MEMORANDUM

To:	Charlie Refvem, Department of Mechanical Engineering, Cal Poly SLO
	crefvem@calpoly.edu
From:	Caiden Bonney
	clbonney@calpoly.edu

Date:	September 21, 2025
RE:	**Preliminary Design and Romi Familiarization**

The installed Motor Driver and Power Distribution board is designed to drive the Romi chassis motors and power any connected electronics. The board consists of two DRV8838 motor drivers and a switching step regulator that can continuously supply 2.5 A at 5 V or 3.3 V for compatibility with a range of other circuit boards. The installed motor drivers are by default powered by the boards 5 V switched battery voltage however they can be modified using jumpers. The drivers consist of 2 pins and 1 timer since each timer can control up to 4 PWM outputs.

The encoder resolution is 12 counts for every revolution of the motor, with the attached gearbox consisting of a gear ratio of 119.76, the effective encoder resolution of each wheel is 1437.1. The smallest increment of distance the encoder can measure therefore is 0.153 mm as this is the distance the 70 mm diameter wheels move when rotated by 1 encoder count. Having two identical sensors does not increase the resolution of the translational motion, however, it does decrease the uncertainty of the distance measured. This is achieved through averaging the measurements each sensor individually reads. Assuming that the motors speed scales linearly with increasing voltage, the linear speed of the motor based on voltage from the rated motor voltage, and motor speed is,

$$v\left[\frac{m}{sec}\right] = \frac{150\left[\frac{rev}{min}\right]}{60\left[\frac{min}{sec}\right]}\left(\frac{V}{4.5[V]}\right) * 2\pi(0.035[m])$$

$$v\left[\frac{m}{sec}\right] \approx 0.122173048\left[\frac{m}{V * sec}\right] * V[V]$$

inputting the rated voltage of 4.5V results in a maximum no-load linear speed of 0.5498 m/s as expected. 6xAA NiMH batteries supply 7.2V which using the previous equation results in a maximum no-load linear speed of 0.8796 m/s. If 6xAA Alkaline batteries are used, providing a total of 9V, then the maximum no-load linear speed of 1.0996 m/s. Therefore, Romi is 25% faster with 9V Alkaline batteries than 7.2V NiMH batteries at top speed. This calculation assumes that the speed of the motor scales linearly with voltage and that the system is under no loading, therefore real world testing will result in reduced speeds. Additional losses not included in this calculation are internal battery resistance, torque limits, and gearbox losses increasing at higher speeds.

The Romi is incapable of moving holonomically as the chassis is constrained by the movement of each of its wheels. Expanding upon this if one wheel is held still and the other rotates a circle if formed and likewise with the other wheel; the Romi can only move within these circles at any one point time as these are the only component on a basic Romi that can translate it in any way. This means that a Romi cannot move directly sidewise and must turn its "forward" or "backward" direction to face the desired direction of movement. If the Romi's wheels were to slip the Romi would no longer be constrained in the previously mentioned form. This is clearly seen in that if both wheels were to slip the Romi would move based on its momentum which could be "sideways". It is unlikely that the wheels will slip due to the outer material of the wheels being made of rubber, a material designed to provide traction against the ground, however, it is still possible in extreme circumstances such as if the wheels were moving at very fast speeds or the Romi were against an immovable object such as a wall.

The IMU will provide the Romi with, three axis orientation data, four point quaternion output, three axis of ration speed in rad/s, three axis of acceleration in m/s^2 (not including gravity's effects), three axis magnetic field sensing in micro Tesla, three axis gravitational acceleration in m/s^2 (not including movement), and ambient temperature in degrees Celsius. The IMU provides much more information than the wheel encoders, therefore it supplements the wheel encoder's data with no direct overlapping of information.

An example of a sensor that is useful for sensing lines would be infrared sensors which can determine whether the point they are sensing is light or dark based on the reflected infrared data. By using 2 sensors, one on each side of the line being sensed, the Romi can determine when the line is within the 2 sensors allowing it follow it even if it curves as it will know which sensor crossed the line and turn in that direction until the line is within the two sensors again. The infrared sensor could have an internal comparator so that the sensor provides the MCU with a high or low signal or the infrared sensor could provide the MCU with a voltage proportional to the detected IR light. While having additional sensors is useful for confirming one another or filling the gaps between sampling, too many sensors will quickly fill up RAM and flash memory which MCU's are limited on. Having different types of sensors also require multiple different software drivers, libraries, and processing algorithms which further decrease the available space for the code itself.

There are multiple types of bump sensors that could be implemented from physical switches that compress when an object contacts them, to more complex sensors such as radar, LIDAR, or camera sensors. Due to the circular nature of the Romi's design and the movement constraints of the wheels basic bump sensors would include a front and rear bump sensor. However, I would include sensors 45 degrees from the forward direction in both directions to ensure objects that do not directly impact the front of the Romi are still sensed. These sensors could be mounted using the built in holes in the Romi chassis or using adapters made on a 3D printer.

Additional sensors useful to Romi for obstacle avoidance would be those for determining where an obstacle is at a distance such as the more complex "bump" sensors discussed above such as radar, LIDAR, or a camera. The ability to detect obstacles at a distance is the most important thing an autonomous vehicle can have whether the purpose is to avoid or purposely grab and interact with the detected object. These types of sensors are much more than a simple physical switch bump sensor which may make it difficult to interface with a standard Microcontroller. However, simple versions of these sensors may be possible to interface such as only using 1-3 lasers for LIDAR instead of the up to dozens of lasers used in some more advanced systems.

Table 1. Critical Parameters

Parameters	Value	Units
Chassis Diameter	163	mm
Track Width (Wheel Center to Wheel Center)	141	mm
Wheel Radius	35	mm
Gear Ratio (Exact)	119.7576	-
Encoder Resolution (at Motor)	12	counts/rev
Motor Voltage (Rated)	4.5	V
Motor Torque (Stall)	25	oz-in
Motor Speed (No-Load)	150	RPM
Max Speed (Translational)	0.5498	m/s