develop a tiered caregiver alert system (primary → secondary → tertiary).
- Incorporate caregiver "check-in" and reset functions.
- Maintain a low false alarm rate without compromising safety.
- Keep the system simple, reliable, and low-maintenance.

Expert Interview - Amal Graafstra Interview 1

Focus: Feasibility and adoption of implantable technology for identification.

Our team met with Amal Graafstra, founder of Dangerous Things and CEO of VivoKey Technologies, to discuss our project exploring the use of implantable technology for medical identification. We introduced our initial concept: a medical ID implant designed for biohackers, outdoor enthusiasts, and individuals who may not always have access to traditional medical ID options. The goal was to create a system that could provide first responders with essential medical information when a person is unconscious or unable to communicate.

Amal shared insights from his extensive experience in the biohacking and implant industry. He explained that while the technical side of creating a medical ID implant is straightforward, the real challenges lie in adoption and integration. Through his previous work and conversations with EMTs, he found that emergency responders rarely rely on patient identity or medical history in the field. Their primary focus is stabilizing the patient and transporting them to a hospital, where identity and medical records can be addressed.

Key Takeaways:

- Adoption depends on clear, high-impact use cases
- Ideal application: dementia care
- Use passive NFC technology (Recommended: VivoKey Spark 2 NFC implant)
- Restrict data to identity and emergency contact info only
- Design for quick scan by first responders via smartphone
- Include privacy safeguards and limited access authorization.
- Conduct pilot testing with care centers before deployment.

Expert Interview - Amal Graafstra Interview 2

Focus: Feasibility and system design of implantable and wearable RFID/NFC technology for dementia safety monitoring.

To better understand the differences between NFC and RFID implants and how we can build a reliable system to read in real time through the skin barriers, we consulted with Amal's expertise again.

Amal drew on his experience designing and deploying commercial RFID and access-control systems to guide our hardware and system architecture decisions. He strongly recommended using the VivoKey Spark 1 implant over newer options such as Spark 2, explaining that Spark 1 operates on the NFC Type 5 vicinity protocol, which provides a longer read range and is better suited for doorway or gate-based detection. He emphasized that Spark 1 is compatible with common NFC readers and smartphones, includes Electronic Article Surveillance (EAS) features from established security standards, and offers a reliable, unique identifier (UID) for tracking individuals as they pass through monitored exits.

Beyond the implant itself, Amal stressed that detection reliability depends on system-level design, not just the chip. He recommended installing gate-style antennas at all exits, supplemented by door sensors to confirm door opening events and cameras to provide visual confirmation. This layered approach reduces false negatives and false positives, ensuring alerts are meaningful and minimizing caregiver alert fatigue.

Amal also highlighted the importance of form-factor flexibility. While implants offer higher reliability since they cannot be removed, he advised offering wearable alternatives such as rings or bracelets for families hesitant about implants. This flexibility improves adoption while still allowing consistent detection using the same Spark 1 technology.

Amal discussed deployment and adoption considerations, noting that commercial-grade gate antennas typically cost $2,500–$3,500 per door, similar to existing access-control retrofits. He suggested that insurance reimbursement or institutional adoption would be critical for scaling beyond pilot deployments. For law enforcement and first responder use, he recommended standardized implant placement, simple scanning instructions, and clear system indicators to ensure rapid identification when a wandering individual is found.

Key Takeaways:

- Recommended hardware: VivoKey Spark 1 (NFC Type 5 vicinity protocol) for increased read range and doorway detection
- Use gate antennas at all exits, supplemented with door sensors and cameras for reliability
- Layered sensing reduces false alarms and caregiver alert fatigue
- Support both implant and wearable options to improve adoption and patient compliance
- Unique ID detection at choke points enables rapid caregiver and law enforcement response
- Anticipate higher installation costs; insurance or institutional support may be required for home use

Amal sponsored a Vivokey Spark 1 implant, along with testing and demo cards shown in the appendix.

Rationale for chosen methods

We chose interviews as our primary research method because they allowed us to gather rich, qualitative insights that could not be captured through surveys or secondary research alone. Speaking directly with experts, caregivers, and individuals affected by dementia helped us uncover nuanced needs, real-world constraints, and adoption barriers that shaped our design decisions. As a result of these interviews, our team pivoted twice, refining both the problem space and the solution to better align with genuine user needs and technical realities.

User Research

To identify core product requirements, we conducted qualitative user research across multiple stakeholder groups. This included structured interviews with family members of dementia patients, professional caregivers, and experts in implantable technology. We also consulted with system design experts to inform the structure of our product.

Personas & Journey Overview

We developed personas to ground our design decisions in realistic user needs, constraints and emotional contexts. These personas were synthesized from qualitative interviews with family caregivers, professional caregivers and older adults at risk of dementia. Rather than representing hypothetical users, the personas reflect recurring patterns observed across multiple participants.

Persona 1: Ellen Anderson // caregiver, age 46

Ellen works full-time at a tech company while caring for her father, who has mid-stage dementia and needs help with daily activities such as managing his medications. When at work, she worries constantly about her father being at home alone. She has heard stories about dementia patients who wander off and get lost, and she is highly paranoid about her father leaving the house alone.

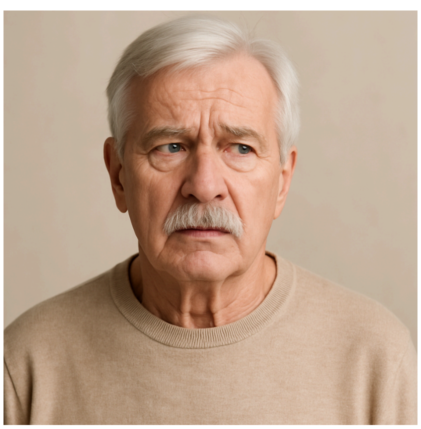
"I need something that will alert me in time to prevent harm — I can't always watch him."

Fears	**Loves**
• Her father wandering off	• Spending time with her family

• Missing an alert or emergency when away • Burnout from stress	• Her work • Technology that makes life easier
Aspirations • Maintain balance in her life • Keep her father safe while allowing him as much independence as possible • Find an automated solution that will provide peace of mind	**Traits** • Busy balancing work and her father's medical needs • Worried about the future as her father's memory lapses worsen • Analytical thinker who loves elegant solutions to problems • Uses tech to organize her life: smartwatch, home voice assistants, health and productivity apps

Familiar with: Smartphone apps, emergency alert systems, GPS tracking, smart home devices

Persona 2: Joseph Anderson // dementia patient, age 72



Joe is a mid-stage dementia patient who spends most of his time at home. He dislikes relying on others for help, but sometimes he experiences memory lapses that leave him disoriented and scared. Joe is concerned about being a burden to his family members, although he doesn't want to be placed in assisted living. He knows very little about technology but is open to solutions that are reliable and discreet.

"I don't want to be treated like a child, but sometimes I need help to make sure I don't get lost."

Fears • Losing autonomy and independence • Being isolated from family • Getting lost or injured	**Loves** • His family and friends • His home and routines there • Being connected to those around him

Aspirations	Traits
• Maintain independence and dignity • Give his family peace of mind • Stay safe	• Enjoys his home hobbies of reading and gardening • Not tech-savvy, but uses his smartphone for simple things like calling and texting

Familiar with: Medical bracelets and wearable identifiers, texting and calling apps, hearing aids, simple medical procedures (e.g. vaccinations)

Design Process

Following synthesis of research findings, we translated user needs into system-level design requirements. The design process focused on balancing safety, autonomy, feasibility and ethical responsibility while remaining realistic within a semester-long scope.

We consulted with our client to gain feedback and refine the user flows, accounting for edge cases and error states as we iterated on the initial concepts. Creating a system that can smoothly communicate errors and emergencies, as well as facilitate their mitigation by the user, was the core goal of the design process.

Concept Selection

Early concept exploration included:

- GPS-based tracking systems
- Continuous monitoring wearables
- Implant-only identification systems

Through expert feedback and caregiver interviews, we identified key limitations in these approaches, including high false alarm rates, patient resistance to wearables, and ethical concerns surrounding continuous surveillance.

Based on these findings, we selected a hybrid, event-based system combining:

- A passive NFC implant or wearable identifier
- Short-range detection using Gate Antennas at home exit points along with Camera sensors
- A caregiver-facing mobile application called Safelink

This approach minimizes invasiveness while ensuring timely alerts during safety-critical moments.

System Architecture

The proposed system consists of three primary components:

1. **Passive Identifier (Implant or Wearable)**
   Stores a unique identifier that can be detected without requiring user interaction.
2. **Home Detection Infrastructure**
   Short-range readers placed at exit points detect threshold crossings rather than tracking continuous movement. This reduces false alarms and improves location specificity.
3. **Caregiver Application**
   Displays patient status, sends real-time alerts, and supports multi-caregiver escalation and accountability.

This architecture was selected to prioritize **missed-alert prevention**, acknowledging that false alarms are less costly than undetected wandering events.

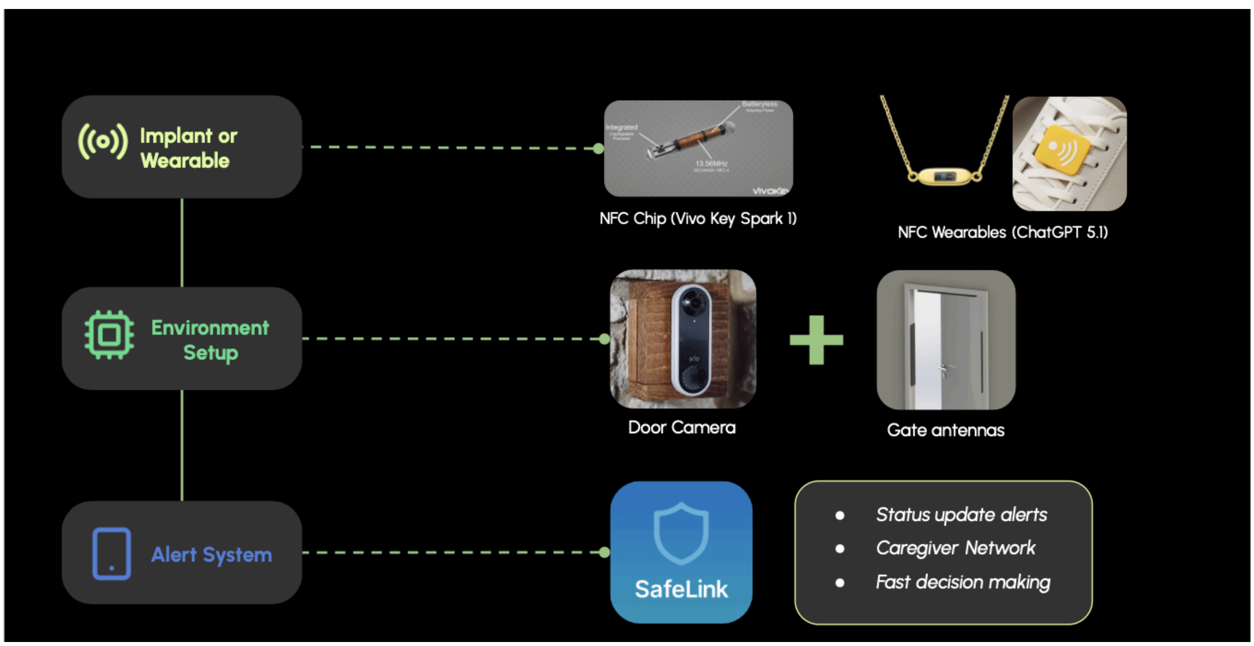


Figure: Concept Design of our alert system technology

Prototyping SafeLink Application

Based on caregiver interviews, we identified key feature requirements for the mobile application component of the product. To begin the design process, we created task analysis, early user flows and information architecture maps based off of these resources.We developed early information architecture diagrams and user flows to map key caregiver tasks, including:

- Normal home presence
- Detecting a safe zone breach
- Interpreting patient status under time pressure
- Acknowledging responsibility
- Resolving alerts and restoring system state

Figure: Early Task Analysis

(insert userflows images)

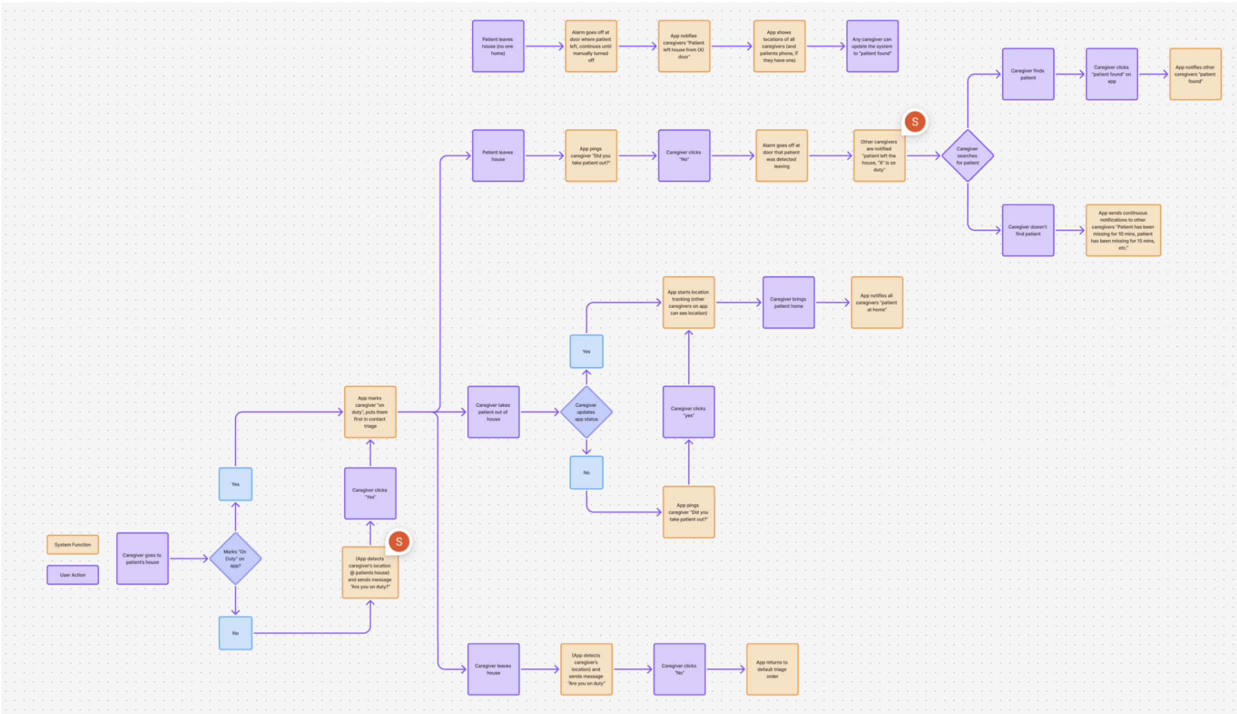


Figure: Alarm activation and edge case flows

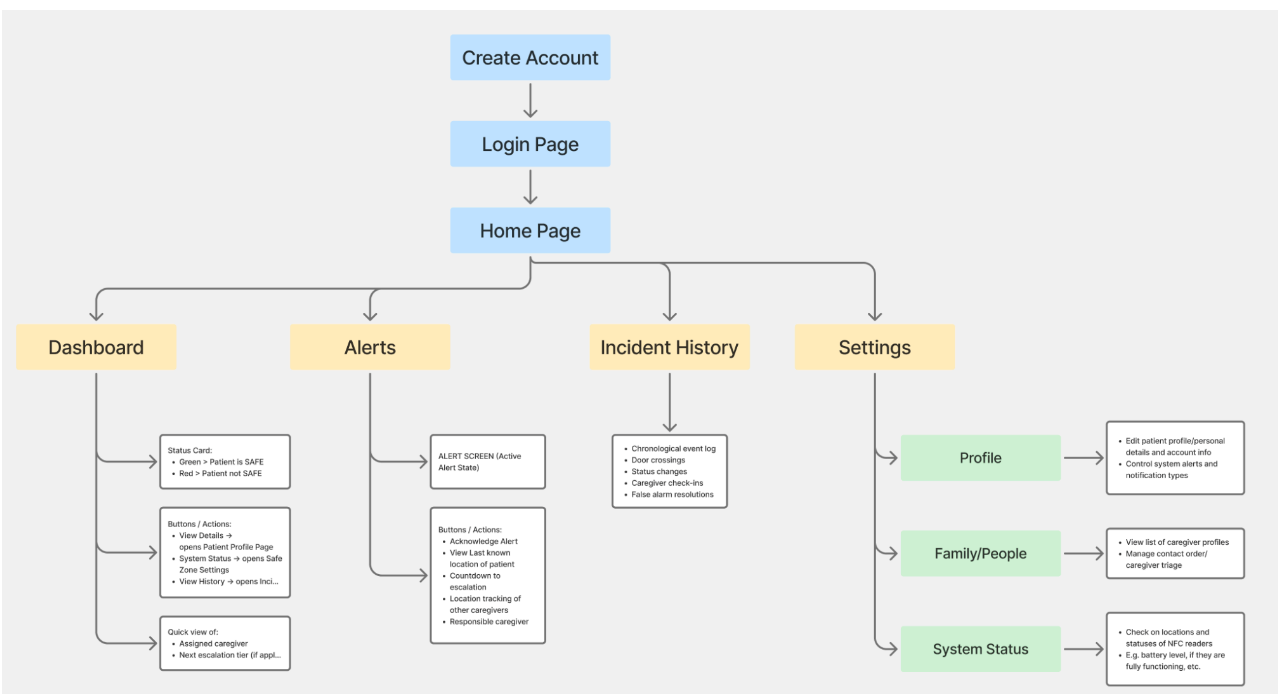


Figure: App Information Architecture for feature overview

Figma (interactive app prototype)

Figure: Onboarding Screens

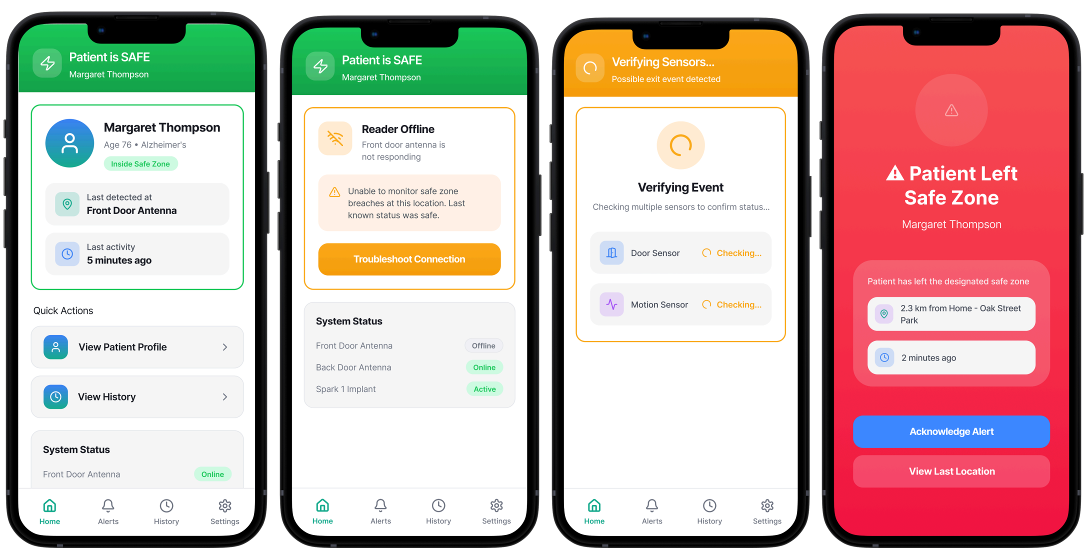


Figure: HomePage Status Screens (including edgecases)

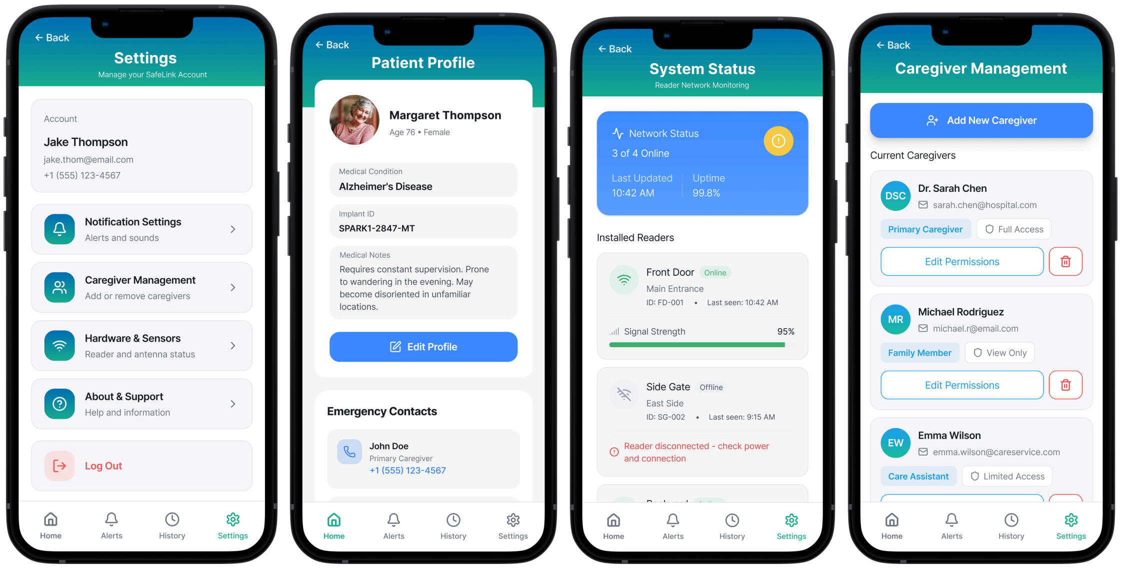


Figure: Settings Screens

These flows were iteratively refined through client feedback and expert input. We then created an interactive Figma prototype simulating core caregiver tasks such as onboarding, alert acknowledgment, system status review, and incident resolution.

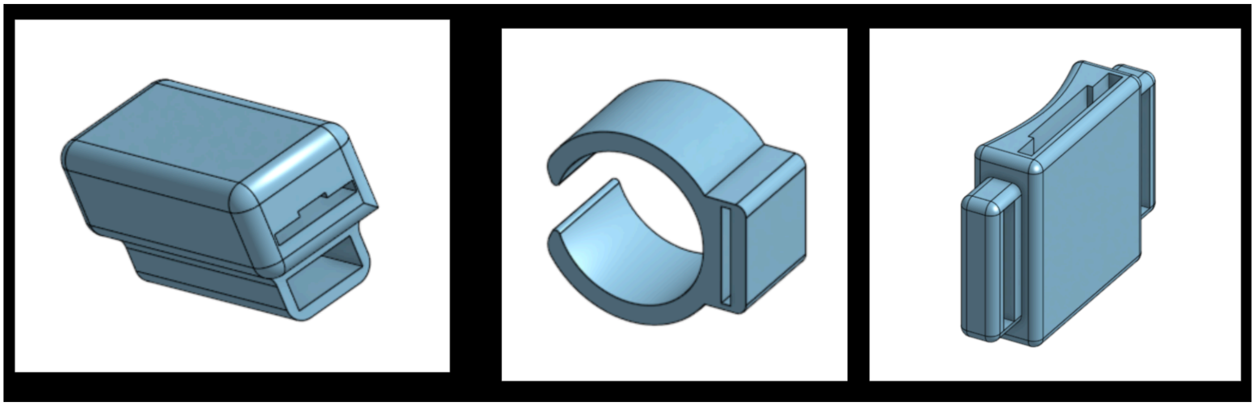
The prototype was designed to emphasize clarity, urgency, and low cognitive load, particularly during emergency scenarios.

Next, we used Figma to create an interactive prototype of the application, with flows for key tasks such as onboarding, emergency resolution, system maintenance, and activity history.

Prototyping Wearable Design Model

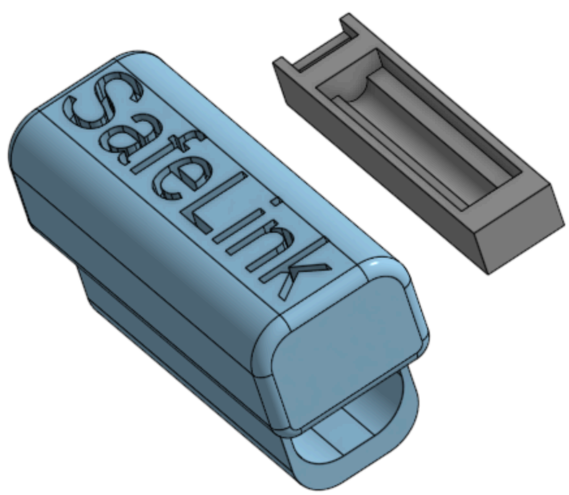
Next, we focused on creating a wearable design for users, since having an implant was not the most preferred method, based on our feedback and responses from interviews.

The first three ideas presented were a shoe charm, a ring, and an ankle bracelet.

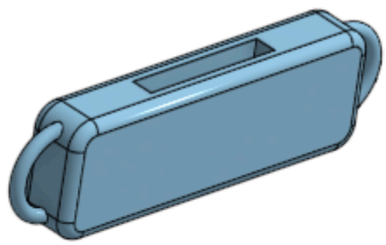


Initial 3D CAD models

After reviewing these designs with the professor and the class, we ultimately decided to move forward with the shoe charm and create a necklace option. The improvement with the show charm is that it allowed a space to insert the implant for a tighter fit. It was made smaller to prevent looking bulky on the user's foot, and overall more aesthetically pleasing. The necklace design was made simple so that it would not be distracting for users. And there will be a chain connecting both ends of the necklace, which wasn't added in the model for simplicity.



Shoe Charm Final Design



Main necklace portion

Usability Testing Plan

For our testing plan, we wanted to gather further feedback with our prototypes. The purpose of this evaluation is to assess how effectively the app supports caregivers in managing their daily responsibilities. Insights gathered will identify usability strengths and areas for improvement to ensure the app better meets caregivers' needs. We plan to recruit caregivers of varying ages and experience levels to ensure the app is easy to understand and usable for a wide range of users. The testing process will be structured but accessible, with clear instructions and straightforward language to reduce confusion during tasks. Participation will be voluntary, and all participants will be informed that they may choose to stop participating at any time. Throughout testing, we will observe how users navigate the app, interpret information, and complete key actions without additional guidance.

Participants will be asked to complete the following tasks, which are designed to reflect realistic and essential interactions with the app:

- Create an Account
- Check patient status
- View Most Recent Incident
- Resolve Safe Zone Breach Alert
- Check System Status

We will evaluate usability using metrics such as task completion time, task success rate, navigation errors, and moments of hesitation or confusion. Observational notes and brief follow-up questions will be used to gather qualitative feedback on clarity, ease of use, and overall user experience. The insights gained from these tasks and metrics will help us identify usability issues and guide design improvements to better support caregivers in time-sensitive situations.

Results

For the app prototype usability test, caregivers were asked to complete core tasks including:

- Interpreting patient status
- Responding to exit alerts
- Acknowledging responsibility
- Resolving alerts

Feedback

For the SafeLink app prototype, most participants successfully completed primary tasks without external guidance. Participants consistently identified alert notifications as clear and noticeable, and were able to navigate to relevant system information following an alert. The System Usability Scale (SUS) score was 86.7%, which exceeded the team's predefined success threshold, indicating overall usability and clarity of the interface.

For the 3D wearable model, participants expressed a preference for passive solutions that did not require daily interaction. Wearable mockup for showcharm was viewed as acceptable but vulnerable to removal or loss, particularly for dementia patients prone to removing all items of clothing including shoes. The implant concept was perceived as more reliable for high-risk users, provided that safety and reversibility were clearly communicated.

Design-Related Findings

- Participants favored automatic alerts over manual status checks
- Multi-caregiver escalation was consistently viewed as necessary
- Clear differentiation between "safe," "out with caregiver," and "unresolved" states reduced confusion

Notes on Improvement

Discussion

Based on the usability evaluation, SafeLink was generally understandable and usable for caregivers when completing core monitoring and alert-related tasks. Most participants were able to navigate the application and interpret system feedback with minimal instruction. However, multiple instances of hesitation and incorrect navigation indicated that certain interface elements did not align with caregiver expectations. In particular, confusion frequently arose around the presentation of patient status and overall system state. Participants often attempted to locate incident history or system-level information in areas that felt intuitive to them but did not correspond with the implemented information architecture. These behaviors suggest a difference between caregiver mental models and the system's hierarchy of information. This misalignment is especially problematic during alert scenarios, where caregivers may be operating under increased stress and time pressure. In such critical contexts, even brief uncertainty can elevate cognitive load and delay a response. Therefore, these findings emphasized the importance of making essential features noticeable and clearly prioritizing safety-relevant information in the app's visual hierarchy. To address the highlighted issues, we made status indicators more visually prominent and simplified terminology to reduce ambiguity. We repositioned access to incident history in order to support rapid comprehension during alerts. The expert feedback we collected further informed our new design decisions regarding alert sensitivity and system thresholds. Given that the consequences of a missed wandering event outweigh the costs of occasional false alarms, we prioritized preventing missed alerts over reducing nuisance. This trade-off aligns with the system's event-based architecture and reinforces SafeLink's role as a decision-support tool rather than a continuous monitoring system. Overall, the results of our testing indicate that an event-based approach can effectively support caregiver response when paired with a straightforward, low-cognitive-load interface.

When interpreting these findings, we have considered several limitations. The usability evaluation involved a small number of participants, limiting the generalizability of the results. While the sessions provided meaningful insight into caregiver reasoning and expectations, additional testing with a broader range of users would be necessary to validate these patterns. Furthermore, the evaluation was conducted using a simulated prototype rather than a fully implemented system, which prevented assessment of detection latency, environmental interference, long-term reliability, and real-world false-alarm rates. There are also ethical and regulatory constraints that limit direct testing of implantable technologies, and user perceptions may differ in real deployment contexts.

As SafeLink scales beyond a pilot context, both ethical and practical considerations become increasingly important. Monitoring technologies for individuals with cognitive impairment raise ongoing questions regarding privacy, consent, and autonomy. We have attempted to address these concerns by avoiding continuous tracking, minimizing the amount of stored data, and triggering system activity only during discrete safety-related events. However, at a larger scale, caregivers must have a clear understanding of alert conditions, data access, and shared responsibility across caregiver networks. From a systems perspective, scaling would also require reliable hardware installation, robust backend infrastructure, clear alert escalation logic, and compliance with relevant regulatory standards.

Conclusion

This project explored the feasibility of a passive, event-based monitoring system designed to support individuals living with dementia and their caregivers. By leveraging NFC technology and safe-zone detection, SafeLink aims to improve safety while avoiding continuous surveillance or real-time location tracking. Throughout the project, we iteratively integrated user research, expert input, and design refinement to evaluate both the technical feasibility and usability of this approach. Usability testing demonstrated that caregivers were generally able to interact with the system effectively, while also revealing specific areas where interface clarity and information hierarchy required improvement. These findings highlight the importance of minimizing cognitive load and supporting rapid interpretation in safety-critical caregiving contexts. Together, the results suggest that an event-based monitoring approach can meaningfully support caregiver response when paired with a straightforward, low-cognitive-load interface.

In addition to technical and usability feasibility, SafeLink demonstrates potential viability from a deployment and cost perspective. By relying on passive NFC components and event-based detection rather than continuous tracking or proprietary wearable devices, the system avoids recurring hardware, battery, and subscription costs associated with existing monitoring solutions. This lightweight infrastructure supports adoption in at-home caregiving contexts while remaining scalable to assisted living or clinical environments.

Future work would focus on strengthening both system reliability and real-world applicability. A primary next step would be to implement false-alarm filtering logic to better distinguish routine movement from genuine safety risks, reducing caregiver fatigue without increasing the likelihood of missed events. Additionally, a fully implemented patient-facing portal could further support autonomy by allowing individuals living with dementia to engage with the system in appropriate and non-intrusive ways. Most importantly, longitudinal field testing in real home environments would be necessary to evaluate long-term usability, trust, and system performance.

Overall, SafeLink represents a scalable and ethically grounded approach to dementia safety that prioritizes caregiver decision-making while preserving patient dignity and autonomy.

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- *ChatGPT was used to polish and lightly edit*

Appendix

Appendix A — Interview Materials and Summaries

Professional Caregiver — Yuli Guzman

1. Have you experienced situations where a patient has wandered or left a safe area? What happened, and how was it handled?
2. When a patient wanders off, what information would you want to receive immediately (location, direction, time, etc.)?
3. If this system existed, what would make you confident enough to use it in your care practice?

Full Interview Questions and responses: Linked here

Older Adult at Risk of Dementia — Louis Pamblanco

1. Can you tell me what a typical day looks like for you?
2. Do you ever like to go out for walks, errands, or visits alone?
3. What helps you feel safe and confident when you're out on your own?
4. How do you let your family know you're okay during the day?
5. Do you ever feel your family worries too much about you, or not enough?
6. What makes you feel reassured when you're away from home?

7. Have you used anything like a smartwatch, phone tracker, or alert pendant before?
8. Would you rather wear something (like a watch or tag) or have something small that you don't have to think about?
9. Is there anything we could change to make it feel more comfortable or respectful to you?

Full Interview Questions and responses: Linked here

Family Caregiver — Nancy Yang

- What challenges do you face in keeping your loved ones safe and preventing wandering?
- How do you currently manage those situations day to day?
- How do you feel about using implantable or wearable technologies to support safety?
- Would you prefer a system that works proactively or one that you check manually?
- What factors would influence your family's decision to adopt a system like this?

Expert — Amal

- At Vivokey, have you explored applications similar to what we are planning (implantable medical IDs), and what advice would you give us based on your past experience?
- From your experience, what technical limitations do current RFID/NFC implants face when it comes to securely storing or transmitting personal data, such as medical information?
  - What encryption or authentication methods have proven most reliable in implant use cases so far?
  - What are the best practices for preventing unauthorized scans, PINs, biometrics, and encryption?
- In what areas do implants outperform wearable tech? For what applications are implants better suited?
- What regulatory or ethical boundaries should we be mindful of at this stage?

Expert - Dan Hannon

- How could we design this system to minimize the false alarms and misses?
- How could we involve caregivers in the system?
- What is your opinion on this system?

- Anything that you see needs to be improved?

Appendix B — Concept Derivations

Cognitive Check System

- Performs orientation check before safety setting changes.
- Delays or escalates requests if confusion is detected.
- Uses friendly prompts like "Let's check this together."
- Requires dual caregiver consent for major changes.

Tiered Alert Logic

- Escalation path: Primary → Secondary → Emergency responder.
- Each alert requires acknowledgment to ensure accountability.

Implant Scan Flow

1. Responder scans implant.
2. Securely displays patient ID and emergency contact.
3. Sends automatic caregiver alerts through the app.

Appendix C — Project Task Allocation

Section	Team Member	Responsibility
Project Overview & Pivot	Fatima Tahir	Clarify purpose, target group, and pivot rationale.
Research Methodology	Fatima Tahir	Detail methods, participant overview, and ethics.

Personas	Summer Peterson	Create consistent personal layouts.
Research Insights	Nancy Yang, Iris Guzman, Joey Marmo	Summarize patterns and condense findings.
Requirements	Nancy Yang, Iris Guzman, Joey Marmo	Format detailed requirements per user group.
Next Steps & Plan	Summer Peterson	Connect research insights to upcoming prototype goals.

Appendix D — Vivokey Spark 1

Appendix E — Link to final presentation

Link to our final presentation:
https://docs.google.com/presentation/d/1BtnxmYFjAbmDz5NkCW5kFvyUaDX6pyTfCiU4M6YlvPg/edit?usp=sharing