



# SP Technical Research Institute of Sweden



# The SP RC Car

---

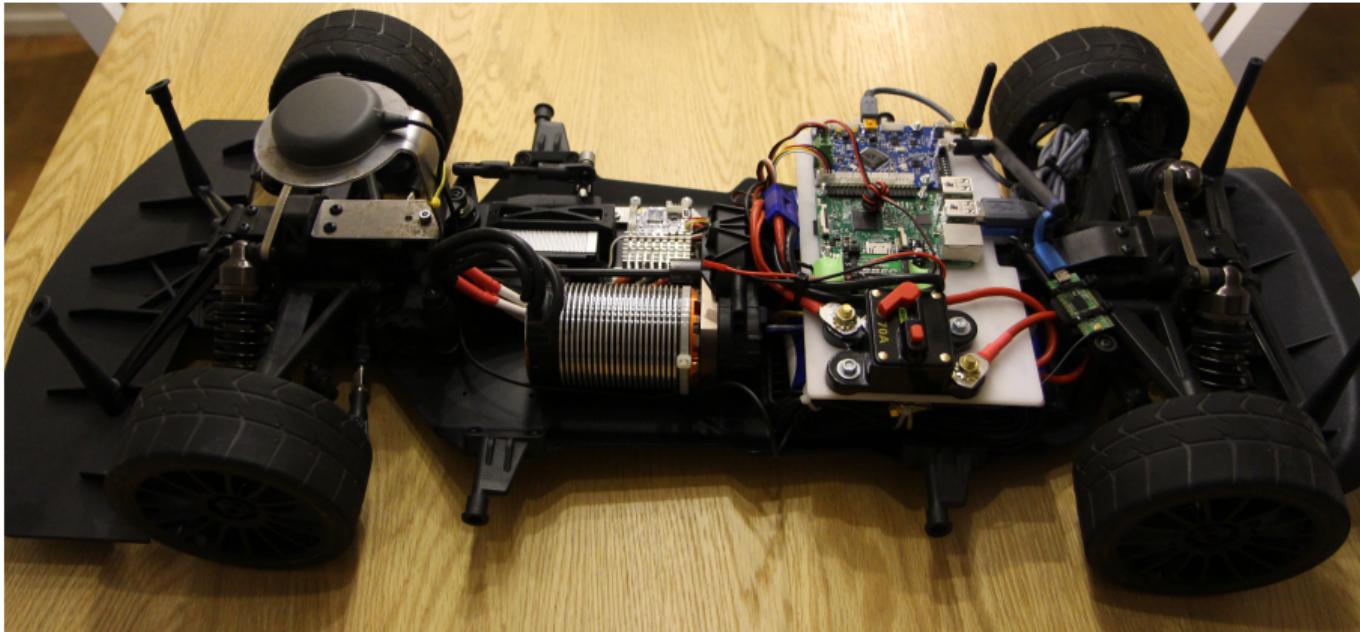
Benjamin Vedder

[benjamin.vedder@sp.se](mailto:benjamin.vedder@sp.se)

April 25, 2016, Borås



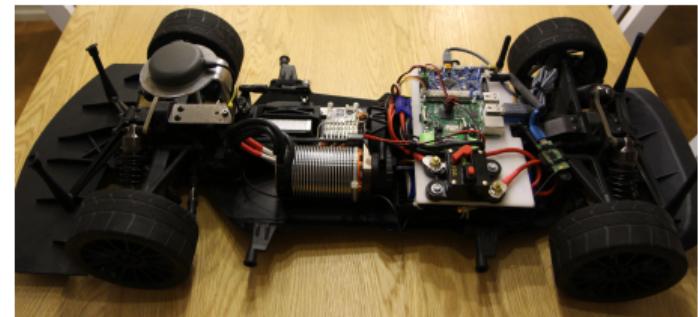
## The SP RC Car





## 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.

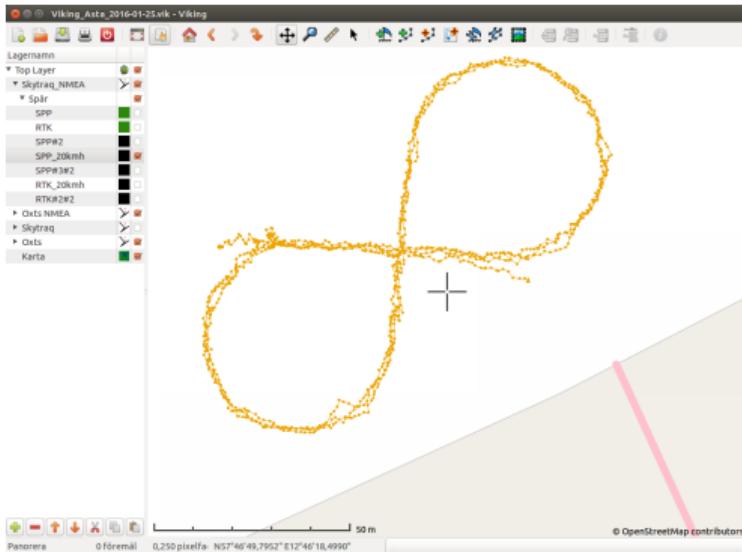




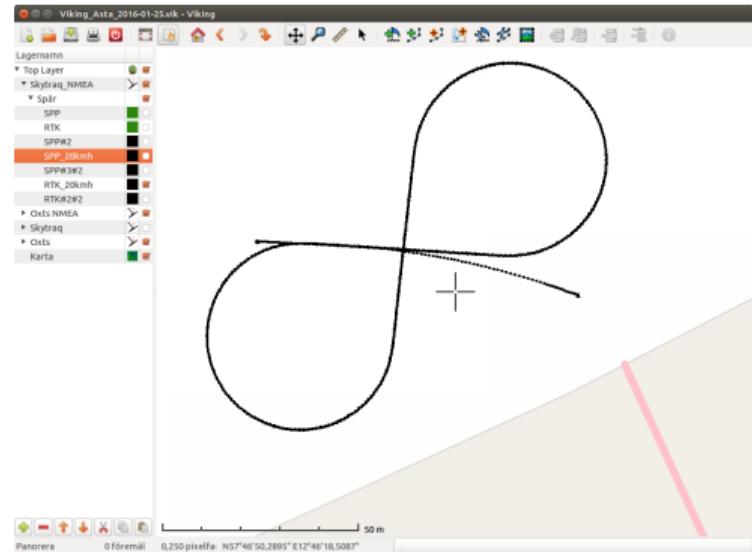
# The SP RC Car

## RTK GPS for accurate positioning

SPP



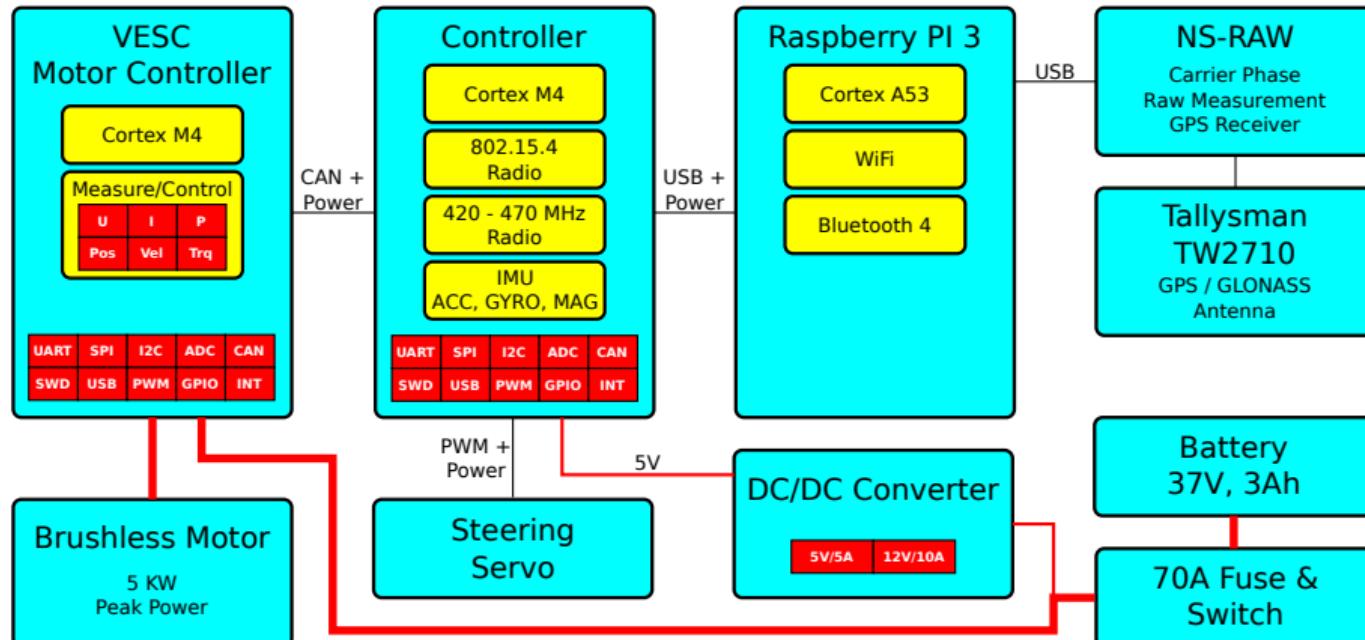
RTK





# The SP RC Car

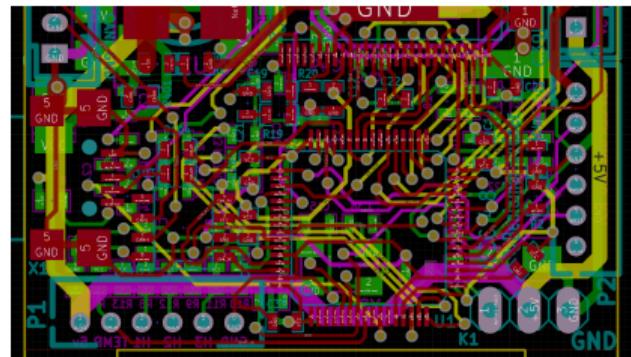
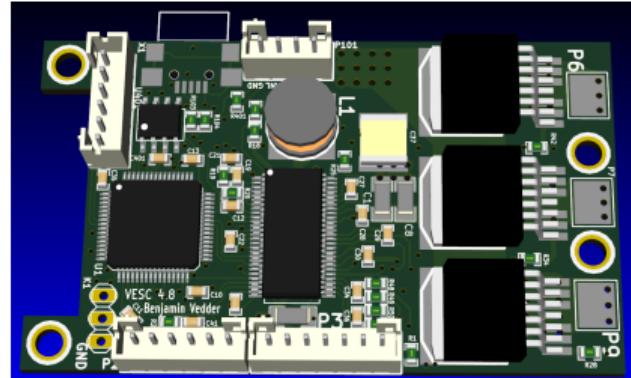
## Hardware Block Diagram





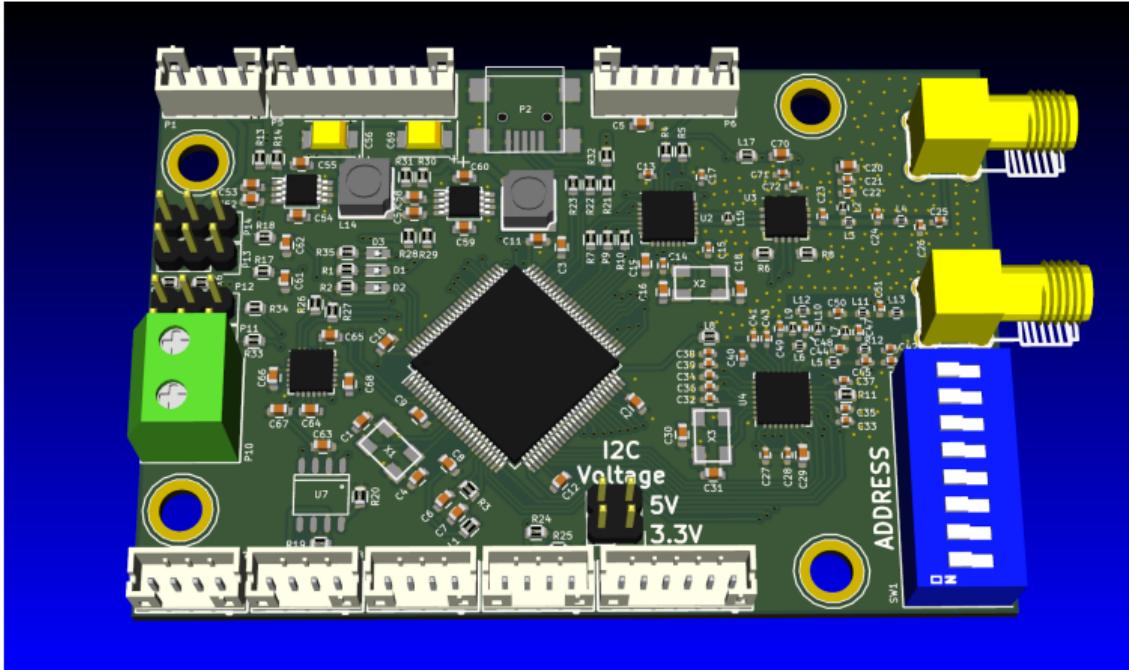
## The SP RC Car VESC Motor Controller

- Benjamins open source and open hardware spare time project developed during the past 3 years.
- 20 000 lines of C code in 100 files.
- 12 threads + interrupts and DMA.
- Cont power: 2000W
- Peak power: over 5000W
- Size: 40mm x 60mm and 40g weight.



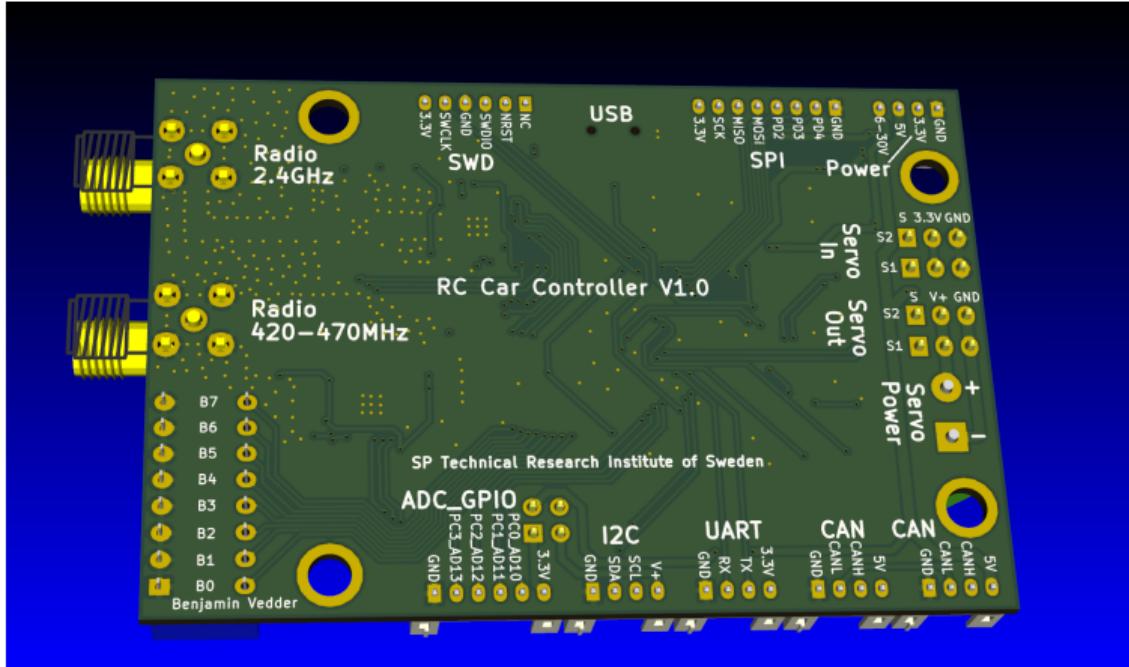


# The SP RC Car Controller - front





# 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

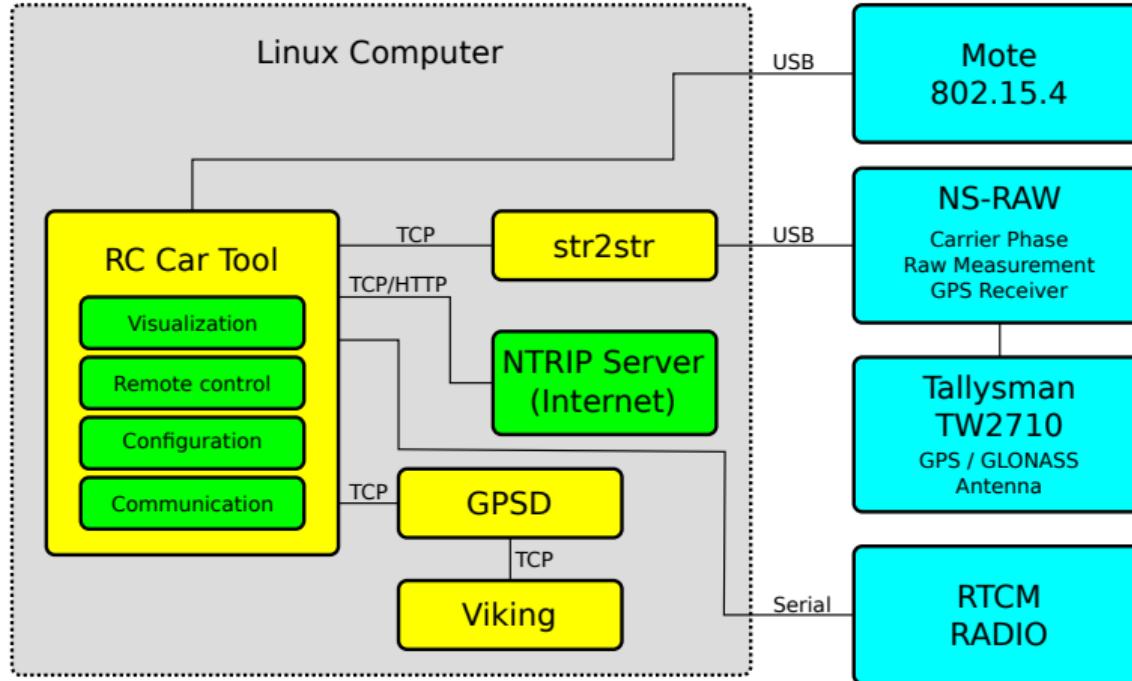
FAULT\_CODE\_NONE

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

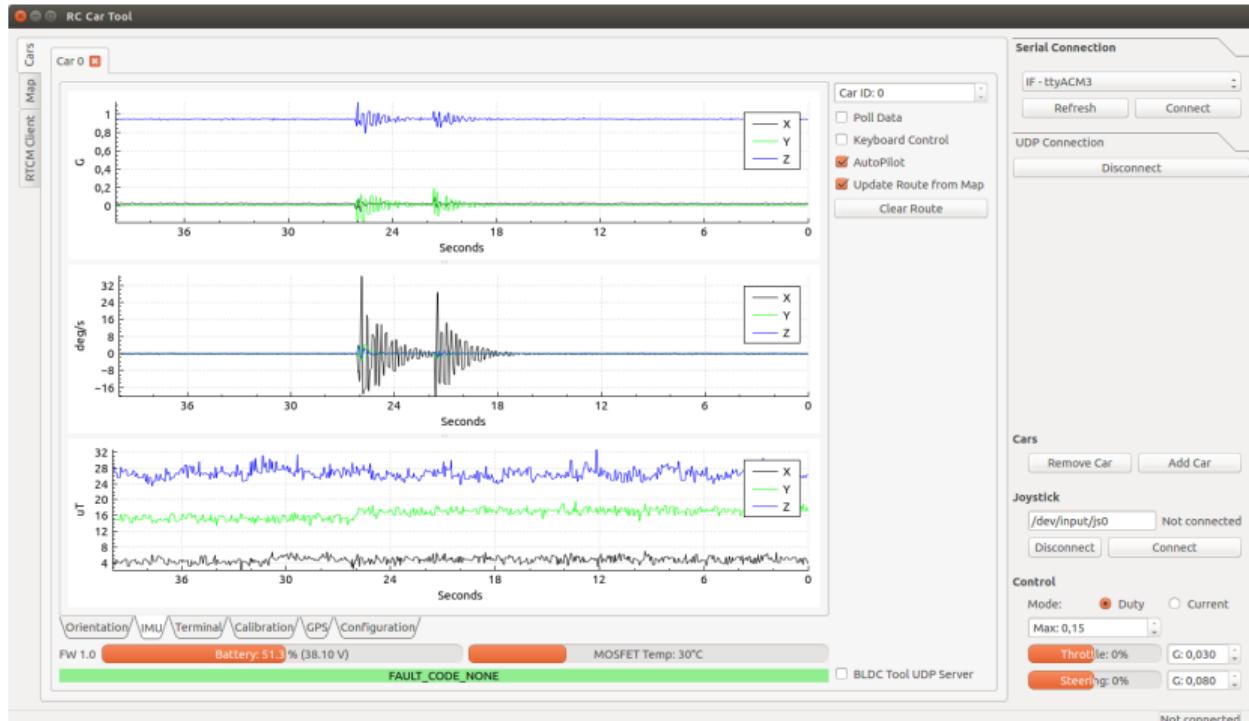
## Linux Computer Block Diagram





# 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	20001124	1	1	READY	idle	9988705
20001500	20001174	2	1	SUSPENDED	usb_lld pump	4668
20007290	2000714d	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	2000b0cc	64	1	SLEEPING	Servo ramp	8
20004270	20004a9c	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	2000cb74	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\*00  
\$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

IF - 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 for a vehicle. The log includes sentences for RMC, GLL, GSA, and GSV. Below the log are tabs for Orientation, IMU, Terminal, Calibration, GPS, and Configuration. At the bottom, there's information about 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. To the right, there are three main control panels: "Serial Connection" (using IF - ttyACM3), "UDP Connection" (with a disconnect button), and "Control" (with tabs for Duty and Current mode, and sliders for Throttle and Steering). On the far left, there are tabs for Cars, Map, and RTCM Client. A sidebar on the right lists "Cars" with buttons for Remove Car and Add Car, and a "Joystick" section for connecting to /dev/input/js0.



# The SP RC Car

## RC Car Tool - Configuration



RC Car Tool

Cars Map RTCM Client

Car 0

**Car Parameters**

Gear Ratio: 0,189	Wheel Diameter: 0,120 m	Motor Poles: 4
Turn Radius: 1,062 m	Steering Ramp: 0,600	Axis Distance: 0,475 m
Servo Left: 0,810	Servo Center: 0,520	Servo Right: 0,230

Magnetometer Compensation (disable for calibration)

CX: 0,8400	XY: 0,8537	YX: 0,0000	ZX: 0,0046
CY: 10,0000	XY: -0,0370	YY: 0,8620	ZY: 0,0060
CZ: -13,1000	XZ: 0,0046	YZ: -0,0060	ZZ: 0,9990

**Misc**

Yaw IMU Gain: 0,00000

Read Read Default Write

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

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

BLDC Tool UDP Server

Not connected

A screenshot of the 'RC Car Tool - Configuration' software. The main window displays 'Car 0' settings for car parameters like gear ratio and wheel diameter, and magnetometer compensation values. It also includes sections for miscellanous parameters and control modes. On the right side, there are tabs for serial and UDP connections, a cars list, joystick settings, and a control panel for duty cycle and steering. At the bottom, there's a status bar showing the firmware version, battery level, and MOSFET temperature.



# The SP RC Car

## RC Car Tool - RTCM correction data

The screenshot shows the "RC Car Tool" application window. The left sidebar has tabs for "RTCM Client", "Map", "Cars", and "Serial". The main area has tabs for "TCP / NTRIP" (selected), "Serial", and "UDP Connection".

**TCP / NTRIP:** Server: localhost, Port: 65300. Includes fields for NTRIP User and Password, and Stream SPT00. Status: Not connected. Buttons: Disconnect, Connect.

**Serial:** Refresh, ttyS4, Baud: 115200. Status: Not Connected. Buttons: Disconnect, Connect.

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

**Received RTCM Messages:** GPS Observations: 1001, 1002, 1003, 1004, 1005; GLONASS Observations: 1009, 1010, 1011, 1012, 1019, 1020. Ref Station Position. Buttons: Reset All.

**Last Ref Position:** (empty)

**Serial Connection:** IF: /dev/ttyACM3. Buttons: Refresh, Connect.

**UDP Connection:** Disconnect.

**Cars:** Remove Car, Add Car.

**Joystick:** /dev/input/js0. Status: Not connected. Buttons: Disconnect, Connect.

**Control:** Mode: Duty (radio button selected), Current. Max: 0,15. Throttle: 0%. Steering: 0%. Buttons: G: 0,030, G: 0,080.

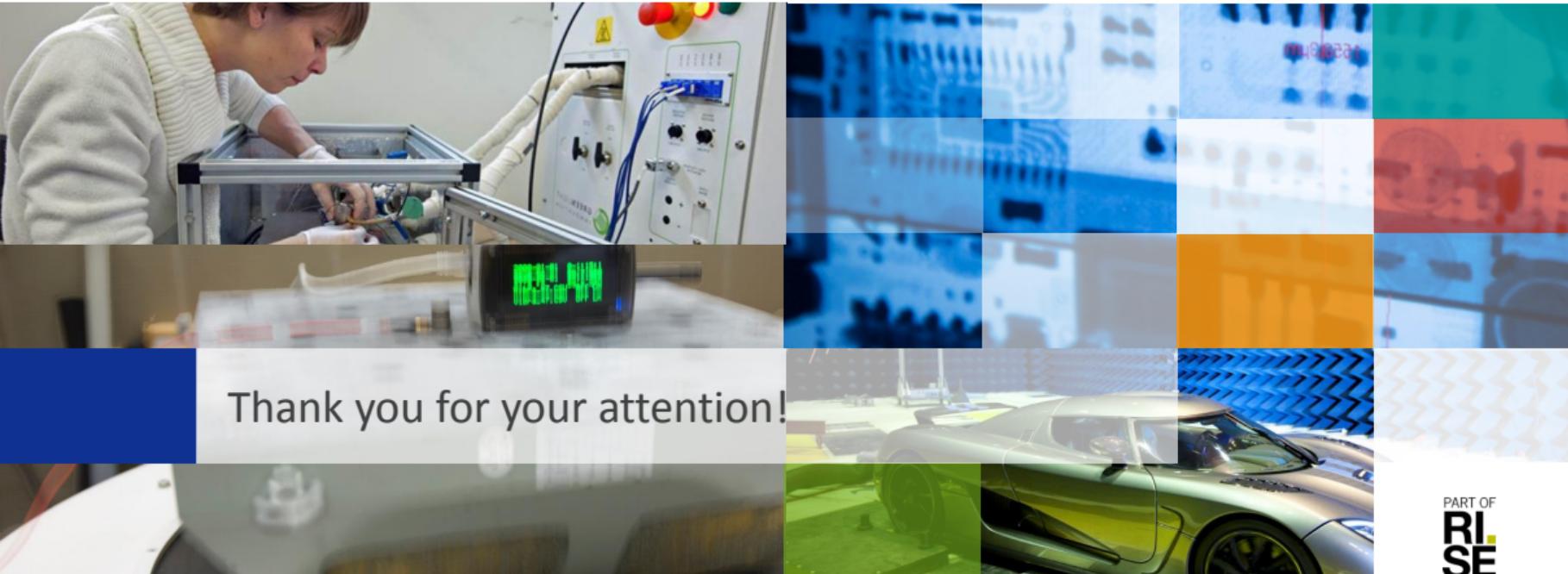
Not connected.



# The SP RC Car

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





Thank you for your attention!