



SP Technical Research Institute of Sweden



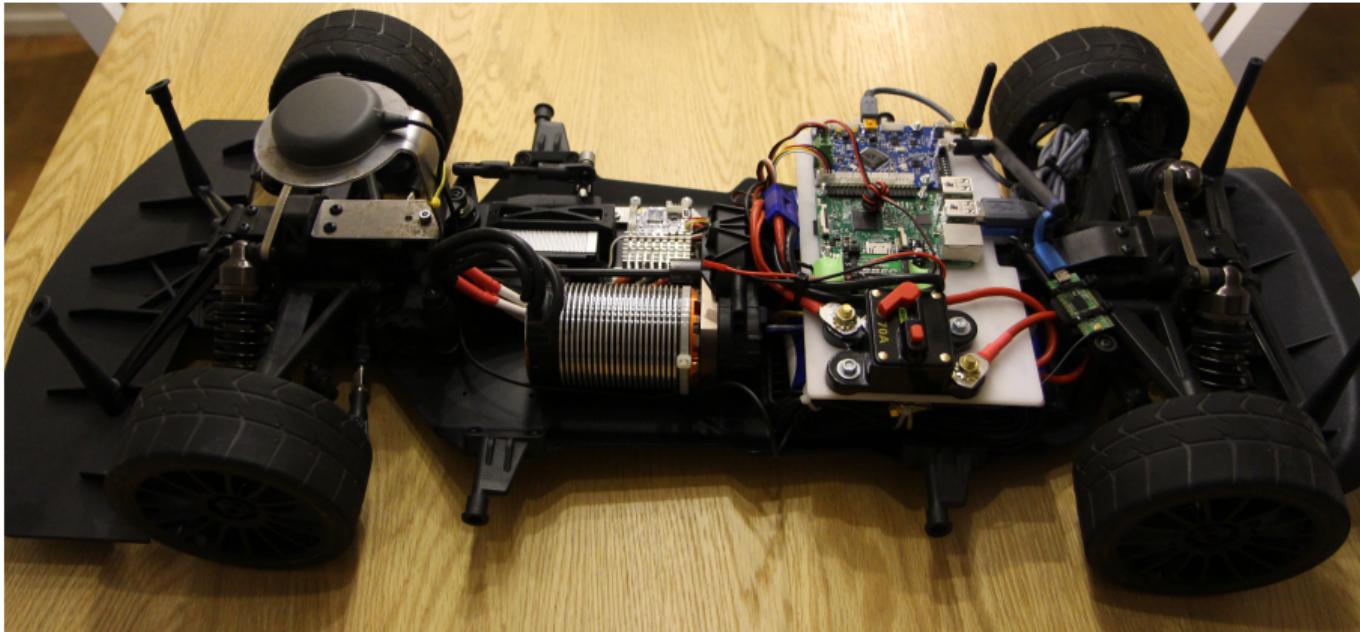
The SP RC Car

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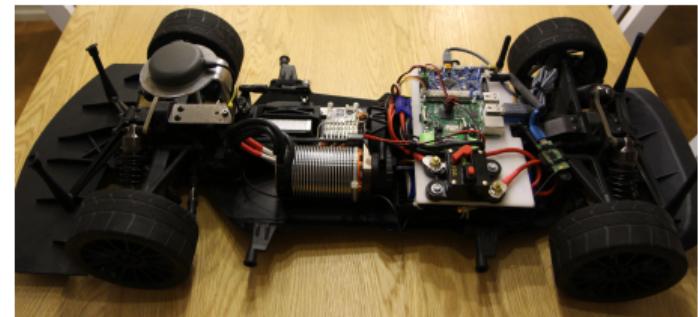
The SP RC Car





The SP RC Car Overview

- Positioning:
 - IMU (Accelerometer, Gyroscope, Magnetometer).
 - RTK GPS.
 - Odometry.
- Speed from <1 Km/h to 80 Km/h
- Autopilot.
- Custom user interface.
 - Visualization, remote control, configuration, communication.
 - RTK correction data from different possible sources.
- Fully open source.

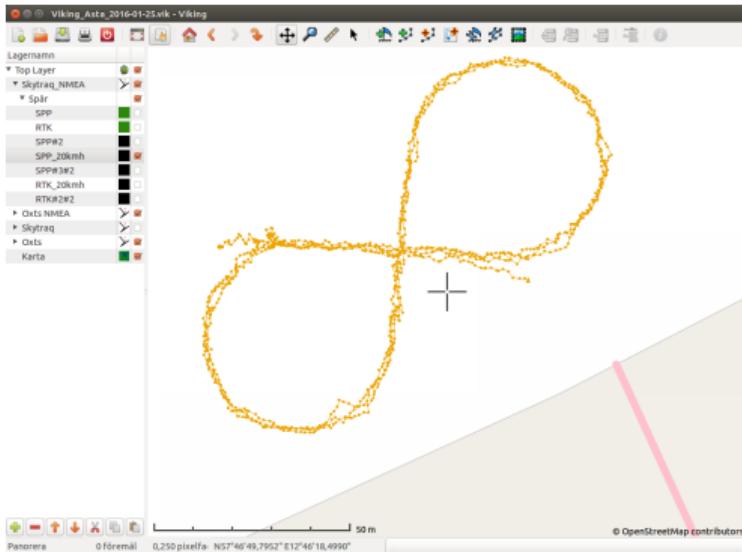




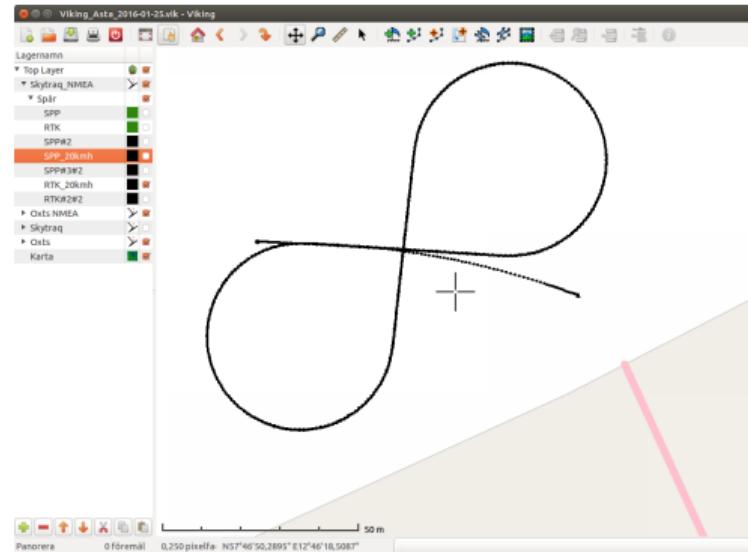
The SP RC Car

RTK GPS for accurate positioning

SPP



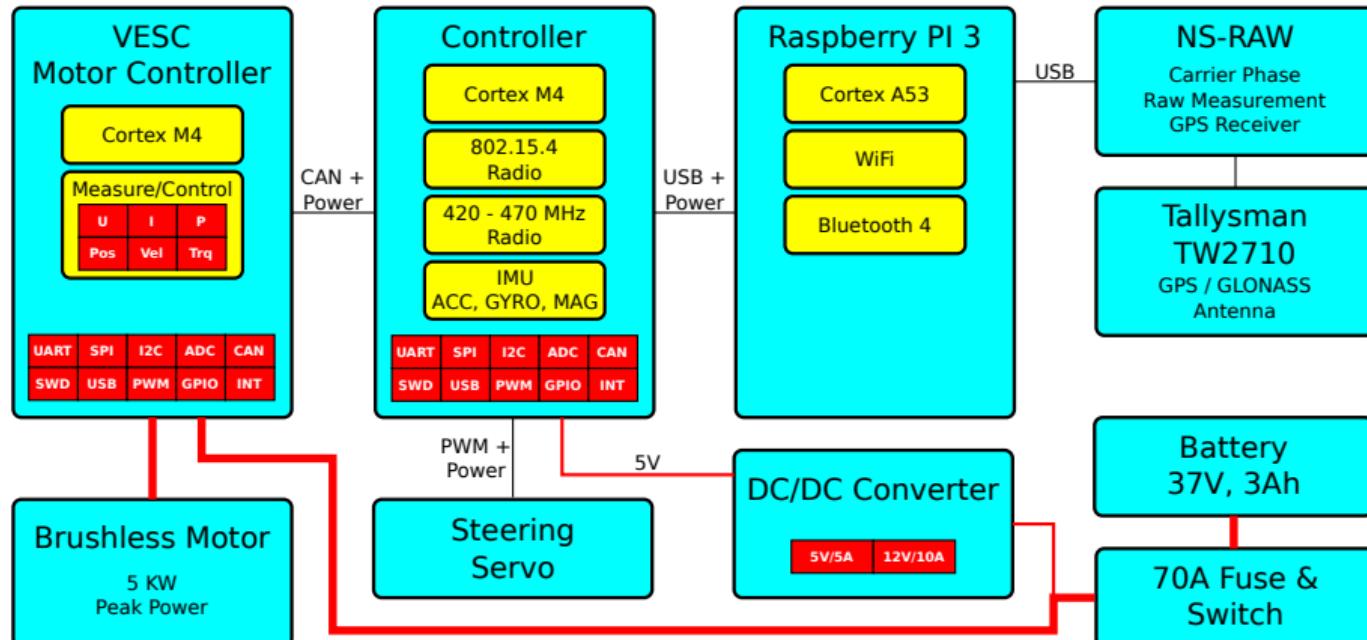
RTK





The SP RC Car

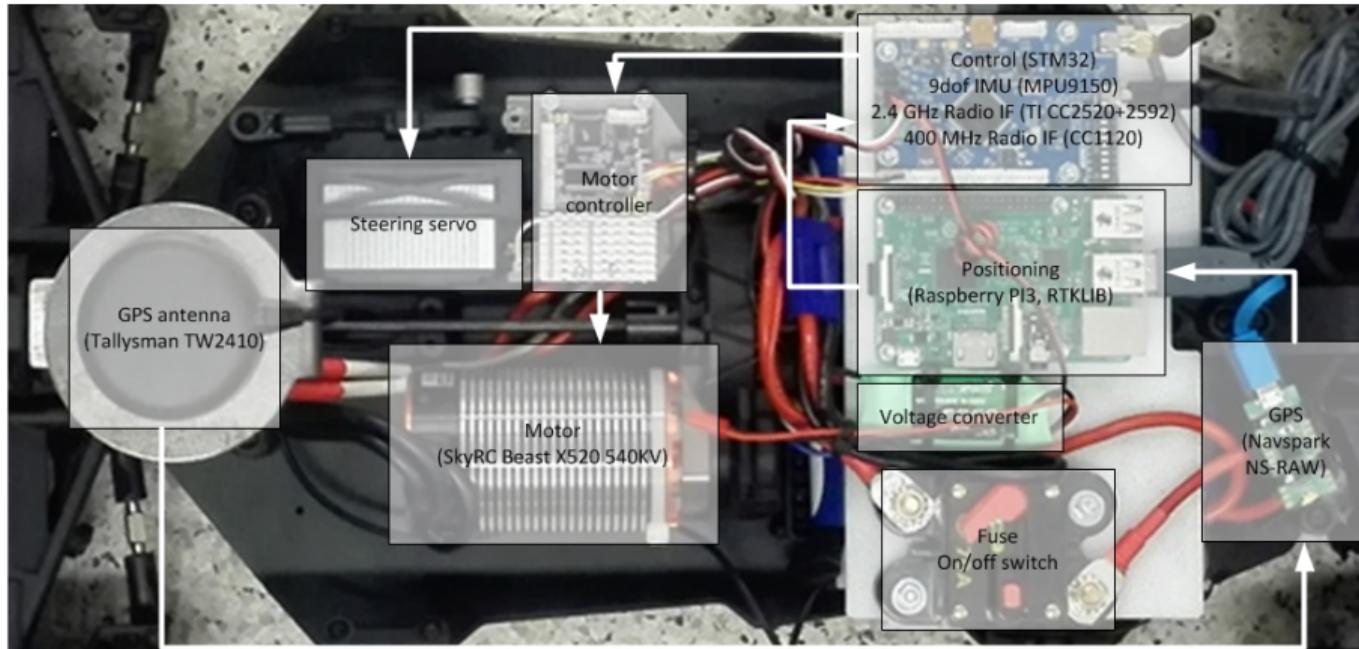
Hardware Block Diagram





The SP RC Car

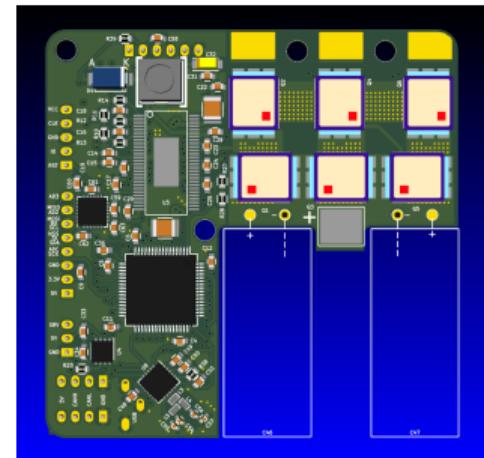
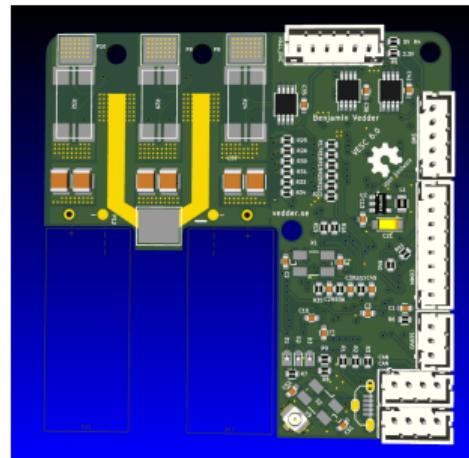
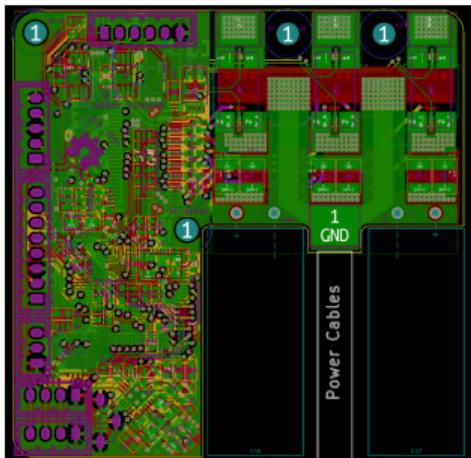
Hardware Locations





The SP RC Car VESC Motor Controller

- Benjamins open source and open hardware spare time project developed during the past 4 years.
- 20 000+ lines of C code in 100+ files.
- 14 threads + interrupts and DMA.
- Cont power: 2000 W
- Peak power: over 5000 W
- Size: 60 x 60 x 20 mm





The SP RC Car VESC - BLDC Tool GUI



BLDC Tool

Motor Configuration App Configuration Realtime Data BEMF Plot Current Plot Terminal Firmware Rotor Position Experiment

General

Sensor Mode: Encoder Hall Sensorless

Current Control: $K_p: 0,0036$ $K_i: 5,05$

Encoder: $Ofs: 180,00$ $Rat: 7,00$

Sensorless ERPM: $2500,00$ Invert Encoder

F_SW and DTc: $F_{SW}: 20000 \text{ Hz}$ $DTc: 0,080 \mu\text{s}$

Speed Tracker: $Kp: 2000,00$ $Ki: 20000,00$

Duty Downramp: $Kp: 10,00$ $Ki: 200,00$

Openloop RPM: $600,00 \text{ RPM}$

Motor Parameters (for the sensorless observer)

$R: 0,00505 \Omega$ $L: 3,58 \mu\text{H}$ $\lambda: 0,003544$

Observer Gain (x1M): $200,99$

Sensorless Startup and Low Speed

Open Loop: $Hyst: 0,500 \text{ s}$ $Time: 0,500 \text{ s}$

D Current Injection: $Duty: 0,000$ $Factor: 0,00$

Hall Sensors

Table: 255 255 255 255 255 255 255 255

Detect and Calculate Parameters

Measure R and L: $R: 0,00000 \Omega$ $L: 0,00 \mu\text{H}$ $\lambda: 0,00000000$

Measure λ (Req: R): $I: 6,00 \text{ A}$ $Duty: 0,50$ $RPM: 700,0$ ← To spin up for λ

Calc CC (Req: R and L): $TC: 1000,0 \mu\text{s}$ $Kp: 0,0000$ $Ki: 0,00$

Detect Encoder

Measure: $I: 15,00 \text{ A}$ $Ofs: 0,00$ $Rat: 0,00$ Invert Encoder

Detect Hall Sensors

Measure: $I: 15,00 \text{ A}$ $0 0 0 0 0 0 0 0$

Control

0,20 15000 3,0 A 3,0 A 0,000 KB Ctrl $I: 3,0 \text{ A}$

Plot and Sample

Release Motor (ESC)

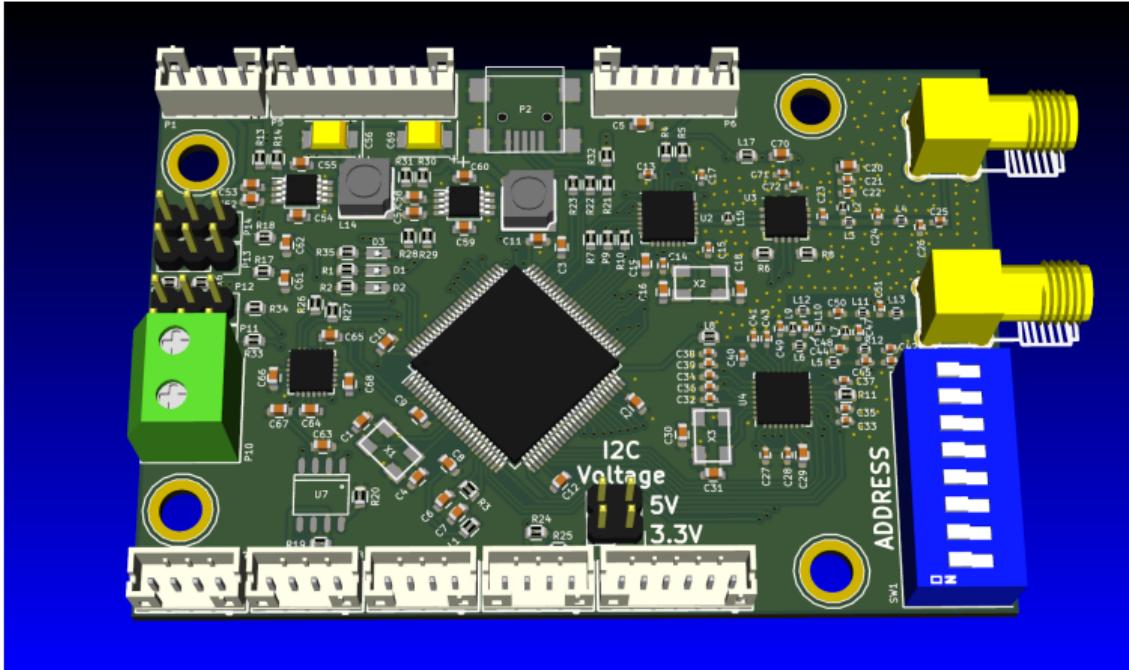
Read configuration Write configuration Save XML

Not connected



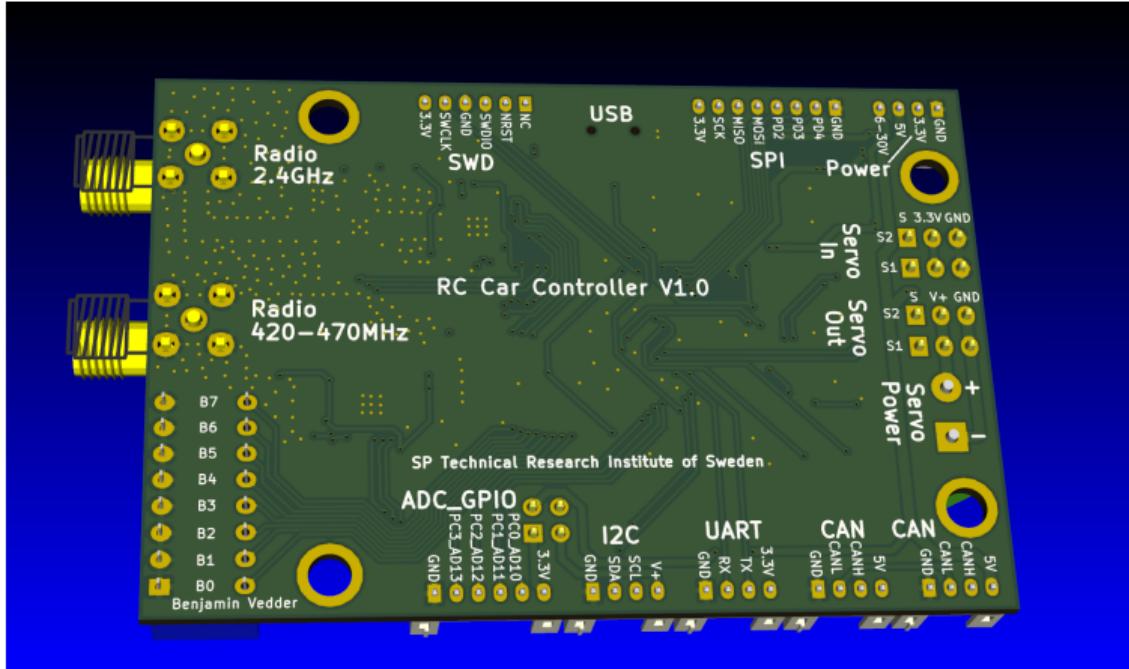
The SP RC Car

Main Controller - front





The SP RC Car Controller - back





The SP RC Car RC Car Tool - Main Page



RC Car Tool

Cars

Car 0

RTCM Client Map

Serial Connection

IF - /dev/ttyACM3

Refresh Connect

UDP Connection

Disconnect

Cars

Remove Car Add Car

Joystick

/dev/input/js0 Not connected

Disconnect Connect

Control

Mode: Duty Current

Max: 0,15

Throttle: 0% G: 0,030

Steering: 0% G: 0,080

BLDC Tool UDP Server

Not connected

Car ID: 0

Poll Data

Keyboard Control

AutoPilot

Update Route from Map

Clear Route

Orientation IMU Terminal Calibration GPS Configuration

Roll: 0° Pitch: -1° Yaw: -169° Speed: 0.00 km/h

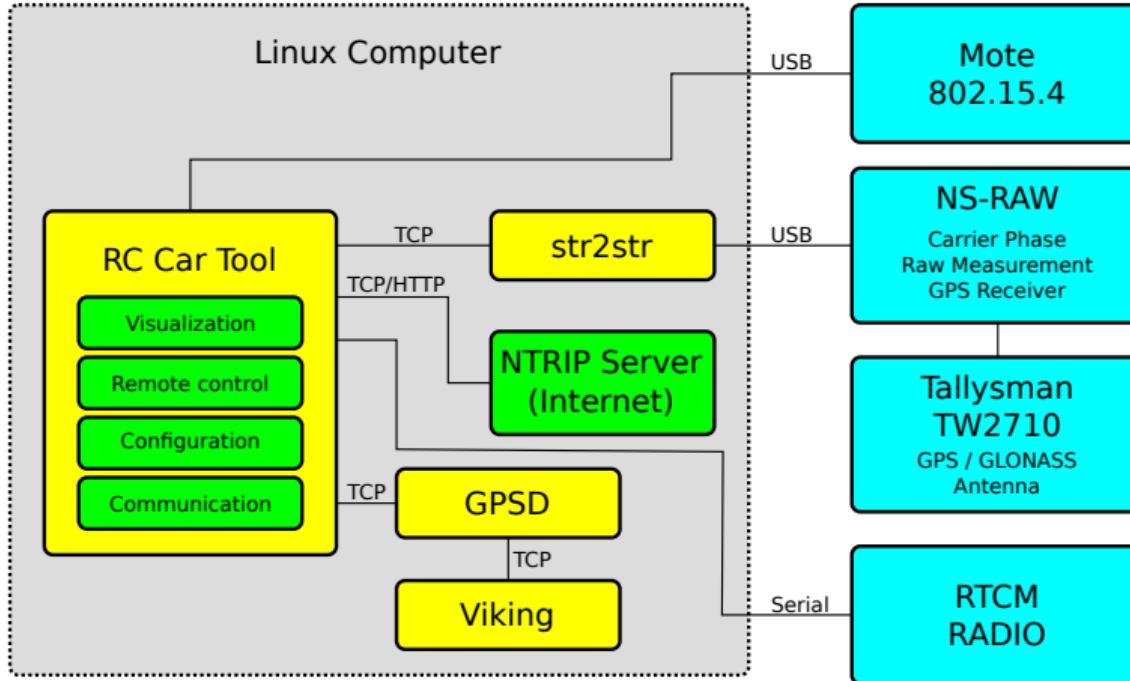
FW 1.0 Battery: 51.3 % (38.10 V) MOSFET Temp: 30°C

FAULT_CODE_NONE

A screenshot of the RC Car Tool software interface. The main window displays a 3D model of a red toy car. Below the car are four horizontal bars showing orientation data: Roll (0°), Pitch (-1°), Yaw (-169°), and Speed (0.00 km/h). At the bottom of the screen, there are tabs for Orientation, IMU, Terminal, Calibration, GPS, and Configuration. A status bar at the very bottom shows FW 1.0, a battery level of 51.3% (38.10 V), and a MOSFET temperature of 30°C. The interface includes sections for Serial Connection (using /dev/ttyACM3), UDP Connection (with a Disconnect button), and Control (with tabs for Duty and Current mode, and sliders for Throttle and Steering). On the left, there's a sidebar with tabs for Cars, RTCM Client, and Map. The Cars tab is active, showing 'Car 0'. Other tabs include RTIM Client and Map. The top of the window has standard OS controls (minimize, maximize, close).

The SP RC Car

Linux Computer Block Diagram





The SP RC Car

RC Car Tool - IMU raw data





The SP RC Car RC Car Tool - Terminal

RC Car Tool

Cars

Car 0

addr	stack	prio	refs	state	name	time
200010e8	20000764	64	1	SLEEPING	main	148
20001138	200011244	1	1	READY	idle	9988705
20001500	200011674	2	1	SUSPENDED	usb_lld pump	4668
20007290	2000714dc	64	1	QUEUED	USB-Serial read	26588
20006ef8	20007214	64	1	WTOREVT	USB-Serial write	8
20005560	2000667c	64	1	WTOREVT	USB-Serial process	16215
20009f68	2000b08cc	64	1	SLEEPING	Servo ramp	8
20004270	20004aafc	65	1	SUSPENDED	MPU Sampling	1133009
20001788	20001ca4	66	1	WTOREVT	CC2520 EXTI	6834
20001db8	20001fb4	64	1	SLEEPING	CC2520 EXC	85
20003448	2000393c	64	1	CURRENT	CC2520 RX	488
20003ed9	200041ec	64	1	WTOREVT	CC2520 TX	22160
2000a538	2000a7ec	65	1	WTOREVT	CAN read	15810
200086f0	200097c4	64	1	READY	CAN process	38424
2000c908	2000cb4	64	1	SLEEPING	Autopilot	23

Valid commands are:

```
help
Show this help
ping
Print pong here to see if the reply works
mem
Show memory usage
threads
List all threads
vesc
Forward command to VESC
```

Orientation IMU Terminal Calibration GPS Configuration

FW 1.0 Battery: 51.3 % (38.10 V) MOSFET Temp: 30°C FAULT_CODE_NONE

BLDC Tool UDP Server

Serial Connection

IF - /dev/ttyACM3

Car ID: 0

Poll Data

Keyboard Control

AutoPilot

Update Route from Map

Clear Route

UDP Connection

Disconnect

Cars

Remove Car Add Car

Joystick

/dev/input/js0 Not connected

Disconnect Connect

Control

Mode: Duty Current

Max: 0,15

Throttle: 0% G: 0,030

Steering: 0% G: 0,080

Not connected



The SP RC Car RC Car Tool - GPS Data

RC Car Tool

Cars Map RTCM Client

Car 0

NMEA TCP Server Log to File

Port: 27910 Activate log_nmea.txt Choose... Activate

\$GPRMC,110325,30,A,5742.9886989,N,01253.5043005,E,4.47,12.29,150416,0.0,E,A*0B
\$GPGLL,110325,30,5742.9886989,N,01253.5043005,E,1,04,1.0,268.345,M,35.026,M,0.0,*4D

\$GPGSA,A,3,15,18,24,30,,*,3.6,2,3,2,8,1*29
\$GPGSV,1,1,04,15,61,271,21,18,26,308,38,24,26,265,37,30,23,085,27,1*64

\$GPRMC,110325,40,A,5742.9893408,N,01253.5052139,E,1,37,12.29,150416,0.0,E,A*0B
\$GPGLL,110325,40,5742.9893408,N,01253.5052139,E,1,04,1.0,262.036,M,35.026,M,0.0,*49

\$GPGSA,A,3,15,18,24,30,,*,3.6,2,3,2,8,1*29
\$GPGSV,1,1,04,15,61,271,21,18,26,308,38,24,26,265,37,30,23,085,27,1*64

\$GPRMC,110325,50,A,5742.9891378,N,01253.5062437,E,7,43,7.69,150416,0.0,E,A*3E
\$GPGLL,110325,50,5742.9891378,N,01253.5062437,E,1,04,1.0,247.435,M,35.026,M,0.0,*42

\$GPGSA,A,3,15,18,24,30,,*,3.6,2,3,2,8,1*29
\$GPGSV,1,1,04,15,61,271,21,18,26,308,38,24,26,265,37,30,23,085,27,1*64

\$GPGSA,A,1,,*,*1E
\$GPGSV,1,1,0,,*,*49

\$GPGSA,A,1,,*,*1E
\$GPGSV,1,1,0,,*,*49

\$GPGSA,A,1,,*,*1E
\$GPGSV,1,1,0,,*,*49

Orientation IMU Terminal Calibration GPS Configuration

Clear

FW 1.0 Battery: 51.3% (38.10 V) MOSFET Temp: 30°C FAULT_CODE_NONE BLDC Tool UDP Server

Serial Connection

Car ID: 0 Poll Data Keyboard Control AutoPilot Update Route from Map Clear Route

IF - /dev/ttyACM3 Refresh Connect

UDP Connection

Disconnect

Cars

Remove Car Add Car

Joystick

/dev/input/js0 Not connected Disconnect Connect

Control

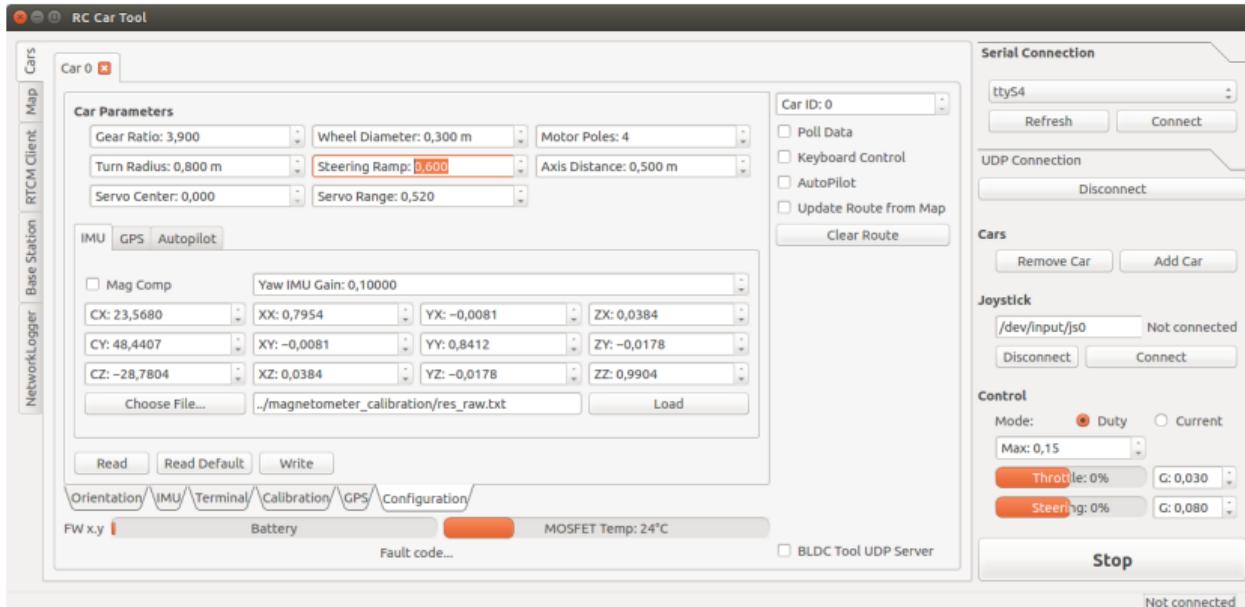
Mode: Duty Current Max: 0,15 Throttle: 0% G: 0,030 Steering: 0% G: 0,080

Not connected

A screenshot of the RC Car Tool software. The main window displays a log of NMEA GPS data. The interface includes tabs for Orientation, IMU, Terminal, Calibration, GPS, and Configuration. At the bottom, it shows the firmware version (FW 1.0), battery level (51.3%), and MOSFET temperature (30°C). A green bar at the bottom indicates no fault codes. On the right side, there are panels for serial connection (using /dev/ttyACM3), UDP connection (disconnected), and control settings (duty mode, max 0.15, throttle 0%, steering 0%). Navigation tabs on the left include Cars, Map, and RTCM Client. A decorative graphic of colored squares is in the top right corner.

The SP RC Car

RC Car Tool - Configuration





The SP RC Car

RC Car Tool - RTCM correction data

RC Car Tool

TCP / NTRIP
Server: localhost
 NTRIP User: _____ Password: _____ Stream: SPT00 Port: 65300
Not connected

Serial
 /dev/ttyS4 Baud: 115200
Not Connected

Send (or override) Reference Station Position
Lat: 57,71495867 Lon: 12,89134921 h: 219,000 Ant h: 0,000

Received RTCM Messages
GPS Observations GLONASS Observations
1001 [] 1003 [] 1009 [] 1011 []
1002 [] 1004 [] 1010 [] 1012 []
Ref Station Position GPS and GLONASS Ephemeris
1005 [] 1006 [] 1019 [] 1020 []

Last Ref Position

Serial Connection
IF - /dev/ttyACM3 Refresh Connect

UDP Connection

Cars

Joystick
/dev/input/js0 Not connected

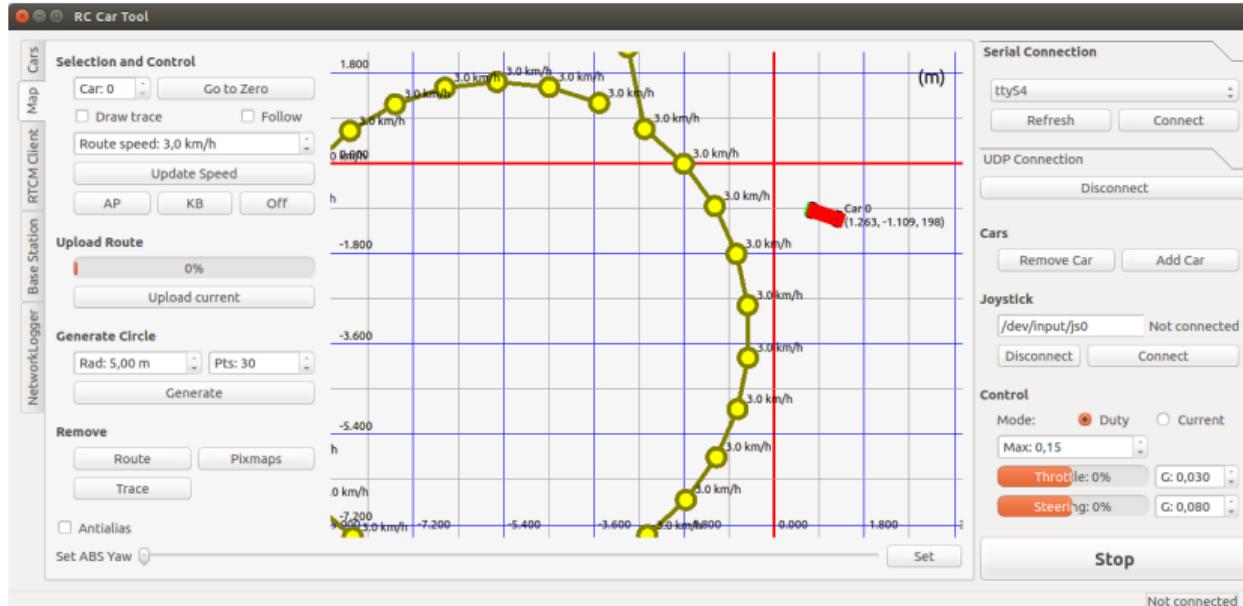
Control
Mode: Duty Current
Max: 0,15
Throttle: 0% G: 0,030
Steering: 0% G: 0,080

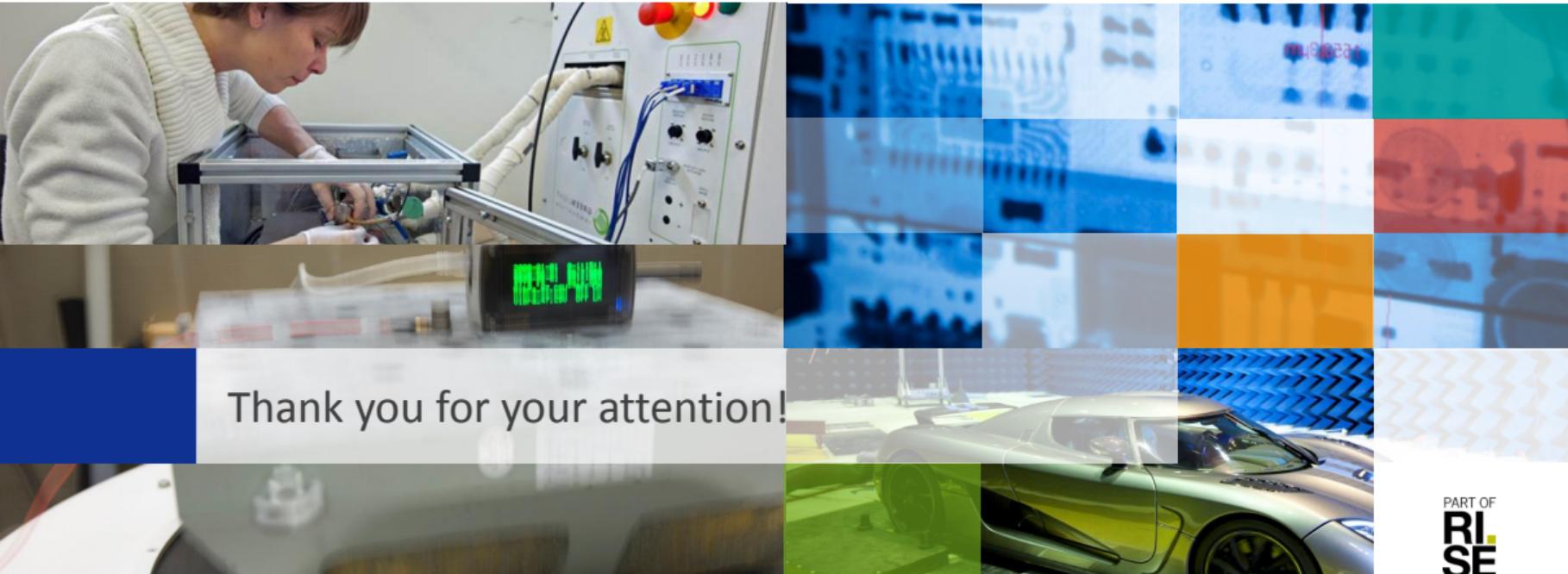
Not connected



The SP RC Car

RC Car Tool - Real-time plot and track editor for the autopilot





Thank you for your attention!