DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

SYSTEM REQUIREMENTS SPECIFICATION
CSE 4316: SENIOR DESIGN I
FALL 2024

HEALS ON WHEELS
HMETV

NICHOLAS DOERFLER
RENCY KANSAGRA
TRISTAN MOSES
DYANA RAHHAL
CHRISTIAN BROWN

Revision History

Revision	Date	Author(s)	Description
0.1	10.02.2024	CB	document creation
0.2	10.21.2024	All	complete draft
0.3	10.21.2024	All	release candidate 1
1.0	tbd		official release
1.1	tbd		added customer change requests

CONTENTS

List of Figures

1 Product Concept

Heals on Wheels is an autonomous medical supply cart designed to improve hospital efficiency by transporting medical supplies, samples, and medicine within hospital environments. It alleviates the workload on nurses, reducing physical strain and allowing them to focus on patient care. Users of Heals on Wheels will be able to schedule deliveries, order supplies, and report issues using a mobile application integrated into the hospital's Wi-Fi network.

1.1 Purpose and Use

The Heals on Wheels product is intended to streamline the delivery and retrieval of medical supplies within hospitals. By automating these tasks, the cart eliminates the need for nurses to leave patients unattended during critical care moments. It is designed to optimize supply transportation through autonomous navigation and real-time obstacle detection. Nurses, hospital staff, and administrators can interact with the cart via a mobile app, enabling them to place orders, schedule deliveries, and monitor the cart's status in real-time.

1.2 Intended Audience

The intended audience for this product includes hospital personnel such as nurses, doctors, medical staff, and hospital administrators. Heals on Wheels is designed for hospital environments that need to enhance logistical efficiency and reduce nurse workload. The product is targeted at both large and small hospitals that could benefit from reducing unnecessary trips to supply rooms, thus improving operational efficiency.

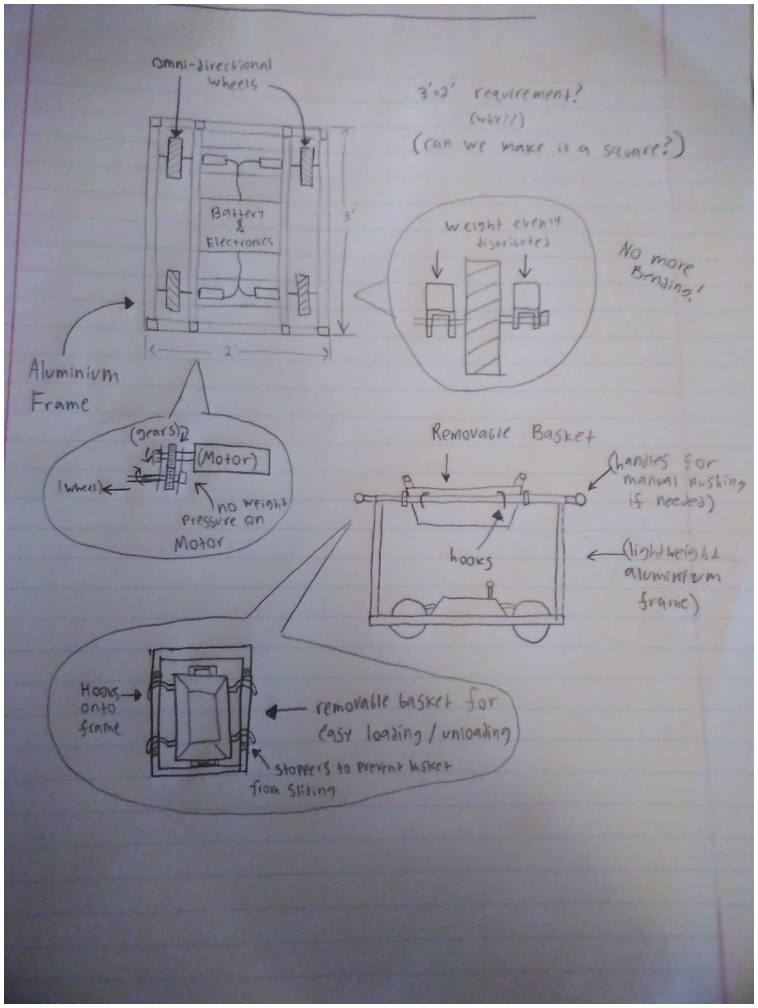

Figure 1: HMETV conceptual drawing

2 Product Description

The primary operational aspects of the product, from the perspective of end users, maintainers, and administrators, are defined here. The key features and functions, critical user interactions, and user interfaces are described in detail.

2.1 Features & Functions

Heals on Wheels automates the transportation of medical supplies between hospital rooms and the supply room. The cart uses pathfinding algorithms to navigate the hospital, avoiding obstacles with real-time detection. Its key components include a lightweight plastic frame, an enhanced motor and wheel design for better weight distribution, and a removable basket for easy loading and unloading. The mobile application allows users to place orders, schedule deliveries, and report stuck or lost carts.

Feature	Description
Autonomous Navigation	The cart moves between rooms and avoids obstacles using sensors and pathfinding algorithms.
Mobile Application	Users can order supplies, schedule deliveries, and report issues via a mobile interface.
Lightweight Design	The cart is constructed from lightweight materials, reducing noise and strain on the motors.
Removable Basket	A detachable basket allows for efficient loading and unloading of supplies.

2.2 External Inputs & Outputs

Data Element	Description	Input/Output
Order Details	Room number, supply, type and quantity	Input (User to System)
Cart Status	Cart location and battery level	Output (System to User)
Delivery ScheduleÂ	Room-to-room transport detail	Input (User to System)
Cart Issue Reports	Reports of stuck or lost carts	Input (User to System)

2.3 Product Interfaces

Heals on Wheels offers a mobile interface for hospital staff. The app has a simple design, featuring three main options: order supplies, schedule a delivery, and report a cart issue. The interface includes drop-down menus for item selection, delivery scheduling, and cart tracking. Mock-up screens show the intuitive layout designed to minimize training time for hospital staff.

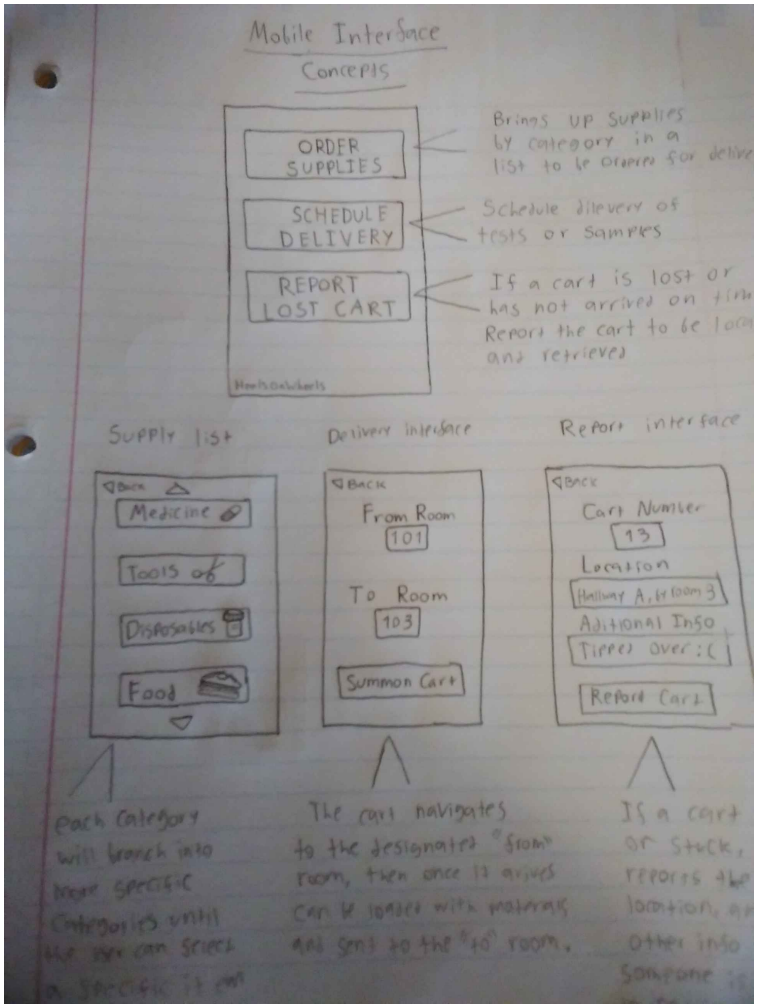

Figure 2: HMETV Mobile Interace Conceptual Drawing

3 Customer Requirements

This section outlines the core customer requirements for the "Heals on the Wheels" medical equipment transport vehicle project. These requirements reflect the directly observable features and functionalities that address the specific needs and priorities of the intended users. Each requirement is designed to ensure the product aligns with customer expectations and operational goals. These requirements are crucial and should only be altered with explicit agreement from the stakeholders.

3.1 Automated Supply Delivery

3.1.1 Description

The vehicle must autonomously navigate to the supply room, collect requested medical supplies (e.g., syringes, gauze, saline), and deliver them to the designated location.

3.1.2 Source

Usability studies conducted to streamline nurses' workload and improve operational efficiency.

3.1.3 Constraints

The vehicle must navigate safely within the hospital environment and handle a variety of medical supplies securely.

3.1.4 Standards

Compliance with healthcare safety regulations for autonomous equipment.

3.1.5 Priority

Critical, as automating supply delivery is the project's primary objective.

3.2 Emergency Response

3.2.1 Description

In emergency situations, the vehicle must prioritize the delivery of urgent medical supplies to designated areas quickly.

3.2.2 Source

Usability studies focused on enhancing patient care during critical emergencies.

3.2.3 Constraints

Implement real-time decision-making systems to expedite responses while maintaining safety.

3.2.4 Standards

Adhere to established protocols and safety standards for emergency response in healthcare facilities.

3.2.5 Priority

Critical, as it directly affects patient outcomes and safety

3.3 Route Selection and Navigation

3.3.1 Description

The vehicle must be capable of receiving and following navigation instructions via a central control system or mobile application, utilizing predefined waypoints. It must also adapt to real-time changes in its environment.

3.3.2 Source

Usability studies on efficient route planning and control flexibility.

3.3.3 Constraints

The navigation system must accommodate dynamic hospital conditions, avoiding obstacles autonomously.

3.3.4 Standards

Compliance with robotic navigation and path-planning standards.

3.3.5 Priority

High, as effective navigation is essential to minimize nurses' workload and ensure timely deliveries.

3.4 Mobile App Integration

3.4.1 Description

A mobile application must be developed for hospital staff to request deliveries, track the vehicle's location, and modify tasks remotely.

3.4.2 Source

Usability studies aimed at providing remote control and oversight for hospital staff.

3.4.3 Constraints

The app must be compatible with various devices and maintain secure communication between the vehicle and staff.

3.4.4 Standards

Adhere to mobile app development and data security standards.

3.4.5 Priority

High, as it improves usability and control over the vehicle's operations.

3.5 Lightweight Body Cart with Spacious Storage

3.5.1 Description

The vehicle should be designed with a lightweight body to ensure easy mobility while providing ample space to securely transport a variety of medical equipment and supplies.

3.5.2 Source

Usability studies emphasizing the need for a balance between portability and storage capacity.

3.5.3 Constraints

The lightweight design must not compromise the durability or stability of the vehicle, and the storage compartments should be easy to access while ensuring equipment is secured during transport.

3.5.4 Standards

Compliance with hospital safety guidelines regarding medical equipment carts and transport devices.

3.5.5 Priority

High, as the design affects both efficiency and the safety of medical supply transportation.

3.6 Removable Basket

3.6.1 Description

The vehicle should be equipped with a detachable basket, allowing for efficient loading and unloading of medical supplies. This feature enhances flexibility when transporting items to different locations within the hospital.

3.6.2 Source

Usability studies focused on improving convenience and reducing handling time for hospital staff.

3.6.3 Constraints

The removable basket should be lightweight yet sturdy, ensuring it can carry various medical supplies securely without adding unnecessary weight to the cart.

3.6.4 Standards

Comply with ergonomic design standards for easy handling and hospital safety protocols.

3.6.5 Priority

High, as it improves efficiency in the transport process.

3.7 Emergency Button

3.7.1 Description

The vehicle must include an easily accessible emergency button that halts all operations when pressed, ensuring rapid intervention in critical situations.

3.7.2 Source

Usability studies and safety considerations.

3.7.3 Constraints

The emergency button must be placed in an easily reachable location and must override all ongoing tasks instantly.

3.7.4 Standards

Compliance with emergency shutdown standards in healthcare facilities.

3.7.5 Priority

High, as it directly relates to patient and staff safety

3.8 Full-Range Mobility

3.8.1 Description

The vehicle should employ omnidirectional wheels, allowing it to move seamlessly in any direction, including lateral and diagonal movements, to navigate tight hospital spaces efficiently.

3.8.2 Source

Usability studies emphasizing maneuverability in narrow hospital corridors.

3.8.3 Constraints

The omnidirectional wheels must be durable and capable of withstanding constant use.

3.8.4 Standards

Compliance with robotic mobility and wheel durability standards.

3.8.5 Priority

High, as it enhances the vehicle's movement and flexibility in busy environments.

3.9 Obstacle Avoidance

3.9.1 Description

The vehicle must have obstacle detection and avoidance capabilities to autonomously navigate around people, equipment, and other potential obstructions.

3.9.2 Source

Usability studies focused on safety and efficiency in a dynamic hospital environment.

3.9.3 Constraints

Reliable sensors and avoidance algorithms must be implemented for effective real-time navigation.

3.9.4 Standards

Compliance with safety and collision avoidance standards in robotics.

3.9.5 Priority

High, as safe navigation is critical to prevent accidents or disruptions

4 Packaging Requirements

This section provides an outline of the packaging needs for the "Heals on the Wheels" medical transport vehicle. The packaging must ensure that the product is secure during shipping while presenting it in a professional and efficient manner for the end-user. Special attention is given to sustainability, ease of use, and brand representation.

4.1 Durable, Eco-Friendly Packaging

4.1.1 Description

The outer packaging should be crafted from sustainable and durable materials, such as biodegradable or recyclable plastics and cardboard, to ensure the safe delivery of the vehicle while minimizing environmental impact.

4.1.2 Source

Derived from sustainability goals and industry trends favoring eco-friendly packaging solutions.

4.1.3 Constraints

Materials must be strong enough to prevent damage during transit and comply with regulations for sustainable packaging.

4.1.4 Standards

Adhere to eco-friendly packaging standards, such as ISO 14001 for environmental claims and ASTM standards for package durability.

4.1.5 Priority

Moderate, as the packaging should prioritize both environmental sustainability and product protection.

4.2 Easy-to-open Packaging Design

4.2.1 Description

The packaging must be designed to allow users to easily open it without the need for additional tools, while still providing enough protection to prevent tampering or accidental damage.

4.2.2 Source

Usability studies emphasizing ease of access for healthcare professionals.

4.2.3 Constraints

The design must balance between being secure during transportation and simple to open for users with limited time or physical capability.

4.2.4 Standards

Follow packaging ease-of-use guidelines, such as ISO 17480, which outlines methods for reducing opening force and improving accessibility.

4.2.5 Priority

High, as ease of access is critical in healthcare settings where time efficiency and user convenience are paramount.

4.3 Integrated Handling Features

4.3.1 Description

The packaging should include integrated features like handles or grips to make it easy for healthcare staff to lift and move the product without risk of injury or damage to the product when not in use.

4.3.2 Source

Derived from usability studies and ergonomic guidelines to support safe handling and transportation.

4.3.3 Constraints

The added features must not compromise the structural integrity of the packaging or add excessive weight.

4.3.4 Standards

Comply with ergonomic packaging standards to minimize strain and ensure safe manual handling, such as those outlined by OSHA.

4.3.5 Priority

High, as safe and efficient handling is crucial in fast-paced medical environments.

4.4 Reusable Packaging for Internal Use

4.4.1 Description

The packaging should be designed in a way that allows it to be reused for internal hospital use, such as storing or transferring supplies within the facility after the initial product delivery.

4.4.2 Source

Guided by hospital sustainability efforts and user needs for efficient supply management.

4.4.3 Constraints

The packaging must be durable enough for multiple uses without deteriorating, and its structure should be easily adaptable for repurposing.

4.4.4 Standards

Adhere to standards for reusable packaging, such as those for healthcare facilities that focus on material longevity and safety.

4.4.5 Priority

Moderate, as reusable packaging adds value by extending the life cycle of the materials and supporting internal logistics within the hospital.

5 Performance Requirements

Though we have not been given any concrete performance requirements, we can infer a few of them as simply common sense that would be universally applicable. We cannot imagine any situation where these requirements would not apply.

5.1 Reasonable Maneuvering Speed

5.1.1 Description

The cart should not be significantly slower than the average person's walking speed in order to be useful. However it should also not be so fast that it becomes a hazard for staff and patients as it barrels down the hallways.

5.1.2 Source

Common sense

5.1.3 Constraints

Weight of the cart, power of the motors, turning speed.

5.1.4 Standards

N/A

5.1.5 Priority

HIGH, the whole thing would be useless if this is not the case.

5.2 Mobile App Compatibility

5.2.1 Description

The mobile app used to call or report the carts should be available on a wide range of common mobile platforms like IOS and Android so that nurses and doctors can natively install the app on their smartphone.

5.2.2 Source

Common sense

5.2.3 Constraints

Programming ability, build options, legacy or foreign hardware

5.2.4 Standards

N/A

5.2.5 Priority

HIGH, if nurses could not get the app on their mobile devices the hospital would either need to provide devices which are expensive or pass the financial burden onto the individual staff members.

6 Safety Requirements

The following safety requirements were provided by the Engineering Department of UTA and our sponsor Cook Children's. Our team is committed to ensuring the safety of project members, hospital staff, and Cook Children's Patients.

6.1 Laboratory equipment lockout/tagout (LOTO) procedures

6.1.1 Description

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 Source

CSE Senior Design laboratory policy

6.1.3 Constraints

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 Standards

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 Priority

Critical

6.2 National Electric Code (NEC) wiring compliance

6.2.1 Description

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 Source

CSE Senior Design laboratory policy

6.2.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 Standards

NFPA 70

6.2.5 Priority

Critical

6.3 RIA robotic manipulator safety standards

6.3.1 Description

Robotic manipulators, if used, will either housed in a compliant lockout cell with all required safety interlocks, or certified as a "collaborative" unit from the manufacturer.

6.3.2 Source

CSE Senior Design laboratory policy

6.3.3 Constraints

Collaborative robotic manipulators will be preferred over non-collaborative units in order to minimize potential hazards. Sourcing and use of any required safety interlock mechanisms will be the responsibility of the engineering team.

6.3.4 Standards

ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems, RIA TR15.606-2016 Collaborative Robots

6.3.5 Priority

Critical

6.4 Speed Requirements

6.4.1 Description

The Medical Cart shall move no faster than 4 mph, or .45 meters/second.

6.4.2 Source

Cook Children's document in Teams

6.4.3 Priority

High

7 Security Requirements

In addition to the aforementioned safety requirements, the system shall implement common security procedures to safeguard the system from cyber attacks and protect the PHI of patients. The following requirements are procedures put in place to assure compliance with commonly accepted security standards such as HIPAA and GDPR.

7.1 Encryption of Data at Rest

7.1.1 Description

All stored data shall be encrypted at rest with the AES-256 algorithm

7.1.2 Source

HIPAA [3]

7.1.3 Standards

AES 256

7.1.4 Constraints

Proper key management systems will need to be in place to access and encrypt data

7.1.5 Priority

Critical

7.2 Encryption of Data in Transit

7.2.1 Description

Any network communications within the system must be, at minimum, encrypted with standard TLS

7.2.2 Source

NIST [2], HIPAA [1]

7.2.3 Standards

TLS / NIST 800-52

7.2.4 Constraints

Using TLS will require a slight increase in computation and system complexity

7.2.5 Priority

Critical

8 Maintenance & Support Requirements

The product delivered is an autonomous medical cart with the purpose to aid nurses in obtaining supplies from a medical closet. The subsequent maintenance and support items listed below are for keeping the cart in proper working order and ensuring all involved handle the cart in the intended fashion in order to prevent mishaps.

8.1 Documentation User Manual

8.1.1 Description

Documentation will be included to have an overview of the entire system, and user manual to use and set up.

8.1.2 Source

Heals on Wheels senior design team in addition to documentation from any parts used

8.1.3 Constraints

There is a limit to how much time can be spent on documentation in addition to possible lack of documentation for some parts

8.1.4 Standards

The documentation should be sufficient to understand from a development point of view and any user manual should be sufficient for developers and nurses as well as the technicians that would need to set up or repair the carts.

8.1.5 Priority

High

8.2 Repair and maintenance

8.2.1 Description

In order to deal with any unforeseen circumstances repairs must be possible. It should be possible for the cart to have service through troubleshooting with technicians over the phone with minor problems that are user fixable. In other cases it should be possible for technicians to repair the cart. If any maintenance is required it should also be documented what is needed and work in a similar fashion to repairs.

8.2.2 Source

Heals on Wheels development team

8.2.3 Constraints

Repair and maintenance must be done in a safe way.

8.2.4 Standards

The cart should not have any malfunctions if it has proper maintenance.

8.2.5 Priority

High

9 Other Requirements

Include a header paragraph specific to your product here. In this section specify anything else that is required for the product to be deemed complete. Include requirements related to customer setup and configuration if not specified in a previous requirement. Add any known requirements related to product architecture/design, such as modularity, extensibility (for future enhancements), or adaptation for a specific programming language. Consider requirements such as portability of your source code to various platforms (Windows, Linux, Unix Mac OS, etc.).

9.1 Requirement Name

9.1.1 Description

Detailed requirement description...

9.1.2 Source

Source

9.1.3 Constraints

Detailed description of applicable constraints...

9.1.4 Standards

List of applicable standards

9.1.5 Priority

Priority

10 Future Items

This section contains parts of the project that will not be implemented. These future plans are not implemented due to budget and time constraints along with skill issues.

10.1 Charging Dock

10.1.1 Description

A charging doc is a place for the autonomous medical cart to automatically go to in order to recharge the power of the battery/batteries. Also for the purpose of minimizing time spent by nurses and other hospital staff.

10.1.2 Source

Heals on Wheels senior design team

10.1.3 Constraints

A safe way to charge the carts without human intervention

10.1.4 Standards

IEC 62133-2:2017 - Safety requirements for secondary lithium cells and batteries, ISO 61508:2010 - Functional safety of electrical/electronic/programmable electronic safety-related systems

10.1.5 Priority

Moderate

10.2 Greater sensor view

10.2.1 Description

Having more sensors around the cart in order to maximize the ability to deal with unexpected obstacles.

10.2.2 Source

Heals on Wheels senior design team

10.2.3 Constraints

This should not deteriorate the performance of the processing speed nor the battery life of the cart too drastically. This should also not cause any structural or safety issues.

10.2.4 Standards

IEC 62133-2:2017 - Safety requirements for secondary lithium cells and batteries, ISO 61508:2010 - Functional safety of electrical/electronic/programmable electronic safety-related systems

10.2.5 Priority

Low

REFERENCES

[1] Steve Alder. HIPAA Encryption Requirements - 2024 Update, January 2023.

[2] Kerry A McKay and David A Cooper. Guidelines for the selection, configuration, and use of Transport Layer Security (TLS) implementations. Technical Report NIST SP 800-52r2, National Institute of Standards and Technology, Gaithersburg, MD, August 2019.

[3] National Institute of Standards and Technology (US). Advanced Encryption Standard (AES). Technical Report NIST FIPS 197-upd1, National Institute of Standards and Technology (U.S.), Washington, D.C., May 2023.