CAV Model Conceptualisation and Feasibility Study

Executive summary:

The development of Connected Automated Vehicles (CAV) requires integrated systems to maintain continuous connection to external domains as to allow for intercommunication between other road going vehicles. While communicating, CAV may be vulnerable to potential network-based threats from external sources. The following report attempts to provide a surface level configuration and costing for a testing platform to challenge the resilience of CAV onboard processes from externally based attacks. Modern methods of autonomous navigation and control require input from a multiple integrated systems. The components listed below are commercially available and reflect current technology within CAV control and communication. These systems will be utilised to determine their robustness to potential incidents.

The test assembly contains integrated circuits which utilise multiple forms of sensory data acquisition. Research conducted into industry wide applications of CAV has shown that the primary means of sensory input is centred around LiDAR, stereo camera-based computer vision, and ultrasonic perception. The integration of these systems enables CAV to interpret their surrounds based upon these sensory devices which render a 3D map of the vehicles environment. Multi-channel sensing is vital within CAV as their ability to navigate their environment is based upon the accuracy and availability of information. Muli-channel sensing enables the CAV to verify and adjust its sense of state based upon the collective information channels, rather than from a singular source. This creates more robust spatial awareness within the CAV and enables a variety of sources to be utilised to confirm its state with respect to environmental conditions.
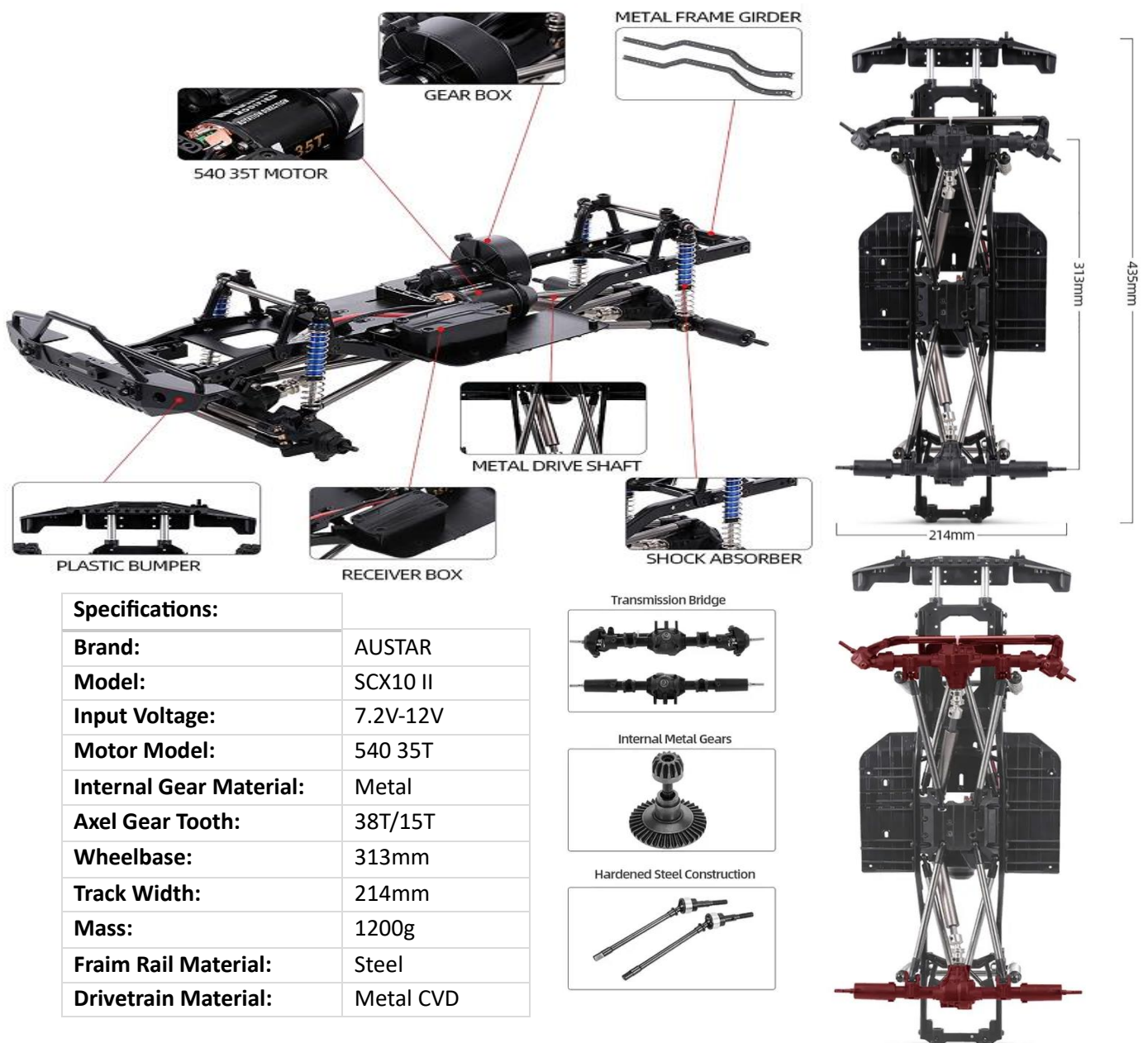
Communications has been considered as a primary attribute within the model. The means of communication will encompass a range of transceivers consisting of WIFI, 5G, Bluetooth, GPS and radio frequency modules. The CAV has onboard processing capabilities which allow the vehicle to determine its spatial awareness and navigate autonomously through its environment. The information concerning the state of the vehicle can then be transmitted to a third party where it's current state can be interpreted and modified as required. The secure connection between the vehicle and the third party is the primary focus of this study.

The control of the CAV will be determined through the onboard computer, where localised and external information will render a map of its immediate surroundings and will pass on navigational information to an onboard Micro-Controller Unit (MCU). The MCU will be dedicated to the control of the vehicles motion, reception of localised data and receiving instructions from the on-board computer.

Contents

Model Chassis and Drive Train

METAL FRAME GIRDER

GEAR BOX

540 35T MOTOR

METAL DRIVE SHAFT

PLASTIC BUMPER

RECEIVER BOX

SHOCK ABSORBER

313mm
435mm
214mm

Transmission Bridge

Internal Metal Gears

Hardened Steel Construction

Specifications:	
Brand:	AUSTAR
Model:	SCX10 II
Input Voltage:	7.2V-12V
Motor Model:	540 35T
Internal Gear Material:	Metal
Axel Gear Tooth:	38T/15T
Wheelbase:	313mm
Track Width:	214mm
Mass:	1200g
Fraim Rail Material:	Steel
Drivetrain Material:	Metal CVD

Injora 540 Brushed Motor 35T

Specifications:	
Brand:	Injora
Motor Model:	540 35T
Input Voltage Range:	7.2V-12V
Motor Diameter:	36mm
Shaft Length:	12mm
Shaft Diameter	3.17mm
Stall Current:	50A
No Load Current:	<1.5A
Mass:	184g
Motor Configuration:	Brushed DC

53mm/2.08in
12mm
3.17mm
36mm/1.41in
35T

17831226 CAV Model

Steering Servo

Specifications:	
Brand:	FiTec
Model:	FS5106B
Input Voltage Range:	4.8-6V
Torque:	0.589Nm
Speed:	0.16Sec/60°
Degree of Motion:	180°
Gear Composition:	Nylon
Output Sprocket:	25T Spline
Mass:	40g
Dimensions:	40.8x20.1x38mm

Battery and Charger:

Specifications:	
Brand:	HRB
Model:	3S
Nominal Voltage:	11.1V
Continuous Current:	50C
Max Burst Discharge Rate:	100C
Charging Current:	3-6A
Storage Capacity:	6000mAh
Power Capacity:	66.6Wh
Battery Type:	LiPo
Mass:	425g
Wire Guage:	10AWG
Dimensions:	155x48x27mm
Monitoring:	Thermal Monitoring

2-Channel Speed Controller:

Specifications:	
Brand:	Hobbywing
Model:	30120301
Input Range:	2-4S LiPo
Continuous Current:	80A
Max Current:	400A
BEC:	4A
Motor Limit 3S	<20000RPM@7.4V
Built In Channels:	Brushed motor & PWM
Programmable Channels:	Separate Port
Mass:	75g
Wire Terminators:	4mm Female Bullet
Dimensions:	49.5x34.7x26.5mm
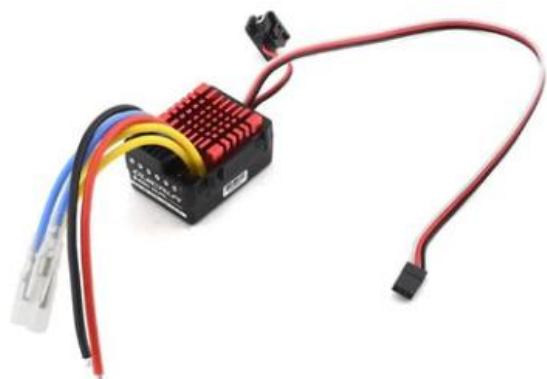
2.4GHz Remote Control and Transceiver Kit

Specifications:	
Brand:	Flysky
Model:	GT3B
Input Voltage:	12V DC
RF Type:	2.4GHz
Sensitivity:	1024
Bandwidth:	500Hz
DCS Port:	3.5mm PPM
Built In Channels:	3 Channels
Programmable Channels:	Separate Port
Mass:	328g
Programming Options:	ServoNOR/REV, Steering Trim, Throttle Trim, Dual Rate, Endpoint Adjustment, ABS Settings, EXP Settings

reComputer J2022-Edge

Specifications:	
Brand:	reComputer
Model:	J2022-Edge
Power Requirements:	19V / 4.75A DC
UBS:	4x 3.1 Type A Ports, 1x USB-C
M.2 Key Supports:	WIFI, BLE, SSD, RTC, CAN, Raspberry Pi GPIO 40 pin
Module:	Jetson Xavier NX 16 GB
GPU:	384-Core NVIDIA Volta
CPU:	6-Core NVIDIA Carmel ARM, V8.2 64-bit CPU 6 MB L2+ 4 MB L3
Memory:	8GB 128bit LPDDR4x
Storage:	16GB eMMc 5.1 + SDD Expansion
Video Encoder:	2x4K60, 4x4K30, 10x1080p60
Video Decoder:	6x4K60 22x1080p60
Display:	HDMI Type A
Camera:	2*CSI Camera (15pos, 1mm pitch, MIPI CSI-2)
Dimensions:	130x120x50mm
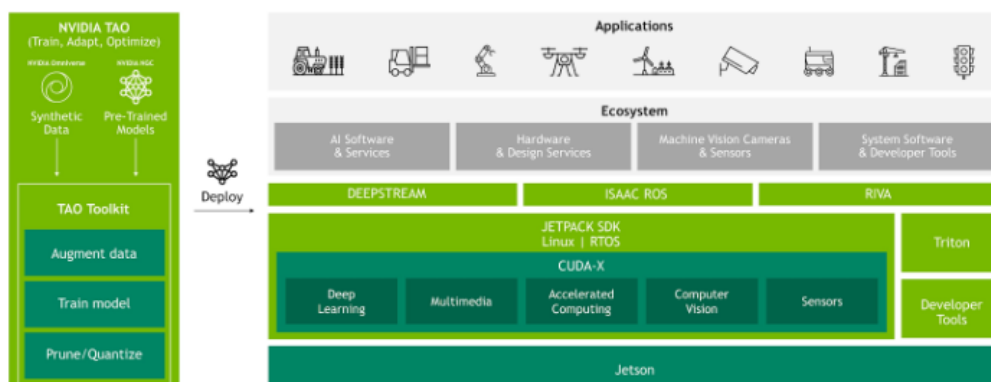
17831226 CAV Model

LiDAR Module

Specifications:	
Brand:	Slamtec
Model:	A2M12
Input Voltage:	5V DC
Communication Output:	UART Serial (2560000bps)
Range Resolution:	Min: <2% @ Range of 12m
Range Accuracy:	Min: <2.5% @ Range of 5-25m
Sample Rate:	16KHz
Mapping Footprint:	100000m^2
Range:	16m
Max Laser Inclination:	±3°
Data Refresh Frequency:	10Hz
Mass:	217g
Power Consumption:	3W

DC-DC Converter

Specifications:	
Brand:	SKU:009328
Model:	DC Voltage Regulator
Input Voltage:	6V-40V DC
Output Voltage:	1.2-36V DC
Max Continuous Current:	20A
Type:	CC-CV Step Down
Efficiency Conversion:	95%
Dimensions:	6x5.5x2.8mm
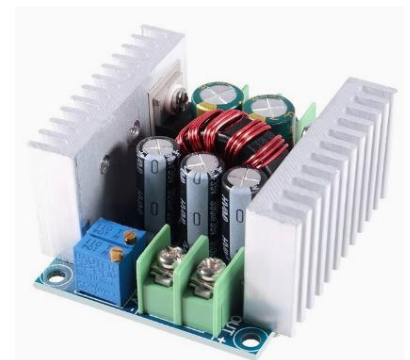
WIFI – Bluetooth Module

Specifications:	
Brand:	ASUS
Model:	PCE-AX3000
Network Configuration:	IEEE 802.11 ax, Bluetooth 5.0
Data Rate:	11Mbps – 2.4Gbps
Operating Frequency:	2.4Ghz – 5Ghz
OS Supported:	Windows 10-64bit, Linux
Weight:	80g

5G LTE Module

Specifications:	
Brand:	EXVIST
Model:	M.2(NGFF)
Network Configuration:	5G/4G-LTE
Input Voltage:	5V
Sim Card Support:	NANO
OS Supported:	Windows 10-64bit, Raspberry Pi
Port Interface:	USB 3.0

Raspberry Pi GPS Module

Specifications:	
Brand:	Seed Studio
Model:	Raspberry Pi GPS Module
Connection Interface:	GPIO, USB Micro
Input Voltage:	5V
Communication Protocol:	UART, USB
Sensitivity:	-165 dBm
Update Rate:	1Hz

IMU Module

Specifications:	
Brand:	GY6500
Model:	MPU-6500 6 DOF Sensor
Connection Interface:	GPIO
Input Voltage:	5V
Communication Protocol:	I2C
Axis Range:	9 Axis Tracking
Sensitivity:	131 LSB/dps
Sensitivity Range:	250 – 2000 dps
Dimensions:	14x21mm

Stereo Camera Module

Specifications:	
Brand:	Astra 3D
Model:	Stereo/RGB Camera Module
Supported Platform:	Raspberry Pi
Output Speed:	1x CSI-2 2-Lane Output Port – 1 Gbps
Output Format:	RAW10
Video Format:	1920 1080P @ 50Hz
Focal Length:	4.74mm
Focus Distance:	10cm – inf
Communication Protocol:	I2C

Ultrasonic Sensor

Specifications:	
Brand:	AHEM Engineering
Model:	HC-SR04
Supported Platform:	Raspberry Pi
Operating Frequency:	40KHz
Connection Interface:	GPIO
Effective Range:	60-4500mm
Accuracy:	3mm
Dimensions:	45x20x15mm
Input Voltage:	3.3-5V

17831226 CAV Model
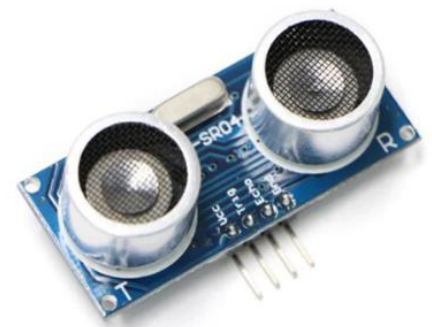
Specifications:	
Brand:	DFRobot
Model:	Distance Sensor Radar
Supported Platform:	Raspberry Pi
Operating Frequency:	2Hz
Connection Interface:	USB
Effective Range:	50m
Accuracy:	+-1mm
Dimensions:	48x42x18mm
Input Voltage:	3.3-5V

System Architecture
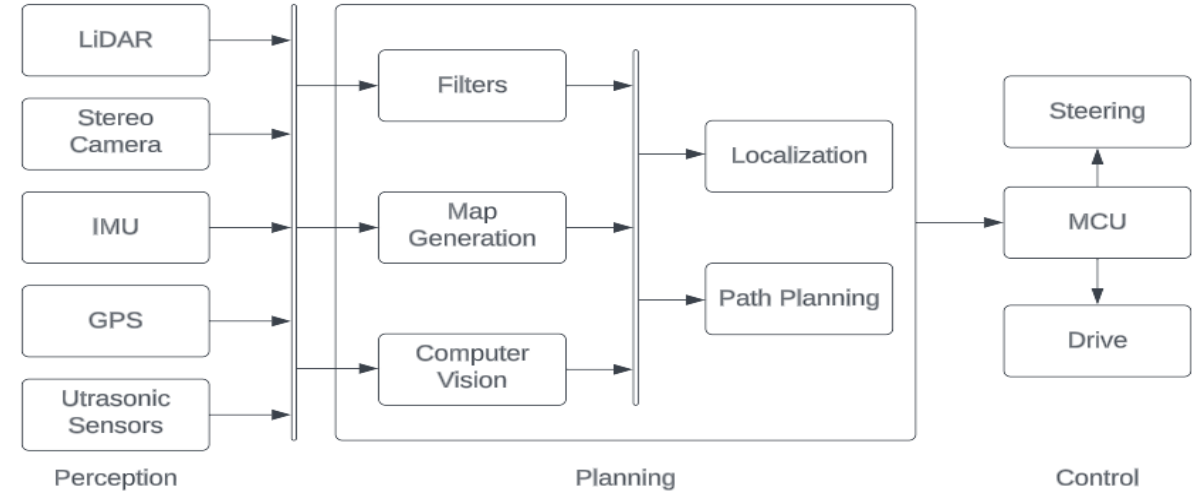
Module Interconnection Map

17831226 CAV Model
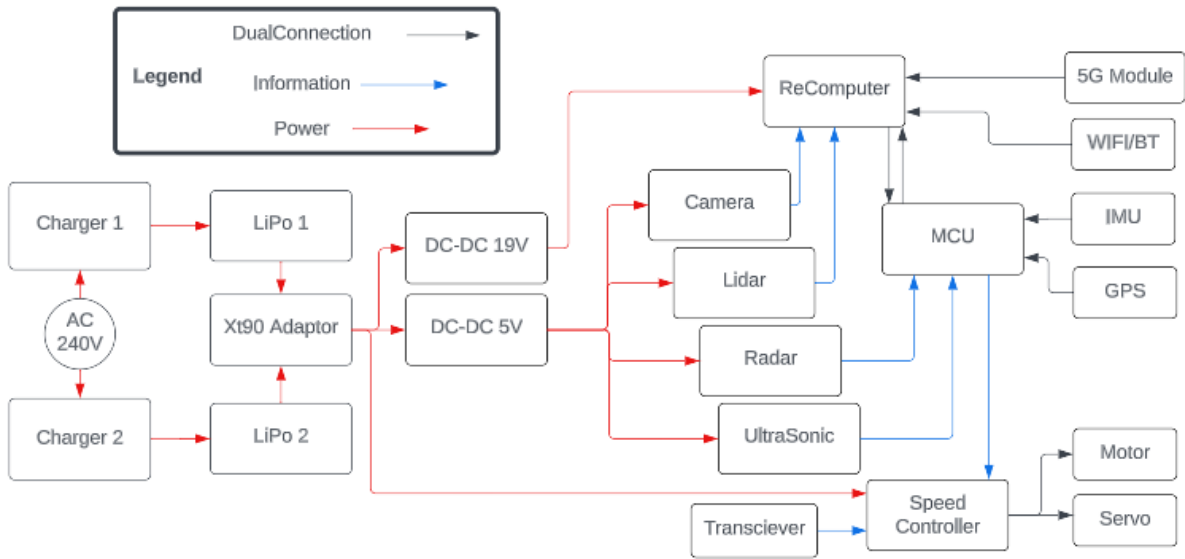
Costing Table

The costings table shows all listed components mentioned above where and their respective price and potential shipping cost.

The List contains most of the needed connectors and terminators but may require additional adaptors or circuit protection hardware with respect to the onboard power supply.

Each of the components are available within Australia and have their associated links listed within the references section.

Qty	Item Title	Description	Item Cost (AUD)	Shipping
1	AUSTAR - SCX II	Chassis And Drive Train	$ 234.80	$ -
1	Injora 540 35ST	Brushed DC Motor	$ -	$ -
1	FiTec - FS5106B	Steering Control Servo PWM	$ 23.50	$ 6.00
1	Yowoo - LiPo Battery	2x 3S 11.1V 5000mAh Lipo	$ 124.01	$ -
1	Hobbywing - 30120301	2-Channel Speed Controller	$ 44.12	$ -
1	FlySky - GT3B	2.4GHz Remote Transceiver	$ 79.95	$ -
1	reComputer - J2022-Edge	Onboard CPU, GPU, MCU	$ 1,116.18	$ 16.80
4	AHEM - HC-SR04	Ultrasonic Sensor	$ 5.45	$ -
1	Astra 3D Camera	Stereo Camera Module	$ 179.89	$ 8.80
1	Slamtec Mapper - A2M12	LiDAR Mapping Sensor	$ 336.76	$ -
1	ASUS - PCE-AX3000	WIFI - Bluetooth Module	$ 69.00	$ 11.77
1	Seed Studio - GPS Module	GPS Module for Raspberry Pi	$ 77.75	$ 6.00
1	MPU - GY6500	IMU Module	$ 7.74	$ 2.20
3	22AWG 1m	Connection Wires Spool variety	$ 1.47	$ 1.66
4	4mm Bullet Adapters	Motor Speed controller connection	$ 0.14	$ 5.61
1	DC6-40V	DC-DC Converter	$ 25.60	$ 4.51
1	HDMI Emulator	HDMI Connector	$ 1.55	$ 4.15
1	512GB Micro SD Card	Read:40-50Mbs Write 9-12Mbs	$ 53.95	$ -
1	XT90 splitter	Male to Female Split Connector	$ 13.32	$ -
2	IMax B6AC	Lipo Battery Charger	$ 38.95	$ -
1	DFRobot	Radar Distance Sensor	$ 101.47	$ 11.99
1	EXVIST	5G LTE Industrial Adapter	$ 139.00	$ -
			Total (AUD)	$ 2,812.75

References

1.) **DC-DC Converter Link:**
https://au.banggood.com/Geekcreit-DC-6-40V-To-1_2-36V-300W-20A-Constant-Current-Adjustable-Buck-Converter-Step-Down-Module-Board-p-1203369.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=AU&utm_content=minha&utm_campaign=aceng-pmax-au-en-pc&currency=AUD&cur_warehouse=CN&createTmp=1&utm_source=googleshopping&utm_medium=cpc_us&utm_content=massa&gltraceid=11189449523&utm_campaign=aceng-pla-au-tsq90d-20221202-massa&ad_id=638753241280&gad=1&gclid=Cj0KCQjw7aqkBhDPARIsAKGa0oJY_xvUAuHHIZsR-NYtQHDwufqsThnz8WooAyxmEJNssyv6dGadPR0aAomyEALw_wcB

2.) **Chassis and Drivetrain Link:**
https://www.kogan.com/au/buy/zoestore-for-110-scx10-ii-rc-crawler-diy-austar-313mm-wheelbase-chassis-frame-car-kit-rm12098-1/

3.) **Steering Servo Link:**
https://core-electronics.com.au/servo-generic-high-torque-standard-size.html

4.) **LiPo Battery Link:**
https://www.ebay.com.au/itm/124866144408?chn=ps&_ul=AU&mkevt=1&mkcid=28

5.) **2 Channel Speed controller link:**
https://www.amazon.com.au/HobbyWing-HWI30120201-Quicrun-1060-Brushed/dp/B01LZHBJ85/ref=pd_bxgy_sccl_1/356-2263202-4773006?pd_rd_w=YIa91&content-id=amzn1.sym.b1232fb4-5a84-447e-abbc-9086244e433a&pf_rd_p=b1232fb4-5a84-447e-abbc-9086244e433a&pf_rd_r=BP1QW357QJYAC87J985K&pd_rd_wg=sIEQi&pd_rd_r=378806f6-2f90-4b39-b263-78d716f5f396&pd_rd_i=B01LZHBJ85&psc=1

6.) **Transmitter Receiver Kit link:**
https://www.auselectronicsdirect.com.au/2.4ghz-lcd-digital-remote-control-transmitter-and?gclid=CjwKCAjw1MajBhAcEiwAagW9MadGqfm23Q7tFE9SOsErAD_FlPuGNiFa4ILKQmtkJZsbezuwEjSXSxoC-cQQAvD_BwE

7.) **reComputer Link:**
https://www.seeedstudio.com/reComputer-J2022-p-5497.html

8.) **m2 Wi-Fi Module – Bluetooth Module link:**
https://www.ple.com.au/Products/638892/asus-pce-ax3000-80211ax-dual-band-wireless-ax3000-pcie-adapter-with-bluetooth-oem-packaging?gclid=Cj0KCQjw98ujBhCgARIsAD7QeAjZo0NNzeKks1qxSvhIhk7Si8tyk3hEZfHysWr6jBku4DKjreMt0JwaApACEALw_wcB

9.) **Lidar Module:**
https://www.dfrobot.com/product-1461.html

10.) **5G Module link:**
https://www.cocoonpower.com/product-page/exvist-5g-lte-industrial-m-2-ngff-to-usb3-0-adapter-w-nano-sim-card-slot-for-5g?gclid=Cj0KCQjw98ujBhCgARIsAD7QeAgEOPAT2ls1mIPFiGd2ePPWAJWpIWGWvXXIibIcr2D-w1-Q-bi2ukoaAoGfEALw_wcB

11.) **Raspberry Pi GPS Module Link:**
https://core-electronics.com.au/raspberry-pi-gps-module-seeed-studio.html?gclid=Cj0KCQjw98ujBhCgARIsAD7QeAhl7KndOD2iPr0o6CNCTs0RX1_oXknpe9zdOVjBnU1fGnL1s95h12YaAmd8EALw_wcB

12.) IMU Sensor Link:
https://www.aliexpress.com/item/4001240214260.html?pdp_npi=2%40dis%21AUD%21AU%242.91%21AU%242.32%21%21%21%21%21%40210318ef16854529066595652e5a66%2110000015424502018%21btf&_t=pvid:00375a29-a579-4a3d-8a6f-9c17c187ab27&afTraceInfo=4001240214260__pc__pcBridgePPC__xxxxxx__1685452907&spm=a2g0o.ppclist.product.mainProduct

13.) Stereo Cameras Link:
https://www.ebay.com.au/itm/165588800146?chn=ps&_ul=AU&_trkparms=ispr%3D1&amdata=enc%3A1OlLsZ3xzR9yWUHmbsSk2kQ46&norover=1&mkevt=1&mkrid=705-139619-5960-0&mkcid=2&mkscid=101&itemid=165588800146&targetid=&device=c&mktype=pla&googleloc=9070552&poi=&campaignid=19657035965&mkgroupid=&rlsatarget=&abcId=9305370&merchantid=640689592&gclid=Cj0KCQjw7aqkBhDPARIsAKGa0oJY22L__A3xLo84vzZa7p-cuUYUrtzaytb5C--oID8xqT2WZ7Ea7joaAmGmEALw_wcB

14.) Ultra Sonic Distance Sensors Link:
https://shop.ahem.net.au/products/sen01100?variant=42969407881437&currency=AUD&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&gclid=Cj0KCQjw98ujBhCgARIsAD7QeAgs0YEc9uYEdZ5RFW7nWFouLmUSlkgIIv7BTmQttwPB3YKYg2pCYN4aAh4GEALw_wcB

15.) 4mm Bullet Adaptors Link:
https://www.aliexpress.com/item/1005005605889418.html?pdp_npi=2%40dis%21AUD%21AU%240.17%21AU%240.14%21%21%21%21%21%402101c5a716854533184572308ec85f%2112000033736043114%21btf&_t=pvid:934445cf-5dc9-47c1-bd4c-c97a82401814&afTraceInfo=1005005605889418__pc__pcBridgePPC__xxxxxx__1685453318&spm=a2g0o.ppclist.product.mainProduct

16.) HDMI cable Link:
https://www.aliexpress.com/item/1005005320279507.html?pdp_npi=2%40dis%21AUD%21AU%241.55%21AU%241.55%21%21%21%21%21%40210318ef16854541974902098e5a98%2112000032617034477%21btf&_t=pvid:3201ec98-dc04-4f2c-8e45-9c3da21b4b5e&afTraceInfo=1005005320279507__pc__pcBridgePPC__xxxxxx__1685454197&spm=a2g0o.ppclist.product.mainProduct

17.) 22AWG Wire Link:
https://www.aliexpress.com/item/1005005553166655.html?pdp_npi=2%40dis%21AUD%21AU%243.08%21AU%242.50%21%21%21%21%21%402101c5a716854531518448004ec86f%2112000033515726708%21btf&_t=pvid:5a889c51-3f6a-41d2-a46b-6e1069db8586&afTraceInfo=1005005553166655__pc__pcBridgePPC__xxxxxx__1685453152&spm=a2g0o.ppclist.product.mainProduct

18.) Battery Charger:
https://www.ebay.com.au/itm/224306627425?hash=item3439b78361:g:w7cAAOSwwXdjYdzn&amdata=enc%3AAQAIAAAA4Bylnsddolltr6WdZGiOf1hr9Y4DBcZbSfFJUsdLs%2BpDSZQzvDVNlSjczejWcZ58OEcl5R5tKs9JR1U7DuzsBD6SMjYV%2F9BUXVK9zxru2J%2BqDBvtcjprqJdHe5QCNQLFSDq3hc72opH%2FgxBaW9cWG8WHxAsMrZWTKf6ZoQqyCt3hRp6S0i0CW5sKEX9BdwMaHh0dk4cYIBtIGu8ayNJIoGeZecZGswo746H0ht9aDIMRK%2BMjBZzrkLWTAVhuQrp%2FWiU4CRAezleeD1ku%2BGYDBH9mcWh3MM1YBvALddaSrNn6%7Ctkp%3ABFBMjtzhmZVi

19.) XT90 Splitter – DC Adaptor Connector Link:
   https://rcbox.com.au/products/xt90-parallel-y-lead-battery-connector-wire?variant=41136990814388

20.) Radar Sensor Link:
   https://www.dfrobot.com/product-2108.html

21.) 512GB Micro SD Card Link:
   https://www.flashtrend.com.au/samsung-evo-plus-512gb-micro-sd-card-sdxc-uhs-i-10?gclid=Cj0KCQjw7aqkBhDPARIsAKGa0oLrGmAxCSZDfkVAtLiSOEXXq5UsQCxXeDXMRu3-uJZAdl8drauTDTIaAgeOEALw_wcB