INCLUDE? -> MARKET LEADER BOOSTED USES 12c and also used brushless with ESCs

Modern brushless DC motors lack complexity themselves, simply constructed of 3 windings in a XXX configuration, driven by a 3 phase AC voltage. Electrical power for this project will be a battery, producing a DC voltage, therefore an inverter will be required to produce the correct drive voltages. This hardware is called an Electronic Speed Controller (ESC) and converts a DC voltage to a 3 phase AC voltage source in order to drive the motor. To use this technology in an electric skateboard, size and weight of the circuitry must be minimised, as space under the deck of the skateboard is at a premium, and any increase in the weight of the board reduces the top end speed. ESCs are a well-documented piece of circuity, and a bespoke controller could be designed specifically for the skateboard. However due to time constraints of team members it was evaluated to be more effective to purchase a pre-existing model that meets the requirements recommended by the motor manufacturer, whilst remaining compact and lightweight. The hobby remote control sector is one of the largest users of ESC technology, as a result of this market there is a full catalogue of ESCs available at a wide range of voltage and current limits, whilst remaining small and light in order that battery life can be maximised in their designed applications. Recommended rating values for the chosen motors are a maximum of 50v (DC), at a continuous current of 120A, giving a factor of safety of 1.5 for the motor’s 80A nominal current draw.

To set the motor speed, electronic control signals are sent to the speed controller, that then manipulates the characteristics of the voltages it produces to accelerate or decelerate the motor to the speed requested. There is a wide range of signal protocols used for this purpose, however the most common (and easiest to implement) is Pulse Width Modulation (PWM) where the ‘high’ period of a repeating square wave is varied between a predetermined range to signify to the controller the requested motor speed. The total time period of the square wave is maintained, resulting in the ‘low’ duration reducing as the ‘high’ duration increases, before the next wave begins. Therefore, as the total wave period decreases, the latency to the controller decreases, as the time taken to transmit a command signal is reduced. However, this signal is often sent over an unshielded wire at a logic high voltage level of 5v, making it sensitive to interference, especially in remote control applications, and therefore there is a lower limit on wave period where the signal becomes indistinguishable from background noise.

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A vital aspect of the control system to consider is the method of relaying information back to the rider, in order that they understand the remaining battery and range, alongside any error states or other information. Therefore, an LCD screen is going to be used, which can display 32 characters at a time in 2 rows of 16. Data transfer to the LCD is performed using an established communication standard - Universal Asynchronous Receiver/Transmitter (UART). Text data (ASCII values) to be displayed is decoded by the LCD hardware and displayed until the next refresh signal arrives with new data. An LCD was chosen over an array of seven segment displays due to the availability of displaying letters in addition to numbers, allowing for enhanced information to be relayed to the rider. This was also in addition to the nature of the LCD arriving in a self-contained functional module, rather than having to design a controller if using a 7 segment display bank.

For the user to control the board speed, pressure pads will be used. If the rider shifts their weight forwards, the board will accelerate, and if the rider leans backwards the board will decelerate. By mapping the weight differential to a requested acceleration, the speed the motors need to turn can be calculated, and the signal sent to the ESCs for each motor. Pressure pad control was chosen rather than a remote control or a direct wire connection due to the ease of design and manufacture, as a remote control especially has a great deal of debugging and loss of signal concerns. Further to this, the system can detect when the rider dismounts, and can stop the board if required.

In order for the pressure pads to affect the system, the information represented by their varying resistances must be interpreted, and the resulting commands changing the speed of the board as required. Therefore, a central control unit must be designed, to interface with the analogue inputs, and create digital control signals the ESCs and LCD can interpret.

However, a microcontroller such as an Arduino nano is powered by a 5v supply rail, which is 10 times smaller than the 50v nominal that the motors will be running at, and therefore a method of producing this voltage is required. The hobby rc industry is again has a circuit such as this available, and a 20A maximum current rating 5v UBEC will be used, which is designed to convert a 12 cell lipo battery voltage to 5v.

The battery voltage is dangerous, running at 50v DC, therefore isolation procedures must be undertaken to ensure that they are electrically safe. Firstly, there is no point in the design where a connection at 50v DC can be accessed without removing the casing of the skateboard, which (NEED TO LOOK UP THE LAW ON HIGH VOLTAGES ETC) makes it safe blah blah blah cover it in insulation blah blah blah

TALK ABOUT FAILURE MODE ANALYSIS? ME AND SAM TOGETHER??