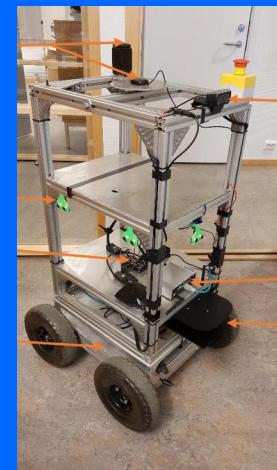


# Autonomous Mobile Greenhouse Robot

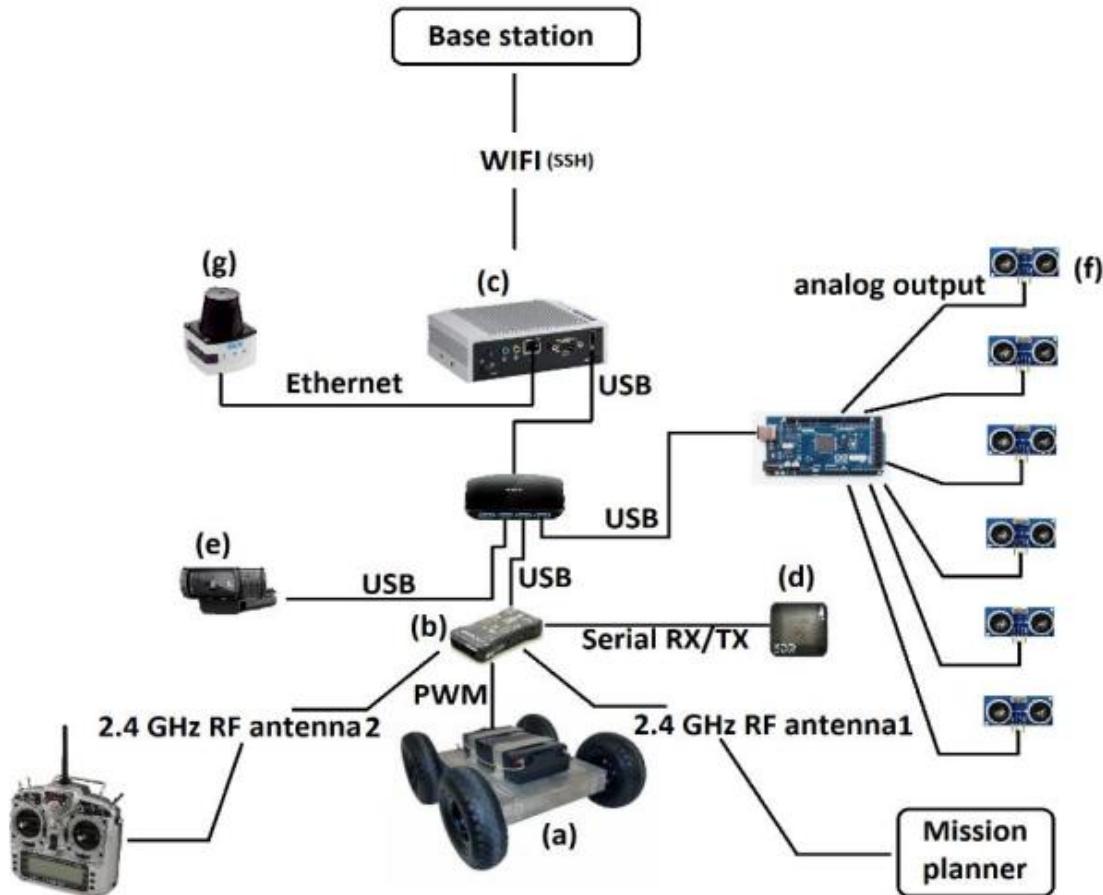
Harik, E. H. C., & Korsaeth, A. (2018). Combining hector SLAM and artificial potential field for autonomous navigation inside a greenhouse. *Robotics*, 7(2).  
<https://doi.org/10.3390/robotics7020022>

# Introduction

- An autonomous mobile ground robot used for fertilization, monitoring physical growth conditions, disease detection, and crop harvesting in modern greenhouse.
- Has an ability to navigate safely in indoor environment with an active obstacle detection system.
- Navigate in small and tight conditions

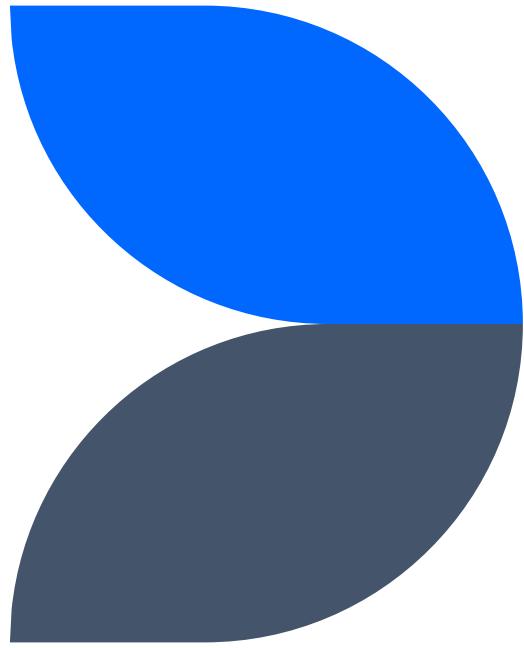


# Hardware Architecture



# Body Design & Materials

AUTONOMOUS MOBILE GREENHOUSE ROBOT



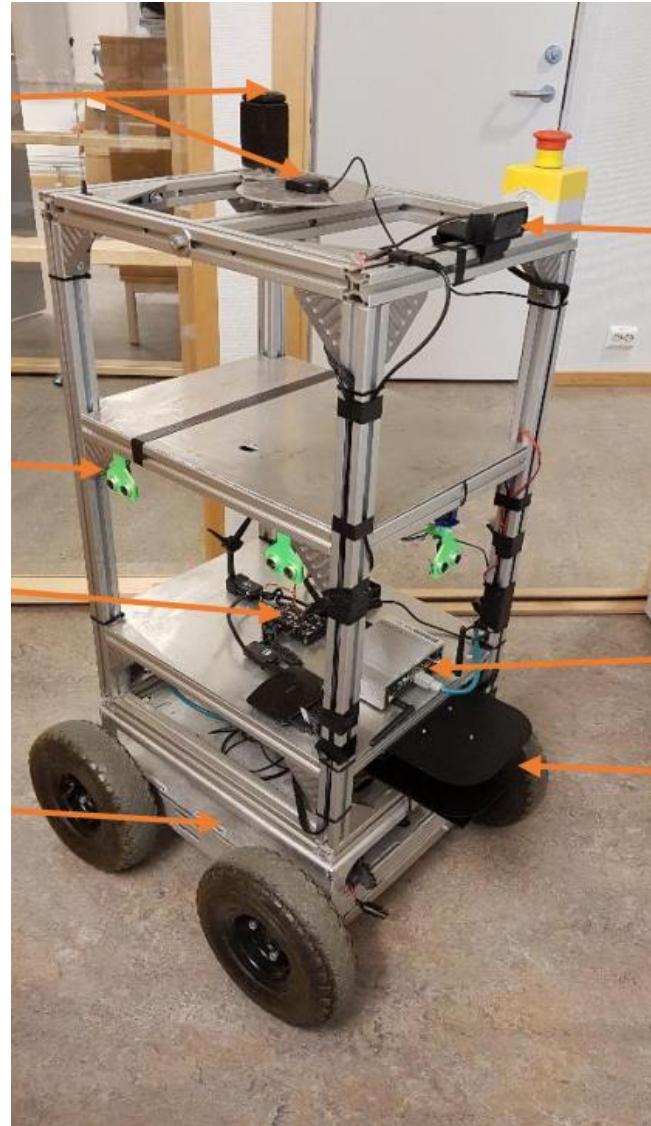
# Body Design

## Design Advantages

- Ability to move in small and tight path.
- Good traction and stability in uneven terrain.

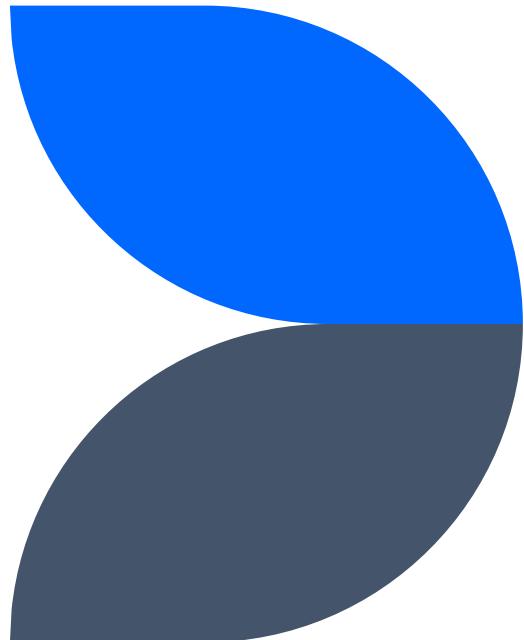
## Material

- Aluminium Extrusion Connected with L- Joints
- Rubber Pneumatic Tyre



# Locomotion

AUTONOMOUS MOBILE GREENHOUSE ROBOT



# Locomotion



**IG52 – DB4**

**10-inch Pneumatic  
Wheels**



# IG52 – DB4

## Specifications

Dimensions (LxWxH): 25.5" x 22.0" x 10.5"

Weight: 31.8 kg

Drive Method: Direct Drive

Payload range: 9 to 72.5 kg

Top Speed: 5.8 km/h

Gear Motors: Four (4) IG52 285 RPM Gear Motors (one per axle/wheel).

Wheels: Two (2) pair of 10-inch pneumatic wheels.

Battery System: Two (2) Interstate 12V 18 Ah Lead Acid Battery providing 1-3 hours of operation depending on use.

Motor Controller(s): One (1) Sabertooth Dual 12A Motor Driver.

Steering Method: Differential Steering (Varying Motor Speed)



# PNEUMATIC TYRE

## Advantages

- Ability to absorb the unevenness of terrain by providing smoother ride, and less bumping and shaking.
- Thicker thread provide good traction.
- Higher durability than cushion tyre.



3.

# Navigation System & Controller

# Controller

# ARK-1123H Embedded Computer



Processor	
CPU	Intel Celeron Processor J1900 Quad Core 2.0 GHz SoC
Core Number	4
Frequency	2.0 GHz (Up to 2.41 GHz w/ burst frequency enabled)
L2 Cache	2 MB
BIOS	AMI EFI 64 Mbit (Default BIOS is supported for 64-bit OS installation, BIOS for 32-bit OS is supported by project)
Memory	
Technology	DDR3L 1333 MHz
Max. Capacity	8GB
Socket	1 x 204-pin SO-DIMM
Graphics	
Chipset	Intel® Atom SoC integrated
Graphic Engine	DirectX® 11.1, OGL 3.0, OCL 1.1, OGL ES 2.0 Encode: H264, MPEG2/4, VC1, WMV9 Decode: H264, MPEG2
HDMI	2 x Lockable HDMI connector, support up to 1920 x 1080 at 60Hz (2nd HDMI w/o audio function by Intel limitation)
Audio	
Main System	ALC-888S, High Definition Audio. Line-out & Line-in
Ethernet	
LAN1	10/100/1000 Mbps Intel i210 GbE, support Wake On Lan
LAN2	10/100/1000 Mbps Intel I210 GbE, support Wake on LAN
I/O Interface	
Serial Port	1 x RS-232/422/485 (BIOS selectable)
USB Interface	2 x USB 2.0 & 1 x USB3.0
Other	
Watchdog Timer	255 levels timer interval, setup by software
Expansion	
Mini PCIe	1 x Full-size Mini PCIe, support WLAN or WWAN module
Storage	
2.5" Drive Bay	1 x 2.5" SATA HDD Bay (Max Height 9.5mm)
mSATA	1 x Half-size mPCIe (Suggest to assembly by CTOS or T-Part due to complex installation)
Software Support	
Microsoft Windows	WES7, Windows 7, WE8S, Windows 8 and Windows 10 (32-bit support by project)
Linux	Support (by Project)
Power	
Input Voltage	12 VDC
Power Adaptor	AC to DC, DC12 V/3 A, 36 W with threaded design
Consumption	Typical 5.64 W, Max. 14.04 W
Mechanical	
Construction	Aluminum housing
Mounting	VESA/DIN Rail/Wall Mounting Kits (Optional)
Dimensions	133.8 x 43.1 x 94.2 mm (5.27" x 1.7" x 3.71")
Weight	0.8kg
Environment	
Operating Temperature	With extended temperature SSD/mSATA/RAM : -20 ~ 60° C with 0.7m/s air flow With standard temperature HDD/SSD/mSATA/RAM peripherals: 0 ~ 40° C with 0.7m/s air flow
Storage Temperature	-40 ~ 85° C (-40 ~ 185° F)
Relative Humidity	95% @ 40° C (non-condensing)
Vibration during Operation	With mSATA/SSD: 3 Grms, IEC 60068-2-64, random, 5 ~ 500 Hz, 1 hr/axis With HDD: 0.5Grms, IEC 60068-2-64, random, 5~500Hz, 3 axes, 1hr/axis
Shock During Operation	With mSATA/SSD: 30 G, IEC 60068-2-27, half sine, 11 ms duration With HDD: 10G, IEC 60068-2-27, half sine, 11 ms duration
Certification	
EMC	CE/FCC Class B, CCC, BSMI
Safety Certifications	UL 62368, CB 62368, CCC, BSMI

Does all the computational work from all the peripherals

## Pixhawk PX4



# Mission Planner software

## Manual control

### Control PWM for motors

Dimensions	84mm x44mm x12mm
Weight	G.W 15.8g
Battery	Exclude
Technical specifications	
Main FMU Processor	STM32F765 (32 Bit Arm® Cortex®-M7, 216MHz, 2MB memory, 512KB RAM)
IO Processor	STM32F100(32 Bit Arm® Cortex®-M3, 24MHz, 8KB SRAM)
On-board sensors	Accel/Gyro: ICM-20689, Accel/Gyro: BMI055, Mag: IST8310, Barometer: MS5611
GPS	ublox Neo-M8N GPS/GLONASS receiver; integrated magnetometer IST8310
Interfaces	
	8-16 PWM servo outputs (8 from IO, 8 from FMU)
	3 dedicated PWM/Capture inputs on FMU
	Dedicated R/C input for CPPM
	Dedicated R/C input for Spektrum / DSM and S.Bus with analog / PWM RSSI input

Dedicated S.Bus servo output
5 general purpose serial ports(2 with full flow control, 1 with separate 1.5A current limit)
3 I2C ports
1 internal high speed SPI sensor bus with 4 chip selects and 6 DRDYs
1 internal low noise SPI bus dedicated for Barometer with 2 chip selects, no DRDYs
1 internal SPI bus dedicated for FRAM, Supports dedicated SPI calibration EEPROM located on sensor module
1 external SPI buses
Up to 2 CANBuses for dual CAN with serial ESC
Analog inputs for voltage / current of 2 batteries
2 additional analog inputs
Power module output
4.9~5.5V
Max input voltage
6V
Max current sensing
120A
USB Power Input
4.75~5.25V
Servo Rail Input
0~36V
Operating temp
-40~85°C
Storage temp
-40~85°C
Certificates
CE, FCC, RoHS compliant (lead-free)

# Arduino Mega



Used for its ADC feature

Communicate with high level computer  
for ultrasonic sensors data

## Tech specs

MICROCONTROLLER	ATmega2560
OPERATING VOLTAGE	5V
INPUT VOLTAGE (RECOMMENDED)	7-12V
INPUT VOLTAGE (LIMIT)	6-20V
DIGITAL I/O PINS	54 (of which 15 provide PWM output)
ANALOG INPUT PINS	16
DC CURRENT PER I/O PIN	20 mA
DC CURRENT FOR 3.3V PIN	50 mA
FLASH MEMORY	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
CLOCK SPEED	16 MHz
LED_BUILTIN	13
LENGTH	101.52 mm
WIDTH	53.3 mm
WEIGHT	37 g

# Sensor

# Outdoor Navigation

3DR uBlox GNSS  
Receiver with  
compass



Features and Specifications:	
ublox LEA-6H module	
5 Hz update rate	
25 x 25 x 4 mm ceramic patch antenna	
LNA and SAW filter	
Rechargeable 3V lithium backup battery	
Low noise 3.3V regulator	
I2C EEPROM for configuration storage	
Power and fix indicator LEDs	
Protective case	
APM compatible 6-pin DF13 connector	
Exposed RX, TX, 5V and GND pad	
38 x 38 x 8.5 mm total size, 16.8 grams.	

Swift Navigation  
Piksi GNSS RTK



## Features

- Centimeter-level Accurate
- Dual Frequency RTK up to 10Hz:
  - GPS L1/L2
  - GLONASS G1/G2
  - BeiDou B1/B2
  - Galileo E1/E5b
- Raw Measurement output up to 20Hz
- SBAS
- Hardware-ready for:
  - QZSS L1/L2
- On-board MEMS IMU and Magnetometer
- Flexible Interfaces
  - UART
  - Ethernet
  - CAN
  - USB
- Communication Protocols
  - Swift Binary Protocol
  - NMEA 0183
  - RTCM v3
- External Clock Input
- 32 User-definable GPIO Pins for Customization
- Wide power supply range: 5.0 - 15.0 V DC
- Linux Open Platform

## TIM561 SICK LiDAR



Range readings

SLAM

<b>Model N°</b>	TIM 561
<b>Accuracy</b>	+/- 20 mm
<b>Interface</b>	Ethernet
<b>Ambient illuminance</b>	80.000 lux
<b>Ambient temperature / humidity</b>	-25° to +50°
<b>Voltage</b>	9 – 28 VDC
<b>Resolution angle</b>	0.33°
<b>Range</b>	270°
<b>IP</b>	IP67
<b>Environment</b>	Indoors
<b>Distance</b>	0.05- 10 m
<b>Scan frequency</b>	15 Hz

## Ultrasonic Sensor HC-SR04



Obstacle avoidance

General	
Type	Ultrasonic Sensor
Model	HC-SR04
Quantity	1 Piece
Arduino Library	HCSR04Ultrasonic
Power Supply	Working voltage: 3-5.5VDC Static current: less than 2 mA IO logic voltage: 3.3V / 5V
Measurement	Induction angle: not more than 15 degrees Detection range: 2-400 cm Accuracy: 3mm
Compatible	Arduino,NodeMCU

# 4. Data Collection

## Logitech C920 Camera



Data sent to computer

Visual target tracking

### TECHNICAL SPECIFICATIONS

Max Resolution: 1080 p/30 fps - 720p/ 30 fps

Camera mega pixel: 3

Focus type: Autofocus

Lens type: Glass

Built-in mic: Stereo

Mic range: Up to 1 m

Diagonal field of view (dFoV): 78°

Tripod-ready universal mounting clip fits laptops, LCD or monitors<sup>1</sup>

### DIMENSIONS

Dimensions including fixed mounting clip

Height: 43.3 mm

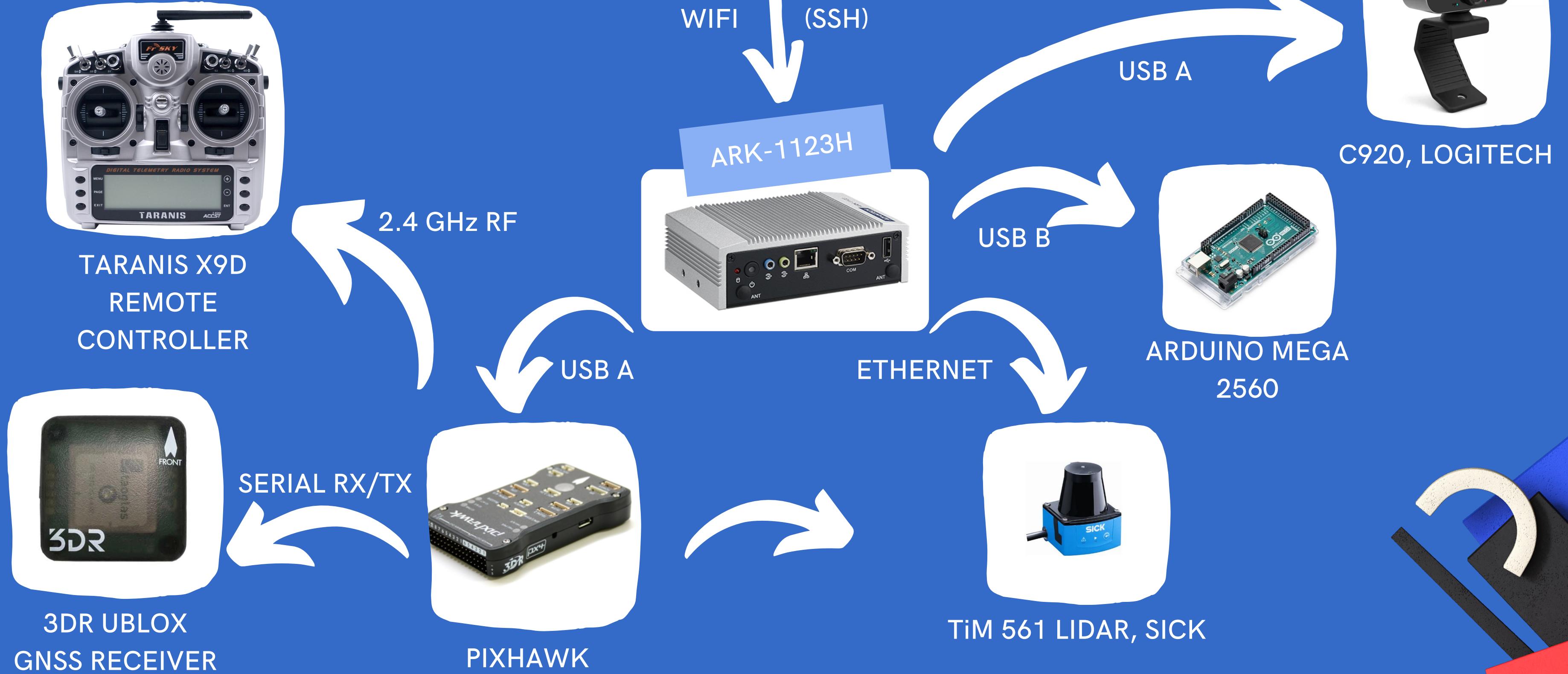
Width: 94 mm

Depth: 71 mm

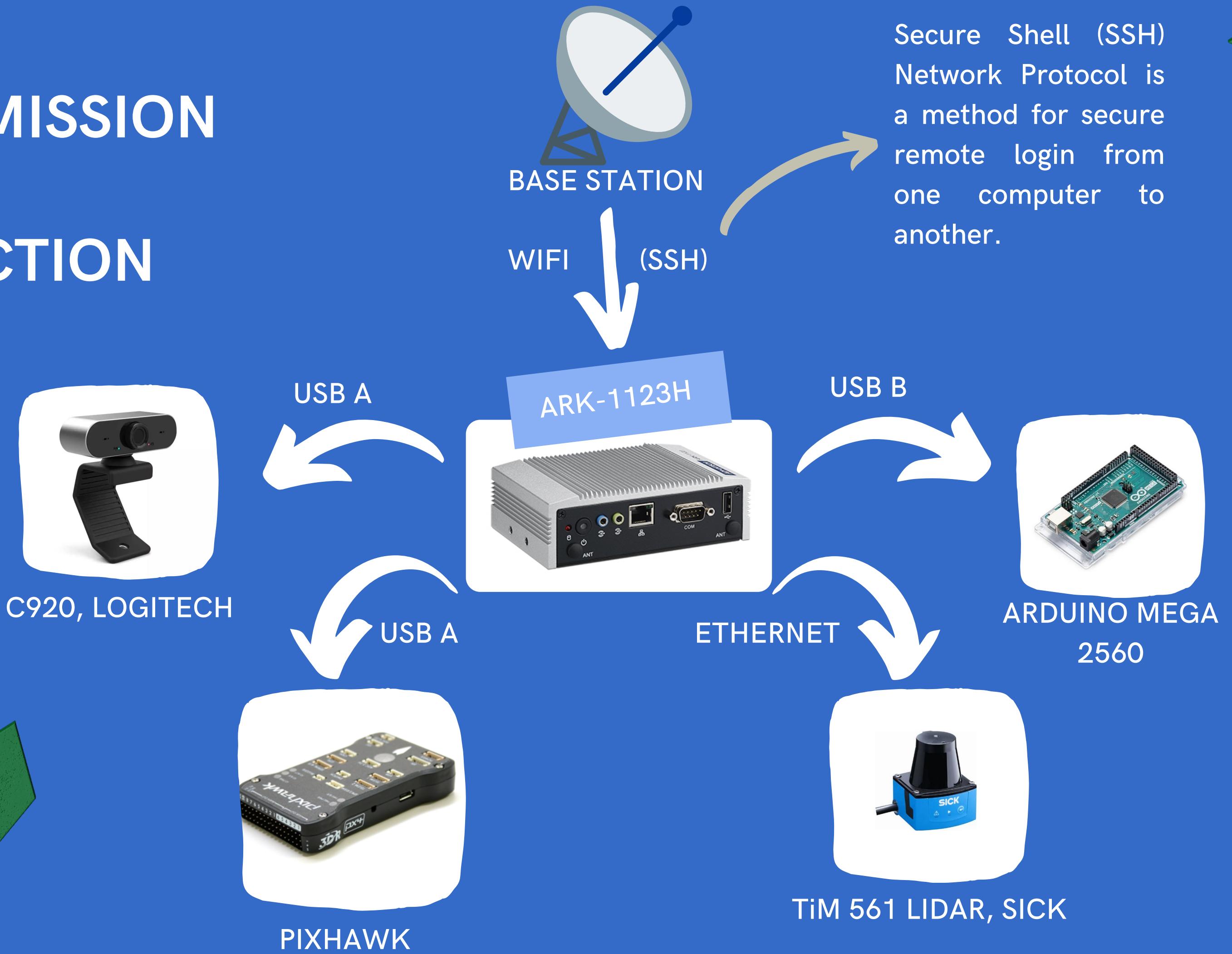
Cable length: 1.5 m

Weight: 162 g

# DATA TRANSMISSION AND COLLECTION



# DATA TRANSMISSION AND COLLECTION



# DATA TRANSMISSION AND COLLECTION



2.4 GHz RF



SERIAL RX/TX



3DR UBLOX  
GNSS RECEIVER

# POWER MANAGEMENT



INTERSTATE 12 VOLT 18  
AH SEALED LEAD ACID  
BATTERY (SLA)

- 12V 18Ah batteries
- Rechargeable
- 2-5 operation time, depending on payload velocity
- Robust, have a high cycle ability, a high performance and are easy to maintain

IG52-DB4 Superdroidrobots  
(Mobile Robot Platform)