Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Fall 2024

Heals on Wheels
HMETV

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	9.13.2024	GH	document creation
0.2	9.30.2024	AT, GH	complete draft
0.3	10.12.2021	AT, GH	release candidate 1
1.0	10.20.2021	AT, GH, CB	official release
1.1	10.31.2021	AL	added customer change requests

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1 Problem Statement

Nurses frequently require immediate access to medical supplies, necessitating trips to the supply room even during critical patient care moments. These trips not only leave patients unattended but also impose physical strain on nurses, potentially impacting their well-being and alertness. By reducing or eliminating the need for these trips, we can ensure that nurses remain with their patients during vital moments and are less physically exhausted. This would enhance their capacity to provide consistent, high-quality care throughout their shifts, ultimately improving patient outcomes and overall healthcare efficiency.

2 Methodology

Our team is going to improve on an existing autonomous ground vehicle designed to deliver medical supplies from the supply room to the requested site in place of a nurse, so that the nurses don't have to make that trip themselves. We will gather input from nurses, doctors, and hospital staff to determine how we should improve on this vehicle, as well as research existing models of autonomous medical carts to develop practical solutions for increasing their efficiency and effectiveness.

3 Value Proposition

Our product will allow the hospital to run more efficiently two fold. First by automating tasks that are rarely optimized and inefficient such as fetching supplies, transporting tests, and delivering medicine. It will also allow for some of the strain to be taken off of nurses, no longer having to spend time going from place to place doing tedious fetch work and can instead focus their efforts on more involved and critical tasks.

4 Development Milestones

This list of core project milestones should include all major documents, demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document may be listed by month.

Provide a list of milestones and completion dates in the following format:

- Project Charter first draft - September 2024
- System Requirements Specification - October 2024
- Architectural Design Specification - November 2024
- Demonstration of autonomous cart navigation - January 2025
- Detailed Design Specification - January 2025
- Demonstration of real-time obstacle detection - February 2025
- CoE Innovation Day Poster Presentation - March 2025
- Demonstration of wireless order placing system - March 2025
- Final Project Demonstration - April 2025

5 Background

Hospitals are fast-paced environments where time, accuracy, and efficiency are essential. Medical staff must follow strict schedules, maintain sterile conditions, and provide high-quality care, all while managing numerous routine tasks. These ongoing demands often result in increased stress, fatigue, and reduced attention to critical responsibilities.

One recurring but time-consuming task in hospital units, such as the Pediatric Intensive Care Unit, involves retrieving and delivering essential medical supplies. Items like gauze, syringes, and saline are stored in central supply rooms that are often located far from patient care areas. Nurses frequently have to leave their assigned patients to collect these supplies, which can reduce their availability for urgent care needs.

To address this issue, our team is developing the Hospital Medical Equipment Transport Vehicle, an autonomous medical cart that assists staff by handling supply deliveries. This project builds upon previous work aimed at improving hospital workflows and reducing the burden placed on nurses.

The goal is to enhance efficiency, support timely access to necessary items during emergencies, and allow healthcare workers to focus more on direct patient care. By automating these logistical tasks, the project seeks to improve overall operations and help create a more supportive and responsive hospital environment.

6 Related Work

Autonomous medical carts are becoming a significant focus in healthcare logistics due to their potential to enhance hospital efficiency and reduce nurse workload [5]. Existing solutions like the Tug Atheon robot, used in over 400 hospitals globally, provide fully autonomous delivery of medical supplies, linens, and meals. This system is equipped with laser scanners, IR sensors, and a fingerprint scanner for security, ensuring smooth navigation through hospital environments [3]. Another example is the robotic courier system used in Jena University Hospital, Germany, which automates the transportation of food and medical containers via a central computer that controls its pathfinding and obstacle detection [1].

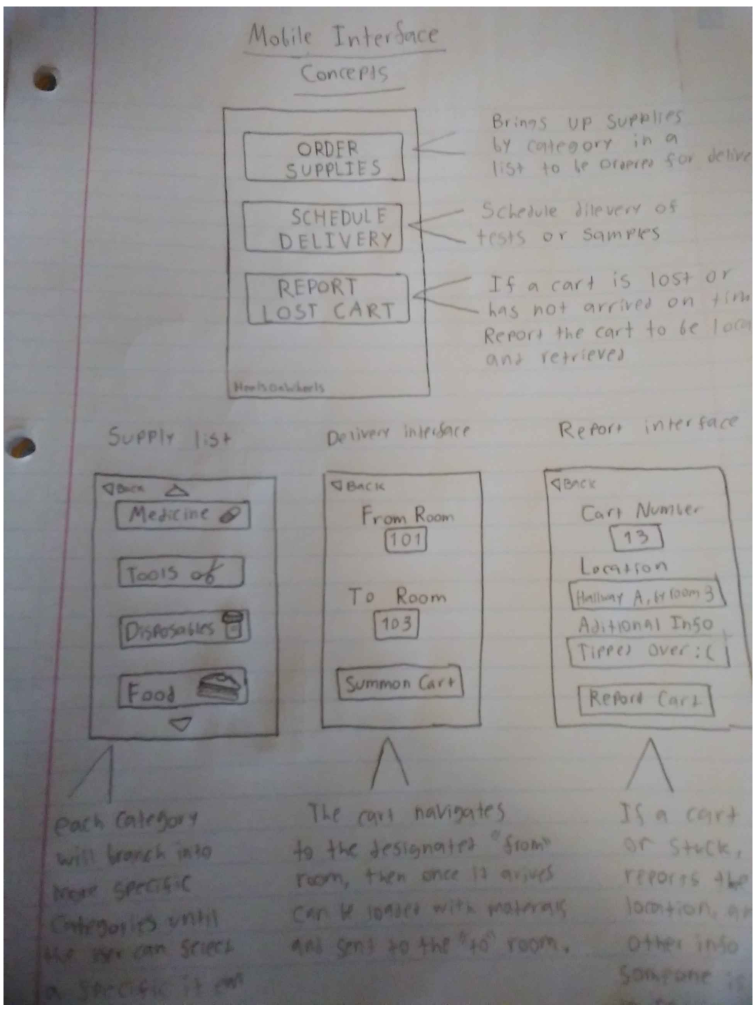
Additionally, Yujin Robotics has developed various models like GoCart, which are deployed in hospitals across Korea and Europe. These robots specialize in delivering medicine and handling tasks in restricted areas, such as COVID-19 wards, showcasing how autonomous systems can be tailored for specific medical environments [4].

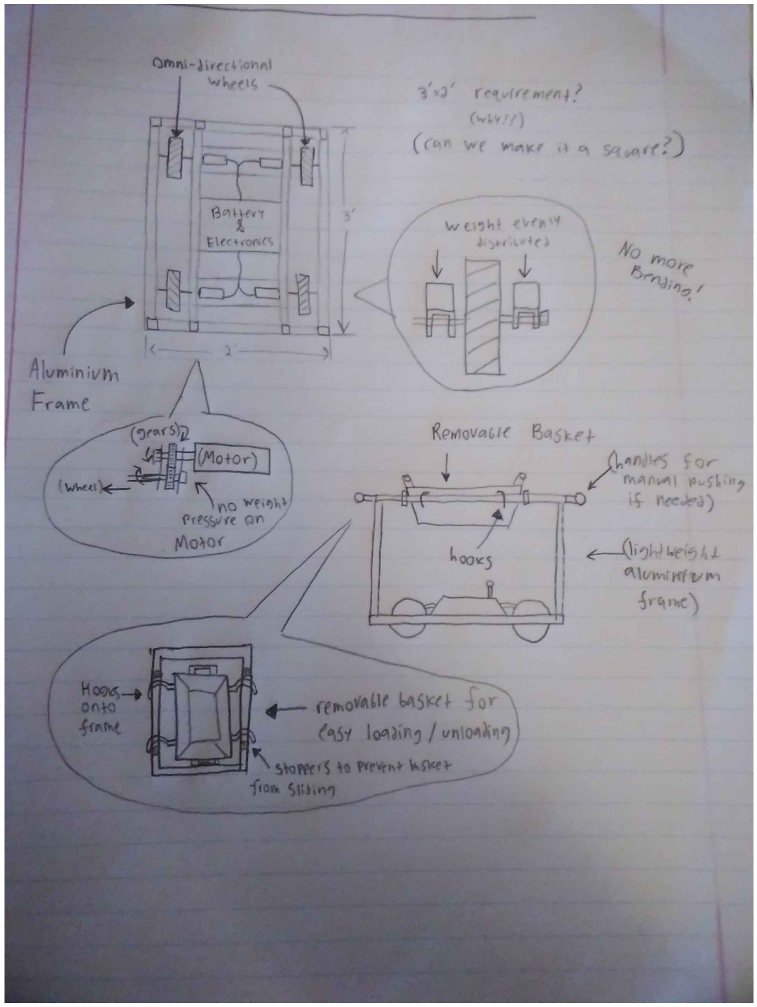
While these systems are highly advanced, they often present cost challenges, and some models, like Tug, may not fully integrate into the fast-paced environment of smaller hospitals. A systematic review has shown that while these systems improve medication safety by reducing human error, they may also require significant initial investment, making them less accessible for smaller or underfunded facilities [2].

7 System Overview

For our software implementation, we have come up with a concept for a mobile application that can be installed on a mobile device and send commands to the carts wirelessly on the hospital's wi-fi network. The app includes a streamlined interface with 3 primary functions. The first is to order supplies, this option brings up a tree of lists that get more specific going through different categories and types of items, until the selected item is found, then it takes an amount and a room number, and a free cart goes and takes the order, or if all carts are busy it is entered into a queue. A human stocker loads up a basket with the supplies and once the cart arrives, the place the basket on the cart and send it to the requested room. After arriving and dropping off the supplies it returns to the charging station. The second option is to schedule a delivery. If some kind of test or sample needs to be delivered to another room, the user selects "schedule delivery" enters the room they are in, and the room they want to deliver to, and the cart makes the trip from home to the "from" room, then to the "to" room and finally back home. The final function is for reporting a lost, stuck, or dead cart. This interface has the user enter the cart's number, location it's stuck, and any additional information. Once the report is submitted it pings a technician to go retrieve the cart.

On the hardware side, we seek to first improve the shortcomings we were made aware of when we visited the ERB as a team, namely issues with the cart being too heavy and the motors bowing under the weight. Our proposed solution is to rebuild the body of the cart out of a lightweight aluminum skeleton, rather than the heavy steel chassis the current model has. This should also serve to make the cart quieter, because the current frame rattles while it moves. We have also come up with a redesign for how the wheels attach to the frame, with the wheels now sitting under the frame of the cart, with the axle extending to both sides of the wheel, evenly distributing the weight across the when instead of all on one side which should hopefully solve the bowing issue. We have also proposed a solution to add a gear system to the motors so that they are no longer directly connected to the wheels, which should relieve the pressure of supporting the weight of the cart off of them. Finally, to improve efficiency of loading and unloading the cart, we came up with an idea to have a removable basket that simply sits on the top of the cart's frame and can be freely removed and replaced.





8 Roles & Responsibilities

- Tristan Moses: Hardware Specialist
- Rency Kansagra : Hardware & Software Specialist
- Nicholas Doerfler: Software Specialist & Architect
- Dyana Rahhal: Hardware & Software Specialist
- Christian Brown: Point of Contact, Software Specialist

9 Cost Proposal

Key project expenses will primarily focus on securing essential materials and components necessary for enhancing the functionality of the autonomous medical supply cart. This may include replacing critical mechanical parts, electronic hardware, sensors, and possibly redesigning the framework completely to optimize performance. Ensuring the quality and durability of these materials is vital for the cart's safe and efficient operation. Additionally, software development costs will be significant, covering the creation of an autonomous navigation system and user interface, which are core to the cart's functionality.This may include licensing fees for development tools and software, along with the integration of a screen to display critical information on the cart, ensuring seamless operation and user interaction.Furthermore, if the design requires adjustments in size or the addition of compartments, there will be costs associated with prototyping and refining the cart's design through multiple iterations. These expenditures are crucial to delivering a reliable, safe, and effective solution tailored to the needs of PICU nurses.

9.1 Preliminary Budget

The preliminary budget for the project is summarized in the table below. The budget covers key expense areas including components, fabrication, software licensing, development hardware, and miscellaneous costs.

Expense Category	**Description**
Hardware Framework	Costs related to the physical structure of the cart that needs replacement
Software	Expenses related to software tools and licensing fees required for the development and implementation of the software systems
Mechanical and Electrical Components	Includes costs for motors, sensors, batteries, microcontrollers, wiring, and any other necessary electronics
Testing and Quality	Costs for testing the cart's functionality, safety assessments, and quality assurance processes
Miscellaneous	Any additional expenses for unforeseen events

Figure 1: Expected Expenses

9.2 Current & Pending Support

The primary funding for the project is provided by the Computer Science and Engineering (CSE) department, with a budget of $800.This allocation will serve as the foundational financial support for the initiative. Furthermore, the team will seek out potential sources of additional funding from external sources, including grants, sponsorships, or donations. The budget section will include documentation of any external contributions, along with their corresponding amounts. The team is dedicated to securing supplementary financial resources to guarantee that the project is successfully completed within the allocated budget.

10 Facilities & Equipment

The successful development and testing of the autonomous medical supply cart prototype will require access to a dedicated workspace, with ERB 208 being an ideal location due to its sufficient space for assembly, remodeling, and testing activities. The workspace must provide a controlled environment that replicates the conditions of a Pediatric Intensive Care Unit (PICU), including stable temperature, humidity control, and appropriate lighting. These factors are essential as the cart will be used to transport sterilized medical instruments, which must remain uncontaminated throughout the process. Adequate access to doorways and pathways within the workspace is crucial to mimic the layout of a typical PICU, allowing for the testing of the cart's navigation system in realistic scenarios.The project will also require a variety of tools and equipment, including mechanical tools for potential modifications to the cart's frame, as well as electrical components that may need replacement, such as motors, collision avoidance sensors, microcontrollers (e.g., Raspberry Pi), and batteries to facilitate autonomous navigation. To acquire these resources, the team will utilize a combination of purchasing essential components, utilizing in-house resources, borrowing or leasing specialized equipment from partner institutions, and outsourcing specific tasks when highly specialized expertise is required.

11 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- A suitable indoor testing location that mimics PICU environmental conditions will be available during prototype testing
- Necessary hardware purchases will arrive in a timely manner, without severe unforeseen delays
- The funds provided by the CSE Department and Cook Children's will be sufficient to cover all hardware and technical expenses during development
- The Cook Children's staff survey will be completed by no less than 20 nurses who have worked with similar devices before
- Contact will be established between our team and Cook Children's by the start of the second sprint cycle

12 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by April 25th, 2025
- Cook Children's will provide limited personnel and support during the installation and site testing process
- The system installation site will only be accessible to the development team by scheduled appointment during normal business hours
- Total development costs must not exceed the budget allocated by the CSE department and the customer
- Any data collected by the system must be compliant with Cook Children's data security policies such as HIPAA and GDPR
- Cook Children's has a limited amount of time and funding they can dedicate to this project
- The limited time and budget, and inherent complexity of the project may result in an unfinished product to be continued by another team
- The Professors we are working with have limited time and may be unavailable when the team requires their help

13 Risks

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Communication delays between Sponsor and Team	.50	15	7.5
Delays in Supply Chain	.80	15	12
Unforeseen Software Challenges	.50	6	3
Unforeseen Hardware Challenges	.80	10	8
Mid-Project Requirement Changes	.30	20	6

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The Project Charter will be revised after the completion of each deliverable and after new risks, constraints, or critical information are revealed during development. The initial version will be delivered on 9/30/2024, the final version will be delivered in April 2025.

14.1.2 System Requirements Specification

The System Requirements Specification will be revised after the completion of each deliverable and after new risks, constraints, or critical information are revealed during development.The final version will be delivered in April 2025.

14.1.3 Architectural Design Specification

The Architectural Design Specification will be revised after the completion of each deliverable and after new risks, constraints, or critical information are revealed during development.The final version will be delivered in April 2025.

14.1.4 Detailed Design Specification

The Detailed Design Specification will be revised after the completion of each deliverable and after new risks, constraints, or critical information are revealed during development.The final version will be delivered in April 2025.

14.2 Recurring Sprint Items

The following items will be documented and maintained during each individual sprint:

- Project Charter
- System Requirements Specification
- Architectural Design Specification
- Detailed Design Specification
- Burndown Charts
- Sprint Backlog

14.2.1 Product Backlog

The product owner, in collaboration with the development team, will prioritize backlog items. A digital product backlog will be maintained using Microsoft Teams and Overleaf to facilitate transparency and collaboration.

14.2.2 Sprint Planning

Planning will occur at the start of the sprint, and there will be 8 sprints total.

14.2.3 Sprint Goal

The sprint goal is determined during initial planning, each sprint has a general high level goal that is assigned by the instructor that will be broken into smaller project-specific goals by the ea

14.2.4 Sprint Backlog

Sprint backlog items will be decided by the team, or Cook Children's should they decide to get involved. Backlog items will be selected from a number of criteria, such as relevance to the assigned sprint goal, and the task's position on the Critical Path.

14.2.5 Task Breakdown

Tasks will be assigned first to the individual who volunteers, or otherwise delegated to the team member with skills most suited to the task. Time spent on the project will be logged in a Google Sheets file shared within the team.

14.2.6 Sprint Burn Down Charts

Burndown charts will be generated by 1 team member at the end of each sprint, the efforts of individuals will be logged in a Google Sheets document shared by project members.

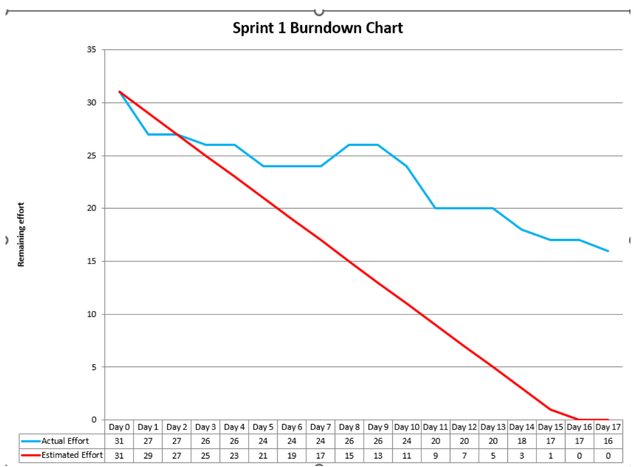


Figure 2: Sprint 1 Burndown Chart

14.2.7 Sprint Retrospective

Sprint retrospectives will be conducted by the whole team during the last 2 days of the sprint, we will document what we intended to accomplish, what was actually accomplished, what we didn't accomplish, and what we will improve on in our next sprint.

14.2.8 Individual Status Reports

Individual Status Reports will be created by each team member at the end of each sprint, on average once every 2.5 weeks. These will include how much effort was spent on the project, what they planned to do, what they actually ended up doing, and any expected or unexpected challenges they faced.

14.2.9 Engineering Notebooks

Engineering notebooks will be regularly updated after the completion of each deliverable. Accountability will be maintained through peer reviews and.

14.3 Closeout Materials

The following materials, in addition to major documentation deliverables, will be provided to the customer upon project closeout.

14.3.1 System Prototype

The final prototype includes a functional medical cart with a redesigned chassis, mounted motors, omnidirectional wheels, and a TCP-connected GUI for control. It will be demonstrated at Innovation Day in April 2025. While no formal PAT or FAT is planned, the system is built for future deployment and continuation by the next team.

14.3.2 Project Poster

A project poster will be created, showcasing the projectâs goals, features, and accomplishments. The final poster will be delivered at project closeout on April 2025.

14.3.3 Web Page

A project web page will be created, providing information about the projectâs objectives, progress, and outcomes. The web page may be accessible to the public and will be updated throughout the project. The web page will be fully delivered by April 2025.

14.3.4 Demo Video

A demo video will be produced, demonstrating the HMETVâs functionality and key features. The video will include footage of the vehicle transporting medical supplies to nurses and similar tests done throughout our progress on campus in ERB. We will show the omnidirectional movement of the vehicle as well as how it will be called to deliver supplies.

14.3.5 Source Code

Source code will be maintained using GitHub and will be provided to the customer.

14.3.6 Source Code Documentation

The source code will be documented using clear inline comments and README files. No automated tools like Doxygen will be used. Final documentation will be provided as Markdown and PDF files in the GitHub repository.

14.3.7 Hardware Schematics

Components such as motors, batteries, and microcontrollers were connected using wiring. Wiring diagrams showing power distribution and motor connections will be included in the final documentation.

14.3.8 CAD files

CAD files for 3D printed or laser-cut parts will be provided in suitable formats (e.g., STL, STEP). AutoCAD will be used for CAD files.

14.3.9 Installation Scripts

The system will likely not require installation scripts.

14.3.10 User Manual

Digital user manuals will be provided to the customer’s technical staff on delivery.

References

[1] Robotic couriers at the Jena University Hospital in Germany | Britannica.

[2] Hanne Katriina Ahtiainen, Miia Marjukka Kallio, Marja Airaksinen, and Anna-Riia HolmstrÃ¶m. Safety, time and cost evaluation of automated and semi-automated drug distribution systems in hospitals: a systematic review. *European Journal of Hospital Pharmacy*, 27(5):253–262, September 2020. Publisher: British Medical Journal Publishing Group Section: Systematic review.

[3] CNBC. Aethon 'Tug' Hospital Robot | CNBC, December 2014.

[4] YUJIN ROBOT Co Ltd. Unmanned Hospital robot delivery for medical supplies or meals | YUJIN ROBOT.

[5] Robotic Automation P/L. Automated Trolley Delivery System - Royal Adelaide Hospital, June 2023.