SCOPING DOCUMENT

2024 Blade Runner Project

ENGG 2000/3000 Engineering Project
GROUP ID: WEDAM_T4_COMMS2
TEAMS: BR20 & BR21

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Preface

This Scoping Document created by the ENGG2000/3000 students of the T4_C2 team, outlines the comprehensive scope, requirements, and expectations for the development of a section of the Integrated Mass Transit System, specifically the BladeRunner System. This document aims to clearly communicate the project's objectives, constraints, and deliverables within the team, to all other engineers involved and to the stakeholders, ensuring a common ground of understanding and alignment among all the parties and therefore bridging any gaps of information.

The contents of this document will serve as a foundational reference throughout the project's lifecycle: guiding, decision-making, execution and evaluation. Each section of the document has been carefully crafted to address the critical aspects of the project, from the initial problem statement to the final performance, testing schedule and preliminary design. The team has dedicated significant effort to ensure that this document is both detailed and written in simple words, providing a clear roadmap for achieving the project's goals.

Generative AI Statement

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Document Version History

Authors:

Kevin La (KL), Khalidur Rahman (KR), Avi (AM), Fiha (F), Guryash Arora (GA), Josh Espino (JE)

Revision History

Version	Revised On	Author	Revision Description
1.0	14/08/2024	KL	Document creation
1.1	14/08/2024	KL, KR, AM	Adding core scoping document headings, adding content for main headings. Assumptions, requirements, constraints, and deliverables chart
1.2	14/08/2024	F	Draft of document summary & problem statement
1.3	15/08/2024	JE	Revised functional and non-functional requirements, formatting, & requirements summary
1.4	17/08/2024	JE, KR	Added interface requirements, inclusions and exclusions, TPMs
1.5	17/08/2024	F, KR	Added preface, updated deliverables, updated problem statement, added contributors, preliminary design
1.6	17/08/2024	KL	Subsystems, revision of assumptions/constraints, appendix attachments, requirement sign offs
1.7	18/08/2024	JE, KR, AM	Formatting & minor revisions

Glossary

Term	Definition
MCP	Master Control Program
CCP	Carriage Control Program
ENGG2000 / ENGG3000	Engineering Practice / Engineering Project Practice
Blade Runner	Refers to the vehicles that will navigate the track, these vehicles run a Carrier Control Program. May also be referred to as 'carriers' or 'trains'.

Contributors

The team contributing to this scoping document is one of the Communications Team (T4-C2), a group of enthusiastic Student Software Engineers, currently in 2nd and 3rd years of degree at

Macquarie University. This team is in charge of creating a Carrier Control Program (CCP) for smooth commuting of a BladeRunner in the Urban Transit System. Contributing members include:

Member Name	Student ID
Avi Mehta	46427767
Kevin La	45229082
Khalidur Rahman	47491833
Bushra Fiha	47586443
Josh Espino	47355239
Guryash Arora	47193336

1. Introduction

This report focuses on the project of developing a section of the **Integrated Mass Transit System**, specifically a suspended monorail network, also known as the **BladeRunner System**. The system will utilise narrow rail-blades along which the BladeRunners (or carriers) will move and transport passengers between stops.

Therefore, the ENGG 2000/3000 engineers are responsible for providing this clear, concise, and comprehensive document that effectively communicates the tasks and the goals to all stakeholders involved in this project.

This scoping document highlights the practice of Software Engineering in this project. Each of the Comms (communications) team is responsible for developing a Carriage Control Program (CCP) that collaborates with the Master Control Program (MCP) of this project and sends messages regarding the acceleration, deceleration, and stopping of carriers, and all the states shall be conveyed by the colour of onboarding LEDs. The whole communication channel must be established over the TCP/IP protocol.

1.1 Executive Summary

Project Overview:

The project focuses on designing, prototyping, and building a section of the Integrated Mass Transit System. The carriers, or the BladeRunners will be suspended from narrow-rail bladed tracks. A communication channel will be set over the protocols to ensure seamless messaging between the Master Control Program (MCP) and its subsystems. These subsystems comprise the multiple Carrier Control Program (CCP) that will run on each of the carriages.

Different teams are working on different aspects of the project. T4_C2, or Team Four, Communications 2 has been assigned to design a Carrier Control Program (CCP) for one of the BladeRunners.

Scope of the project:

The task involves the development of the CCP to communicate with the MCP over a Wi-Fi network. The scope of the CCP consists of controlling the movement speed, avoiding collisions, imposing the limp mode, and demonstrating the states of the CCP by LED signals.

Key Findings and Decisions:

Based on discussions with the peers and supervisors, it has been decided that C++ will be used as the programming language. Arduino IDE and its surrounding libraries will be used in programming of CCP and MCP. Moreover, TCP/IP protocol will be used to establish the communication channel and both the MCP and the CCPs will be using the same protocols and data format.

Constraints and Assumptions:

The main constraints for the project are the 13-weeks timeframe, minimal budget, sourcing the materials only from permitted suppliers, communication time and radius for the BladeRunners, and some certain software related limitations.

The assumptions include: no network interference surrounding the system, MCP will generate global commands, and there will be IR sensors on the track to locate the carriers

Expected Deliverables:

The project will deliver a comprehensive set of documents, including a Bill of Materials, Scoping Document, Design Document, Testing Document, Statement of Work and a Final Artefact Presentation.

End Goal:

The success of the project lies in designing and building the BladeRunner System. To be precise, the goal for the T4_C2 team is to ensure that the CCP can connect to the MCP, and the necessary controls imposed on the carrier are working within parameters.

1.2 Problem Statement

The goal of this project team is to design an highly-efficient and advanced mass transit system, also termed as the **BladeRunner** system, that meets the growing needs of a city while keeping sustainability, budget, and environmental factors in mind.

Each of the teams assigned to build the BladeRunner system are divided into 3 subgroups: The Structure team consisting of Civil Engineers, the Motions Team consisting of Mechanical Engineers, and the Communications team consisting of Software Engineers. Given the narrow blade-like rail track, the structure team is responsible for building the body of the BladeRunner or carriage and ensuring that it aligns with the entire physical system, and the Motions team will be working on making the BladeRunners move. The Communications team will create a communication channel to ensure seamless operation of the carriers on the track by exchange of signals between a Master Control Program (MCP) and Carrier Control Programs (CCP) associated with each BladeRunner.

This report is being documented by one of the Communications Team, T4_C2, whose primary challenge is to create an efficient CCP for a BladeRunner within the allocated budget, and ensure that the CCP communicates and follows control commands of MCP as per the client requirements. To be more precise, the CCP should be able to provide commands to maintain speeds, movements, demonstrate current state though LEDs, and ensure limp mode during network failures or to avoid collisions. It should also be able to send real-time status updates to the MCP and receive necessary directions, commands etc. from the MCP as well. Additionally, it should be ensured that there are minimal or almost no service interruptions during the network failures or, in the other emergency cases when the limp mode is activated.

1.3 Assumptions

Below is a list of assumptions that will apply during the design and development of the CCPs. Certain assumptions are based on aspects of the project development that are outside of the Comms scope of works. For example, the physical construction of the carriage will be held responsible to structural teams. These types of assumptions are made in prediction that the implementation of these areas will meet functional level of completion.

ID	Category	Assumption Description	Status
A1.1	Resources	The supplied $100 budget will remain the same across the duration of the project.	**Valid**
A1.2		Approved suppliers will have sought materials and parts for carriage construction, if not, similar alternatives shall exist	**Valid**
A1.3		Materials and parts will arrive from suppliers within the project timeline	**Valid**
A2.1	Blade Runner Course	During project demonstrations, a prebuilt blade runner track will be available. The track itself will contain be a oval-shaped circuit with no diversions or obstacles	**Valid**
A2.2		The demonstration track will contain checkpoints indicated by LEDs	**Valid**
A2.3		Track will contain stations. Stations cannot move	**Valid**
A2.4		Track will be indoors, and not exposed to the elements	**Valid**
A2.5		At any point in time, there may be a maximum of 5 blade runners on the same track	**Open**
A3.1	Carriages	Blade runner will be robust and durable enough for multiple operations along the track	**Open**
A3.2		Blade runners will mechanically capable of stopping and moving forwards and backwards	**Open**
A3.3		Blade runner will have adequate power to maintain stable operation during operation	**Open**
A3.4		Blade runners will have: 1. A programmable propulsion motor system	**Open**

		2. Programmable mounted LED(s) 3. Programmable sensor(s) 4. Programmable doors for station passengers	
A3.5	Communication	There will be no connection interferences with wireless communication during the operation of the blade runner system	**Valid**
ID	**Category**	**Assumption Description**	**Status**
A3.6	Communication	MCP will provide global commands to direct actions of the CCPs over wireless communication. These commands will align with the project objectives.	**Valid**
A3.7		MCP and CCP will communicate and exchange information using the same protocols and data formats	**Valid**
A3.8		Communication protocols and standards will be dedicated by the MCP teams	**Valid**
A4.1	Software	C++ and Arduino's surrounding tools and libraries will be used in the programming of the MCP & CCP	**Valid**

1.4 Subsystems

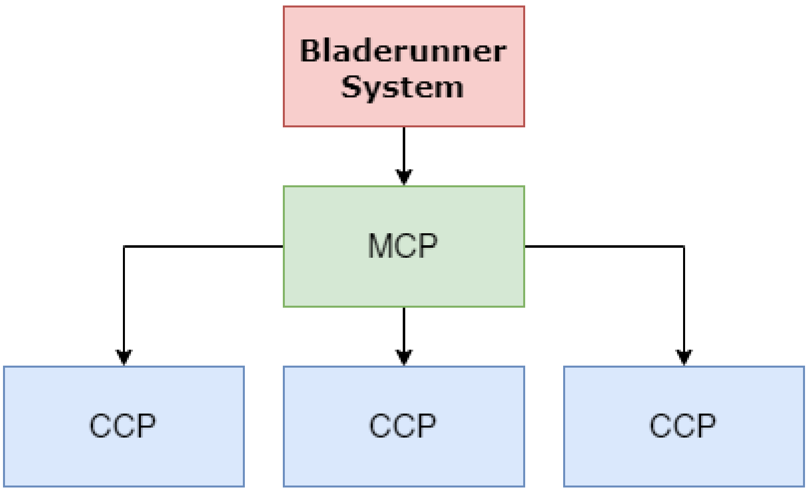


Figure 1.4.1 Software subsystems diagram of Blade Runner Project.

The MCP and CCP being developed by the ENGG 2000/3000 teams are two subsystems of the larger Blade Runner System. As shown in **Figure 1.4.1**, the MCP represents the central node of the system, controlling multiple blade runners hosting individual CCPs. In the scope of this COMMS team, CCP development is the focus. Therefore, outside of interfacing with the MCP, the MCP subsystems are not within the scope of works. Architecturly, the CCP software can be broken down into further subsystems to reveal more ground level modules and components. The team has abstracted the following components with their purposes and potential interfaces:

1.4.1 Motor subsystem

The motor subsystem is responsible for managing the blade runner's propulsion motor used for forward and backwards movement as well as braking. This subsystem enables controlled movement of the carriage in response to commands made by the control subsystem. To drive the motor, the subsystem will utilise the supplied battery to provide electrical power in order to create motion in the motor, the level of supplied energy will determine the speed of the carriage.

1.4.2 LED subsystem

The LED subsystem is responsible for managing any mounted LED(s) on the blade runner. These LED(s) will indicate the current state of the blade runner, providing visual feedback for presentation and troubleshooting purposes. The subsystem should handle turning OFF and ON the LED(s) as well as changing the colours depending on commands made by the control subsystem.

1.4.3 Door subsystem

The Door subsystem is responsible for controlling any/all door functionalities when stopping at stations to unload or load passengers. This may include handling any motors used to mechanically operate an existing door system, ultimately this depends on the implementation of structural and motions teams.

1.4.4 Sensor subsystem

The Sensor subsystem is responsible for capturing real-time data about the blade runner's environment, this may include the carriage's position, proximity to objects, speed etc.. Data gathered by these sensors are sent to the control subsystem to make intelligent decisions regarding the trains actions. This subsystem involves handling the calibration, operation and data management of all onboard sensors. There may be different types of sensors, each of which would be its own subsystem. Identified sensors include:

1. **Close-Proximity detection → Ultrasonic sensor:** Detecting objects, specifically other carriages, in front and behind the carriage.
2. **Track position detection → Phototransistor:** Detecting checkpoints of the track marked by LEDs to determine the blade runner's global position .

1.4.5 Fail-Safe subsystem

The Fail-Safe subsystem is responsible for ensuring the safety of the carriage in the event of failures in the system. This includes emergency stop mechanisms, carriage 'limp' mode, loss of communication protocols, and battery level monitoring. Requires interfacing with most other systems or may be coupled together with the control subsystem depending on implementation.

1.4.6 ESP32 Communication subsystem

The Communication subsystem is responsible for managing the ESP32 microcontroller and its Wi-Fi connection network. This includes any communication protocols and security implementations used to establish and maintain a connection to the MCP.

1.4.7 Control / Data Processing subsystem

The Control subsystem is responsible for coordinating the individual subsystems to perform the carriage's functionalities as dictated by the MCP. Being a module that interfaces with all subsystems, its tasks range from using the communication module to send and receive messages to using motor and door subsystems to move and carry passengers between stations.

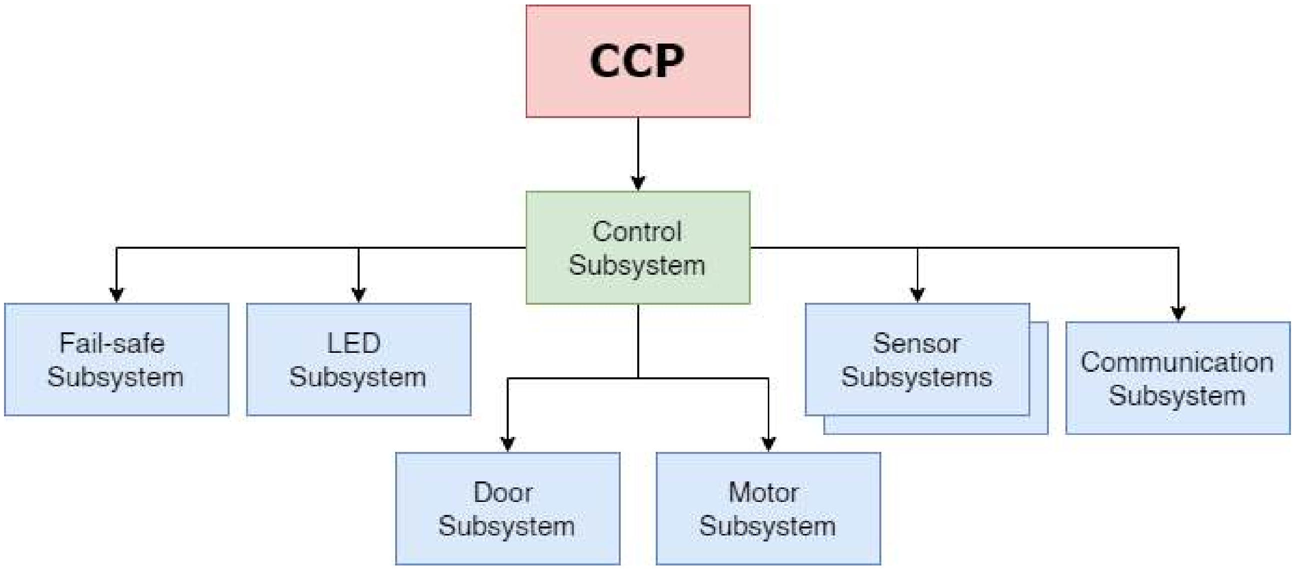


Figure 1.4.2 CCP subsystems

1.5 Constraints

Constraints are an essential part of any working project and this is no exception. Understanding these constraints would be key to an effective project planning and implementation as they define certain boundaries while the project is being worked on. By clearly defining these constraints early on, we aim to mitigate as much risk as possible while ensuring we set realistic goals.

ID	Constraint	Constraint Description
Resources		
C1.01	Project timeframe requires a functional prototype in **eight weeks** and a final product in **thirteen weeks.**	Project must produce a testable and functional prototype in eight weeks and deliver the final product in thirteen weeks. Final product must meet the requirements for the full-system demonstration.
C1.02	Cost of materials and parts for **EACH** individual blade runner must not exceed $100	COMMS_2 team will be responsible for two separate CCPs, each construction of each carriage must exceed $100
C1.03	Any work done must be produced by members of the COMMS_2 team	Design and development of the designated CCPs must be conducted by the six team members involved, this includes documentation. Further human resources and assistance is not permitted.
Physical		

C2.01	Materials and parts purchased for the construction of the blade runner must be sourced from permitted suppliers.	Allowed suppliers include: Bunnings, RS Online, Core Electronics, and Jaycar
C2.02	Supplied battery must be used. The total power consumption of the carriage, including all electronics, shall not exceed 12W.	*Self-Explanatory*
C2.03	No modifications or additions can be made to the supplied blade runner track	*Self-Explanatory*
Software & Communications		
C3.01	Code and data shall not exceed the 32KB memory and 2KB of SRAM on the Arduino Uno [2]	*Self-Explanatory*
C3.02	Software should be modular, allowing quick maintenance and changes to its subsystems	*Self-Explanatory*
C3.03	Arduino Uno's [2] processor speed runs at a maximum 16 MHz. Algorithms and computations should account for this limitation	*Self-Explanatory*

2. Scope of Works

2.1 Deliverables

The deliverable ensures that all the vital aspects of the project are thoroughly documented, so it can be checked back and forth every time that the ongoing development process is kept up with the project goals. Therefore, the team will be providing with the following deliverables within the duration of working on this project:

ID	Name	Description	Due Date
DL01	Bill of Materials	A structured list of required components, their description, required quantity, and per unit cost.	11/08/2024

DL02	Scoping Document	A document detailing project objectives, scope, deliverables, and ultimate goals.	18/08/2024
DL03	Design Document	Document outlining software design and the UI design, including a high-level overview of system architecture.	29/09/2024
DL04	Testing Document	Document highlighting CCP functions, operations, and the different types of testing based on that for further evaluation	03/11/2024
DL05	Statement of Work	Document outlining the scope, deliverables and project timeline of the Communications team.	03/11/2024
DL06	Final Artefact Presentation	A final presentation that clarifies and markets the final product of the communications team to interested parties i.e. interested customers, potential stakeholders.	28-30/10/2024

2.2 Inclusions

Documentation:

- **Bill of Materials (BOM):** A comprehensive list of all materials and components required for the development of the Blade Runner, including costs.
- **Scoping Document:** A detailed document outlining the project scope, assumptions, constraints, and other critical elements.
- **Design Documentation:** Includes initial, preliminary, and final design documents detailing the architecture, interfaces, and subsystems of the Blade Runner.
- **Testing Documentation:** Detailed test plans, cases, and results for all functional, performance, and integration tests conducted during the project.
- **Statement of Work:** A formal document summarising the work completed, outcomes achieved, and the project's overall impact.

Implementation:

- **Development on Arduino Uno:** Utilising C++ for programming the Carriage Control Program (CCP).
- **Adafruit Library Integration:** Implementing the Adafruit library to control all LEDs on the Blade Runner.
- **TCP/IP Protocol Communication:** Establishing communication between the CCP and the Master Control Program (MCP) over Wi-Fi using the TCP/IP protocol.
- **JSON Command Structure:** Utilising JSON format for sending and receiving commands between the CCP and MCP.

Testing:

- **Comprehensive Test Coverage:** All functional, performance, and integration requirements will be thoroughly tested.
- **Simulation and Real-World Testing:** The system will undergo both simulated environment testing and real-world scenarios to ensure robust performance.
- **Failsafe Mechanisms:** Testing the effectiveness of the failsafe mechanisms, including limp mode activation and recovery processes

Subsystems:

- **Motor Control Module:** Development and testing of the motor control system for the Blade Runner.
- **LED Indicator Module:** Integration and control of LEDs for status indication.
- **Door Control Module:** Implementation of the door control system for passenger operations.

2.3 Exclusions

Master Control Program (MCP) Development:

- The design and development of the MCP are not within the scope of the Communications team. The MCP is assumed to be provided and fully functional by another team.

Hardware Design and Construction:

- **Blade Runner Materials and Parts:** The purchasing, ordering, and physical assembly of the Blade Runner carriage are excluded from the Communication team's scope.
- **Blade Runner Track and Infrastructure:** The design, construction, and modification of the Blade Runner track or any related infrastructure are excluded from the Communication team's scope.

Post-Deployment Support:

- **Long-Term Maintenance:** Ongoing maintenance, support, and future upgrades after the initial deployment are not included in the scope of this project.
- **User Training:** The development of user training materials or conducting training sessions for operators is excluded.

2.4 Project Schedule

Tasks/Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13
Team Setup													
Brainstorming													
Review and Evaluation													
Dependency Structure Matrix													
UML Diagram													
Initial Design													
Scoping Document													
Conceptual Design													
Final Design													
Design Document Submission													
Development													
Deployment													
Testing													
Integration													
Integration Testing													
Test Demonstration													
Final Demonstration and Submission													

3. Requirements

The control carriage program acts as the local intelligence for each carriage, interfacing with the master control program, local signals, and on-board sensors to execute commands, report status updates, and manage the carriage's operational state. To effectively meet the objectives of the BladeRunner system, the control carriage program must adhere to a comprehensive set of functional, performance, and interface requirements. These requirements are designed to ensure that the program is not only functionally robust but also achievable.

3.1 Functional Requirements

The functional requirements define the core capabilities and behaviours that the program must exhibit. These functions are essential for the successful operation of each carriage and the overall BladeRunner system.

Functional Requirement	ID	Description
FR01: Communication with MCP	FR01.1	The CCP MUST establish and maintain a reliable two-way communication link with the central control system (MCP) at all running times.
	FR01.2	The CCP MUST transmit the carriage's current location, speed, and operational status to the MCP at a set interval.
	FR01.3	The CCP MUST be capable of receiving and executing commands from the MCP, including but not limited to: move, stop, slow down, and speed up.
	FR01.4	The CCP MUST implement a failsafe mechanism in case of temporary communication failures.
FR02: Visual Indicators (LEDs)	FR02.1	The CCP MUST control the visual indicators to reflect the carriage's operational status.
	FR02.2	The CCP MUST allow the MCP to remotely adjust or override the visual indicators.
FR03: Location Tracking	FR03.1	The CCP MUST be equipped with a location tracking system to provide real-time updates on the carriage's position.
	FR03.2	The CCP MUST generate alerts and log events when location data is inconsistent.
	FR03.3	The CCP SHOULD have an estimation of the speed it is going at based on the motor.
	FR03.4	The CCp MUST be able to differentiate between stations.
	FR04.1	The CCP MUST implement a prioritised command queue, ensuring critical commands are executed first.
	FR04.2	The CCP MUST include safety protocols (limp mode)

FR04: Command Execution		such as stopping when an object in front is detected by the sensor.
	FR04.3	The CCP MUST validate commands received from the MCP to prevent the execution of potentially harmful commands.
FR05: Power Management	FR05.1	The CCP MUST keep track of the battery level and inform the MCP in the case of low power levels.
	FR05.2	The CCP MUST include a shutdown sequence that safely powers down the carriage's systems when nearing battery depletion.
FR06: Local Communication	FR06.1	The CCP MUST be interfaced with local signal systems such as the lighting system and sensors.
	FR06.2	The CCP MUST ensure that local communication is consistent with the commands from the MCP.
FR07: Physical Dimensions	FR07.1	Each BladeRunner carriage MUST have an external length not exceeding 360mm.
	FR07.2	Each BladeRunner carriage MUST have an external width not exceeding 100mm.
	FR07.3	Each BladeRunner carriage MUST have an external height not exceeding 150mm.

3.2 Performance Requirements

The performance requirements address the performance, reliability, security, and maintainability of the Control Carriage Program. These requirements ensure that the software operates consistently under various conditions.

Performance Requirements	ID	Description
PR01: Reliability	PR01.1	The CCP MUST be designed to operate with an uptime of 95%, ensuring minimal downtime.
	PR01.2	The CCP MUST take commands and enact them in a reasonable timeframe.
	PR01.3	The CCP MUST be able to recover from minor faults without having to reboot. If a reboot is needed, it should take less than 3 minutes.
PR02: Performance	PR02.1	The communication latency from the CCP to the MCP MUST NOT exceed 200 milliseconds.
	PR02.2	The CCP MUST respond to received commands within 500 milliseconds.
	PR02.3	The CCP MUST not exceed 32KB of general memory and 2KB of SRAM from the Arduino.

PR03: Maintainability	PR03.1	The CCP MUST be modular in design, allowing components or classes to be updated/replaced individually.
	PR03.2	The CCP MUST have comprehensive documentation for future development and maintenance.
PR04: Usability	PR04.2	The CCP MUST be designed for easy usage that allows the operators to intuitively understand the carriage's state.
PR05: Energy Efficiency	PR05.1	The CCP MUST have optimised processes for power saving especially during low battery levels and limp mode.

3.3 Interface Requirements

Interface requirements define how the control carriage program interacts with other systems, devices, and operators. For the BladeRunner control carriage program, the interfaces need to cover communication with the central control system, local systems, and the human operators.

Interface Requirements	ID	Description
IR01: Communications	IR01.1	The CCP MUST communicate with the MCP using a defined protocol. (TCP/IP).
	IR01.2	The interface MUST include a handshake mechanism to establish and confirm a connection with the MCP.
	IR01.3	The interface MUST support message formats defined in JSON for structured data exchange.
IR02: Local Interface	IR02.1	The CCP MUST interface with local signals, such as the local sensors, doors, and motors using a defined communication protocol.
	IR02.2	The interface MUST allow the CCP to control local components in real-time based on commands from the MCP.
IR03: User Interface	IR03.1	The CCP MUST provide a graphical user interface (GUI) for remote monitoring and control.
	IR03.2	The GUI must display real-time data of the carriage's location, speed, battery level, and current status.
	IR03.3	The GUI must support alerts for low battery conditions, which should be displayed on the GUI.
IR04: Data Interface	IR04.1	The Data Interface MUST set a standard for receiving and sending information.
	IR04.2	The Data Interface MUST include status of CCP, status of doors, status of LED.
	IR04.3	The Data Interface MUST also be implemented by the

		Bladerunner Object.
IR05: Bladerunner Interface	IR05.1	The Bladerunner Interface MUST set universal values and methods for the Bladerunner.
	IR05.2	The Bladerunner Interface MUST also be implemented by the object of the User.

3.4 Requirements Sign-Offs

Sign-Offs of requirements checked by:

- COMMS MCP Team Leader: **Vikil Chandrapati 47189320**
- MOTIONS_ 1 Team Leader: **Bavatharani Janahiram 47770392**

Requirement ID	Motions Signoff	MCP Signoff	Requirement ID	Motions Signoff	MCP Signoff
FR01.1	**B.J.**	**V.C.**	PR01.1	**B.J.**	**V.C.**
FR01.2	**B.J.**	**V.C.**	PR01.2	**B.J.**	**V.C.**
FR01.3	**B.J.**	**V.C.**	PR02.1	**B.J.**	**V.C.**
FR01.4	**B.J.**	**V.C.**	PR02.2	**B.J.**	**V.C.**
FR02.1	**B.J.**	**V.C.**	PR02.3	**B.J.**	**V.C.**
FR02.2	**B.J.**	**V.C.**	PR03.1	**B.J.**	**V.C.**
FR03.1	**B.J.**	**V.C.**	PR03.2	**B.J.**	**V.C.**
FR03.2	**B.J.**	**V.C.**	PR04.2	**B.J.**	**V.C.**
FR04.1	**B.J.**	**V.C.**	PR05.1	**B.J.**	**V.C.**
FR04.2	**B.J.**	**V.C.**	IR01.1	**B.J.**	**V.C.**
FR04.3	**B.J.**	**V.C.**	IR01.2	**B.J.**	**V.C.**
FR05.1	**B.J.**	**V.C.**	IR01.3	**B.J.**	**V.C.**
FR05.2	**B.J.**	**V.C.**	IR02.1	**B.J.**	**V.C.**
FR06.1	**B.J.**	**V.C.**	IR02.2	**B.J.**	**V.C.**
FR06.2	**B.J.**	**V.C.**	IR03.1	**B.J.**	**V.C.**
FR07.1	**B.J.**	**V.C.**	IR03.2	**B.J.**	**V.C.**
FR07.2	**B.J.**	**V.C.**	IR03.3	**B.J.**	**V.C.**
FR07.3	**B.J.**	**V.C.**			

4. Technical Performance Measurements

TPM ID	Requirement ID	Parameter	Methodology and Results
TPM01	FR01	The CCP MUST establish and maintain a reliable two-way communication link with the MCP.	The communication link between CCP and MCP should maintain an uptime of 95% over a 24-hour testing period.
TPM02	FR02	The CCP MUST control the visual indicators to reflect the carriage;s operational status	LED state changes must occur within 100 milliseconds of receiving a command from the CCP.
TPM03	FR03	The CCP MUST be equipped with a location tracking system to provide real-time updates on the carriage's position.	The location tracking system should update the position data to the MCP every 500 milliseconds.
TPM04	FR04	The CCP MUST implement a prioritized command queue, ensuring critical commands are executed first.	Critical commands (e.g., stop, emergency halt) must be executed within 50 milliseconds of receipt.
TPM05	FR05	The CCP MUST keep track of the battery level and inform the MCP of low power levels.	A low battery alert must be sent to the MCP within 10 seconds of the battery reaching 15% capacity.
TPM06	FR06	The CCP MUST be interfaced with local signal systems such as lighting and sensors.	The CCP must process local signals (e.g., door close sensor) and respond within 200 milliseconds.
TPM07	FR07	Each BladeRunner carriage MUST meet specified physical size constraints.	Verify through physical measurement that each carriage does not exceed the specified dimensions.
TPM08	PR01	The CCP MUST operate with an uptime of 95%, ensuring minimal downtime.	Measure system uptime over a continuous 72-hour operational period to ensure it meets or exceeds 95%.
TPM09	PR02	The communication latency from CCP to MCP MUST NOT exceed 200 milliseconds.	Measure round-trip latency between CCP and MCP commands to ensure it stays below 200 milliseconds.
TPM 10	PR03	The CCP MUST be modular, allowing components to be updated individually.	Measure the time required to replace a module (e.g., MotorController) without disrupting overall system functionality.
TPM 11	PR04	The CCP MUST be designed for easy usage by operators.	Evaluate the time required for a new operator to achieve

			proficiency in using the CCP controls.
TPM 12	PR05	The CCP MUST have optimized processes for power saving during low battery levels.	Measure power consumption in low-power mode to ensure it does not exceed 1W during idle states.

5. Preliminary Design

5.1 Overview

The preliminary design of the Control Carriage Program(CCP) for the Blade Runner has been designed to ensure that all functional, performance, and interface requirements are met. This section outlines the key components and design considerations. There might be additional changes in the design.

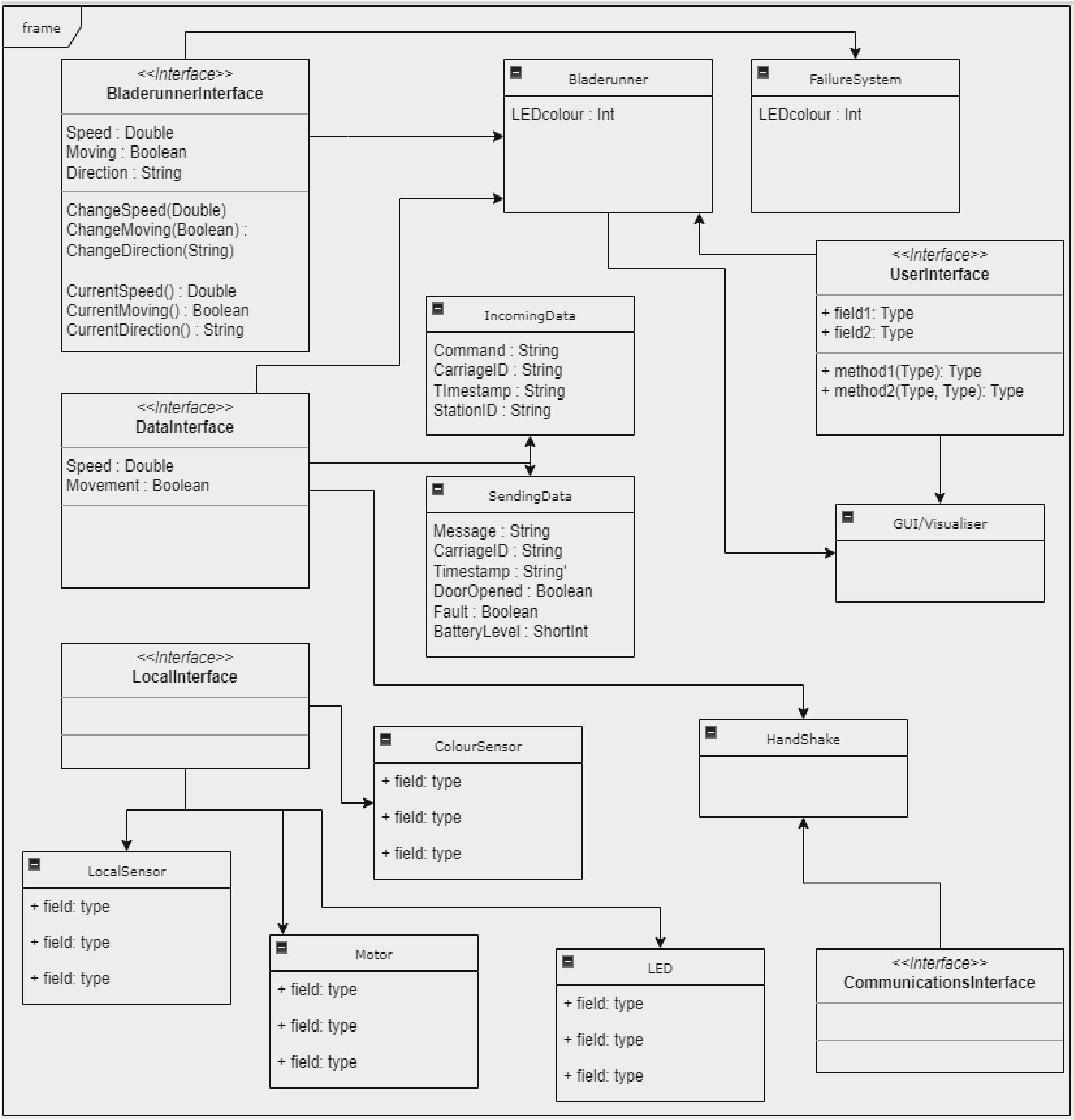
5.2 System Architecture

The CCP is designed to operate as a distributed control system, interacting with the Master Control Program (MCP) and various onboard subsystems. The architecture is modular, allowing for flexibility and scalability. The key components include:

- **Central Control Layer (MCP):** Handles global commands and overall coordination of the BladeRunner system.
- **Carriage Control Layer (CCP):** Local operations for each carriage, responsible for executing commands from the MCP.
- **Communication Layer:** Ensures data exchange between the MCP and CCP using the TCP/IP protocol, ensuring reliable and timely command execution.
- **Subsystems:** Includes Fail-Safe mechanism, door control module, motor control module, sensor control module, communication module.

5.3 Design and Interfaces

This diagram represents the core architecture of the system, with incoming data from the MCP interacting with various modules and sending back the processed data to the MCP.


frame
<<Interface>>
BladerunnerInterface
Speed : Double
Moving : Boolean
Direction : String
ChangeSpeed(Double)
ChangeMoving(Boolean) :
ChangeDirection(String)
CurrentSpeed() : Double
CurrentMoving() : Boolean
CurrentDirection() : String
Bladerunner
LEDcolour : Int
FailureSystem
LEDcolour : Int
<<Interface>>
UserInterface
+ field1: Type
+ field2: Type
+ method1(Type): Type
+ method2(Type, Type): Type
IncomingData
Command : String
CarriageID : String
TImestamp : String
StationID : String
<<Interface>>
DataInterface
Speed : Double
Movement : Boolean
SendingData
Message : String
CarriageID : String
Timestamp : String'
DoorOpened : Boolean
Fault : Boolean
BatteryLevel : ShortInt
GUI/Visualiser
<<Interface>>
LocalInterface
ColourSensor
+ field: type
+ field: type
+ field: type
HandShake
LocalSensor
+ field: type
+ field: type
+ field: type
Motor
+ field: type
+ field: type
+ field: type
LED
+ field: type
+ field: type
+ field: type
<<Interface>>
CommunicationsInterface

6. Bibliography

[1] Espressif, “ESP32WROOM32D & ESP32WROOM32U Datasheet.” Accessed: Aug. 15, 2024. [Online]. Available: https://www.espressif.com/sites/default/files/documentation/esp32-wroom-32d_esp32-wroom-32u_datasheet_en.pdf

[2] Arduino, “Product Reference Manual SKU: A000066.” Accessed: Aug. 11, 2024. [Online]. Available: https://docs.arduino.cc/resources/datasheets/A000066-datasheet.pdf

[3] V. Chandrapati VC, “Protocol Specification Document.” [Online]. Available: https://docs.google.com/document/d/17W4f-VXQut0MFQD01Qk7ndWkSbPoZDMfojv-fTTfrOI/edit#heading=h.hzgg8y533h3q

[4] J. Pachl, *Railway Signalling Principles*. 2020.

7. Appendix

7.1 Design Structure Matrix: COMMS_2

		1	2	3	4	5	6	7	8	9
Sensor Mechanism	1									
Motor Control	2									
LED Control	3									
Door Operation	4									
Wi-Fi connection	5									
Failure System	6			x	x					
Data Transmission	7					x			x	
Process Master data	8						x	x		x
Process Carriage data	9	x	x	x	x	x			x	
Performance Tests	10	x	x	x	x	x	x	x	x	x

7.2 Design Structure Matrix: TEAMS BR20 & BR21

X when row depends on column.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
STRUCTURE MOTIONS COMMS		Carriage Box	Internal Cavity Space	Moveable Weight	Mounting System	Wheel Mechanism	Counter Weight*	Suspension	Doors	Aesthetics	Wiring	Power Supply	Drive Motors	Sensors	Motor Driver	Arduino	Sensor Mechanism	Motor Control	LED Control	Wifi Connection	Failure System	Data Transmission	Process Master Data	Process Carriage Data	Performance Tests
1	Carriage Box																								
2	Internal Cavity Space	x																							
3	Moveable Weight	x	x																						
4	Mounting System	x		x		x																			
5	Wheel Mechanism				x		x																		
6	Counter Weight*			x		x																			
7	Suspension			x																					
8	Doors	x																							
9	Aesthetics	x	x	x	x	x	x	x	x		x				x		x	x							
10	Wiring																								
11	Power Supply																								
12	Drive Motors				x	x					x	x		x	x	x									
13	Sensors											x													
14	Motor Driver				x	x					x	x	x												
15	Arduino										x	x		x											
16	Sensor Mechanism																								
17	Motor Control																								
18	LED Control																								
19	Wifi Connection																								
20	Failure System																	x	x						
21	Data Transmission																			x			x		x
22	Process Master Data																				x	x		x	
23	Process Carriage Data																x	x	x	x	x		x		x
24	Performance Tests																x	x	x	x	x	x	x	x	

7.3 Bill of Materials (BOMs) for B20 & B21 Teams

Project:	2024 Blader Runners
Team:	T4_S1, T4_M1, T4_C2
Group:	T4_S1
Ordered By (SID):	Procumentent by Rex
Order Date:	9-Aug-24
Notes:	Enter one order per team. Only team orders will be processed.

Team Name (BR#, St#, MCP)	Submitter	Total Quantity Required (number of individual things)	Description	Number of packs to purchase from Supplier	Price (AUD) (including GST)	Lead time (Days)	Delivery Date	Shipping Price	Extended Price	Alternative Acceptable?	Supplier URL
T4_Comms2	Tristan Krishna	1	Neodymium Magnet	1	$5.60	7	13/08/24	$6.00	$5.60	no	https://core-electronics.com.au/2912-series-neodymium-magnet-5mm-diameter-15mm-thickness-2-pack.html
T4_Comms2	Tristan Krishna	1	ESP32 WROOM-32D	1	$6.00	2-5	12/08/24	$0.00	$6.00	no	Macquarie School of Engineering
T4_Comms2	Tristan Krishna	1	NeoPixel Strip	1	$12.20	2-3	12/08/24	$0.00	$12.20	no	https://core-electronics.com.au/neopixel-stick-8-x-ws2812-5050-rgb-led-with-integrated-drivers.html
T4_Struct1	Joseph Keys	1	Battery	-	-	-	14/08/24	-	-	no	Macquarie School of Engineering
T4_Struct1	Joseph Keys	1	Acrylic build material	-	-	-	14/08/24	-	-	no	Macquarie School of Engineering
T4_Struct1	Joseph Keys	1	MDF build material	-	-	-	14/08/24	-	-	no	Macquarie School of Engineering
T4_Struct1	Joseph Keys	6	Century Spring Corp 5 x 25.4 x 0.7mm Compression Spring - 6 Pack	1	$9.98	2-5	14/08/24	$0.00	$9.98	yes	https://www.bunnings.com.au/century-spring-corp-5-x-25-4-x-0-7mm-compression-spring-6-pack_p0487964
T4_Struct1	Joseph Keys	4	Richmond 19 x 6 x 6mm	1	$5.50	2-5	14/08/24	$0.00	$5.50	no	https://www.bunnings.com.au/richmond-19-x-6-x-6mm-rubber-sealed-precision-bearing-4-pack_p0356554
T4_Struct1	Joseph Keys	1	9g Continuous Rotation Servo - FS90R (1.5kg/cm)	1	$5.20	2-5	14/08/24	$0.00	$5.20	no	https://core-electronics.com.au/feetech-1-5kg-continuous-rotation-servo-fs90r.html
T4_Motions1	Ryan Whalley	1	Metal DC Geared Motor w/Encoder - 12V 251RPM 18Kg.cm	1	$29.17	5	16/08/24	$0.00	$29.17	no	https://core-electronics.com.au/12v-dc-motor-251rpm-w-encoder.html
T4_Motions1	Ryan Whalley	1	TB6612FNG Dual Motor Driver Carrier	1	$8.35	5	16/08/24	$0.00	$8.35	no	https://core-electronics.com.au/tb6612fng-dual-motor-driver-carrier.html
T4_Motions1	Bavatharani Janahiram	1	Arduino Uno	1	$6.00	-	-	-	$6.00	no	Macquarie School of Engineering
T4_Motions1	Bavatharani Janahiram	1	HC-SR04 Ultrasonic Module Distance Measuring Sensor	1	$2.15	2-5	19/08/2024	$0.00	$2.15	no	https://core-electronics.com.au/hc-sr04-ultrasonic-module-distance-measuring-sensor.html
T4_Motions1	Bavatharani Janahiram	1	USB A→C cable	1	$2.90	-	13/08/2024	-	$2.90	no	Macquarie School of Engineering
T4_Motions1	Bavatharani Janahiram	1	Solderless Breadboard -	1	$2.80	2-5	13/08/2024	$0.00	$2.80	yes	https://core-electronics.com.au/solderless-breadboard-300-tie-points-zy-60.html
T4_Motions1	Bavatharani Janahiram	-	-	-	-	-	-	-	$6.00		$6 shipping for Core Electronics Items
					$95.85				$101.85		*shipping has been excluded from the $100 limit as items will be mass ordered by the University

Project:	Bladerunner
Team:	T4_S4, T4_M1, T4_C2
Group:	T4_Struct_4
Ordered By (SID):	Procurement by Rex Di Bona
Order Date:	12-Aug-24

Group Name	Submitter	Total Quantity Required (number of individual things)	Description	Number of packs to purchase from Supplier	Price (AUD) (including GST)	Lead time (Days)	Delivery Date	Shipping Price	Extended Price	Alternative Acceptable?	Supplier URL
BR20: T4_Comms2	Kevin La	1	Infrared Phototransistor	1	$1.85	3-1	19/08/24	$0.00	$1.85	no	https://www.jaycar.com.au/infrared-phototransistor/p/ZD1950
BR20: T4_Comms2	Kevin La	1	ESP32 WROOM-32D	1	$6.00	2-5	12/08/24	$0.00	$6.00	no	Macquarie School of Engineering
BR20: T4_Comms2	Kevin La	1	NeoPixel Strip	1	$12.20	6	21/08/24	$0.00	$12.20	no	https://core-electronics.com.au/neopixel-stick-8-x-ws2812-5050-rgb-led-with-integrated-drivers.html
BR20: T4_Struct1	Joseph Keys	1	Battery	-	-	-	14/08/24	-	-	no	Macquarie School of Engineering
BR20: T4_Struct1	Joseph Keys	1	Acrylic build material	-	-	-	14/08/24	-	-	no	Macquarie School of Engineering
BR20: T4_Struct1	Joseph Keys	1	MDF build material	-	$9.90	-	14/08/24	-	$9.90	no	Macquarie School of Engineering
BR20: T4_Struct1	Joseph Keys	6	Century Spring Corp 5 x 25.4 x 0.7mm Compression Spring - 6 Pack	1	$9.98	2-5	14/08/24	$0.00	$9.98	yes	https://www.bunnings.com.au/century-spring-corp-5-x-25-4-x-0-7mm-compression-spring-6-pack_p0487964
BR20: T4_Struct1	Joseph Keys	4	Richmond 19 x 6 x 6mm Rubber Sealed Precision Bearing - 4 Pack	1	$5.50	2-5	14/08/24	$0.00	$5.50	no	https://www.bunnings.com.au/richmond-19-x-6-x-6mm-rubber-sealed-precision-bearing-4-pack_p0356554
BR20: T4_Struct1	Joseph Keys	1	9g Continuous Rotation Servo - FS90R (1.5kg/cm)	1	$5.20	2-5	14/08/24	$0.00	$5.20	no	https://core-electronics.com.au/feetech-1-5kg-continuous-rotation-servo-fs90r.html
BR20: T4_Motions1	Ryan Whalley	1	Metal DC Geared Motor w/Encoder - 12V 251RPM 18Kg.cm	1	$29.17	5	16/08/24	$0.00	$29.17	no	https://core-electronics.com.au/12v-dc-motor-251rpm-w-encoder.html
BR20: T4_Motions1	Ryan Whalley	1	TB6612FNG Dual Motor Driver Carrier	1	$8.35	4-1	16/08/24	$0.00	$8.35	no	https://core-electronics.com.au/tb6612fng-dual-motor-driver-carrier.html
BR20: T4_Motions1	Bavatharani Janahiram	1	Arduino Uno	1	$6.00	-	-	-	$6.00	no	Macquarie School of Engineering
BR20: T4_Motions1	Bavatharani Janahiram	1	HC-SR04 Ultrasonic Module Distance Measuring Sensor	1	$2.15	2-5	19/08/2024	$0.00	$2.15	no	https://core-electronics.com.au/hc-sr04-ultrasonic-module-distance-measuring-sensor.html
BR20: T4_Motions1	Bavatharani Janahiram	1	Solderless Breadboard - 400 Tie Points (ZY-60)	1	$2.80	2-5	13/08/2024	$0.00	$2.80	no	https://core-electronics.com.au/solderless-breadboard-300-tie-points-zy-60.html?gad_source=1&gclid=CjwKCAjw_Na1BhAIEiwAM-dm7EDctiWf3VvAS5bq_wRydxh7hIiFp5AuaMElJZaUImLQ9tnG9iHwKxoCp_wQAvD_BwE
BR20: T4_Motions1	Bavatharani Janahiram	1	USB A→C cable	1	$2.90	-	13/08/2024	-	$2.90	no	Macquarie School of Engineering
BR20: T4_Motions1	Bavatharani Janahiram		Shipping		$14.00						Core Electronics + JayCar
BR20: T4_Motions1					$116.00				$102.00		