Deliverable 2.1 c

Design and assembly of the electronic system to control, collect and analyse data from any robot

MONTH 31 – Version c submitted on 1st August 2019

Public overview of the components that constitute the VineScout embedded platform.

SUNDANCE & WALL-YE

Abstract

The VineScout project aims at deploying a ready-to-market (TRL9) robotic solution designed according to a user-centered approach, practically achieved by the permanent feedback from, and interaction with, end-users through intense field testing and the realization of Agronomy Days (Task 5.2).

The VineScout advances beyond the State-of-the-Art by implementing real-time non-invasive monitoring technology in a concept robot adapted to field conditions (Vinescout, 2016).

The strategic relationship between work packages and benchmarks is shown in Figure 1.

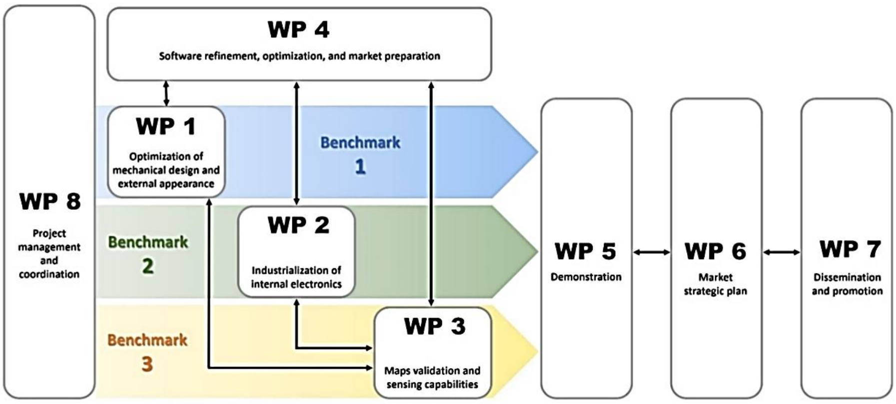

Figure 1: The strategic relationship between work packages and benchmarks.

The D2.1 is an overview of what constitutes the VineScout Embedded Computing System proposed by Sundance and gives background details of the choice of electronics and systems components. The results of the computer system developed for the VineScout prototypes are also reported. The analysis was conducted by Sundance in close collaboration with the other consortium members. Specific details regarding the overall project can be found at the VineScout project official website[1] and commercial details about VCS-1 can be found on Sundance's SlideShare-sites[2] and Web-site[3].

Figure 2: Full presentation of VCS-1

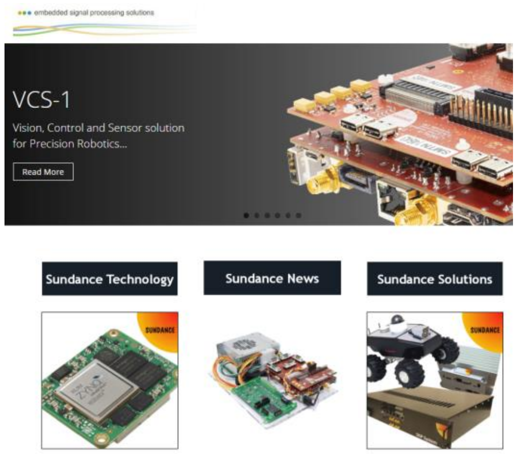

Figure 3: Web-site for VCS-1

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[1] The VineScout project http://VineScout.eu/web/
[2] VSC-1 SlideShare Presentation - http://bit.ly/VineScout_VCS_SlideShare
[3] VSC-1 Home-Page - http://bit.ly/VCS_1_HomePage

Version History

Date	Version	Authors	Description
06/07/2019	0.1	Pedro MACHADO (SUN)	Creation of the D2.1c based on the D2.1b
12/07/2019	0.2	Flemming CHRISTENSEN (SUN)	Initial review of D2.1c
13/07/2019	0.3	Pedro MACHADO (SUN)	Apply changes
15/07/2019	0.4	Timoteo GARCIA-BERTOA (SUN)	Internal review
18/07/2019	0.5	Christopher Millot (Wall-YE)	External review
20/07/2019	1.0	Pedro MACHADO (SUN)	Release candidate version
24/07/2019	1.1	Ben Lovell (SUN)	Internal review
25/07/2019	1.2	Flemming CHRISTENSEN (SUN)	Added better graphics/photos
31/07/2019	2.0	Pedro MACHADO (SUN)	Final version

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List of Abbreviations

Abbreviation	Definition
ADAS	Advanced Driver-Assistance Systems
ARM	Advanced RISC Machine
ATX-PSU	Advanced Technology Extended – Power Supply
BLE	Bluetooth Low energy
CAN	Controller Area Network
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
DDR	Double Data Rate
DoA	Description of the Action
FMC	FPGA Mezzanine Card
FMC-LPC	FMC Low Pin Count
FPGA	Field-Programmable Gate Array
GigE	Industry Standard Video interface on Ethernet cables
GNSS	Global Navigation Satellite System
GPIO	General Proposed Input/Output
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPU	Graphical Processing Unit
HDL	Hardware Description Language
HDMI	High-Definition Multimedia Interface
HSST	High-Speed Serial Transceiver
I/O	Input/Output
I2C	Inter-Integrated Circuit Bus
IC	Integrated Circuit
IMU	Inertial Measurement Unit
Industry 4.0	Current trend of automation and data exchange in manufacturing technologies
IoT	Internet of Things
IP	Intellectual Property
MPSoC	Multi-Processor System on a Chip
OPC-UA	OPC Unified Architecture
OS	Operating System
PC	Personal Computer
PCIe	Peripheral Component Interconnect Express
PCIe/104	Embedded Computer Standard
PHY	Physical Layer
PL	Programmable Logic
PS	Processor System
RF	Radio Frequency
RISC	Reduced Instruction Set Computer
ROM	Read Only Memory
ROS	Robotic Operating System
RS232	Recommended Serial 232
RS485	Recommended Serial 485
RTPU	Real-Time Processing Unit
SATA	Serial Advanced Technology Attachment
SDRAM	Synchronous Dynamic Random-Access Memory
SerDes	Serialiser / Deserialiser
SLAM	Simultaneous Localisation and Mapping
SoC	System on a Chip
SPI	Serial Peripheral Interface
SSD	Solid State Drive
TRL	Technology Readiness Level
UART	Universal Asynchronous Receiver/Transmitter
UAV	Unmanned Aerial Vehicle
USB	Universal Serial Bus
USB3 VISION	AIA Standard with 350MB/s bandwidth
VHDL	VLSI Hardware Description Language
VLSI	Very Large-Scale Integration
WiFi	Wireless Fidelity
WP	Work Package

1. Introduction

In this section the following subjects are discussed:

a. Document structure.
b. Overview of WP2.
c. List of tasks.
d. Requirements and restrictions.
e. Assumptions and Limitations.

1.1. Deliverable structure

The deliverable D2.1 layout is as follows:

Section 1: Introduction – an overview of WP2,
Section 2: Hardware platform – all the details of the platform
Section 3: Conclusions and future work.

1.2. Work Package overview

The main objective for Work Package 2 (WP2) is to design, fabricate, install, and test the complete electronics network for each of the three robots deployed during the project period. It will ensure the seamless integration of software and electromechanical devices. WP2 aims to deliver a complete solution in terms of Hardware and Software, for any robotics and autonomous systems. Prototypes with handcrafted electronics for the developing stages are difficult to replicate at a commercial level, and fail-safe capabilities plus environmental endurance must be granted for the long-life expectancy of the VineScout project. WP2 delivers such a platform [1].

1.3. List of tasks

The WP2 includes the following tasks:

T2.1 – Electrical analysis and proposed amendments for first prototype VS-1 (M1-M10)
T2.2 – Upgrade of electronic system for the final version of the VineScout VS-2 (M12-M22)
T2.3 – Commercially oriented modular design (M18-M34)

1.4. Requirements and Restrictions

MoSCoW [2], a prioritisation technique used in management, was used for extracting the list of requirements and assigning a priority to each requirement in the list. The list of requirements and restrictions that have a direct or indirect impact on the development of the VCS-2 system are listed in Table 1.

Table 1: List of requirements and restrictions

Designation	Description	MoSCoW priority	Implications
R1	The VineScout robot must be power efficient	Should have	• Use solar panels for charging the robot while is being used. • The User should be able to monitor the robot power consumption • The user should be able to monitor power being generated by the solar panel(s).
R2	The robot must be able to adapt to different types of landscapes and weather conditions	Must have	• The robot design must take into consideration a wide range of landscapes. • The selection of enclosures with IP65. • Select components with Industrial/Automotive grade.
R3	Fail-safe electronics and response	Must have	• Selection of high-quality devices/sensors. • Redundancy of sensors/actuators. • The sensors/actuators will be connected to a critical or non-critical network. • The critical network will be routed to a custom programable logic for real-time response. • The non-critical network will be routed to a processor running an Operating System. • The communication with the robot will be made using encryption for preventing hacker's attacks. • Each robot will have unique credentials and users cannot operate robots if the credentials are not valid.
R4	Improve the overall performance of the Embedded computer platform	Must have	• Select a powerful Multi-Processor System-on-a-Chip (MPSoC). • The MPSoC must include a Processor System (PS), Graphical Processing Unit (GPU), Real-Time Unit (RTU) and freely Programmable Logic (PL).
R5	Increase the Runtime performance	Should have	• The Software must be adapted for reflecting the MPSoC architecture.
R6	Commercially-oriented solution	Must have	• The Robot will be compatible with the Robotic Operating System (ROS) • The Robot will have the possibility of CAN bus communications for facilitating the interface with automotive/sensors with ISOBUS certified.
R7	The robot will have to collect a wide range of data for a post-processing phase.	Must have	• Provide 1TB SSD storage for storing the data collected. • Provide Internet connectivity through Ethernet and Wi-Fi for secure upload of the data collected into the cloud.
R8	Provide flexibility to incorporate new sensors into the robot.	Should have	• Provide different connection options following the industrial standards, including DisplayPort, SATA, HDMI, USB, 1000/100 Mbps Ethernet, WiFi, FMC-LPC, BLE, PCIe/104 'Type 3', etc.
R9	Produce the robot at the best possible retail price	Should have	• The price of the parts will be negotiated with suppliers to get the best possible quantity discounts. • The parts selection will be made based on the relation of the price and quality, as well as on the safety needs for standardization
R11	Make the robot compatible with future robots	Should have	• Use the most recent distribution of the Robotic Operating System (ROS), ROS Melodic[4].

[4] Available online, http://wiki.ros.org/melodic/Installation

1.5. Assumptions and Limitations:

The following assumptions were made:

1) A wide range of sensors will be connected to the robot, including navigation and crop sensing;
2) The typical users will be non-experts and therefore the robot must be highly flexible, robust and fail-safe;
3) One Terabyte of space will be provided for storing samples/data;
4) The robot must be able to navigate without GPS, but a GNSS receiver will be necessary for simultaneous localisation and SLAM mapping;
5) 4G/WiFi and BLE will be required for wireless communication;
6) The robot will stop moving if any of the critical sensors or actuators stops working;
7) The user must have easy access to stop buttons and the robot must stop if at least one emergency stop button is pressed;
8) The robot power consumption was estimated during the field tests.

The following limitations were identified:

1) The VS robot is not ISOBUS[5] certified.

5 ISOBUS seeks to establish and maintain transparency regarding the functionalities supported by specific products and their compatibility with others. Available online, http://www.aef-online.org/products/aef-isobus-database.html#/About

2. Hardware platform

Details about the hardware platform are described in this section.

2.1. The VineScout robot

The VineScout robot is the next generation of agri-robots and was designed for providing high flexibility enabling farmers to decide when, where and how to map a vineyard.

Moreover, the VineScout robot will be compatible with most common industry standards (such as OPC-UA) and will be fully compatible with ROS[6].

The VineScout robot is equipped with a wide range of sensors and actuators. The sensors and actuators that are used for navigation belong to the critical sensors network. The sensors that are used for collecting data belong to the non-critical sensors network. The sensors and actuators in the critical sensors network have higher priority for using the computation resources. Figure 4 shows the VineScout robot sensors map.

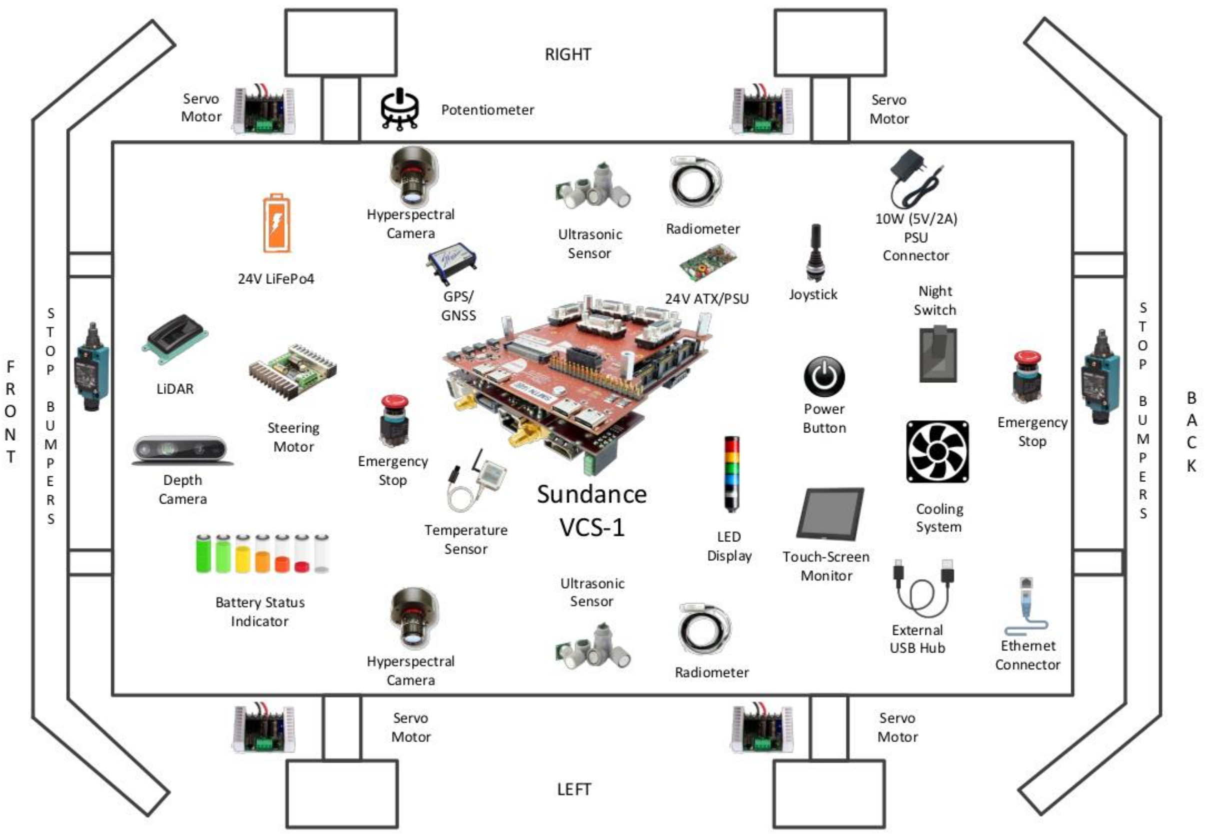

Figure 4: VCS-1 sensors map for VineScout

Power consumption is an important feature of the VineScout project. The VineScout consortium aims to deliver a robot solution with an autonomy of about 6 hours of continuous work. The 6 hours, used as reference, is the average time that a farmer uses a tractor without having to stop for refueling. Table 2 lists the sensors, actuators and power consumption.

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[6] https://www.ros.org/ - Power the World's Robot

Table 2: Sensors and actuators, and its power consumption

Device	Active mode	Weight (Kg)
MB7139-200 XL- TrashSonar-WR ultrasonic sensors.	9.99mW×6 sensors=59.4mW	N/A
Intel RealSense D435	1.9 W	0.200
National Instruments Touchscreen TSM-1015	96 W	3.5
Apogee SD-431	0.312 W	0.190
OCI-M Hyperspectral camera	2 W	0.190
8-Channel 5V Relay module	0.16 W	0.125
Sabertooth dual 12A motor driver	576 W (maximum power)	0.09
Sabertooth dual 25A motor driver	1200 W (maximum power)	0.09
SXBlue L1/L2 GNSS	5 W	
Power supply 24V to DCX2.240 (240W)	5.28 W (idle)	0.190
VCS-1 Embedded Computer System	10 W	1.6
12V@90W Solar Panel	N/A	N/A
Emergency push buttons	3.6 W×4 buttons=14.4 W	N/A
Joystick	N/A	N/A
LED (RYGB) display	44.64 W	0.43
Stop Bumpers	N/A	N/A
2D LiDAR - OMD8000-R2100-B16-2V15	2.88 W	0.250
Bumblebee2 0.3 MP Color FireWire 1394a 6mm (Sony ICX424 sensor)	2.5W	0.342

The table above indicates that in the worst-case scenario, the VineScout robot drains 1952W (includes the motor driver's maximum ratings and excludes the motor power consumption), which is not realistic. Sensors and actuators only drain 100% of full power consumption during the transient regime (e.g. an engine will drain 100% of its power consumption during the transient regime and then lowers the power consumption to 60%-50% of the peak power when it reaches the steady state).

It is assumed that VineScout robot power consumption is 272Wh. The average power consumption measured in the field tests was 144W. In that case, the VineScout's power consumption is 1.637kW for 6h of continuous work. The actual design includes a solar panel capable of generating 60Wh equivalent to generate 300W approximately (assuming an efficiency of 80%) in 6 h of continuous work; The 300W represents 18% of the overall VineScout robot power consumption during the 6h of continuous work.

2.2. First prototype of the Embedded Computer System (ECS)

The first prototype of VineScout's "Embedded Computer System" (ECS), was EMC2-ZU3EG. This comes equipped with a versatile Xilinx MPSoC ZU3EG device as the main processing unit and I/O is using flexible FPGA technology.

This EMC2-ZU3EG ECS was developed by Sundance with help from the Tulipp European Project (Grant agreement number 688403). The system is equipped with ARM Cortex A53 cores are that accessible via common industry interfaces (e.g. USB, GPIO, RS232, HDMI and Ethernet) and has the flexibility to interface to specific vision interfaces (e.g. USB3 Vision, GigE, CameraLink, etc) on the Zynq's FPGA side. The EMC2-ZU3EG computer board (Figure 7) was used for starting the migration/design/testing and updating to enable the support for the latest version of the Xilinx tools (i.e. SDx[7] and AI Inference[8]). This initial platform also allowed Sundance to start porting "ROS", the industry standard for everything robotics, to work on the Embedded 64-bit ARM CPUs as found in the Zynq devices.

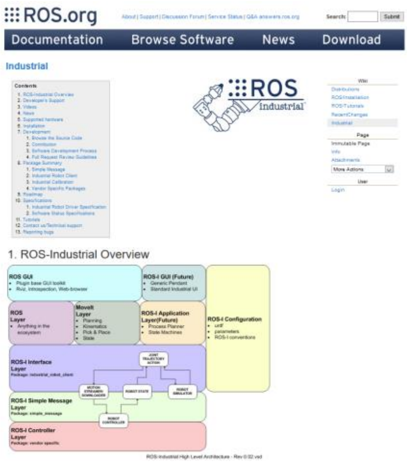

Figure 5: Snapshot of the ROS industrial web site[9]

The work has been shared back to the ROS community, as is customary, to grow adaptations of ROS and can be found on Sundance's GitHub

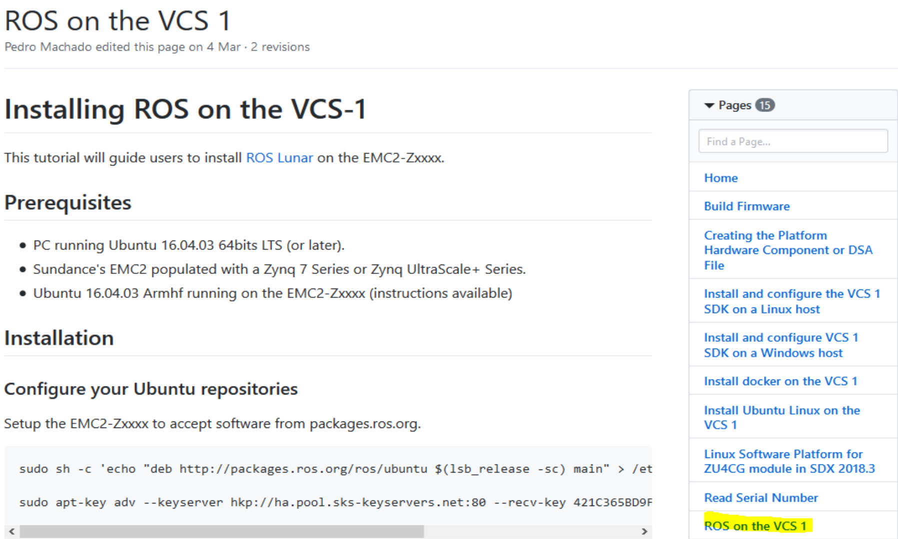

Figure 6: Snapshot of the Wiki tutorial for installing ROS on the VCS-1[10]

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[7] Available online, https://www.xilinx.com/products/design-tools/software-zone/sdsoc.html
[8] Available online, https://www.xilinx.com/products/design-tools/ai-inference.html
[9] Available online, https://rosindustrial.org/
[10] Available online, http://bit.ly/VCS_ROS

The benefit from the migration of the Tulipp Platform to the VCS Platform was that Sundance could port a full Linux Ubuntu 16.04 LTS and 18.04 LTS and test with Image Processing algorithms that will be required when VCS starts to be used for AI and Deep Learning in the future.

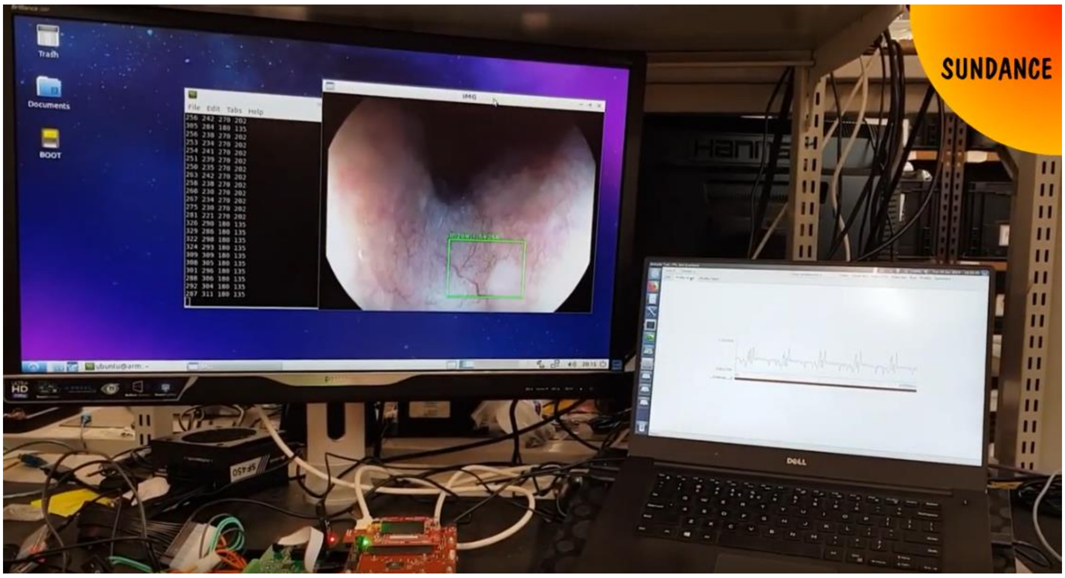

Figure 7: Snapshot of glaucoma detection using AI, running on EMC2-ZU3EG[11]

Another product that was developed in Tulipp is the Lynsyn board to actively measure current taken by the entire system, whilst doing processing and control of the robot. This is part of the system supplied to Partners for integration and development and offered by Sundance to new customers.

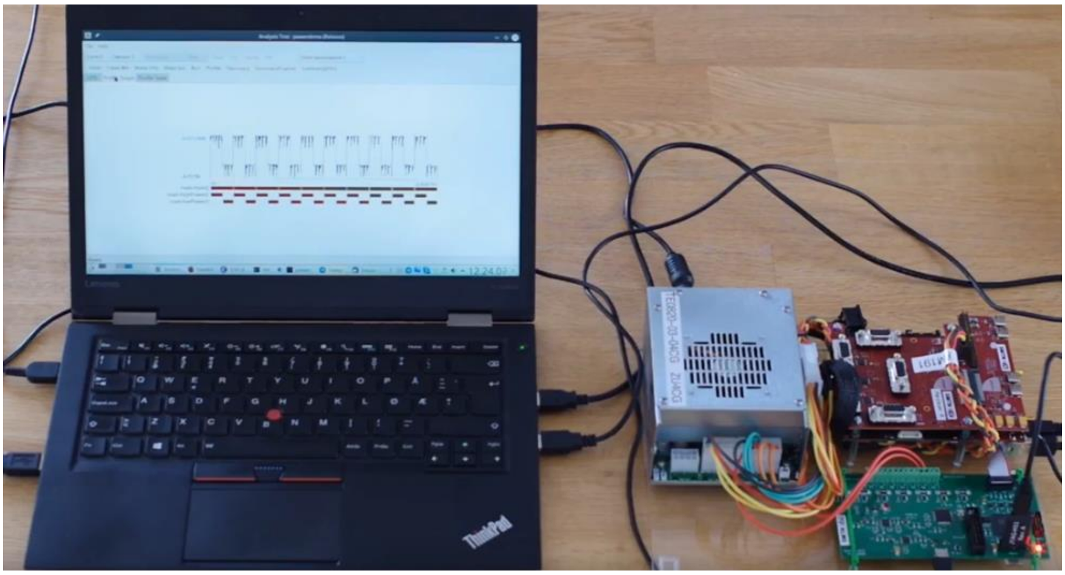

Figure 8: Snapshot of the real-time power estimation using the LynSyn board[12]

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[11] Available online, http://bit.ly/VCS_Lynsyn_Linux_Ubunto
[12] Available online, http://bit.ly/VCS_Lynsyn

2.3. Second prototype of the ECS

The VS-2 was adapted for running the Microsoft Windows 7 as per requested by UPV. Therefore, the VS-2 prototype is composed of two stacks, namely, the Windows and the Linux stacks (see Figure 9 and Figure 10).

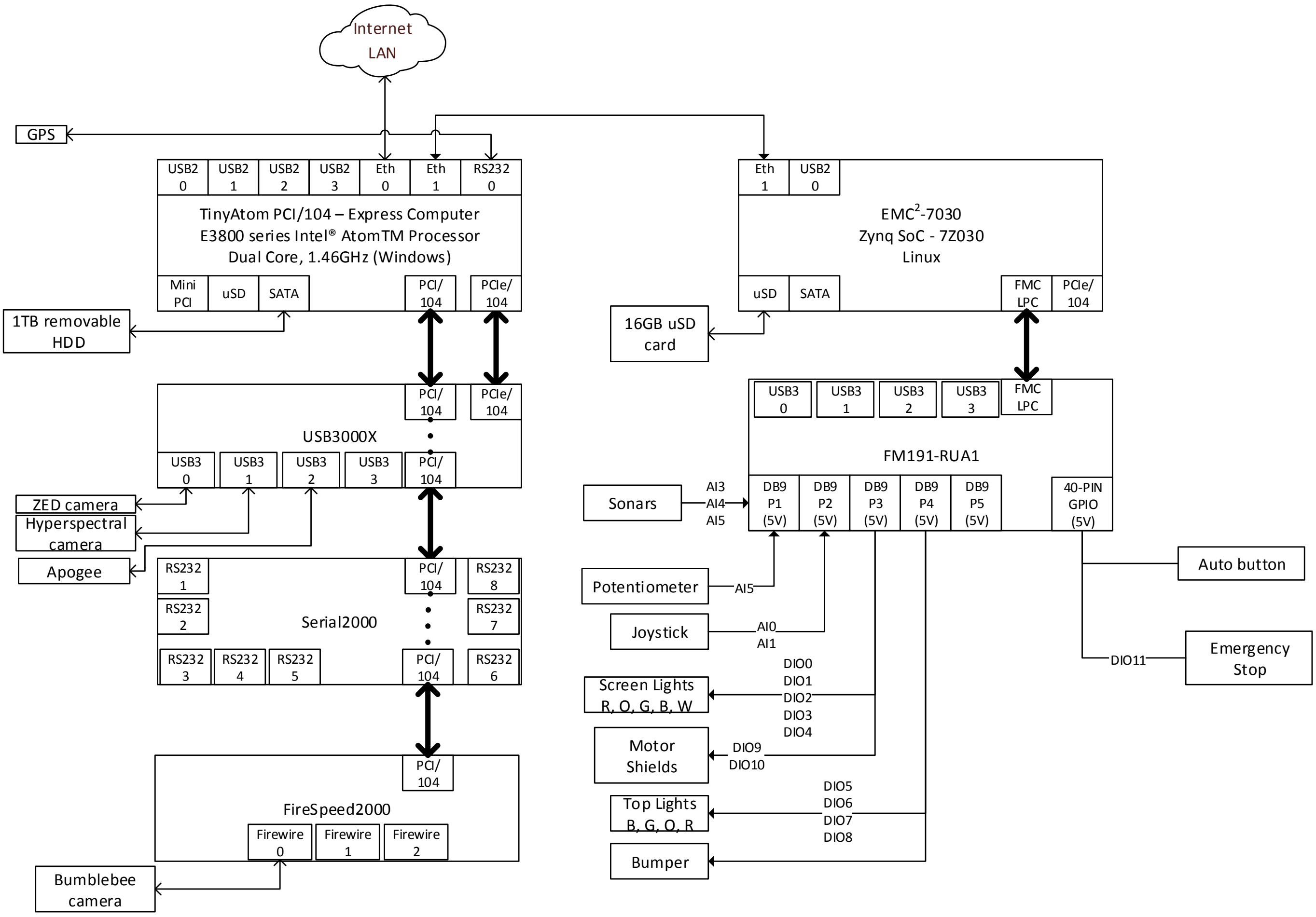

Figure 9: ECS Block Diagram for VS-2

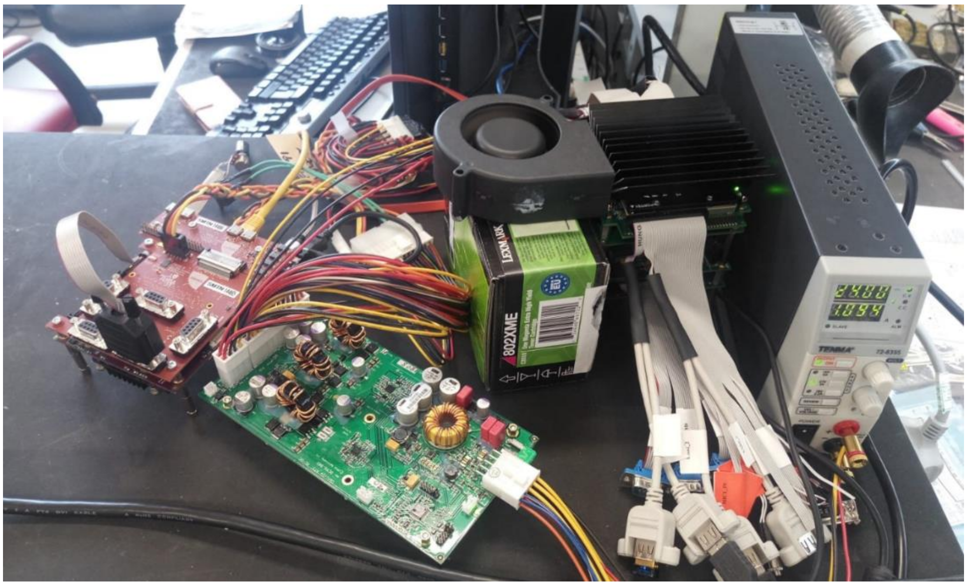

Figure 10: ECS System for VS-2 Prototype[13]

The windows stack is used for running the VineScout main software while the Linux stack is used to provide GPIO, *i.e.* digital and analogue I/Os.

Sundance included a FireWire interface on the Windows stack to enable the connection of the legacy BumbleBee (from VineRobot Project[3]) camera (3D depth sensor) to make porting of software easier.

This stack is composed of 1x Dual Core Intel Atom 64-bit processor with 4x USB2.0 (TinyATOM board) , 4x USB3.0 (USB3000X card) , 9x UART Serial2000 card), 2x Ethernet connections (TinyATOM board) and 4x FireWire ports (FireSpeed2000 card).

The Linux stack, also called VCS-1, (Figure 11) provides Digital and Analogue I/Os (GPIO) connectivity. The VCS-1 (Linux stack) is composed of 2 main components, namely the EMC2 Zynq board and the FM191 expansion card that fans out the I/Os from the Zynq to the outside world.

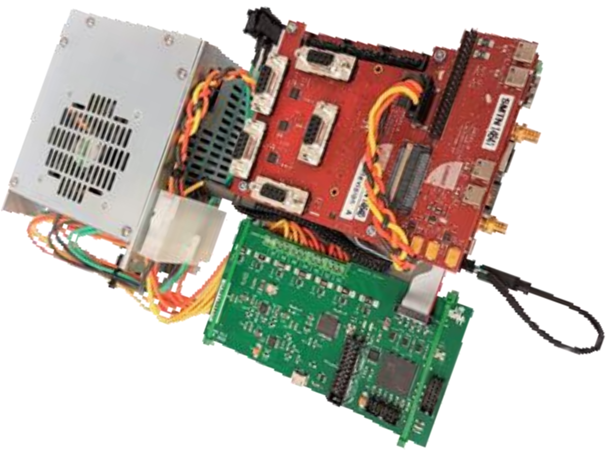

Figure 11: VCS-1 Development Platform w. PSU + Lynsyn

[13] Available online, http://bit.ly/VCS1_in_VS2

The selected SoC was the Xilinx Zynq Z7030 Series (Figure 12) which provides standard connectivity (e.g. SPI, RS232, I2C, USB, GigE, PCIe, etc), Dual Core ARM Cortex A9 (used to run Ubuntu Linux OS and ROS Melodic), memory interfaces and Programmable Logic (used for Hardware acceleration and GPIO).

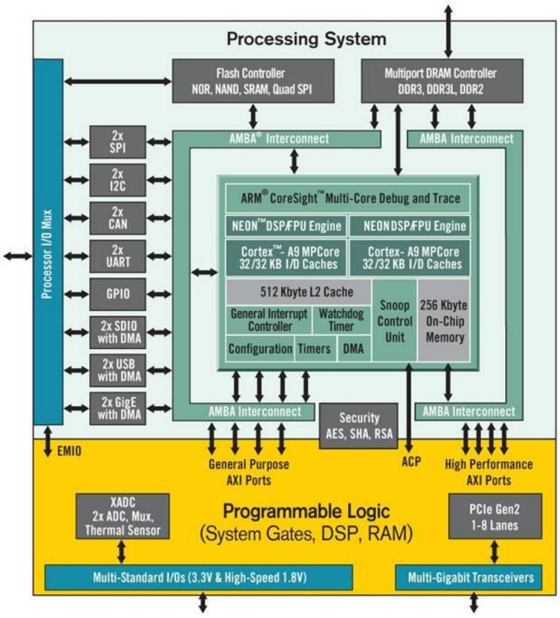

Figure 12: Xilinx Zynq SoC – Z7030

A new module called FM191 daughter card (Figure 13, Figure 14 and Figure 15) was specially designed to fan out the GPIO pins to the outside world via the industry standard FMC-LPC[14] connector. The FM191 module provides 15x single-ended I/Os 5V TTL accessible via 3x DB9 connectors, 12x analogue Inputs 5V TTL (with a resolution of 24-bits@2kSPS) accessible via 2x DB9 connectors, 8x Analogue Outputs (with a resolution of 12-bits) via 2x DB9 connectors, 4x USB3.0 via 4x USB-c connectors and a 40-pin GPIO (compatible with Raspberry Pi 3 rev. B).

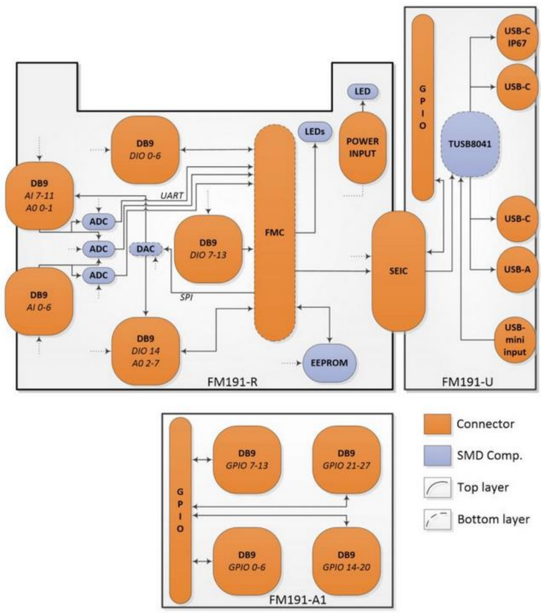

Figure 13: FM191 Block Diagram

[14] Available online, https://www.vita.com/fmc

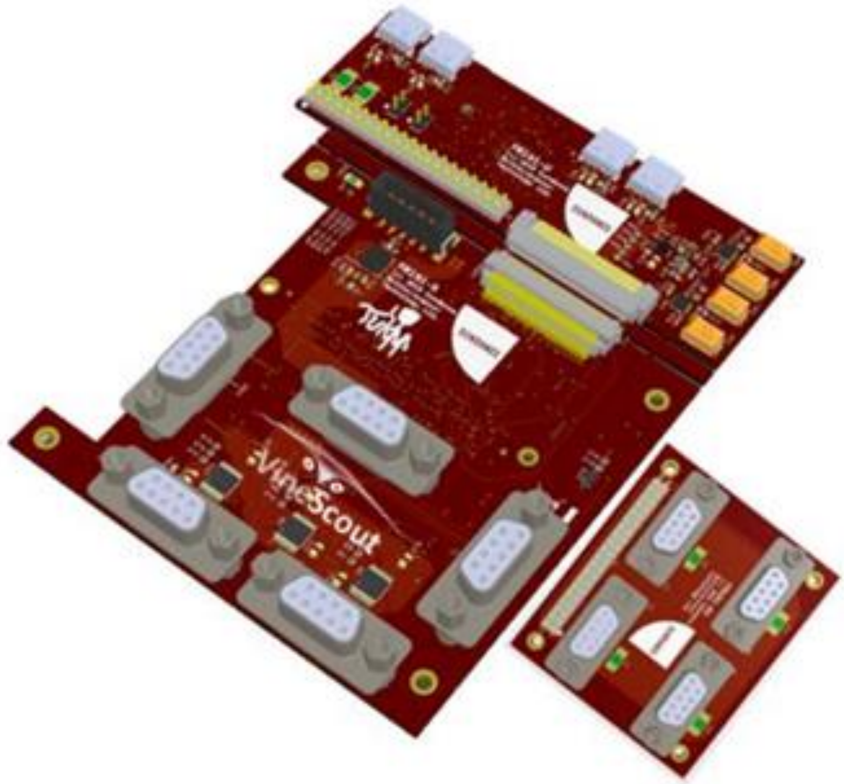

Figure 14: FM191 3D Drawing

The FM191 daughter card was required for:

1) Simplify the connection of sensors (e.g. ultrasonic and switch buttons), lights and actuators.
2) Provide connectors with mechanical lock (DB9 connector) for improving the connectivity and therefore, reduce the vibration stress on the connector.
3) Increase the compatibility with COTS sensors and actuators.

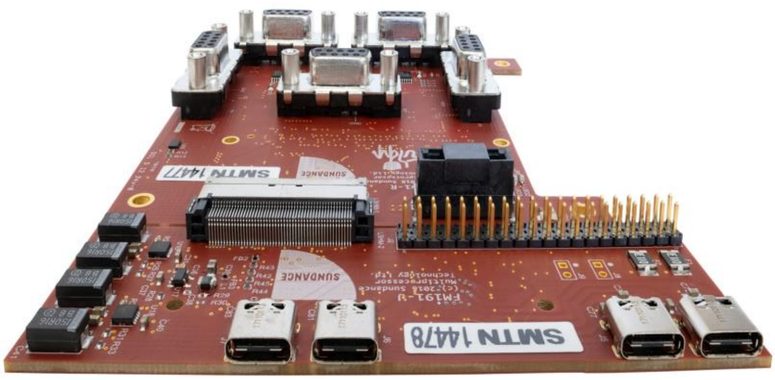

Figure 15: FM191 Module

The control, navigation and safety sensors/actuators are connected to the Linux stack which is interconnected to the Windows stack via Ethernet. The Linux stack software was designed to work with a wide range of Internet-of-Things (IoT) and therefore the communication between the Linux and Windows stack is done using the MQTT machine-to-machine (M2M) protocol.

The documentation and software for VCS-1 are available online and can be found in Sundance's GitHub repository.

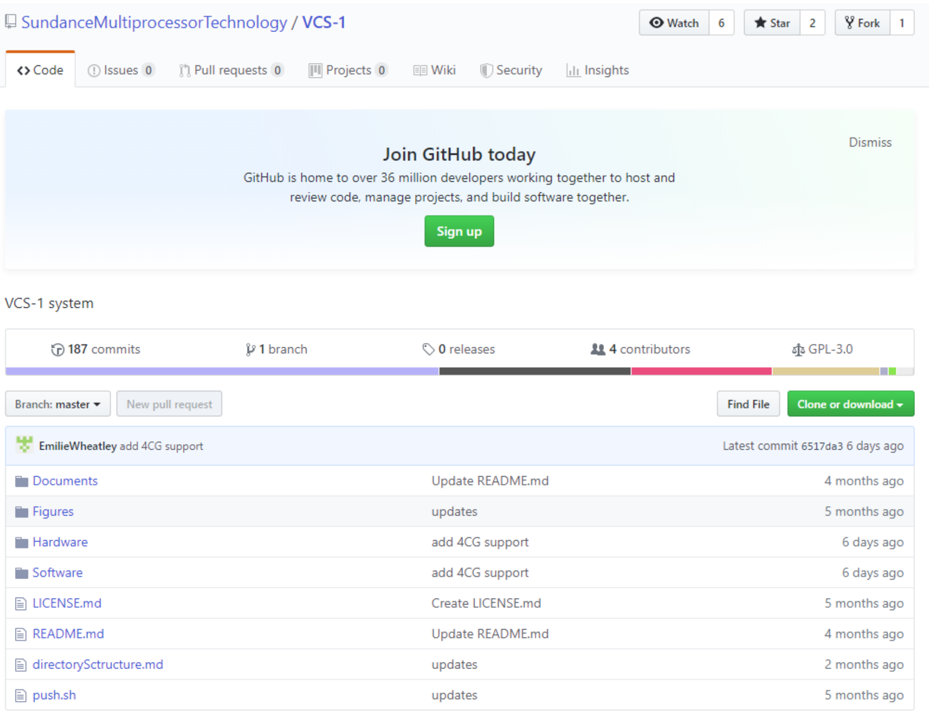

Figure 16: Snapshot of VCS-1 GitHub repository where all the relevant Documents and Source Code are stored

Both stacks are powered by the Opus DCX2.240[15] (Figure 17) which is high-efficiency power source unit that converts the 24V from the battery into the AT, ATX, uATX and mini ATX motherboards. The DCX2.240 delivers the standard voltages of 3.3V (15A@24V maximum ratings), 5V (15A@24V maximum ratings), +12V (9A@24V maximum ratings) and -12V (0.35A@24V maximum ratings) via standard connectors; prevents rebooting the both stack during the robot power up, provides a delayed shut down timer, a stand-by power control for low battery drain and automatic shutdown at low battery voltage to protect the battery. The use of the DCX2.240 as main power supply system prevents the noise propagation and power dips to the electronics systems which reduces undesirable faulty responses of the robot. The DCX2.240 will also supply power to all the actuators and sensors used on the VineScout robot which is desirable for avoiding undesirable faulty responses.

Figure 17: Opus DCX2.240W

[15] Retrieved from https://opussolutions.com/support/DCX2-Lit.pdf

2.1.Third prototype of the ECS

The VCS-2 system (see Figure 19 and Figure 22), the VineScout third prototype, delivers a complete system which can replace the VS-2 Windows stack and uses a Xilinx Zynq Ultrascale+ ZU4EV MPSoC device. The Xilinx Ultrascale+ Zynq ZU4EV[16] device is highly optimised for automotive/ADAS[17] and offered in extended (-25C to +125C) temperature range to cope with extreme environments.

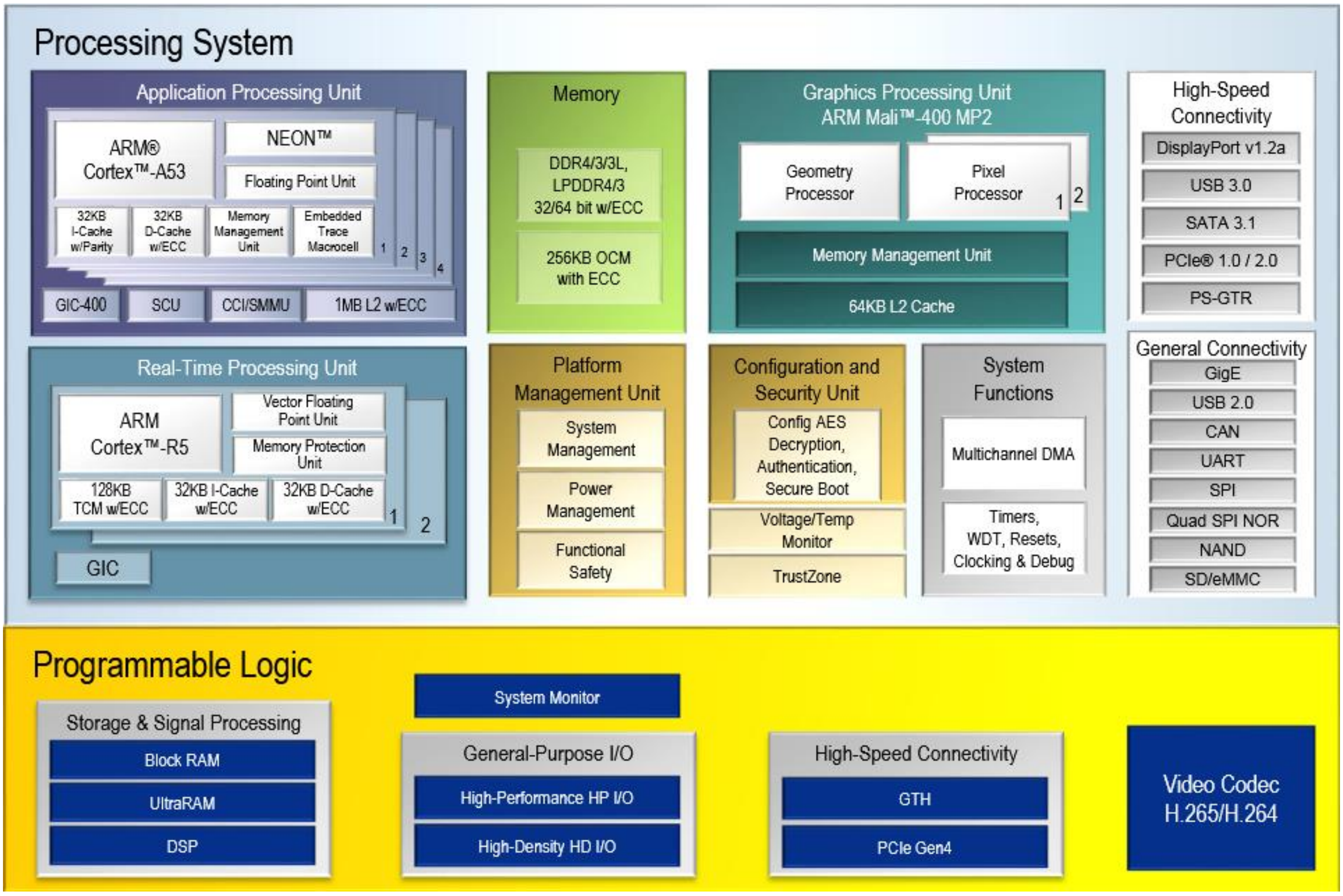

Figure 18: The Zynq EV family with integrated video CODEC

The video CODEC (bottom right corner) is used for efficiently performing real-time encoding/decoding of video streams in the FPGA side, without increasing the power consumption and offload the ARM processor of doing these tasks.

The VCS-2 system enables users to connect a big variety of devices to the VineScout robot. The ZU4EV device allows high-performance because it includes four 64-bit CPUs, GPU, RPU and an FPGA on the same chip. The CPUs are required for running a standard operating system (OS) for delivering the specific services (e.g. Ethernet standard services, databases, etc), the GPU can be used for accelerating graphics processing, the RPU can be used for handling Real Time event and execute real-time tasks (e.g. emergency stop) and the FPGA is used for accelerating the image processing (e.g. autonomous navigation) and control the critical sensors/actuators (e.g. ultrasonic sensors and control the motor drivers).

[16] Available online, https://www.xilinx.com/products/silicon-devices/soc/xa-zynq-ultrascale-mpsoc.html
[17] Available online, https://www.xilinx.com/applications/automotive/adas.html

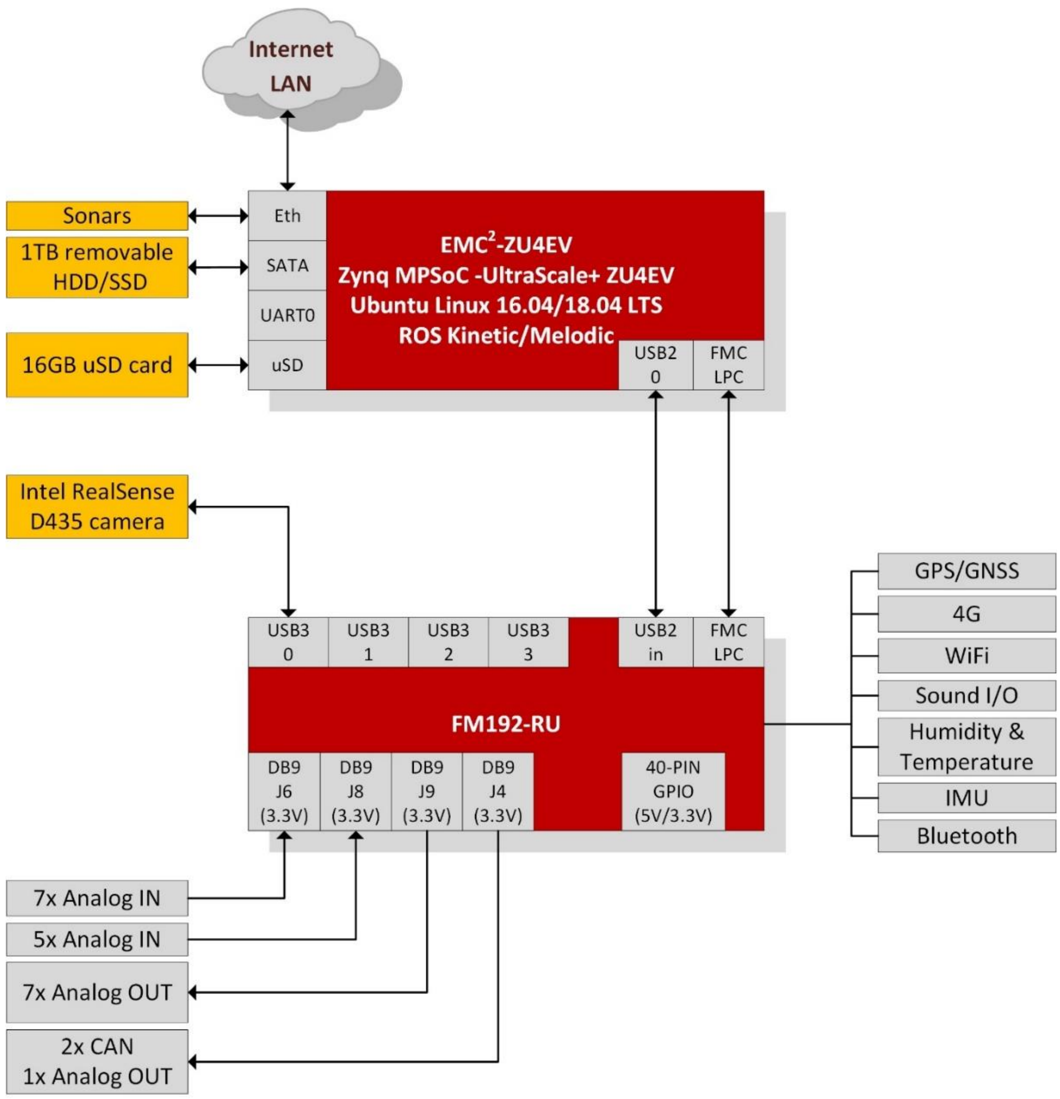

Figure 19: VCS-2 Block Diagram for VS3

All the features and standard interfaces provide the desirable flexibility for designing a highly flexible software platform for the VineScout robot for making the VineScout robot highly compatible with other robots running the Robotic Operating System (ROS) on top of a standard Linux distribution. Two CAN channels can be used to interfacing a wide range of COTS automotive sensors and actuators. These features make the VineScout robot a highly compatible, reliable and easy-to-use robotic platform to work side-by-side with humans and other collaborative robots.

The VCS-2 system is composed of one main computer system (Zynq ZU4 MPSoC component and its carrier board) and I/O module (FMC expansion card). The VCS-2 is fully compatible with the industry standard form-factor, called PC/104. Sundance is a member of the Board of Director of this Consortium[18].

This flexibility allows Users of the VCS range to add extra features. It’s possible to connect multiple VCS platforms together and communicate via a PCI Express interface. This will be very useful for adding even more cameras, sensors and AI processing power

[18] Available online, https://pc104.org/profile/sundance/

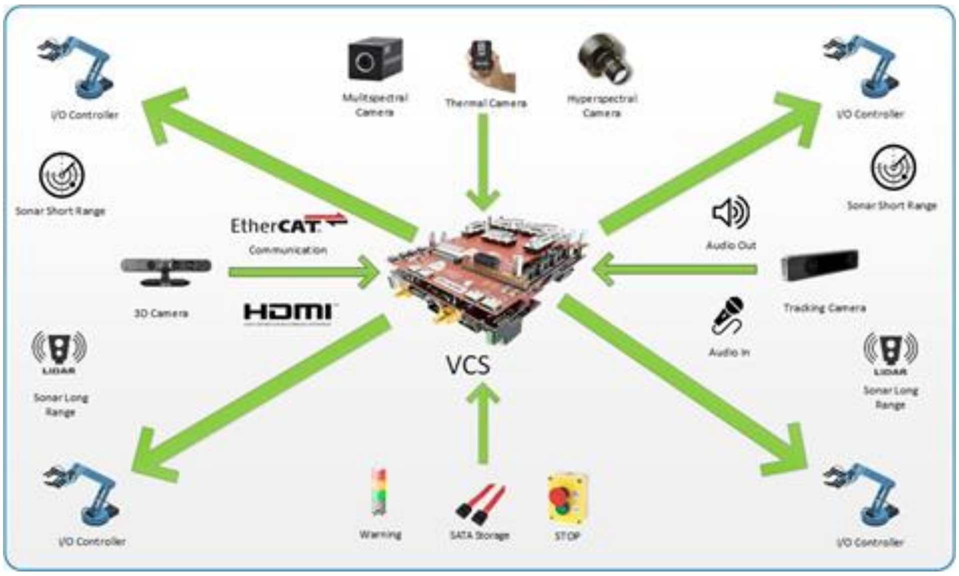

Figure 20: VCS-2 System Overview

The second component is the FM192 daughter card (Figure 21) which is a new Sundance COTS module specially designed to fulfil the requirements of the final VineScout robot, based on the feedback from 2nd Agro-Day meeting and contributions from the VineScout Advisory Board and potential Users.

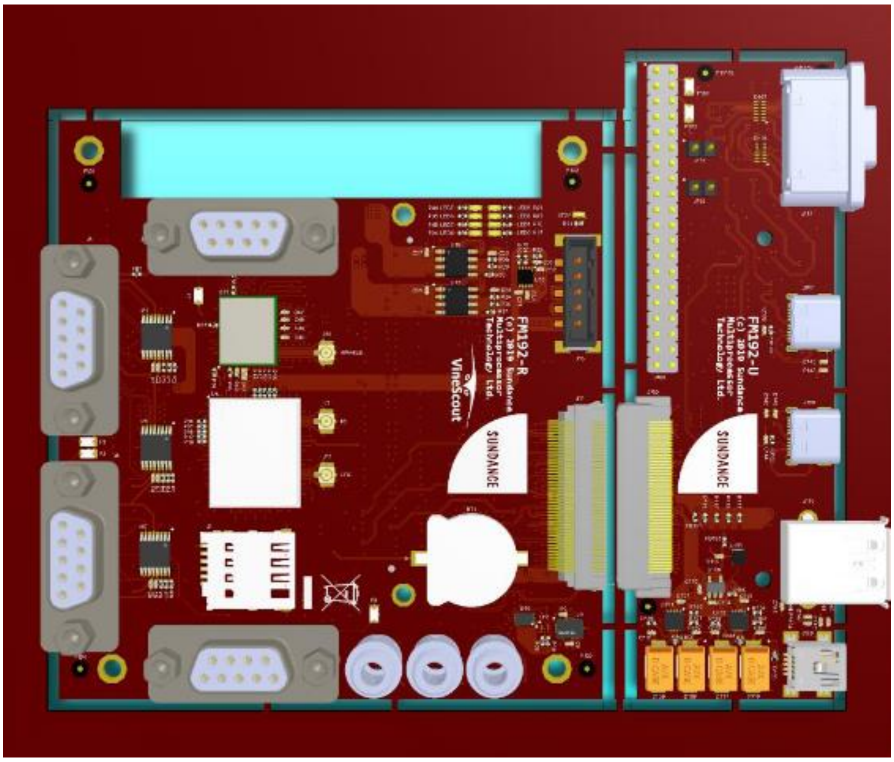

Figure 21: FM192 3D Model

The FM192 board (Figure 22) is designed to fan out the FMC-LPC connector I/Os to 4x DB9 connectors. The FM192 board provides wireless connectivity via WiFi +BLE and 4G+GNSS/GPS modules. 3x antenna connectors (2x for the 4G + GNSS/GPS and 1x WiFi + BLE) are provided for connecting 3x external antennas. Furthermore, the FM192-R provides an IMU sensor, CAN BUS, humidity and temperature sensor, Audio I/O, 4x USB3.0 and 40x pin General Propose Input/Output (GPIO).

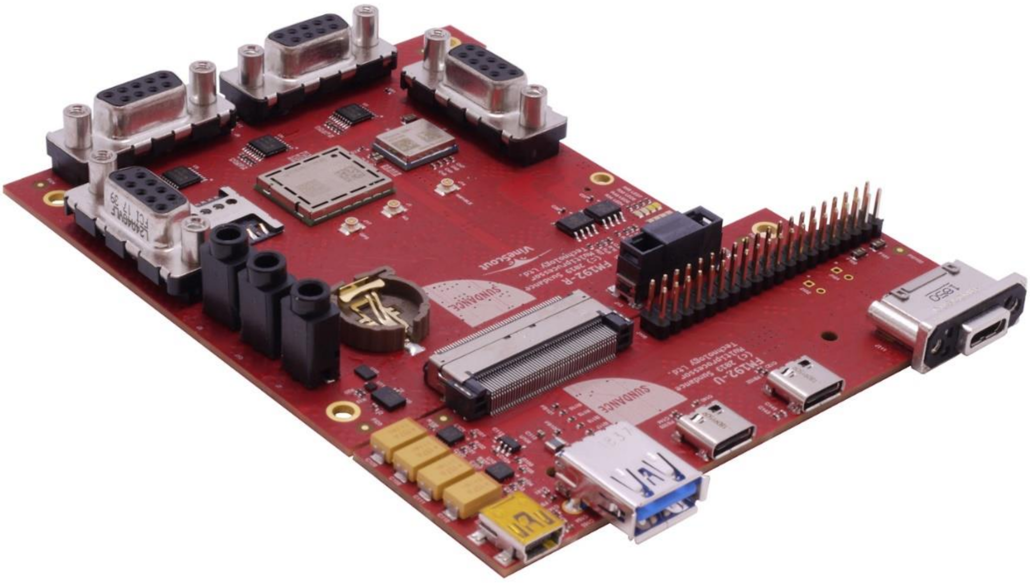

Figure 22: FM192 Module

The FM192 was designed for adapting to Sundance's PC104-Blade concept, developed in the VineScout project, for vision/robotics and autonomous systems/IoT/AI applications.

Figure 23: Enclosure photo without VCS

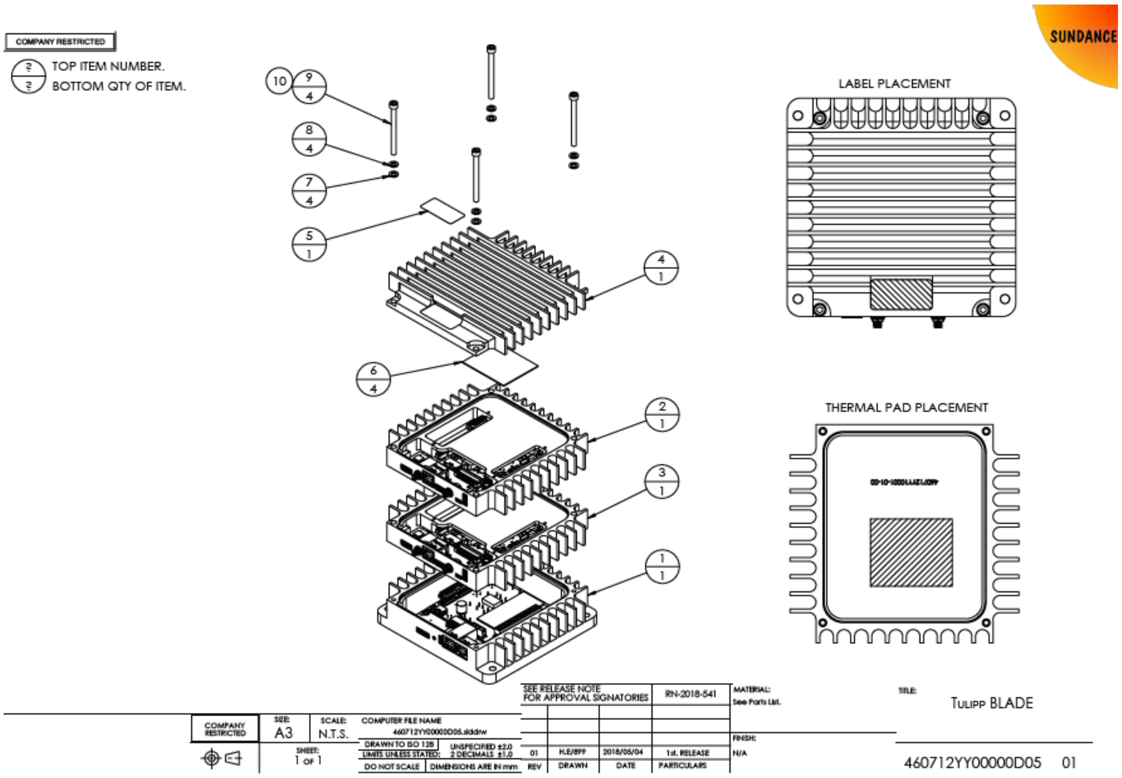

Figure 24: Enclosure drawing. Top view; cross section

The PC104-Blade is Open-Source, hence can be adopted for different robot applications.

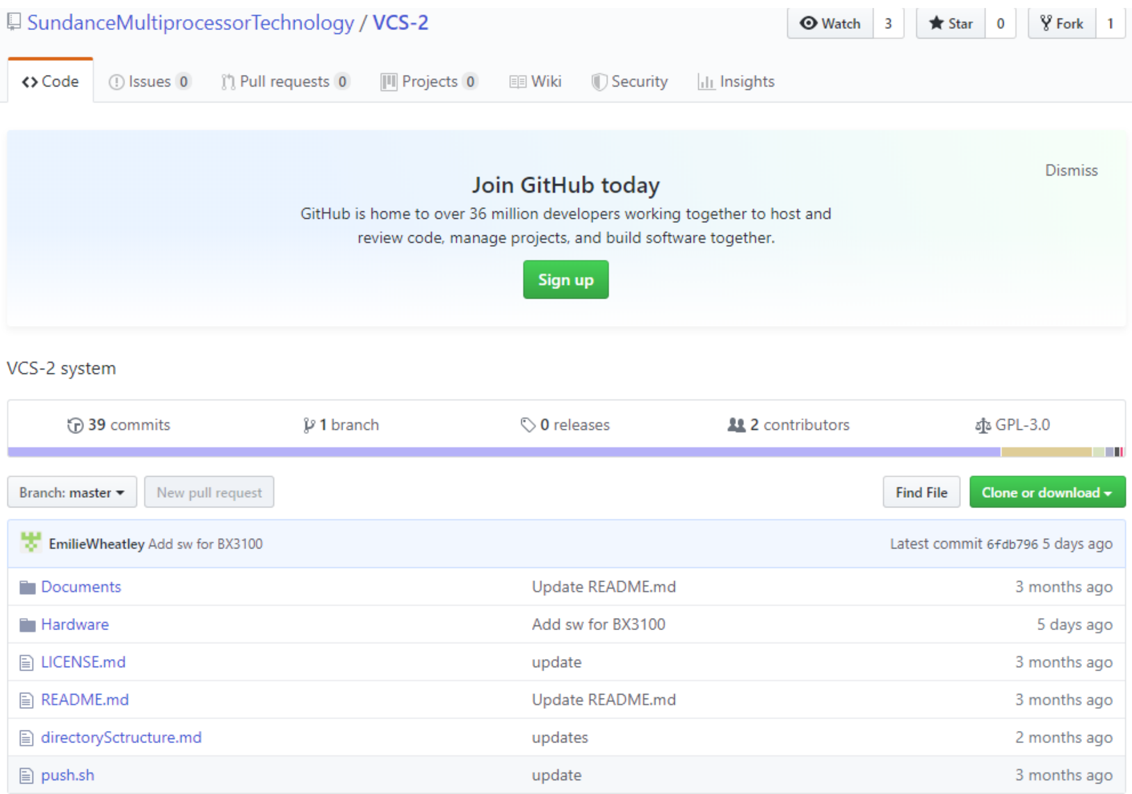

Figure 25: Snapshot of VCS-2 GitHub repository where all the relevant Documents and Source Code are stored

The full documentation for VCS-2 is available online and can be found in Sundance 's GitHub repository.

3. Conclusions and Future Work

The VCS-2 is a mature solution that can be used for incorporating state-of-the-art vision devices, control COTS actuators, interface a wide range of sensors and accelerate Artificial Intelligence algorithms. All of these new features enabled the consortium to remove the Windows stack completely and reduce the complexity of having two systems running different Operating Systems and run the powerful Robotic Operating System (ROS). Power tests show that the VCS-2 is an excellent option because it delivers high performance and low power. Both the VCS-1/VCS-2 systems consume an average of 15W/h (see Figure 26).

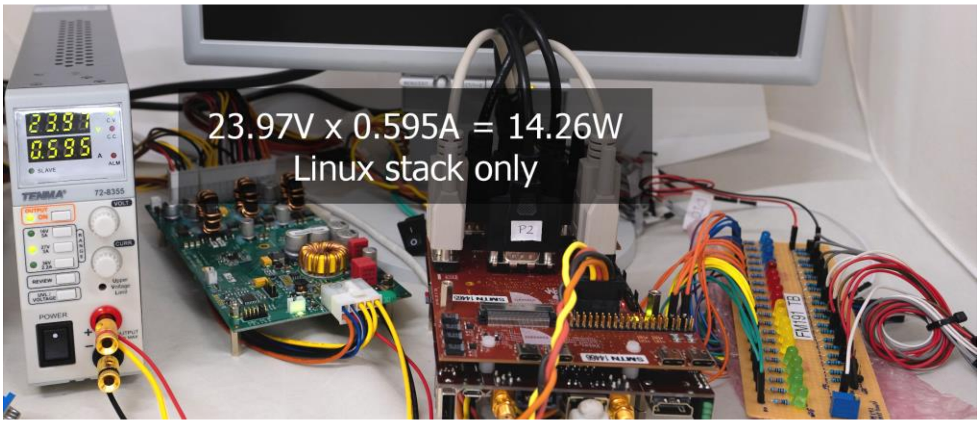

Figure 26: Power consumption of the VCS system (i.e. VCS-1 and VCS-2).

The VCS concept will be reliable and easy to integrate with any autonomous machine on land, sea or in the sky for decades to come. The VCS-2 delivers a computing platform that makes the VineScout robot easy-to-use and highly competitive with any comparable robotics systems for Viticulture.

Figure 27: VineScout-2 (VS2) prototype in 2018

The VCS-2 system is currently being tested in different robotic platforms e.g. RoMoVi robot[19], SEMFIRE robotic platform[20] and Robotnik Summit XL[21].

Figure 28: Field Testing of VCS in a SUMMIT-XL

The VCS-2 system is currently being tested in a Summit-XL[22], due to a new partnership between Sundance, Robotnik[23] and the Nottingham Trent University[24], United Kingdom.

Sundance will also be using the VCS concept as the foundation in a forthcoming project called "ARISE" that will be provide navigation in total darkness without GPS as "ARISE" is targeting hazardous and extreme environments.

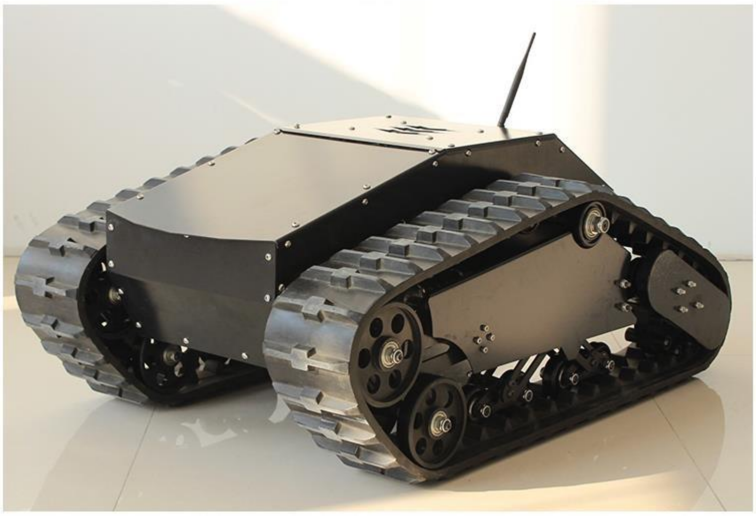

Figure 29: Heavy duty robot for extreme environments

The VCS-2 provides the desirable architecture for running state-of-the-art Artificial Intelligence (AI) algorithms. The VCS-2 will bring the VineScout to the next generation of AI robots and capable to work side-by-side with humans and robots.

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[19] Available online, http://criis.inesctec.pt/index.php/criis-projects/romovi/
[20] Available online, http://semfire.ingeniarius.pt/
[21] Available online, https://www.robotnik.eu/mobile-robots/summit-xl/
[22] Available online, http://bit.ly/VineScout_VCS_Summit_XL
[23] Available online, https://www.robotnik.eu
[24] Available online, https://www.ntu.ac.uk/research/groups-and-centres/groups/computational-neuroscience-and-cognitive-robotics-laboratory

The next step for Sundance is to migrate the VCS-2 to a Single Board Computer with all the required interfaces and connectors on a single PCB to reduce cost to match the target volume OEM price of €1000 for a fully functional and integrated board to be used in VineScout and other Robotics and Autonomous Systems. The current development platform (Figure 30) is available now from Sundance.

Another objective for Sundance is to migrate all electronics components to “Automotive” grades (-25C to +125C) parts and make the VCS platform suitable for solutions beyond VineScout. This will not be completed as part of VineScout funding, but will be done as a commercial agreement between Sundance and Wall-YE after the VineScout has been completed.

Sundance - VCS-1 - Full Robotics Kit

Part/HyperLink	Description/Comments	TSK-AGRI-EV	TSK-AGRI-CG
EMC2-ZU4-EV	PC/104 Platform w. Zynq ZU4/EV	€ 2,885.00	
EMC2-ZU2-CG	PC/104 Platform w. Zynq ZU2/CG		€ 2,285.00
FM191-RUA1	Quad USB3 + ADC/DAC FMC I/O add-on	€ 1,250.00	€ 1,250.00
OPUS DCX2.240	DC/DC PSU, 240W, 24VDC In, ATX Out, Boxed	€ 325.00	€ 325.00
DPS-120AB-3	AC/DC Desktop PSU - 24VDC @ 120W Out	€ 75.00	€ 75.00
Sundance HW		**€ 4,535.00**	**€ 3,935.00**
Lynsyn Monitor	Power Measurement Board	€ 499.00	€ 449.00
Zynq JTAG-HS3 Cable	JTAG Debugger for Zynq PL/SDSoC + ARM	€ 55.00	€ 55.00
Xilinx Tools	Xilinx Vivado Tools + SDSoC	€ 845.00	€ 845.00
XILINX + NTNU HW/SW DEVELOPMENT TOOLS		**€ 1,399.00**	**€ 1,349.00**
TOTAL		**€ 5,934.00**	**€ 5,284.00**

EMC2-DP Open Source Hardware Repository:

OPEN HARDWARE REPOSITORY

VCS-1 GitHub Repository:

GitHub

Figure 30: VCS-1 Development Platform - Cost

References

[1] V. Saiz-Rubio, F. Rovira-Mas, C. Millot, and F. Christensen, "Performance Improvement of a Vineyard Robot through its Mechanical Design," *2017 Spokane, Washington July 16 - July 19, 2017*, 2017. [Online]. Available: http://elibrary.asabe.org/abstract.asp?JID=5&AID=48039&CID=spo2017&T=1

[2] R. S. Beidas *et al.*, "Case Method Fast-Track: A Rad Approach," *Adm. Policy Ment. Heal. Ment. Heal. Serv. Res.*, 2014.

[3] M. P. Diago, J. Fernández-Novales, S. Gutiérrez, M. Marañón, and J. Tardaguila, "Development and Validation of a New Methodology to Assess the Vineyard Water Status by On-the-Go Near Infrared Spectroscopy.," *Frontiers in plant science*, 30-Jan-2018. [Online]. Available: http://journal.frontiersin.org/article/10.3389/fpls.2018.00059/full.