SPEEDBOX
Technical Datasheet

Version 1.1

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1. Introduction

This manual is intended to provide all the information required for integration of a SPEEDBOX unit in to an existing data logging system. It does not cover the general operation of the unit which is fully covered in the SPEEDBOX Instruction manual.

1.1. Product Overview

The SPEEDBOX is the second generation of GPS-Inertial speed measurement system from Race-Technology. The SPEEDBOX combines data from GPS and inertial sensors to provide a full 200Hz speed update rate with outputs on RS232, CAN, digital pulse or analogue.
The RTK option enables the SPEEDBOX to provide high accuracy slip angle, pitch and yaw measurements.
The SPEEDBOX includes 4 high resolution analogue inputs/outputs, CAN bus output, and dual serial ports. All inputs and outputs are configurable from the dedicated PC software supplied.

Figure 1: SPEEDBOX general arrangement

1.2. Applications

The SPEEDBOX is designed to be used as a sensor head either for direct connection to a PC or to an additional data logging system, primarily for OEM testing and high-end motorsport applications, or anywhere a high accuracy real time speed measurement is required. OEM applications are not limited to the automotive industry; units are already in use in the rail industry and other applications have been identified.

1.3. Standard Features

The main feature of the SPEEDBOX is the 200Hz high accuracy speed output derived from combined accelerometer and GPS speed data. Key features of the SPEEDBOX include:

- High accuracy 200Hz speed output.
- 20Hz GPS speed and position output
- 3 Axis acceleration measurements. .
- Optional internal IMU.
- SPI Expansion port.
- Dual serial ports (3 output modes)
- CAN output port
- 4 x Analogue input / output ports
- Brake / event trigger input
- Wide 7-30v supply range
- Extremely low latency (2-3ms)
- Low power (3w)

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2. Port / Connector details

2.1. Analogue Ports

Four ports which can be configured as inputs or outputs. Output levels are -5V to 5V with a 50Ω load, or -10V to 10V with infinite impedance. The four channels can be chosen from:

Combined speed
Longitudinal acceleration
Lateral acceleration
Local Z axis acceleration
GPS heading
GPS gradient
GPS speed
GPS speed accuracy
GPS number of satellites in solution
GPS derived lateral acceleration
GPS derived motorcycle lean angle

2.1.1. With RTK option:

RTK yaw
RTK pitch
RTK slip
RTK baseline
RTK accuracy

2.1.2. With IMU option:

Yaw rate
Pitch rate
Roll rate

When configured as inputs the channels have a range of 0-16V.

2.2. Pulse Output

The SPEEDBOX has a digital pulse output with frequency proportional to combined speed (0-5v). Pulse timing characteristics are user-configurable to allow the SPEEDBOX to act as a drop-in replacement for a wide range of '5th wheel' devices.

Alternatively, the pulse output can be configured to output a time pulse which is precisely synchronised to GPS time, the timepulse is output once per second, at a 50% duty cycle.

2.3. Trigger Input

A trigger input allows synchronisation of the SPEEDBOX output with external events, such as pedal depression, or passing a marker point, such as a laser barrier. The trigger may be configured to either turn the outputs on/off or to send accurate time stamps on the serial port and/or the CAN port.

The RS232 timing message can be used in conjunction with the PC based timing software to give external trigger based timings for test start and end points.

2.4. CAN Output

The SPEEDBOX CAN outputs can be set up for the Race Technology standard CAN output addresses, or can be configured for user defined addresses and rates. Can database (.dbc) files are available for the standard configuration. Full CAN message details are provided in the appendix.

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2.5. RS232 / USB Output

Two serial outputs and one USB port are available. When in use the USB port disables serial port 1.

Serial 1 and 2 output binary messages in uBlox format, ASCII messages in NMEA format, and binary Race Technology format messages. In addition to configuration by the Race Technology configuration software, the uBlox message can also be configured using the uCenter software tool available free of charge from uBlox.

2.6. PC based measurement

In addition to using the SPEEDBOX as a sensor head with a data logging system, the SPEEDBOX can be connected directly to a PC for live data recording via serial or USB as well as real time performance measurements using the dedicated Performance Monitor software.

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3. SPEEDBOX Specification

Specification SPEEDBOX		
Parameter	**Value**	
High accuracy non-interpolated combined speed output	200Hz	
Raw acceleration output	200Hz	
GPS receiver	Race Technology ***PurePhase***	
Raw GPS output	20Hz	
Typical GPS positional accuracy*	3m CEP	
Optimum GPS positional accuracy*	1m CEP	
Typical combined speed output accuracy*	0.05 kph	
Latency	<2 ms	
GPS time accuracy	Better than 120 ns	
Accelerometer	3-axis, high precision, 0.0039g resolution, 2 or 6g range	
Power supply	9-36v 2.4W (RTK option 3W, IMU option 2.9W)	
Weight	800g	
Dimensions	199mm x 135mm x 43mm	
Pulse output	Either: Speed pulse: 0-5V, 10-100µS high time or 50% duty cycle, 1-400 pulses per meter. Frequency range DC – 50kHz Or Time pulse: 0-5V, 1Hz @ 50% duty cycle, precisely synchronised to GPS time.	
Analogue output	Up to 4, -5 to 5V @ 50Ω load, -10 to 10V @ infinite impedance	
Analogue inputs	0-16V single ended, 16 bit resolution	
Connectors	RS232 ports CAN Expansion port (front) Expansion port (back) Analogue ports Power Trigger input Pulse output GPS antenna	9 way male D-type 9 way male D-type 9 way male D-type 9 way male D-type LEMO 0B 4 pin LEMO 0B 2 pin BNC female BNC female SMA female
Antennas	3.3V active antenna	

- GPS speed can be calculated far more accurately than GPS position data. It is impossible to quote absolute positional accuracies of GPS systems simply because accuracy depends on satellite coverage, weather, antenna mounting, tree and building coverage, etc. The figures above represent typical real-world performance.

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3.1. IMU option specifications

Technical Specification Gyroscopes					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
GYROSCOPE SENSITIVITY	Each axis				
Initial sensitivity	25°C, dynamic range = ± 300°/s	0.0725	0.07326	0.0740	°/s/LSB
	25°C, dynamic range = ± 150°/s		0.03663		°/s/LSB
	25°C, dynamic range = ± 75°/s		0.01832		°/s/LSB
Temperature coefficient			40		ppm/°C
Gyroscope axis nonorthogonality	25°C, difference from 90° ideal		±0.05		Degree
Gyroscope axis misalignment	25°C, relative to base-plate and guide pins		±0.5		Degree
Nonlinearity	Best fit straight line		0.1		% of FS
GYROSCOPE BIAS					
In run bias stability	25°C, 1σ		0.015		°/s
Angular random walk	25°C		4.2		°/√hr
Temperature coefficient			0.01		°/s/°C
Linear acceleration effect	Any axis, 1σ		0.05		°/s/*g*
GYROSCOPE NOISE PERFORMANCE					
Output noise	25°C, ± 300°/s range, 2-tap filter setting		0.60		°/s rms
	25°C, ± 150°/s range, 8-tap filter setting		0.35		°/s rms
	25°C, ± 75°/s range, 32-tap filter setting		0.17		°/s rms
Rate noise density	25°C, f= 25 Hz, ± 300°/s, no filtering		0.05		°/s/√Hz rms
GYROSCOPE FREQUENCY RESPONSE					
3 dB bandwidth			350		Hz
Sensor resonant frequency			14		kHz

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Technical Specification Accelerometers					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
ACCELEROMETER SENSITIVITY	Each axis				
Dynamic range		±8	±10		*g*
Initial sensitivity	25°C	2.471	2.522	2.572	m*g*/LSB
Temperature coefficient			40		ppm/°C
Axis nonorthogonality	25°C, difference from 90° ideal		±0.25		Degree
Axis misalignment	25°C, relative to base-plate and guide pins		±0.5		Degree
Nonlinearity	Best fit straight line		±0.2		% of FS
ACCELEROMETER BIAS					
In-run bias stability	25°C, 1σ		0.7		m*g*
Velocity random walk	25°C		2.0		m/s/√hr
Temperature coefficient			0.5		m*g*/°C
ACCELEROMETER NOISE PERFORMANCE					
Output noise	25°C, no filtering		35		m*g* rms
Noise density	25°C, no filtering		1.85		m*g*/√Hz rms
ACCELEROMETER FREQUENCY RESPONSE					
3 dB bandwidth			350		Hz
Sensor resonant frequency			10		kHz

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4. Vehicle Installation and Setup

The unit must be mounted flat and level in order to give accurate acceleration readings. In addition, the unit must be mounted in the correct orientation. Orientate the unit using the marked "direction of travel" arrow. Mounting angle errors of up to 20° can be accommodated with reduced accuracy.

GPS speed and position readings are unaffected by unit mounting position. The GPS unit requires a 3.3V active antenna (supplied) which must be mounted in a position giving a good view of the sky. On top of the vehicle is recommended. Care should be taken not to crush the antenna lead with the vehicle window or door closure.

For the standard SPEEDBOX, GPS1 is the GPS antenna connection.

The SPEEDBOX-RTK unit requires two antennas. Both antennas must be mounted on the roof of the vehicle, on the vehicle centre line, in the same orientation, and the distance between them must be as close as possible to the RTK baseline distance set up in the unit by the configuration program. Note especially that **the antenna that is connected to GPS1 (the "base" antenna) must be to the rear of the antenna that is connected to GPS2 (the "moving" antenna).** The SPEEDBOX-RTK may optionally be supplied with a magnetic-mounting dual antenna strip, containing 2 low-noise antennas mounted 800mm apart on a flexible magnetic mounting strip. The direction of travel is clearly marked on the magnetic strip, and must be followed.

Figure 3 shows the antenna mounting arrangement for the SPEEDBOX-RTK, and the following set of guidelines describe the antenna mounting requirements in more detail. They **must** be followed in order to obtain optimal operation from the MB-RTK system.

- Both antennas must be on the roof of the car, mounted flat on metal. The metal under the antenna acts as a "ground plane" for the antenna and is important for correct operation of the antenna.
- The antennas must be mounted on the centre line of the vehicle
- The antennas must be within 2-3cm of the distance set in the configuration utility. The closer to the initial estimate that the antennas are placed, the faster and more reliable the initial lock-on will be.
- The antennas must be in the same orientation, so the cables should exit in the same direction – for example the cables from both antennas should exit towards the rear of the car.
- Both antennas should be of the same make and model.
- The antennas are magnetic mounting, do not use additional tape over the antennas to hold them down. Some adhesive tapes completely block the GPS signal.
- Care should be taken not to crush the antenna lead with the vehicle window or door closure.
- It is essential that both antennas are mounted on the roof of the vehicle.

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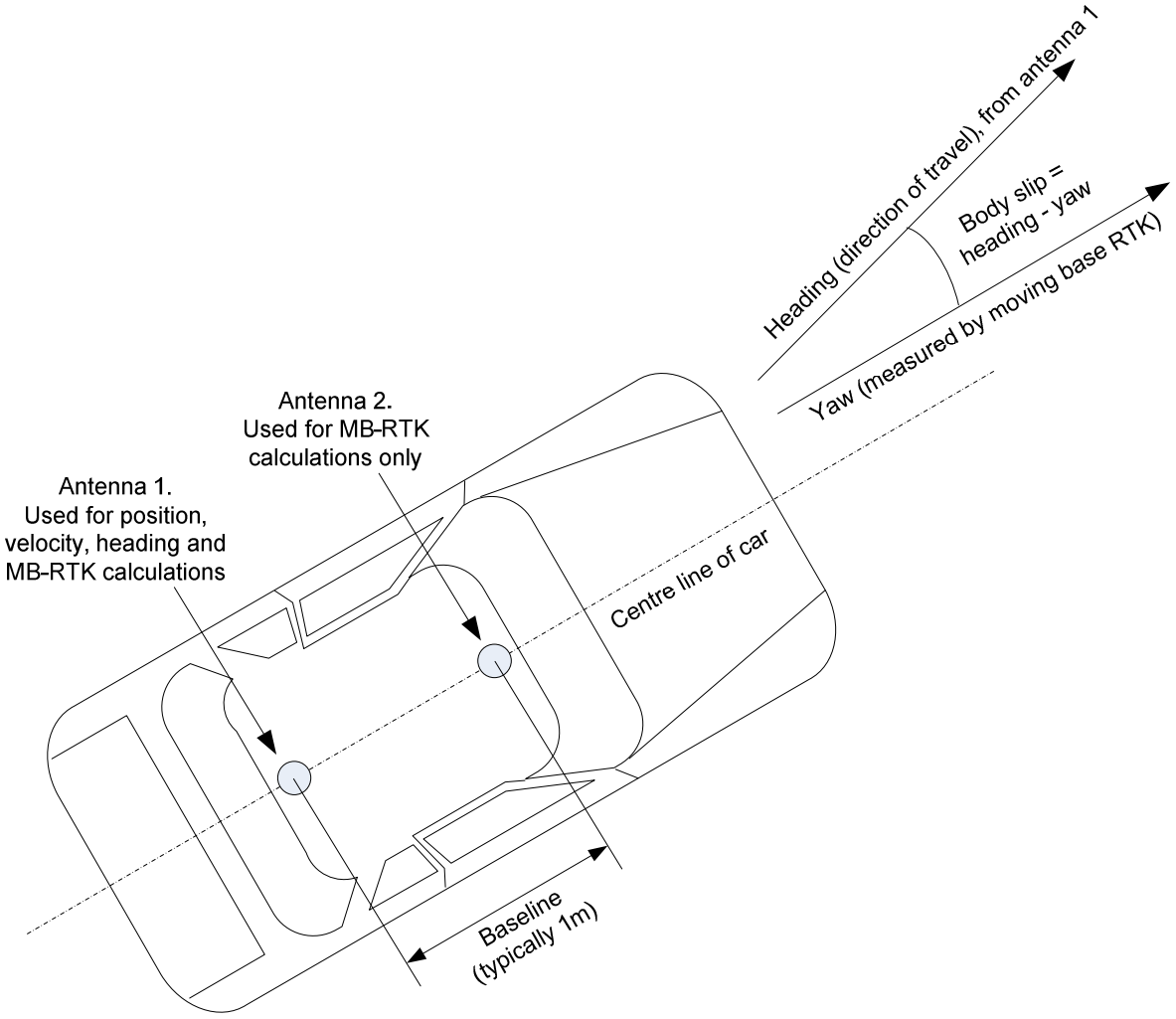

Figure 3: MB-RTK antenna mounting location and angular outputs

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5. Dimensions

The physical dimensions of the SPEEDBOX are shown below in Figure 6. The mounting hole dimensions are shown in Figure 7. The mounting holes are sized to take an M4 socket cap or pan head machine screw.

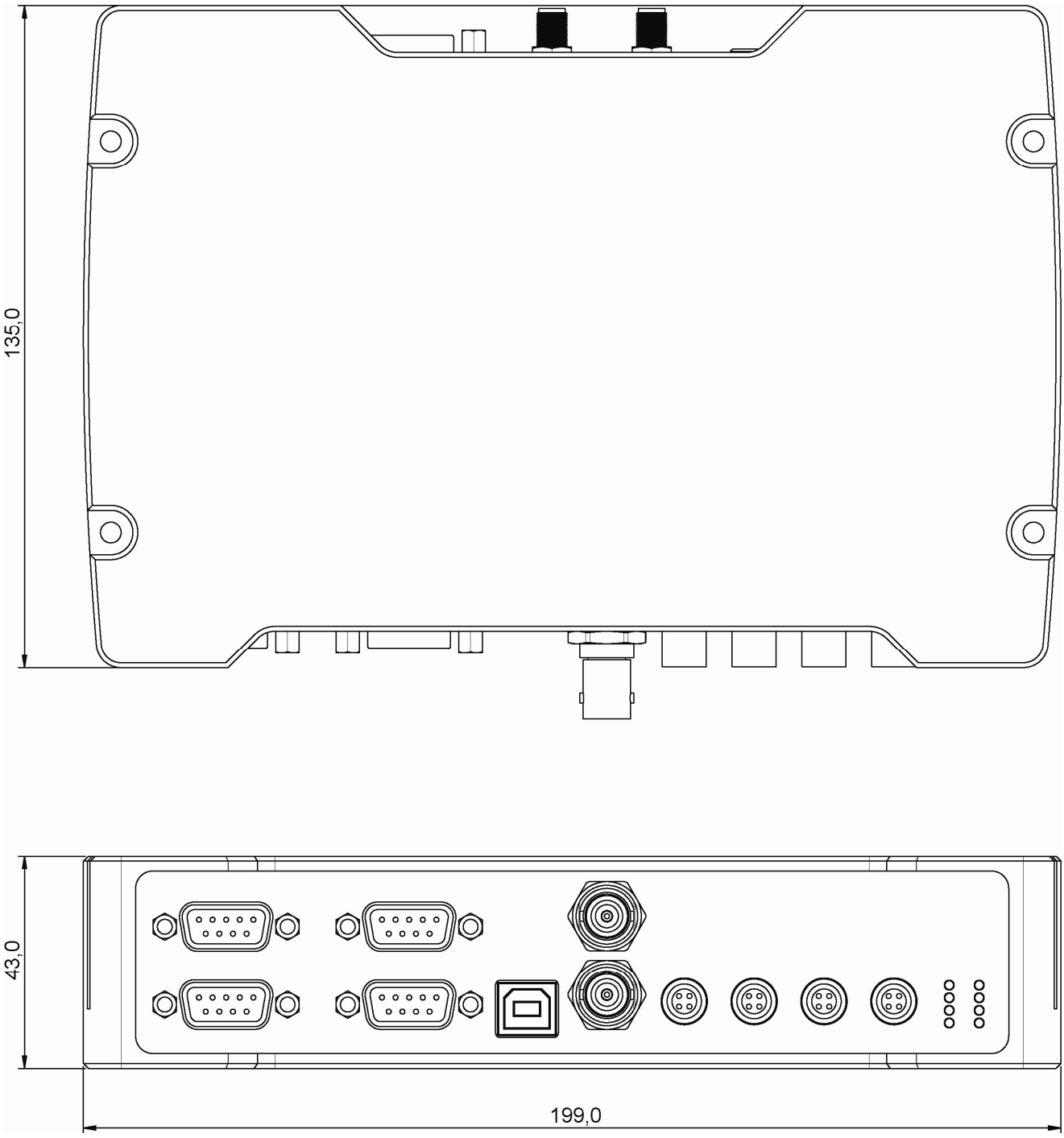

Figure 6: SPEEDBOX physical dimensions.

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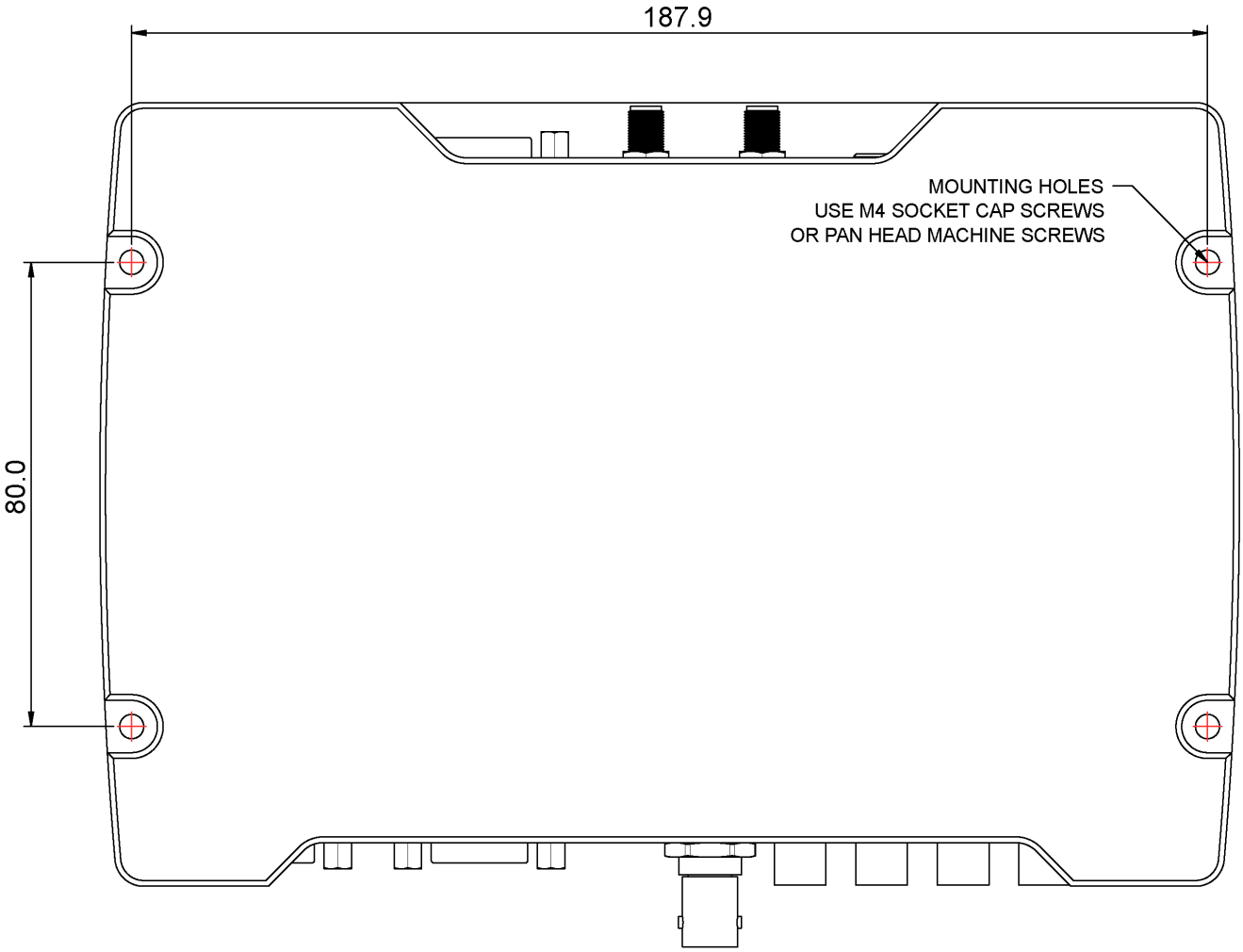

Figure 7: SPEEDBOX mounting detail.

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