



INSTALLATION AND MAINTENANCE GUIDE

for

SAFEmine COLLISION AVOIDANCE SYSTEMS

Firmware Version 2.61

SMTTool version 2.0.7

February 4th, 2013

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Switzerland

Topic:	This document is the reference manual for the installation, configuration and operation of SAFEmine units and tools.		
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Version Control

Version	Modifications
PRO_CAS_QC2_101010 August 29 th 2011	• Original document
PRO_CAS_QC2_130207	• Removed Appendix: Troubleshooting guide. Created a separate document • Added : the main unit enclosure and the metal shrouds of all connectors need to be electrically isolated from the vehicle • Added 'To assist during installation the 'Mode' LED will turn Red to indicate that the digital output has gone high' to Test Station and Boom gate chapters • SMTTool manual was removed. A separate document was added • All features and changes introduced by FW 2.61 were added • Added QC250 specifications (no Wifi configuration)

1	SAFEmine device presentation.....	6
1.1	Objective	6
1.2	Technology.....	6
1.3	Limitations.....	6
2	Safety	8
2.1	Operating precautions.....	8
2.2	Installation precautions.....	8
3	Hardware.....	10
3.1	Main units.....	10
3.2	GPS & RF Antenna.....	11
3.3	Displays and Screens (QD200 and QD204).....	12
3.4	Technical specifications and interfaces.....	13
3.5	I/O Connections	18
4	Installation and operation.....	21
4.1	General advice	21
4.2	Main unit.....	21
4.3	Displays and Screens.....	22
4.4	Antennas	23
4.5	Antenna cables	27
4.6	SIM Card (QC220/QC240 only)	28
4.7	Vehicle tracking (QC220/QC240 only)	28
4.8	General Purpose Input Output (GPIO) connection	28
4.9	General maintenance advice.....	28
5	SAFEmine programming tool (SMTTool).....	31
5.1	Installation.....	31
5.2	Firmware and Configuration File upload.....	31
6	Software overview.....	32
6.1	The collision avoidance principle.....	32
6.2	The display	32
6.3	Alarms	33
7	Features and configuration parameters	34
7.1	The vehicle	34
7.2	The antenna.....	35
7.3	Driver comfort features	35
7.4	Enhancement features.....	36
7.5	General Purpose Input Outputs (GPIOs)	38

8	Configuration parameter specifications	39
8.1	Important remarks	39
8.2	Site specific parameters (required):	40
8.3	Vehicle parameters	40
8.4	Antenna parameters (required).....	43
8.5	Driver comfort parameters	43
8.6	Enhancement features parameters.....	46
9	Special vehicles: configuration & parameter specification	51
9.1	Dual Zone vehicles (Shovels/Excavators/Draglines).....	51
9.2	Unknown heading vehicles (Shovels/Excavators/Track type Dozers)	52
9.3	Stockpile Collision Avoidance	54
10	Additional SAFEmine device capabilities	55
10.1	SyncStation	55
10.2	I/O Connections	58
11	SAFEmine TRACK (QC250/QC240/QC220)	63
11.1	Presentation	63
11.2	Configuration parameters	63
12	Advanced Troubleshooting	67
12.1	Error codes.....	67
12.2	HTerm	67
12.3	HTerm commands.....	68
13	Limitations	77
Appendix A	Declaration of conformity.....	78
Appendix B	Specifications (QC 230/235)	79
Appendix C	Specifications (QC240/QC220).....	80
Appendix D	Specifications (QC250).....	81
Appendix E	Specifications (QD 200: Remote display).....	82
Appendix F	Specifications (QD204: Scope Screen)	83
Appendix G	Recommended parts	84
Appendix H	Configuration example for areas	85
Appendix I	Additional figures and drawings	86
Appendix J	Installation Checklist	89
Appendix K	Maintenance Checklist	91
Appendix L	User guide for QN555	92
Appendix M	Scope FW update instructions	97

Appendix N	FCC compliance.....	97
Appendix O	Legal statement	98



SECTION A Introduction

1 SAFEmine device presentation

1.1 Objective

The main task for SAFEmine QC200 series products is to support the operator while he scans the space ahead and around the vehicle with his own eyes, cameras and other aids. SAFEmine products are simple to use and are designed not to distract the operator from operating the vehicle.

1.2 Technology

The SAFEmine system – based on technology widely used in aviation – consists of a main unit, an operator's interface (both output and input) and a dual antenna (one for GPS, one for radio communication). Depending on the product selected, the operator's interface is either integrated into the main unit or mounted as a separate display unit. The main unit contains all main sensors (GPS engine, radio transceiver, micro-controller, memory, data interfaces and a series of sensors). The operator interface provides both a directional display of nearby traffic and danger, the beeper/loudspeaker for acoustical warnings and one button for input.

SAFEmine QC200 series products receive position and movement information from an internal high-sensitivity 50 channel GPS receiver with an external antenna. Additional sensors and logic further enhance the accuracy of position measurements. The predicted driving path of the vehicle, in which a SAFEmine QC200 series product is installed, is calculated by the main unit and the obtained information is transmitted by radio as a low power digital burst signal at frequent intervals. Provided they are within receiving range, these signals are received by other vehicles also equipped with SAFEmine QC200 series products. The incoming signal is compared with the driving path calculated and predicted for the second vehicle, taking into account configuration parameters like maximum acceleration or vehicle dimension. At the same time, SAFEmine QC200 series products optionally compare the predicted driving path with known static obstacle data, e.g. electric power lines.

If a SAFEmine QC200 series product determines the risk of dangerous proximity to another vehicle or to an obstacle equipped with a SAFEmine QC200 series product, the unit gives the operator a warning of the greatest danger at that moment. This warning is given by a buzzing sound (beep) and bright light emitting diodes (LED). The display also gives indication of the threat level, plus the horizontal bearing to the threat.

The operating range is very dependent upon the antenna installation in or outside the vehicle. The normal range is about 500m for line-of-sight operations, but up to 2 km may be achieved in individual cases.

For their radio communication, SAFEmine QC200 series products use a proprietary patent- and copyright-protected protocol. Any non-licensed use, dissemination, copying, implementation or reverse engineering of the SAFEmine QC200 series radio communication protocol, their hardware and software or parts of it is forbidden by law and will be prosecuted. SAFEmine is a registered trademark and may not be used without license.



1.3 Limitations

SAFEmine is **not** designed for use

- in deep or narrow open pit mines where availability of GPS satellites is not sufficient
- in any other application than open pit mining
- on vehicles with excessive vibration

SAFEmine units are only to be used with other SAFEmine units, otherwise inconsistent function may occur. SAFEmine Ltd. cannot assume any liability from correct or incorrect use

of above specified products other than regular warranty according to SAFEmine Ltd. General Terms and Conditions.

2 Safety

2.1 Operating precautions

Operating any type of vehicle inside a mine at any time of the day is an inherently dangerous activity which is associated with considerable risks for crew, passengers, third parties, pedestrians, other vehicles and any object in its vicinity. In order to make full and safe use of SAFEmine QC200 series products, it is absolutely essential to be fully aware of the risks, operating conditions, restrictions and limitations associated with their use, including to ensure a proper installation and to perform regular software updates. This includes familiarity with and strict adherence to the Operating Manual and the Installation Manual.



A vehicle equipped with the SAFEmine System must be operated in the same safe manner as if the SAFEmine System was not installed. The system is not a substitute for normal safe driving procedures and may never be relied upon.

The SAFEmine System will provide no warning for some hazards, such as vehicles, obstacles, and other objects not equipped with properly operating SAFEmine devices.

SAFEmine products are intended as an additional tool in determining potential traffic threats, supporting an alert and conscientious driver. SAFEmine products are never to be used in any application where failure of the products could result in personal injury or material damage. Before using, the latest versions of the respective manuals are to be consulted for familiarization with product operation and limitations.

SAFEmine makes no warranties with respect to the product. In no event will SAFEmine Ltd be liable for lost use, profits, revenue, cost of procurement of substitute goods, or any damages.

SAFEmine products may not be used in the USA and Canada unless the operator or customer has been authorized to do so in writing by SAFEmine Ltd.

Customers agree to indemnify and hold harmless SAFEmine Ltd., its subsidiaries, and affiliates, and their respective successors and assigns, from and against all third party claims, loss, damage or expense, and any other liabilities whatsoever, which may be incurred by SAFEmine Ltd. with respect to any of the SAFEmine products.

2.2 Installation precautions

All work done to install the SAFEmine Collision Avoidance System shall be done in accordance with safe work standards and shall comply with the latest Health, Safety, and Reclamation Code for mines in the local jurisdiction.

SECTION B Hardware and Installation

3 Hardware

3.1 Main units

3.1.1 Main unit overview

The main unit houses the GPS receiver, radio transceiver, processor, interface logic and additional sensors. The housing is made of aluminum with plastic end-bezels. All connectors are on the backside of the unit.



The main unit is produced in five different models: QC220, 230, 235, 240 and 250.

QC235 and QC230 integrate the collision avoidance system (CAS) with different display options. The QC235 has an integrated operator display, as shown in the picture above. The model QC230 utilizes a separate remote display (QD200) connected by means of the remote display cable (part number QD221).

	QC235 Basic, integrated	QC230 Basic for remote display	QC240 GSM integrated for AVL / IVMS	QC220 AVL / IVMS only	QC250 WiFi integrated for AVL / IVMS
CAS	•	•	•		•
Integrated display	•				
Digital IO	1	1	6	6	6
Analog Input			2	2	2
GSM tracking			•	•	
WiFi tracking					•
Comment				No display Always delivered with speaker and voice option	

The QC240 and QC220 models have an additional GSM connector and have no integrated display. The QC240 and QC220 models support Vehicle tracking via GSM. To enable this feature, a SIM card with an activated data plan must be placed in the SIM card slot of the SAFEmine unit.

The QC250 model has an additional WiFi connector and has no integrated display. The QC250 model supports Vehicle tracking via WiFi.



Vehicle tracking of SAFEmine devices on a website is named SAFEmine Track. On the password-protected web-application at <http://safe-mine.com/track>, vehicle position, status and movement can then be monitored (please contact support@safe-mine.com for information on how to set up the server for your organization).

In addition to the vehicle's position, the following status information can be tracked and or recorded:

- Vehicle-ID, Serial number, Firmware version and Build number (sent once after system reset)
- Supply Voltage
- Digital inputs (e.g. seatbelt, handbrake, idling)
- Analog inputs (e.g. connected to fuel gauge)

The digital IOs of the device can be used to monitor and record vehicle parameters such as: door open, seatbelt clicked, handbrake set, etc.

Another use of this functionality is the switching of cameras based on movement direction or surrounding vehicles and obstacles.

Please contact SAFEmine if you plan to use this option.

The QC240/220 and 250 have two analog inputs. They can be used to monitor fuel gauges, tire gauges or other analog data.

3.1.2 Quick Mount / Contractor unit (QN555)

The QN555 is a roof top magnetic mount, self-powered and self-contained CAS device which offers unprecedented ease and speed of installation on the roof of e.g. a light vehicle.

It is the solution for contractors and temporary visitors in surface mines where all mine vehicles have SAFEmine installed.

Detailed information regarding the QN555 quick mount unit can be found in Appendix L User guide for QN555



3.2 GPS & RF Antenna

The antenna provided by SAFEmine is a customized GPS and RF combined antenna especially designed for harsh environments like mines.

Only antennas supplied by SAFEmine may be attached to the antenna connectors

3.2.1 Through Hole Mount Antenna (QF021)

The screw mount antenna comes with 10/15cm of cable.

The advantage of using short cables on the antenna and then connecting and running extension cables is that in case of damage to either the antenna or the cables the defective part can be replaced separately. Furthermore, testing of the cable and antenna independently is possible with an SWR meter (Contact SAFEmine for SWR recommendations). The Through Hole Mount Antenna is ideal for cars with high vibrations (Haul Trucks) where the antenna and cable must be attached firmly.



Through Hole Mount Antenna (QF012)



Magnetic Mount Antenna (QF024)

3.2.2 Magnetic Mount Antenna (QF024)

The magnetic mount antenna comes with 3.5m of cable, both GPS & RF. It can be magnetically attached to any roof top. It allows an easy installation. It is ideal for light vehicles or other vehicles with little vibration.

3.3 Displays and Screens (QD200 and QD204)

3.3.1 Remote display (QD200)

The remote display unit connects to the QC230 (QC235 also if needed) with the remote display cable QD22x. It connects to a QC240 with a QM109 display Y cable.

The remote display cable can be 1.5m (QD221) or 5m (QD222)



Front view of remote display



Rear view of remote display

Each User Interface has

- 12 red / green LED in a circle, diameter 20mm
- 4 red / green status LEDs (Mode / Reverse / Ready /Power)
- 1 multifunctional button
- Buzzer
- Ambient light sensor
- Ambient noise sensor

The maximum length of the display cable is 15 m. This can be achieved by connecting several display cables (QD221 and QD22) together.

LED brightness is automatically controlled based on ambient light, with backlight for night operation.

A buzzer with a maximum of 85dB sound level (at 10cm distance) volume can be automatically controlled based on ambient noise.

3.3.2 Scope Screen (QD204)

The Scope Screen provides a 4" graphical display of a map-like view of the vehicle's surroundings. It is primarily useful for vehicle operators in rotational vehicles and stockpile applications.



The QD204 Scope Screen can be used with all SAFEmine CAS and CAS/TRACK Main Units, such as QC230, QC235, QC240 and QC250s. The rugged housing is made of blended polycarbonate and polyester. All connectors are on the rear of the unit. The device can be installed with minimal effort and time.

3.4 Technical specifications and interfaces

3.4.1 QC230/235/240/250 main unit specifications

See Appendix B : Specifications (QC 230/235)

See Appendix C : Specifications (QC240/QC220)

See Appendix D : Specifications (QC250)

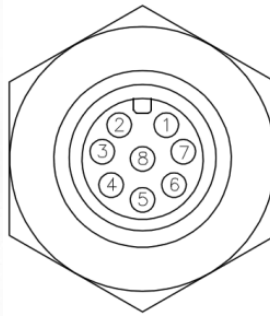
3.4.2 Main unit interfaces and connectors

3.4.2.1 Power / Interface connector (All devices)

The connector is type M12 male, with 8 contacts.



QC230/235



QC240/220/250

This interface is connected to the vehicle or add-on modules.

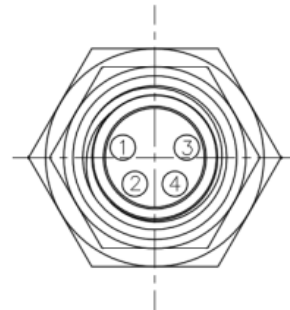
Power / Interface connector (All devices)		QC23x	QC240 QC220 QC250	Cable color
Pin function	Pin type	Pin #	Pin #	
Ground	Power	2	2	brown
Power (+9 to +28VDC) overvoltage and polarity protected	Power in	1	1	white
Digital I/O (IO1 in chapter 3.5 I/O Connections)	Input / Output	7	7	blue
Audio (voice) out (may be left NC)	Output	8	8	red
RS485 (may be left NC) for GPS augmentation input, Modbus for IO modules Allows interfacing to a wide range of commercially available input / output modules, such as switches to control cameras on haul trucks	Input (RX) Output (TX)	5 6	- -	grey pink
RS 232 (data to display and for updates) Firmware can be updated through this interface.	Input (RX) Output (TX)	- -	5 6	grey pink
CAN listener (may be left NC) (typically J1939, ISO 11898)	IO H L	3 4	3 4	green yellow

3.4.2.2 Display / Update connector (QC230/235 and QM109 cable for QC240/20/50)

On the QC230/35 device the display connector (M8 female, 4 contacts) is available directly on the device (see left picture below)

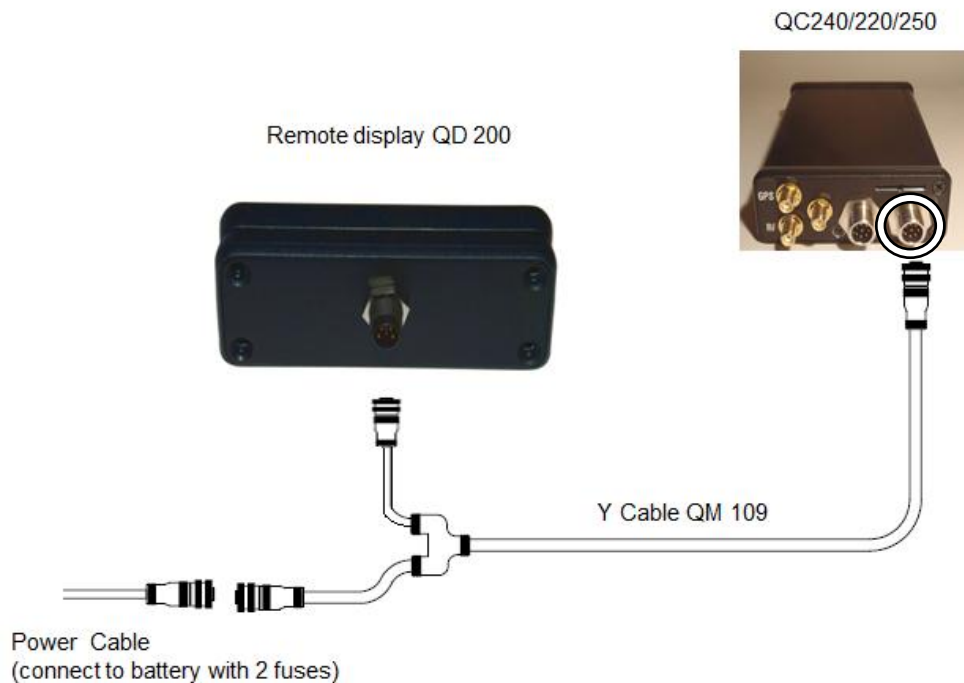


QC230/235



Display connector (M8 female)

On the QC240/220/250 devices the display connector (M8 female, 4 contacts) is available through a Y- cable (QM109) connected to the Power/Interface connector of the device (see picture below)



Display connected to a QC240/220/250 through the QM 109 Y cable

The Y cable QM 109 has a M12 female connector on one end, and a M12 male and M8 female connectors on other the other end.

This M8 female 4 contact connector provides the data and power necessary for the display. The display interface can also be used for debugging and firmware update purposes.

Pin function	# of pins	Pin type	Pin #	Cable color
Ground	1	Power	3	blue
QC23x: sanitized 12V out QC240: raw power out (+9 to +28VDC)	1	Power	1	brown
RS 232 : Display interface Debugging and firmware update interface.	2	Input (RX) Output (TX)	2 4	white black

3.4.2.3 GPS antenna connector

SAFEmine devices use a 50 channel GPS L1 receiver with SBAS (WAAS, EGNOS) capability, integrated RAIM (Receiver Autonomous Integrity Monitoring) and active multipath detection and elimination algorithms. The receiver is GALILEO ready.

The connector is a SMA female for 3.3V active GPS antenna.

Only antennas supplied by SAFEmine may be used.

3.4.2.4 RF antenna connector

SAFEmine devices use an RF transceiver with typically less than 1% Duty Cycle, Peak Pulse Power below 15 mW (ERP).

The license free ISM / SRD bands are software selectable depending on country of use

- Europe, Africa: 868.2 and 868.4 MHz, others
- Australia: 921MHz
- North America: Frequency hopping around 920MHz
- South America: Frequency hopping around 920 to 951MHz
- Asia: various

The country of Origin is Switzerland (Harmonized System Customs Code 852610). The connector for the RF transceiver is a SMA female for 50 Ohm RF antenna

Only antennas supplied by SAFEmine may be used.

3.4.2.5 GSM/GPRS antenna connector (QC240/220 only)

The QC240 and QC220 SAFEmine devices include a full feature quad-band GSM/GPRS module, with embedded TCP/IP stack. The module is Class 4 (2 W) for the 850/900 Mhz bands and class 1 (1 W) for the 1800/1900 Mhz bands.

It is a GPRS Class 10 (4 downlink, 2 uplink, max. 5) and Mobile Station Class B module. It also supports PBCCH, CS 1...CS 4.

The module is approved AT&T, R&TTE, CE, GCF, FCC, PTCRB and more. The connector is a SMA Reverse Polarity female for GSM Antenna.

Only antennas supplied by SAFEmine may be used

3.4.2.6 Wifi antenna connector (QC250 only)

The QC250 SAFEmine devices include a self-contained WLAN module. The module is a complete IEEE 802.11 b/g/n based wireless device.

The module supports WPA2-PSK, WEP (64 and 128 bit) TKIP security.

The typical transmit power is 17dBm for 801.11b, 15dBm for 802.11g/n. The sensitivity is -97dBm @ 1Mbps to -71dBm @65 MBps.

The connector is a SMA Reverse Polarity female.

Only antennas supplied by SAFEmine may be used.

3.4.2.7 SIM Card Interface / Slot (QC240, QC220 only)

SAFEmine devices QC240 and QC220 require a SIM card to connect to the local network for data transmission. The SIM card must allow data to be sent over the network.

Operation without the SIM card label (delivered with the device) voids warranty.



Sim Card interface on QC240/220

3.4.3 Specification for Remote Display (QD200)

See Appendix E : Specification for Remote Display (QD200)

3.4.4 Specification for Screens (QD204)

See Appendix F : Specifications (QD204: Scope Screen)

3.4.5 GPS/RF Antenna Specifications

Parameter	QF012	QF024
Mounting type	Through Hole	Magnetic
Weight	480g	620g
Dimensions	ø107 x 91 mm	
Power Supply	from main unit	
Connector	2 * SMA Male	
Operating temperature	-40°C to +85°C	
Storage temperature	-40°C to +85°C	
Protection rating	IP 67	
Cable	2 * 20cm, coaxial	2 * 3.5m, coaxial

3.5 I/O Connections

3.5.1 Hardware capabilities

SAFEmine devices all have extended GPIO (General purpose Input/Output) functionalities.

On all devices an IO is available on pin 7 of the Power/Interface connector (see chapter 3.4.2.1 Power / Interface connector (All devices) for information about the other pins). It is the blue wire on the Power Connector (see pictures below).



Power connector on QC230/5



Power connector on QC220/40/50

On the QC240/20s and QC250s up to 7 additional IOs can be configured as Input/Output. 7 are available on the I/O connector (see picture below). The I/O connector is type M12 male, with 8 contacts.



I/O connector on QC220/40/50

The I/O connector can be used to monitor vehicle statuses such as seatbelt, emergency break, and voltages like the fuel gauge.

The following table lists the GPIO capabilities of each device type.

Name	Connector	Pin #	Wire Color	Analog In	Digital In	Pull-up	Pull-down	Digital Out	Source Driver	Sink Driver	QC-235/230	QC-220/240/250
IO0	n/a	n/a	n/a	x ^a							x	x
IO1	Power	7	blue		x	x	x ^b	x	x	x ^b	x	x
IO2	I/O	1	white	x								x
IO3	I/O	2	brown	x								x
IO4	I/O	3	green		x	x	x					x
IO5	I/O	4	yellow		x	x	x					x
IO6	I/O	5	gray		x	x	x	x	x	X		x
IO7	I/O	6	pink		x	x	x	x	x	X		x
IO8	I/O	8	red		x	x	x	x	x	X		x

^a Predefined function (supply voltage monitor), not available for configuration.

^b Pull-down and Sink driver were not supported in early hardware revisions. If the desired configuration is not supported by the SAFEmine unit, a GPIO configuration error will be displayed. In addition, the capabilities of a SAFEmine unit can be identified by reversing the last 5 digits of its serial number and comparing the resulting identifier to the revision table (right).

Model	Identifier	Pull-down	Sink Driver
QC230	00001..01999		
	02000..02499	x	
	02500..	x	x
QC235	00001..01999		
	02000..03999	x	
	04000..	x	x

3.5.2 I/O Specifications

3.5.2.1 Digital inputs

A digital input transforms a voltage level into a logical “1” (or “on” state) or “0” (off state).

- SAFEmine interprets a voltage of less than 2.2 volts as logical 0,
- SAFEmine interprets a voltage of more than 8.7 volts as logical 1.
- Each digital input must be configured to incorporate either the 4.7kOhm pull-up or a pull-down resistor in the SAFEmine device:



Care must be taken to select the correct input configuration, depending on the characteristics of the vehicle! Wrong settings can influence or even incapacitate the vehicle! Always ensure that after installation the voltage levels are correct

3.5.2.2 Digital outputs

The digital output is designed to drive modest consumers, such as relays and lamps. Most units support source and sink driver configuration:



Digital Input / Output

- FW configurable as digital input
- FW configurable "High Side Switch" or "Low Side Switch"
- Maximum continuous load current: 0.4A
- Can switch capacitive, inductive and resistive loads
- On-state resistance: 350mOhm
- Short circuit protected
- ESD protection: 5kV

3.5.2.3 Analog Input

- Input voltage range: 0..24V
- Input Resistance: 300k Ohm

4 Installation and operation

4.1 General advice

Unless certified, installation and operation must be on the basis of non-interference with and no hazard to the existing equipment installed for safe operation. When certified, installation and operation must be done according to certification procedures in order to comply with official regulations and requirements.

After installation, an appropriate entry should be made in the vehicle's technical logs and a check is to be made that the installation is in no way detrimental to the mechanical or electrical performance of other vehicle's systems (e.g. radio). The unit serial number and software version is to be recorded in the vehicle's technical log.

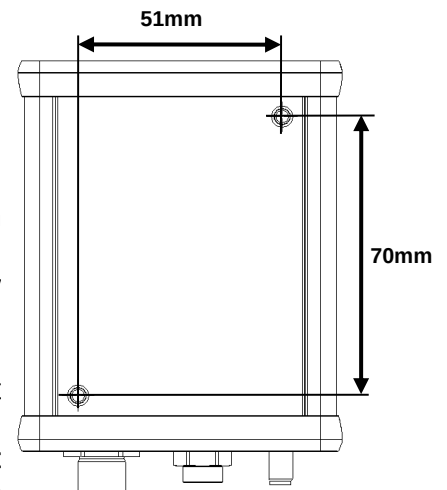
SAFEmine highly recommends establishing a "Radio Map", containing all intentional transmitters on the mine and their operating frequencies. This map will help to minimize radio interference.

4.2 Main unit

4.2.1 General recommendations

The main unit must be secured in such a position that:

- The operator has the front panel display with the LEDs in direct view, can hear the acoustic warning tone and can operate the control button.
- The front panel display may not be obstructed at any time.
- It must not impede the operation of the vehicle (incl. emergency procedures) and in particular it must not reduce the operator's field of view.
- **The connectors at the back of the main unit must remain accessible to allow the upload of firmware and maintenance from a PC with an extension cable.**
- The connectors are tied with a spanner and can't be removed by hand.
- Operation without the SIM card label over the SIM card slot (delivered with the device) will void the warranty (QC240 and QC220 only).



Main unit bottom view

The main unit must be installed such that:

- **The main unit enclosure and the metal shrouds of all connectors need to be electrically isolated from the vehicle** (like for the antenna)
- The unit should be installed on a flat surface so that the housing is not subject to any mechanical stress.
- The mounting plate should be designed such that the two plastic end-bezels are left in the air and aren't pressured against any surface.
- The lower face of the main units' aluminum housing includes two blind threads, so that the housing can easily be secured by two M4 screws. Forcing longer than 8 mm screws into the nuts may cause damage and voids warranty.
- If the vehicle is equipped with a "breaker" the housing should not be connected to vehicle ground as otherwise a ground loop occurs.
- **Care should be taken not to allow the devices to be exposed to liquids.** Should the unit become humid, it must be thoroughly dried prior to use. Wet devices can sustain permanent damage.
- Sudden massive cooling should be avoided, as condensation may occur inside the unit.

Special care must be taken during the installation of the power cables (see chapter 4.5 for antenna cables). It is important that

- They aren't bent, the minimum bending radius must be respected.
- They aren't attached under stress.
- The cables to the vehicle are attached in a semi-permanent way (e.g. cable ties), so they can be (re)moved for service and maintenance
- The installation must allow adequate space for cable connectors and antenna cables.

Other information regarding the main unit installation

- 3D Models (Solidworks) of the housing and all connectors are available on request.
- The housing is black to minimize glare.
- The unit will not work without a display (except for a QC 220 and a QC235).

4.2.2 Power supply

The power supply must be installed such that

- The voltage is above 9.6 V at all times. At voltages below 9V the operation of the SAFEmine unit is no longer guaranteed.
- **The main unit must be connected directly to battery power** to ensure continued operation in case of vehicle stopping or breakdown
- A 2A fuse must be installed near the vehicles battery on **both** power and ground.

If supply voltage is below 9.6V at startup, a 'low supply power' error is displayed and the device will not power up.

If voltages below 9.6V are observed at any time during operation, the 'Power' LED will turn red. If the voice option is enabled 'Error Power' is announced every 30 seconds on the voice output as long as there is sufficient voltage to do so.

A sealable fuse holder is highly recommended. Furthermore, the fuse should be secured with a cable tie to make any tampering obvious

4.3 Displays and Screens

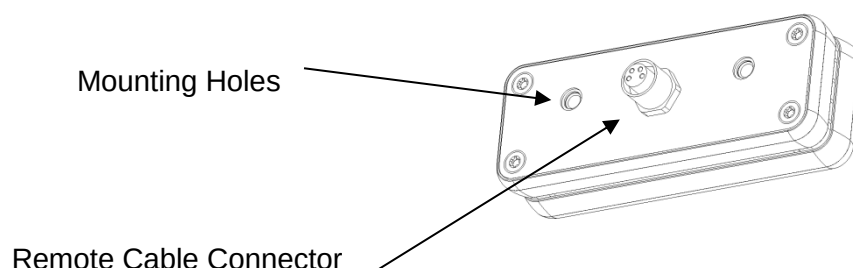
4.3.1 Remote display (QD200)

The display must be installed such that:

- The back side of the aluminum housing includes two blind threads, so that the housing can easily be secured by two M4 screws. Forcing longer than 8 mm screws into the nuts may cause damage and void the warranty.

The display must be installed in such a position that:

- The operator has the front panel display with the LEDs in direct view, can hear the acoustic warning tone and can operate the control button.
- The front panel display may not be obstructed at any time.
- It must not impede the operation of the vehicle (incl. emergency procedures) and in particular it must not reduce the operator's field of view.



The remote display can be fixed with 3M dual lock (see Appendix G Recommended parts). This is ideal for installations where the owner of the vehicle does not want to drill holes in the dashboard.

The Remote Display QD200 can also be used with the Main Unit with integrated display QC235. Please contact SAFEmine for more information regarding this configuration.

4.3.1.1 Connections – Remote Display

The remote display connection contains the data and power from the main unit.

This connector is type M8 male, with 4 contacts. It connects to the cable QD221 for the QC230 (QC235 also if needed). It connects to a QM109 display Y cable for the QC240 and QC220.

4.3.2 Scope screen (QD204)

All connectors are on the rear of the unit. The device can be installed with minimal effort and time, no IT and no radio infrastructure are required.

Maintenance instructions for Scope Firmware 1.3.0.1900 can be found in Appendix M

4.4 Antennas

The external combined GPS & RF antenna supplied with the main unit must be connected.

- The main unit will not operate without the antennas.
- Follow the recommendations regarding antenna cables in chapter '4.5 Antenna cables'

The GPS/RF antennas must be mounted such that:



- **It is mounted on the highest point of the vehicle, with 360° unobstructed view of the sky** and at least 100cm away from any other transmitting antenna.
- The position of the antenna is the same for all the vehicles of the same model. As an example all the Toyota Hilux Single Cabs must have the antenna at the same position.
- The antennas are connected to the correct inputs.
- **On tracked type vehicles, the antenna must be mounted as close as possible to the axis of rotation**, unless the two-antenna (SAFEmine devices) setup is used.
- On haul trucks it may not be possible to install the antenna at the height of the bucket. In such a case place the antenna in one of the front corners of the vehicle i.e not in the center front.

Other information regarding antenna installation

- Improper installation of the antenna and its cables is the prominent cause for malfunction.
- The antenna must be professionally installed by trained personal only.
- Only antennas supplied by SAFEmine may be attached to the antenna connectors!
- Mounting brackets for various vehicles (Haul Trucks etc.) are available from your local SAFEmine distributor.
- Snow and ice buildup reduce the performance of the antenna and must be removed prior to operation.

4.4.1 Through Hole Mount QF012

The screw mount antenna comes with 10/15cm of cable.

To mount the antenna:

- The antenna must be mounted on a horizontal metal surface of diameter 1-2cm larger than the diameter of the antenna. For smaller vehicles the diameter can be larger.
- A hole must be drilled or punched into the surface. The diameter of the hole must be at least 22mm (0.866") for the antenna and the compulsory insulating washer. (Without the washer at least 19mm (3/4"))
- The surface should also not be thicker than 12mm (1/2")
- In order to secure the antenna mounting it is necessary to have access to the underside of the hole.

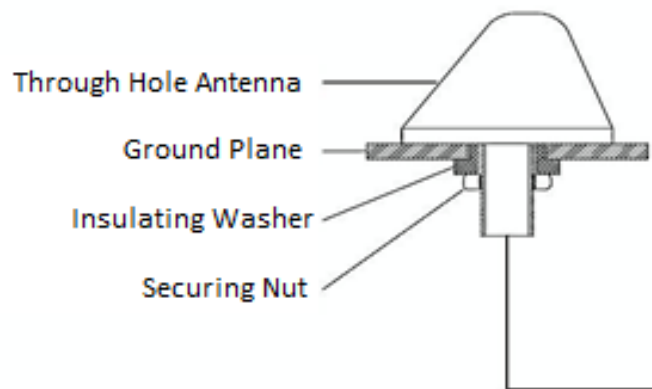
To attach the antenna:

- After removing the nut feed the cables through the hole seat the antenna on the surface
- Add the insulating washer
- Attach the nut. The nut should be tight (Torque: 5 ft-lb, ~6.8 nm) in order to properly seal the gasket. Tighten the nut with a wrench.
- Finally, feed the cables to the receiver thru additional jumper cables.



The mounting screw of the antenna must be isolated from the vehicle to avoid ground loops. Suitable insulating washers are available from SAFEmine.

The attached gasket provides a sealant to prevent moisture from entering.



Vertical cut of a QF012 after installation

4.4.2 Magnetic Mount QF024

The magnetic mount antenna comes with 3.5m of cables, both GPS & RF. It can be quickly mounted on vehicles such as light vehicles. For vehicles with a lot of vibration like Haul Trucks it is recommended to use the through hole mount antenna.

The GPS/RF antenna (QF024) must be mounted such that:

- The antenna should not have any electrically conducting surfaces (e.g. metal, carbon fiber) above or immediately alongside.
- If the roof is made out of non-metallic material, a ground plane of minimum 18cm diameter must be mounted underneath the antenna.

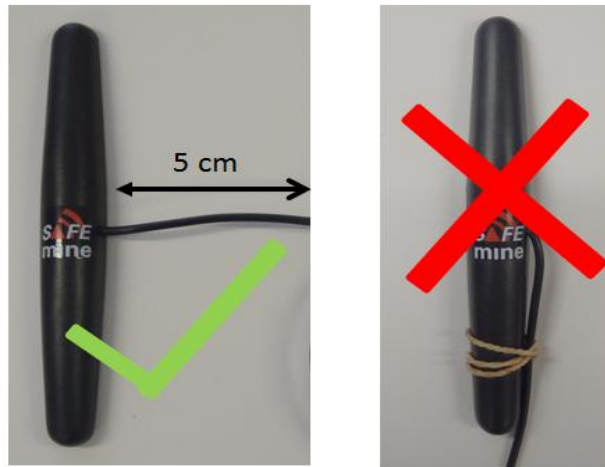
4.4.3 GSM Antenna (QC220/QC240 only)

The antenna comes with a 2.4 meters (8 foot) coaxial RF cable.

The GSM antenna must be installed such that:

- There is 2 meters clearance from the SAFEmine GPS/RF antenna and any other emitting antenna (1 meter if there is a metallic roof between the two antennas)

- There is 5 cm clearance from any metal
- It is mounted inside the vehicle
- It is mounted vertically

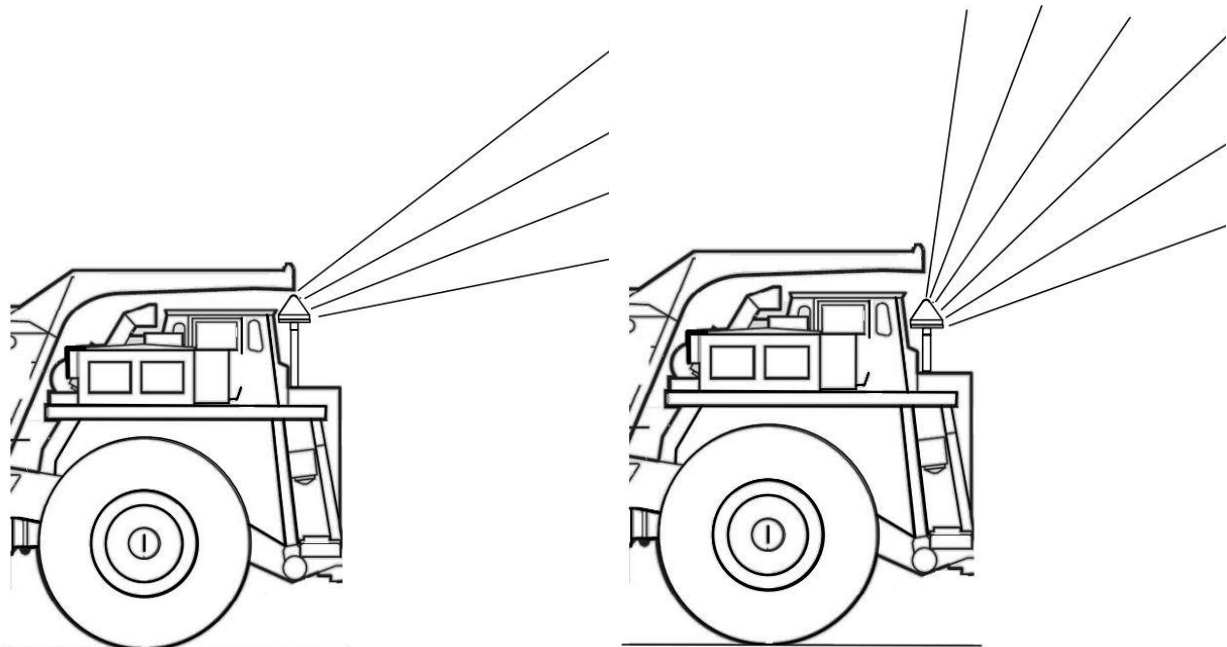


- The cable of the antenna should be perpendicular to the antenna for the first 5 cm
- Connect the antenna cable to the QC240 connector labeled “GSM”. Avoid sharp bending of the antenna cable.

4.4.4 Antennas on Haul Trucks

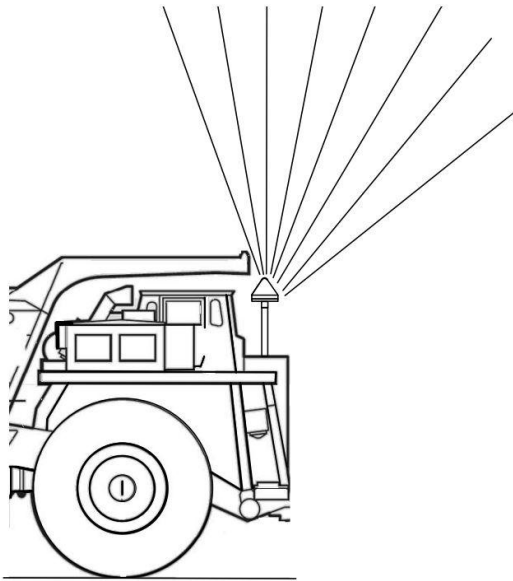
For optimal performance the GPS/RF antenna must be placed on the roof. On haul trucks this is often not possible. SAFEmine recommends building a pole where the antenna can be mounted.

The pictures below show different pole sizes and positions.

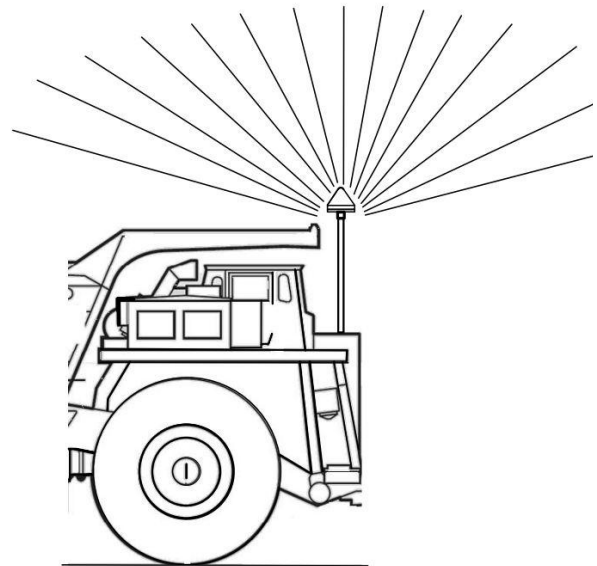


Very bad position

Bad position

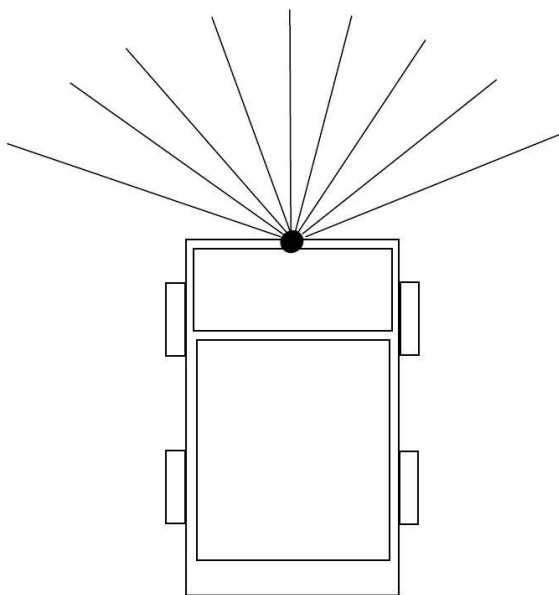


Good position

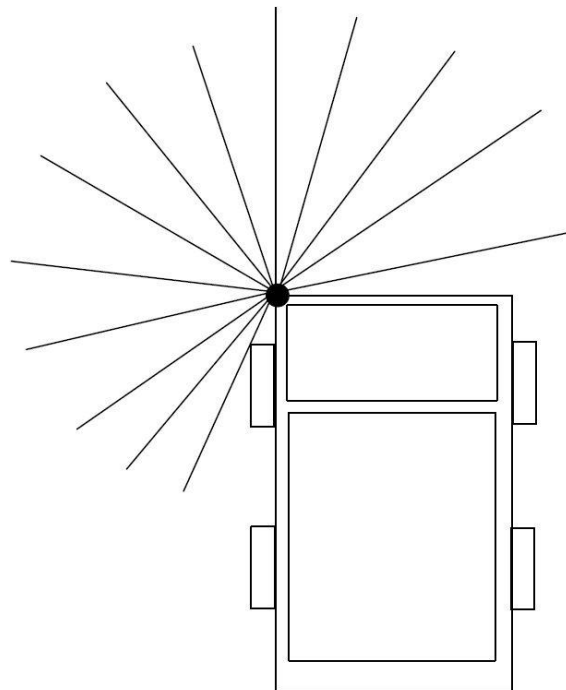


Excellent position

Side View



Position not optimal



Preferred position

Top View

4.4.5 Wifi Antenna (QC250 only)

The Wifi antenna length must not exceed 5 meters. For further information contact SAFEmine.

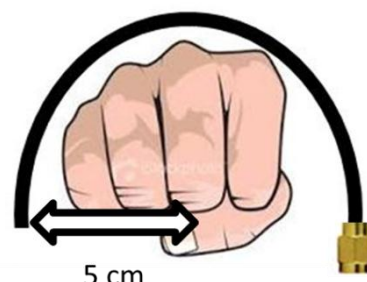
4.5 Antenna cables

The choice of antenna cables and installers must be done carefully. SAFEmine recommends to source cables with SMA connectors already installed:

- **It is recommended to source cables from a professional local supplier.**
- Any work on radio RF cabling must be done professionally by trained personnel according to SAFEmine specifications.
- Coaxial low loss cables as well as connectors of proper length and high quality must be used.
- Respect the maximum cable length (see below)

The RF and GPS cables must follow the following rules:

- The maximum acceptable attenuation rate for the RF cable is 3dB at 900MHz at 10 meters.
- Inner conductor must be solid core



Below is the typical maximum cable length between antenna and main unit per cable type recommended by SAFEmine.

These values are indications and vary between manufacturers. **Please see the datasheet and send it to SAFEmine prior to the installation.**

Use of other coaxial cable types must be approved in writing by SAFEmine!

Coaxial cable type	Max. length RF	Max. length GPS
RG174 / RG58	Do not use	5m
HDF-195/CFD-195 LMR -195/ RF 195 LMR-200	8m	15m
LMR 400	15m	15m

To calculate the attenuation rate, sum up the attenuation of all segments as specified by the cable manufacturer. Add 0.3dB for any connection

For the installation of the antenna cables:

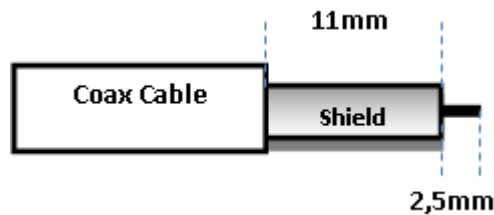


- Respect the minimum bending radius (see right) Typical minimum bend radius for RF195 type cables is 18mm (3/4 in.) for a one time bend (i.e during installation), 50mm (2 1/3 in.) for repeated bending (i.e after installation).
- It is highly recommended to add a braided sleeve around the cables for further UV and abrasion protection.
- **Connections in the antenna cable must be sealed over the whole assembly with heat shrink tubing (glue type).**
- **Outside connections must be sealed with silicone tape** to ensure a reliable, weatherproof operation.
- Never use 'electrical tape' (e.g. black PVC tape) to weatherproof RF connections
- No installation may have more than one (1) connection
- All antenna cables must be carefully tied to the vehicle. Loosely vibrating cable will fatigue and the central conductor will break over time.
- Make all cables removable to prevent them from being cut when the vehicle is being serviced.

Wear and damage to the RF and GPS antenna cables is not covered under warranty.

If the SMA connectors need to be attached, strictly follow the recommendations of the manufacturer as well as the following rules:

- Use 3 blade coax strippers (no knife)
- Adjust the coax stripper blades as recommended by the SMA connector manufacturer. See below for an example :



- Always solder the center pin (or crimp when not possible)
- Only use appropriate crimping tool
- Protect the connection with insulating tape.

Contact SAFEmine with the datasheets of the cables and SMA connectors prior to installation

4.6 SIM Card (QC220/QC240 only)

Insert the SIM card side with angled corner first with the trace side facing down. Push the card into the housing with a screwdriver or a pen until card locks.

To remove the SIM card push with a pen or a screwdriver until card unlocks



After installation of the SIM card seal the SIM card slot with enclosed label. Operation without SIM card label voids warranty.

If the SIM card requires a pin code don't power the device without the pin configured in the SAFEmine device!

4.7 Vehicle tracking (QC220/QC240 only)

The QC240 firmware will connect to a SAFEmine server and start sending position and other data at start-up. Some restrictions apply:

- The tracking server's address is fixed
- No SMS connectivity (e.g. when GPRS fails)
- The unit cannot be configured by the server

Tracking (data sending) is started automatically when the unit is powered on and a GPRS connection is established.



4.8 General Purpose Input Output (GPIO) connection

Care must be taken to select the correct input configuration, depending on the characteristics of the vehicle! Wrong settings can influence or even incapacitate the vehicle! Always ensure that after installation the voltage levels are correct. Please see (SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf) for complete instruction regarding GPIO connections.

The following procedure must be used to ensure proper configuration:

- Disconnect the unit completely (i.e. remove the M12 connector(s))
- Use a volt meter to measure the voltage in both on and off state, against ground.
- Connect the unit.
- Measure voltage again for both states, it should be the same. If not, the unit may influence the vehicle adversely.

4.9 General maintenance advice

Contact your local dealer to find out about available maintenance services.

See Appendix K : Maintenance Checklist for an example of maintenance checklist to be filled out and kept on file for each vehicle.

- The housing should only be cleaned with a slightly moist non-abrasive cloth without any cleaning agents.
- All electrical connection and cables should be checked regularly and the GPS antenna should not be covered by snow or a thick mud layer.
- If a new firmware is available, it should be uploaded to the device at earliest convenience.
- It is highly recommended to install a Test Station on site (e.g. in the brake test area and at site access), where all vehicles and their units can be tested for proper operation before use.
- Solar panels on Test stations must be inspected every week. Any dust, snow or ice buildup must be removed immediately.

SECTION C Software and Programming

The SAFEmine devices are controlled by a configurable firmware. The firmware as well as its configuration will be explained in the following chapters.

Configuration is not only compulsory for the firmware to run but it will also allow the best usage of the device. The SAFEmine device **needs** a unique configuration file created and/or modified by the installer.



Please contact SAFEmine for any question relative to configuration files.

The following chapters will present

- The software and its features
- How to configure the software and the special features

Vehicles requiring special configurations as well as additional functionalities of the device are also presented.

5 SAFEmine programming tool (SMTTool)

5.1 Installation

For the installation and configuration of the Collision Avoidance System firmware the following is needed:

Hardware:

- 1) PC or Laptop running Windows 2000 or later.
- 2) M8 to USB Cable (QL019)
or M8 to serial port cable (QL014) and RS232 to USB converter if PC has no serial port.
(A QM109 Y cable must be added for QC240, QC220 and QC250)
- 3) Power Supply or Battery (12 or 24 volts)

Software:

- 4) SMTTool (SAFEmine Software Utility)
- 5) Microsoft Office
- 6) Latest Firmware
- 7) Configuration File generated by a vehicle register
- 8) USB Driver (if USB port used).
- 9) Net 3.0 or higher

Notes:

- All necessary programs and files referred to above can be obtained on-line through www.safe-mine.com/support/partners. Enter your user name and password and then select the corresponding directory. Contact SAFEmine if you don't have a username and password.
- The SMTTool guide (SMTTool 2.0User_Manual(PRO_SMT_120601).pdf) is available upon request or on www.safe-mine.com/support/partners.

5.2 Firmware and Configuration File upload

Both the firmware and configuration file need to be uploaded to the SAFEmine device for the system to function properly.

Firmware is periodically updated by SAFEmine. Many features and improvements are available by uploading the latest released version. As a helpful feature, the firmware version is displayed during start-up. Three green LEDs are lit sequentially for one second, according to the firmware revision ("2", "6", "1"), where "2" is 2 o'clock, and numbers increment clockwise.

6 Software overview

6.1 The collision avoidance principle

The SAFEmine collision avoidance device is equipped with a GPS receiver, additional sensors and an RF transceiver. The GPS receiver will provide the unit with a position, speed and heading. This information is continuously broadcasted over the air thanks to the RF transmitter/ receiver.

A vehicle will receive the information from all the surrounding vehicles while transmitting its own information. Based on this information, sophisticated SAFEmine algorithms will determine a collision risk level and indicate it to the operator of the vehicle via the display.

For further information regarding the collision avoidance and proximity awareness offered by the SAFEmine system please contact SAFEmine requesting the operator training.

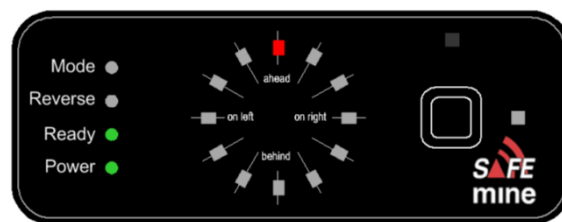
As every vehicle has different dynamics and every mine has different rules, SAFEmine has defined a list of features and configuration possibilities which can be set within the configuration file.

Exact parameter values and configuration files will be described in Chapter 7 : Features and configuration parameters.

Configuration and firmware upload to the SAFEmine device is possible with SMTTool. Please contact support@safe-mine.com to obtain SMTTool.

6.2 The display

The display, either remote (QC230/QC240/QC250) or integrated (QC235), warns the driver of potential threats, gives the status of the device, and allows user interaction with the Square button.



The image above shows the display when the device is operating, going forward ('Reverse LED' OFF) and a vehicle (equipped with a SAFEmine device) is ahead of him (red LED at 12 o'clock). Depending on the distance to that vehicle and to the configuration values an alarm might sound.

The LEDs on the left side of the display show the status of the SAFEmine device. They indicate if the device is operational or not as well as other information about the system.

The center compass displays the visible vehicles and possible error codes. The led on top (at 12 o'clock) indicates the presence of a vehicle in front of the vehicle. Several colors and sounds indicate different threats levels.

The explanation for the status LEDs and the error codes can be found in the troubleshooting guide (Troubleshooting_Guide(PRO_CAS_QC2_111025)) available from SAFEmine

Depending on the configuration the square button on the right can have three functions:

- 1) Every time the button is pressed this will be recorded in the unit's logfile. This feature is useful if a driver wants to flag a special situation (an incident or a situation where the user believes the SAFEmine device didn't perform as expected).
- 2) If the 'Voice Option' is enabled, surrounding vehicles are announced. See relevant 'Voice output' chapter for more info.
- 3) If a driver wants to acknowledge an alarm (i.e stop the warning sound for the particular alarm and vehicle) if this option is enabled.
- 4) Pressing the button for 3 seconds or longer seconds will restart the SAFEmine unit.

The display also has a buzzer, a brightness sensor and a noise sensor.

6.3 Alarms

All alarms are shown for a minimum of 1.5 seconds to allow the operator to see and react to it. The alarm will stop when the threat is gone or once one of the two vehicles stops.

7 Features and configuration parameters

This chapter describes the purpose and behavior of the SAFEmine device features.

It also describes the parameters of the configuration file (for example `VEHID`). Configuration parameter specifics can be found in 'Chapter 8 Configuration parameter specifications'

7.1 The vehicle

Information regarding every vehicle must be stored in the configuration file so that the prediction algorithms stored in the device may adapt collision warnings to the dynamics and the size of the vehicle.

`VEHID` will define the vehicle; **this value must be unique within the site**

The vehicle dimensions `VEHLENGTH`, `VEHWIDTH`, `VEHHEIGHT` must be defined as accurately as possible.

To predict the dynamics of the vehicle information regarding the type of vehicle must be added. The parameter `VEHTYPE` is very important as the dynamics (e.g. deceleration) of a light vehicle aren't the same as for a big dump or haul truck.

7.1.1 Safety zone

In order to have an additional safety area it is possible to 'virtually' extend the size of the vehicle. This will result in a safety zone around the vehicle.

The values `SAFETYLENGTH` and `SAFETYWIDTH` are the percentage of the actual vehicle length and width to be added.

Example: A vehicle with length 5m sets `SAFETYLENGTH = 20` thus will have an additional safety area of 1m ahead and behind the vehicle.

Setting these values too high (typically > 30) may result in unwanted "nuisance alarms" as alerts will sound even though there is no danger of collision. Recommended values for `SAFETYLENGTH` are 20 for haul trucks and 10 for light vehicles, 0 for `SAFETYWIDTH`

7.1.2 LED notification (no sound)

If a vehicle is within a certain distance it will appear on the driver's display. Depending on the distance to the vehicle the display will act differently. Sound alarms for expected collisions depend on distance, speed, vehicle type and other parameters. They are independent from the values described below.

There are three configurable distances. These distances are for LED notification only.

`DISTFAR` indicates when a vehicle should first be displayed. For best situation awareness it is recommended to keep the `DISTFAR` value larger than the maximum braking distance of any vehicle in the mine, typically about 110m. A green led indicates that a vehicle is closer than `DISTFAR`.

`DISTNEAR` is by default 40 meters. A steady red lamp will indicate the driver that a vehicle is closer than `DISTNEAR`.

`DISTCLOSE` is by default 5 meter. A flashing RED led will indicate to the driver if a vehicle is closer than `DISTCLOSE`.

7.1.3 Speeding alert

Speed alerts are issued through the LED display and the voice output if the vehicle goes faster than `MAXSPEED`. `MAXSPEED` is set to 0 by default, this will disable the alert.

7.1.4 Rotating vehicles/ Track-type vehicles

See the chapter on ‘Special vehicles: configuration & parameter specification’ if you are configuring a Dragline, Excavator, Shovel or any Track Type vehicle for additional parameters that must be set.

7.2 The antenna

As the antenna plays a vital role in the SAFEmine software its position must be chosen with an optimal sky view and known precisely by the algorithm. The parameters, `ANTENNAFT`, `ANTENNARIGHT` and `ANTENNAUP` define the position of the antenna with regards to the front left of the vehicle.

7.3 Driver comfort features

7.3.1 Buzzer

In order to improve the comfort of the driver the volume of the output can be set through the parameter `VOLUME`.

7.3.2 Infobeeep

The SAFEmine device indicates to the driver that a vehicle is passing. Depending on the configuration and the width of the road, this may result in sound alarms for vehicles that the driver has already seen. Infobeeep is a lighter and shorter notification sound that can be configured for situations where vehicles are passing and is in the line of sight of the driver. It avoids potentially distracting alarms for non-critical situations.

All the following conditions must be met in order to trigger an Infobeeep for a passing vehicle:

- a) The passing vehicle must be within +/- 30 degrees from my direction of travel (i.e line of sight)
- b) My vehicle must be within +/- 30 degrees from the passing vehicle’s direction of travel (i.e line of sight).
- c) The passing vehicle is within `DISTFAR`
- d) The vehicle will pass within 10 seconds

A vehicle that has been announced through “Infobeeep” will never generate a full (Dangerous Movement alarm) alarm on approaching, as it is assumed that the operator is aware of the approaching vehicle and will avoid it. Once the vehicle is passed it will no longer be in ‘Infobeeep’ state and might create full alarms again.

To enable Infobeeep, clear `UIMASK` bit number 5 e.g. with `UIMASK = 0xEF`. The `UIMASK` is described in detail in the Chapter ‘User Interface Mask (`UIMASK`)’:

7.3.3 Alarm suppressions (replacing alarm exceptions)

To avoid unnecessary ‘nuisance alarms’ it is possible to remove the alarms between certain vehicle types when performing normal ‘approved’ operations (see details in chapter 8.5.3: Alarm suppressions (replacing alarm exceptions)). This will result in certain dangerous movements (DM) not being announced or alarmed by the SAFEmine unit. Special care must be taken when suppressing alarms.

By default all alarms are switched on. In order to disable an alarm the parameter `ALARMSUPPRESSION` must be defined in the configuration file.

The example `ALARMSUPPRESSION = 0x15` will disable all alarms between light vehicles.



The parameter `ALARMSUPPRESSION` replaces `ALARMEXCEPTIONS`. The parameter `ALARMEXCEPTIONS` will still be recognized by the firmware and will be interpreted exactly like `ALARMSUPPRESSION`. It will no longer be documented.

7.3.4 Maximum exception speed

The alarm suppressions described in the chapter above (7.3.3: Alarm suppressions) will disable an alarm between certain vehicle types. The setting `MAXEXSPEED` will set a speed limit above which the disabled alarm will alert the driver despite the alarm suppression. The alarm suppression defined by `ALARMSUPPRESSION` will only be applied when driving below the speed defined by `MAXEXSPEED`.

If `MAXEXSPEED` is not set, there will be no limiting speed for alarm suppressions.

Example:

In a Large Front End Loader configuration file, `MAXEXSPEED = 5` and `ALARMSUPPRESSION = 0XB033`. There will be no DM (sound) alarms if the Large Front End Loader approaches a Dump- or Haul truck from the side, except if the Large Front End Loader is going faster than 5km/h.

7.3.5 Alarm acknowledge button

In some situations, e.g. when pushing a grader with a dozer or carrying a vehicle on a low bed trailer, nuisance-alarms are inevitable as the two vehicles are in very close proximity. In this situation, operators can acknowledge the currently active collision warning by pressing the square button on the SAFEmine interface. From that point, the acknowledged vehicle will not cause any more collision warnings, until it has left the radius defined by the configuration option `DISTNEAR` for more than 5 seconds. The alarm acknowledge button has no effect on obstacle alerts.

The Acknowledge functionality must be enabled in the `UIMASK` configuration option by clearing the second most significant bit (`0x40`). The `UIMASK` is described in detail in the Chapter '8.5.2 User Interface Mask (UIMASK) (required)':

7.4 Enhancement features

This chapter presents the features and configuration parameters available. The specification of the parameters and implementation details of the features is presented in Chapter 8 Configuration parameter specifications.

7.4.1 Areas

Areas allow automatically changing the parameters based on the location of the vehicle, e.g. to have different speed limits in the pit and out of the mine.

The `AREA` module in the SAFEmine firmware allows the user to define certain areas in which special property settings apply. The general rules are:

- A setting defined at the beginning of the configuration file will apply unless the vehicle is in a certain area and that setting is modified for this area.
- If a vehicle is inside one of the defined areas, the properties which are set in this area's section get redefined accordingly, the others are kept unchanged.
- Parameters which are only set in areas do not revert back to default when the vehicle goes outside the area i.e all parameter set in an certain area must also be set outside this area

To make the syntax shorter and cleaner, it is also possible to work with `AREA` types (`AREATYPE`), which describe a certain set of property definitions.

7.4.2 Obstacles

Fixed obstacles can be defined. If a vehicle approaches these obstacles the operator will be warned.

Obstacle data must be placed in a separate file named "obst.ini". It can be updated through the SyncStation or manually through SMTTool.

Obstacles can either be defined as circles or as lines.

The maximum number of obstacles is 60. The maximum numbers of characters in a line is 80. Obstacle alarms will continue when standing still under or over an obstacle.

Distance to obstacles is calculated from the GPS antenna of the vehicle, no vehicle dimensions and antenna locations are considered! This will be improved in future releases.

7.4.3 Rollover alert

All rollover alert functions are still in a 'BETA' state and may only be used for testing!

An alert can be configured if the truck is tipping above a defined angle. The angle is defined by the parameter `ROLLOVER`.

By default this feature is disabled i.e `ROLLOVER = 0` means there will be no alert. The angle is defined on the front to back axis of the truck. This means if a truck is climbing straight up a steep slope there will no alert. If the truck is driving along a slope (for ex: Left wheels higher than right wheels) an alarm might happen. More information regarding this alarm can be found in chapter '8.6.4 Voice output'.



For the rollover alert to work the unit must be mounted horizontally and with the long side of the unit in the direction of the vehicle.

7.4.4 Voice output

All voice output functions are still in a 'BETA' state and may only be used for testing!

As a special option the SAFEmine device can have a loudspeaker attached with a voice announcing nearby vehicles. Voice is currently available in English and Spanish. More languages can be ordered through your SAFEmine dealer. The voice output requires extra hardware (QP112) and software (Contact SAFEmine for more information).

The parameter `DISTVOICE` must be set to determine at which distance a vehicle will be announced over the speaker. An extra file must also be uploaded with SMTTool (See chapter 5 'SAFEmine programming tool (SMTTool)'. By pressing on the square button the Speaker will announce all the surrounding vehicles again (without distance indication). This can be useful if the driver didn't understand the first announcement properly.

Voice plays for the first time if its predicted trajectories come within `DISTVOICE`.

If the amount of surrounding vehicles would result in too many vehicle announcements the clustered vehicles are announced as "n vehicles".

7.4.5 Data recording

The internal flash memory will overwrite the oldest logs after about 70h of vehicle movement (if 1 second interval is chosen). To save memory the log interval is multiplied by 60 when the vehicle is stationary.

The device logs position, speed, heading, alarms, vibration. Fatal errors that lead to a device reset are also recorded. Contact SAFEmine for more information regarding log files.

Surrounding vehicles are only recorded if they trigger a sound alarm, or if a sound alarm was suppressed by an alarm suppression setting. A led notification will not be recorded.

The logging interval can be defined with the parameter `LOGINTERVAL`

7.4.6 Dim Mode

After 5 minutes of vibration-free standstill, the SAFEmine unit will power down its user interface, including the sound-amplifier and the warning LEDs. Only the mode LEDs will remain active. These will be dimmed, and signal the unit's dim status by a short increase in brightness every 6 seconds.

Dim mode must be enabled in the `UIMASK` configuration option by setting the most significant bit (`0x80`). The `UIMASK` is described in detail in the Chapter 'User Interface Mask (`UIMASK`)'. SAFEmine recommends not enabling Dim mode when not absolutely necessary as it may create confusion among the operators.

7.4.7 Inside detection

The unit automatically detects when the vehicle is inside (e.g. a garage) and goes into standby mode. This prevents nuisance alarms due to bad GPS coverage and also prevents spurious GPS ok/not ok signals while being parked inside.

When the unit detects that it is inside, the 'Ready' LED changes to red.

7.5 General Purpose Input Outputs (GPIOs)

A versatile scheme of relaying environmental information from and to the SAFEmine unit is available through the GPIOs of the SAFEmine unit. To set this up, two configuration steps are necessary:

1. The electrical characteristics of the I/O pin need to be configured. Available options are: digital input, digital output, and analog input. For digital input, it is further necessary to configure the internal pull-up or pull-down resistors (see below). For digital output, source or sink drivers can be configured (also see below). The characteristics need to match the characteristics of the vehicle. Not all GPIO pins support the same amount or combination of configurations.
2. The I/O pin needs to be assigned a function, such as "fuel gauge" or "reverse gear sensor" for the firmware to use it.

8 Configuration parameter specifications

8.1 Important remarks

8.1.1 Configuration management

The generation, upload and maintenance of the configuration files plays an essential role for a successful installation.

Prior to an installation SAFEmine recommends the following:

- Completing the Pre_installation_checklist document available upon request. This document provides important guidelines for the preparation of an installation.
- Creating a complete list of all vehicles to be equipped with a SAFEmine device with the properties required (Ex: VEHID, VEHTYPE, SIZE, ANTENNA POSITION....).
- Preparing the configuration files by using the vehicle register.

The vehicle register is a tool provided by SAFEmine used to assist with the configuration management. Together with the SMTTool it will generate all the configuration files needed for the mine.

More information on the vehicle register and it's usage can be found in the following document: Vehicle_Register_Instructions(PRO_UTI_CON_120528).pdf

SAFEmine provides training for the configuration management and vehicle register.

8.1.2 Configurations files



A unique configuration file must be compiled and uploaded for each vehicle. VEHID must be different for every vehicle in the mine.

The file name should consist of the individual "Plant Number" of the vehicle and end with .ini

Example: HT10.ini

Sample configuration files for various vehicles are available from SAFEmine. **We strongly recommend that you submit your Vehicle Register for review to support@safemine.com or have the vehicle register available online.**

Configuration file syntax:

- Parameter = value (Ex: VEHID = HT123)
- The "#" character at the beginning of a line indicates a comment. Comments are ignored and have no effect on the function of the configuration file.

NOTE: Values not set in a configuration file are automatically treated as default value. For instance, if there is no "VOLUME = XXX" entry in the configuration file, it will be set to "100".

To facilitate detection of improperly configured SAFEmine units, the following conditions lead to a fatal configuration error:

- Absence of the configuration file
- Configuration errors in Area definitions
- SyncStation: inconsistencies between configured updates and files present in storage

8.2 Site specific parameters (required):

Site specific parameters must be set on all units

Radio Channel

Parameter	Description	Unit	Range	Default	Example
CHANNEL	RF Radio Channel	-	117 - 381	-	117

Sets the frequency of the radio transmission

117: for Europe / Africa

287: North / South America

301: North American countries under FCC regulations

122: New Zealand

381: Australia

357: Israel

Channel Hopping



This value must be the same for all devices on the mine

Parameter	Description	Unit	Range	Default	Example
HOPPING	Number of channels to use for hopping	-	1 - 30	1	1

50: North America countries under FCC regulation

1: All other areas

Transmit Power

Keyword	Description	Unit	Range	Default	Example
RFPOWER	Transmit Power Setting.	-	0 - 3	3	3

Sets the transmit power of the radio. A setting of 3 results in maximum power and range of the radio. Do not modify.

8.3 Vehicle parameters

8.3.1 Required vehicle parameters

Vehicle ID



Parameter	Description	Unit	Range	Default	Example
VEHID	Vehicle ID, e.g. mine plant number	-	max 6 char	-	LV007

Must be unique within the site

Vehicle Type

Parameter	Description	Unit	Range	Default	Example
VEHTYPE	Vehicle Type	-	10 - 100	-	31

Description	VEHTYPE value	Examples/ Remarks
Light Vehicle	10	Ford F150,F250
Small Tractor	11	
Haul Truck	21	Komatsu 730E,
Dump Truck	22	Caterpillar 789C
Water Tanker	23	CAT 777
ADT (Articulated Dump Truck)	31	Volvo A25E
Fuel Bowser	32	

Service Truck	33	Mitsubishi Canter; Volvo Fm12
Mobile Crane	34	Franna AT 20
Low Bed Truck	35	
Rear Tip Truck	36	
Excavator	41	CAT 385C
Shovel	42	Liebherr 3994, Bucyrus 495HR2
PC	43	Komatsu PC 4000
Dozer	44	Cat D9T
Dragline	45	
Drill	46	Atlas Copco PV271
Large Front End Loader	51	Le Tourneau L1850
Small Front End Loader	52	CAT 988H
Tyre Handler	53	
Cable Handler	54	
Grader	55	Cat 24H , Cart 16M
TLB, JCB	56	John Deere 110 TLB, (Back Hoe)
Large Tractor	57	CAT 992C
Train	61	
Stockpile Stacker	71	
Test Station	72	
Stockpile Dozer	73	
Lighting Plant	74	Alight 22KV _a , Multiflo ??
Stockpile Reclaimer	75	
Boomgate	76	
Beacon	100	

Vehicle Dimensions

Parameter	Description	Unit	Range	Default	Example
VEHLENGTH	Vehicle length, overall	meter	0 - 655	10	12.8
VEHWIDTH	Vehicle width, overall	meter	0 - 655	4	3.4
VEHHEIGHT	Vehicle height, overall	meter	0 - 50	3	2.34

8.3.2 Highly recommended vehicle parameters

Vehicle Weight

Parameter	Description	Unit	Range	Default	Example
VEHWEIGHT	Maximum vehicle weight (with no load)	Ton	0 -1500	50	430

LED notification distances

Parameter	Description	Unit	Range	Default	Example
DISTFAR	Green LED indicates vehicle closer than distfar meters	meter	0 - 500	150	180
DISTNEAR	Steady Red LED indicates vehicle closer than disnear meters	meter	0 - 250	40	40
DISTCLOSE	Flashing Red LED indicates vehicle closer than disclose meters	meter	0 - 250	5	5

For best situation awareness it is recommended to keep the DISTFAR value larger than the maximum breaking distance of any vehicle in the mine, typically about 110m.

Additional safety distances

Parameter	Description	Unit	Range	Default	Example
SAFETYLENGTH	Extends the alarm region in percent of vehicle length.	% of length	0 - 100	10	20
SAFETYWIDTH	Extends the alarm region in percent of vehicle width.	% of width	1 - 100	10	0

Example: A vehicle with length 5m sets SAFETYLENGTH = 30 thus will have an additional safety area of 1.5m ahead AND behind the vehicle.

8.3.3 Optional vehicle parameters

Parameter	Description	Unit	Range	Default	Example
VEHMANU	Vehicle Manufacturer	-	max. 31 characters	-	KOMATSU
VEHMOD	Manufacturers model name	-	max. 31 characters	-	785

Parameter	Description	Unit	Default	Example
MINTURNRAD	This value must be set to 1.	Meter	1	1
DRIVERAFT	Distance between front of vehicle and driver	Meter		1.5
DRIVERRIGHT	Distance between left side of vehicle and driver	Meter		1.5
DRIVERUP	Elevation of driver above ground	Meter		4
MAXSPEED	Maximum speed before alert.	Km/h	0 (disabled)	70

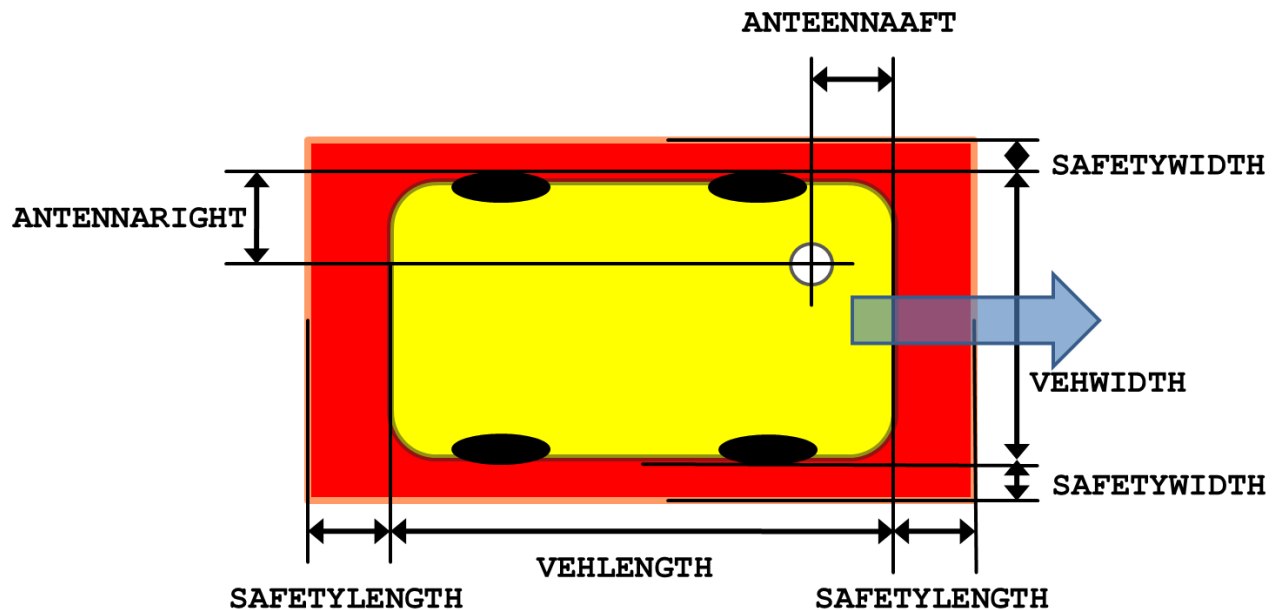
8.3.4 Rotating vehicles/ Track-type vehicles

See 'Chapter 9 Special vehicles: configuration & parameter specification if you are configuring a Dragline, Excavator, Shovel or any Track Type vehicle for additional parameters.

8.4 Antenna parameters (required)

8.4.1 Antenna position

Parameter	Description	Unit	Range	Default	Example
ANTENNAAFT	Distance between front of vehicle and antenna.	meter	0 - 655	5	3.4
ANTENNARIGHT	Distance between left side of vehicle and antenna.	meter	0 - 655	2	1.2
ANTENNAUP	Elevation of antenna above ground	meter	0 - 50	1.5	2.1



The figure above illustrates the vehicle dimensions and antenna position parameters

8.5 Driver comfort parameters

8.5.1 Buzzer volume (required)

Parameter	Description	Unit	Range	Default	Example
VOLUME	Volume of the buzzer of the display in percent of full volume -1: automatic (not yet implemented)	%	0 - 100	100	60

8.5.2 User Interface Mask (UIMASK) (required)

In order to disable or enable certain parameters and interfaces of the SAFEmine device the UIMASK parameter can be used.

Parameter	Description	Unit	Range	Default	Example
UIMASK	Deactivates selected user interface components, e.g. buzzer, LED circle. Individual user interface components can be deactivated (e.g. buzzer, LED circle).	Flags	0 – 0xFF	0xFF	0xE2

In order to define the UIMASK parameters please use UIMASK generator which is available at support@safe-mine.com and in the Vehicle Register.

User Interface	Hex Code					State	Entered
Type	Bit	Dec	Hex	Default			Value
Buzzer	1	1	0x01	ON		ON	1
Warning LED's	2	2	0x02	ON		ON	2
Voice	3	4	0x04	ON		ON	4
GPS Up/Down Warn	4	8	0x08	ON		ON	8
Info Beep	5	16	0x10	OFF		OFF	16
All LED's	6	32	0x20	ON		ON	32
Acknowledge Button	7	64	0x40	OFF		OFF	64
Dim Mode	8	128	0x80	ON		ON	128
						Dec	255
				UIMASK	=	Hex	FF

The value of UIMASK must be set to the sum of the **code** (hex) values

Note that the number entered for the parameter UIMASK is hexadecimal. A single digital hex number can range from 0 to 15, so letters are used to represent numbers greater than 9, i.e., 10=A, 11=B, 12=C, 13=D, 14=E, and 15=F. Hence when numbers are added they are done one column at a time. If the total for a column is greater than 9 letters between A and F are used to represent the hex number.

8.5.3 Alarm suppressions (replacing alarm exceptions)



The parameter ALARMSUPPRESSION replaces ALARMEXCEPTIONS. The parameter ALARMEXCEPTION will still be recognized by the firmware and will be interpreted exactly like ALARMSUPPRESSION. It will no longer be documented.

The parameter ALARMSUPPRESSION is required.

Parameter	Description	Unit	Range	Default	Example
ALARMSUPPRESSION		N/A	0-0xFFFFFFFF F	0	0FFFFFFFF

By default all alarms are switched on. In order to disable an alarm the parameter ALARMSUPPRESSION must be defined in the configuration file.

The example

ALARMSUPPRESSION = 0x15 will disable all alarms between light vehicles.

To allow flexibility, certain alarms can be switched on or off. The value of ALARMSUPPRESSION must be set to the sum of the **code** (hex) values described in the table below.

		code
--	--	-------------

My vehicle	My vehicle is moving	Type of other vehicle I am approaching	Direction where I come from	off	on
Light Vehicle	forward	Light Vehicle	anywhere	0	0x1
		Small Tractor		0	0x2
	backwards	Light Vehicle	anywhere	0	0x4
		Small Tractor		0	0x8
Small Tractor	forward	Light Vehicle	anywhere	0	0x10
		Small Tractor		0	0x20
	backwards	Light Vehicle	anywhere	0	0x40
		Small Tractor		0	0x80
ADT	forward	PC	anywhere	0	0x100
Small Front End Loader	forward	ADT	side	0	0x200
		Dump Truck	side	0	0x400
		Rear Tip Truck	side	0	0x800
Large Front End Loader	forward	Haul Truck	side	0	0x1000
		Dump Truck	side	0	0x2000
Tyre Handler	forward	Grader	side	0	0x4000
		Service Truck	side	0	0x8000
		Fuel Bowser	side	0	0x10000
		Small Front End Loader	side	0	0x20000
		Large Front End Loader	side	0	0x40000
		Tyre Handler	side	0	0x80000
		Haul Truck	side	0	0x100000
		Water Tanker	side	0	0x200000
		Dump Truck	side	0	0x400000
Haul Truck	All	Excavator	anywhere	0	0x800000
		PC	anywhere	0	0x1000000
Dump Truck	All	PC	anywhere	0	0x2000000
Rear Tip Truck	forward	PC	anywhere	0	0x4000000
Excavator	All	Haul Truck	anywhere	0	0x8000000
PC	All	ADT	anywhere	0	0x10000000
		Dump Truck	anywhere	0	0x20000000
		Rear Tip Truck	anywhere	0	0x40000000
Dozer	All	Dozer	anywhere	0	0x80000000



Use of this parameter will permanently disable the alarms between certain vehicle types.

Example:

Following alarms are suppressed:

My vehicle	I am moving	Other vehicle I am approaching	Direction where I come from	code to switch alarm suppression on:
Light Vehicle	forward	Light Vehicle	anywhere	0x1
		Small Tractor		0x2
Small Tractor	forward	Light Vehicle	anywhere	0x10
		Small Tractor		0x20
Large Front End Loader	forward	Haul Truck	side	0x1000
		Dump Truck	side	0x2000
Tyre Handler	forward	Service Truck	side	0x8000

All other alarms are turned on:

- ⇒ sum of all codes = 0x4 + 0x8 + 0x40 + 0x80 + 0x1000 + 0x2000 + 0x8000 = **0xB033**
- ⇒ the following line has to be added into the configuration file:
ALARMSUPPRESSION = 0xB033

Note that the number entered for the parameter `ALARMSUPPRESSION` is hexadecimal. A single digital hex number can range from 0 to 15, so letters are used to represent numbers greater than 9, i.e., 10=A, 11=B, 12=C, 13=D, 14=E, and 15=F. Hence when numbers are added they are done one column at a time. If the total for a column is greater than 9 letters between A and F are used to represent the hex number.

8.5.4 Maximum exception speed

Parameter	Description	Unit	Range	Default	Example
MAXEXSPEED	Limit of alarm suppression	km/h	0 – unlimited	0	10

If `MAXEXSPEED` is not set, there will be no limiting speed for alarm suppressions.

(See Chapter '7.3.4 Maximum exception speed' for a detailed explanation)

8.6 Enhancement features parameters

8.6.1 Area

The parameters defined at the beginning of the configuration file will be called the basic (general) parameters.

The basic parameters will apply unless a vehicle enters the zone defined by an area where this parameter has been redefined.

If a vehicle is inside one of the defined areas, the parameters which are set in this area's section get redefined accordingly, the others are kept unchanged.

The general rules below apply when configuring Areas:

- All parameters set in a certain area must also be set in the basic parameters and all other areas. The reason is that parameters which are only set in areas do not revert back to default when the vehicle goes outside the area
- If an Area, A is inside an Area, B then area B must be defined (written) first in the configuration file.

The following must be added to the configuration file in order to enable an area

Syntax for defining areas:

- Add the keyword [AREA]

[AREA] defines the start of an area section. A section ends with the start of a new section.

- Enter the coordinates of the area

Each AREA section has to have at least 3 and **at most 15** COORD assignments, which define the polygon points of the current area (latitude 'N' and longitude 'E' separated by ';').

The polygon can be concave. The first and last point do not have to be the same, they will be connected automatically.

North: N,n South: S,s

East: E,e West: W,w

Order: Both 47.0010n;7.9990e and 7.9990e;47.0010n is allowed.

- Define area specific parameters (for example UIMASK, Maxspeed)

An AREA section can contain several property assignments. These get executed if the vehicle currently is in the area.

The order of COORD, TYPE and property assignments in an AREA section can be arbitrary.

Example:

```
#General parameters
distfar = 60
distnear = 30
distclose = 3
maxspeed = 70

#First area : the pit
[area]
maxspeed = 15
COORD = 47.0010n;8.0010e
COORD = 47.0020n;8.0010e
COORD = 47.0020n;7.9990e
COORD = 47.0010n;7.9990e
#Second area: the plant
[area]
maxspeed = 40
COORD = 48.0010n;8.0010e
COORD = 48.0020n;8.0010e
COORD = 48.0020n;7.9990e
COORD = 48.0010n;7.9990e
```

Other information:

- Areas can overlap each other
- The maximum number of area types is 30
- Sections with unknown titles (like [xyz]) get ignored
- The area module is processed once per second.
- Example for a configuration file containing area definitions can be found in 'Appendix H'

8.6.1.1 Areas (Advanced configuration option: areatype)

Areatypes add no extra features to Areas. They are useful for very big mines to make the syntax shorter and cleaner.

Please contact SAFEmine before using Areatypes.

AREATYPE describes a certain set of property definitions.

An AREA section can be assigned to 1 or more area types. This can be done by a TYPE assignment:

```
TYPE = NAMEOFTYPE.
```

If an area is assigned to a certain type, all the properties defined in the section of this type get loaded if the vehicle currently is in this area.

[AREATYPE] defines the start of an area type section

With the NAME assignment, a name is given to the area type:

```
NAME = NAMEOFTHISAREATYPE
```

Note: The type name should not be longer than 25 characters. Everything after the 25th character is ignored.

To make the syntax shorter and cleaner, it is also possible to work with AREA types (AREATYPE), which describe a certain set of property definitions.

An AREATYPE section can contain several property assignments. These get executed when the vehicle is in an area which is assigned to this type

The order of the NAME assignment and property assignments in an AREATYPE section can be arbitrary.

```
[AREATYPE]
name = Plant
maxspeed = 15
distfar = 60
distnear = 30
distclose = 3
```

```
[areatype]
name = Pit
maxspeed = 40
distfar = 60
distnear = 30
distclose = 3
```

```
[area]
TYPE = Plant
COORD = 47.0010n;8.0010e
COORD = 47.0020n;8.0010e
COORD = 47.0020n;7.9990e
COORD = 47.0010n;7.9990e
```

```
[area]
```

```

TYPE = Pit
COORD = 48.0010n;8.0010e
COORD = 48.0020n;8.0010e
COORD = 48.0020n;7.9990e
COORD = 48.0010n;7.9990e

```

```

[area]
TYPE = Pit
COORD = 49.0010n;8.0010e
COORD = 49.0020n;8.0010e
COORD = 49.0020n;7.9990e

```



If a vehicle currently is in more than one area OR if a property is defined in an area and as well in its type, property settings which are processed later overwrite others. Resulting effects are:

Area sections defined further down in the configuration file have a higher priority.

Property settings or type assignments which are defined further down in an `AREA` section also have a higher priority. The location of `AREATYPE` sections does not matter (a type's property settings are processed when this type gets assigned in an `AREA` section).

- The order of `AREA` and `AREATYPE` sections can be arbitrary

8.6.2 Obstacle

Obstacles are defined in a separate file (i.e not the configuration file) which must be called `obst.ini`. `Obst.ini` isn't generated with the Vehicle Register.

The syntax of an obstacle entry is:

```
OBST = <type>;<geometry type>;<geometry>
```

The fields are:

- | | |
|------------------------------------|---|
| <code><type></code> | A number, where:
0 -> Generic Obstacle (announced as 'Obstacle')
10 -> Building
21 -> Power line
22 -> 'Stop' sign
23 -> reduced speed area
71 -> Coal valve
72 -> Stockpile edge |
| <code><geometry type></code> | one of the following
1d: circular obstacle
2d: line obstacle (i.e. conduit, cable) |
| <code><geometry></code> | depends on geometry type.
For 1d: <code><lat>,<lon>,<radius></code>
For 2d: <code><lat><lon>,<lat>,<lon></code> (designating the start and endpoint of the conduit) |
- `<lat>` latitude, decimal notation (decimal sign is the period "."), followed by "N" or "S" character. E.g.: 48.1234N (trailing zeros may be omitted)
coordinates must be in WGS84 system
 - `<lon>` same as lat, but using "E" or "W" character. E.g.: 167.987552W.
 - `<radius>` radius in meters, decimal notation (when geometry type is 1d only).

Examples:

```
# This is a "line" obstacle, issuing "power line" voice alerts
OBST = 21;2d;37.845N,122.243W;37.847N,122.243W
# This is a circular obstacle, issuing "obstacle" voice alerts
OBST = 0;1d;37.841343N,122.248W;5.3
```

The maximum number of obstacles is 60.

The maximum numbers of characters in a line is to 80.

8.6.3 Rollover alert

Parameter	Description	Unit	Range	Default	Example
ROLLOVER	Maximum roll angle. Alarm will sound on higher angle Requires purchase of additional firmware option 0: disabled	° degrees	0 - 90	0	40

8.6.4 Voice output

Parameter	Description	Unit	Range	Default	Example
VOICEFILE	File name of voice audio file			0	sm_EN_M_1.1.voc
DISTVOICE	Voice distance	N/A	0 - 500	20	100
AUDIOVOLUME	Controls speaker volume independent of the buzzer volume	%	0 - 100	100	80

8.6.5 Data recording

Parameter	Description	Unit	Range	Default	Example
LOGINTERVAL	Log interval for track and data recording.	seconds	0 - 255	1	2

9 Special vehicles: configuration & parameter specification

9.1 Dual Zone vehicles (Shovels/Excavators/Draglines)

Parameter	Description	Unit	Range	Default	Example
VEHBASELENGTH	Length of the vehicle's body	m	0 – 655	0	20

Shovels, Draglines and Excavators can be configured to have a base-length (configuration value "VEHBASELENGTH"). This will separate the vehicle into a vehicle base and a vehicle area. Certain vehicle types will then be able to reverse towards the boom area of an excavator, shovel, or dragline without causing an alarm for both drivers. Also there will be no alarms when an excavator or shovel swings the boom over the haul truck.

However alarms between the vehicle base of the shovel/dragline and the haul truck/dozer will happen as normal.

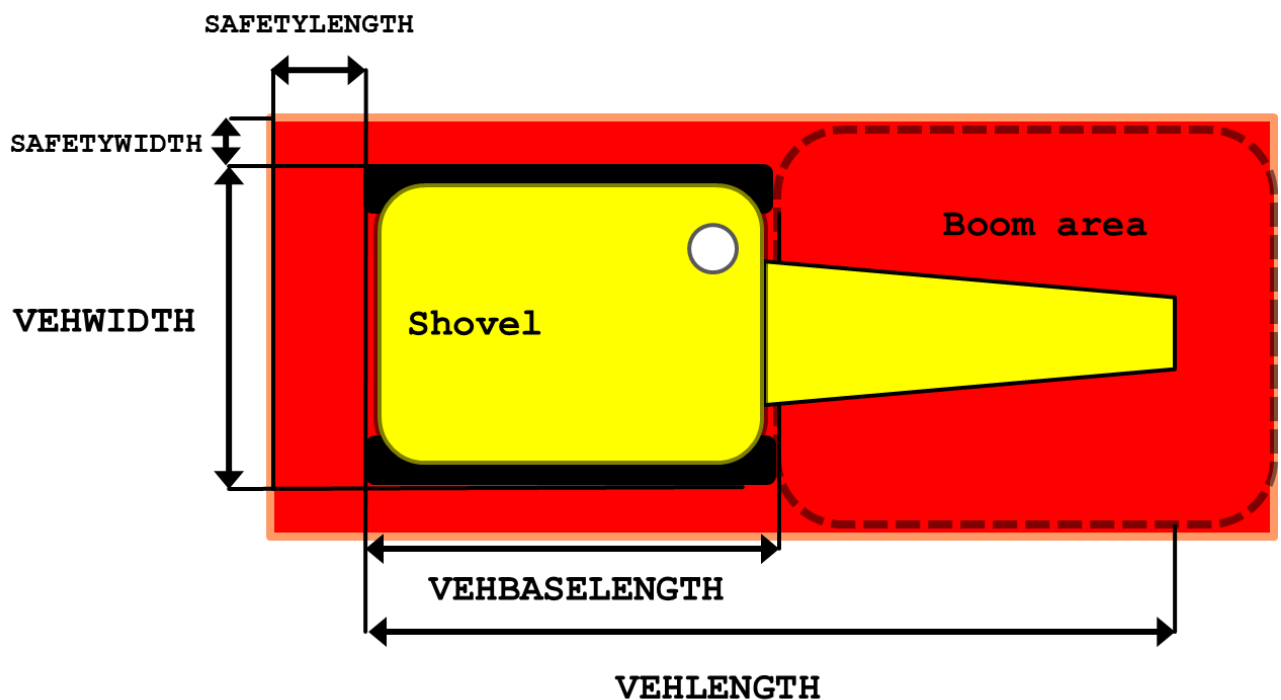
This behavior occurs in interactions between shovels/excavators (VEHTYPE = 41 / 42) and haul/dump trucks (VEHTYPE = 21 / 22).

The behavior also occurs between dozers (VEHTYPE = 44) and draglines (VEHTYPE = 45).

The behavior is only enabled when VEHBASELENGTH is configured in the Shovel, Excavator or Dragline.

The behavior only occurs between the vehicles types as described above. i.e a dozer going near the boom area of an excavator will result in an alarm.

Vehicles with configured VEHBASELENGTH are currently exempt from collision de-escalation. (Collision de-escalation means that the alarm stops as soon as the vehicle moves away from the threatening vehicle)



9.2 Unknown heading vehicles (Shovels/Excavators/Track type Dozers)

9.2.1 Introduction

Some vehicles can turn or rotate and hence change their heading without any forward or backward movement, such as track dozers and shovels. In such cases, it is recommended that a second SAFEmine unit (called beacon) is added so that the direction of movement of the vehicle is always defined.

9.2.2 Unknown heading vehicle with single antenna

For tracked vehicles and other vehicles where the orientation of the driver may differ from the direction of travel the heading information will be discarded once the vehicle enters standstill (typically after 10 seconds).

Vehicles with unknown heading (e.g. non-moving, tracked, rotating vehicles) are calculated as circular objects. No threat headings will be displayed to the operator of such vehicles

A typical example of unknown heading vehicle where a second antenna can't be installed is a small dozer. For such vehicles it is recommended connecting the SAFEmine device to the reverse gear. This will significantly improve the heading accuracy.

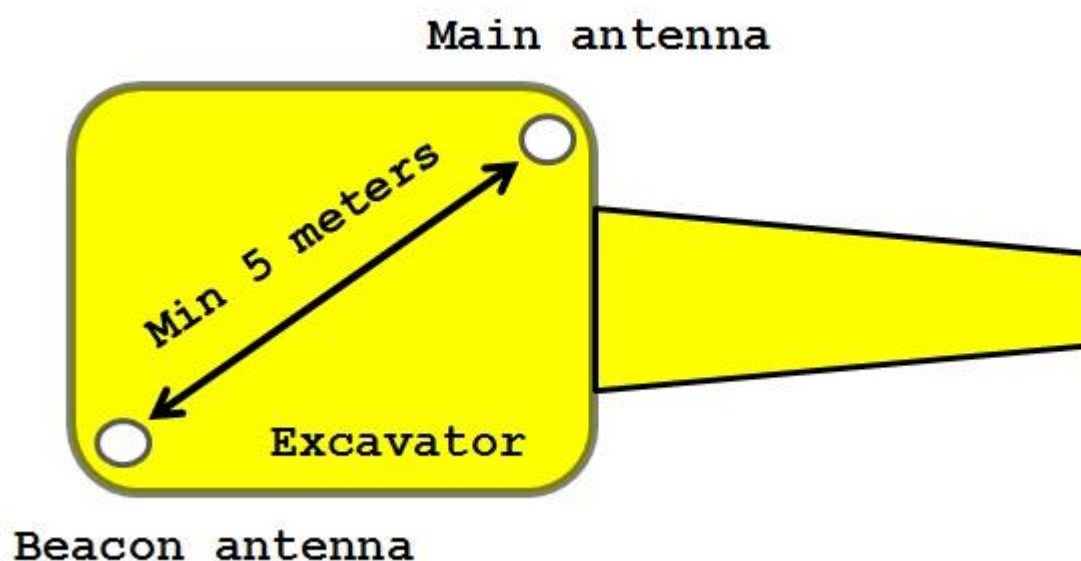
9.2.3 Unknown heading vehicle with dual antenna (beacon)

9.2.3.1 Installing Hardware

The antenna of the main unit should be installed in the corner of the vehicle, the second antenna, referred to as a beacon antenna, should be installed in the opposite corner.

- It is necessary to have both antennas as far away as possible.
- Both antennas require their own SAFEmine unit.

The principal main unit can be either a QC230 with a remote display or a QC235; the beacon unit does not require a display and often a QC230 without a remote display is used here. For convenience, both units are often mounted close together in the cab of the vehicle, in a piggy-back or side-by-side fashion.



It is recommended that the distance between the two antennas be at least 5 meters. For vehicles that operate in regions of the mine where more than 30% of the view of the sky is obstructed, this distance is increased to 15 meters. Contact SAFEmine if these restrictions cannot be met.

It is essential that both antennas are not obstructed by any part of the vehicle and have a 360° view of the horizon (except for terrain obfuscation).

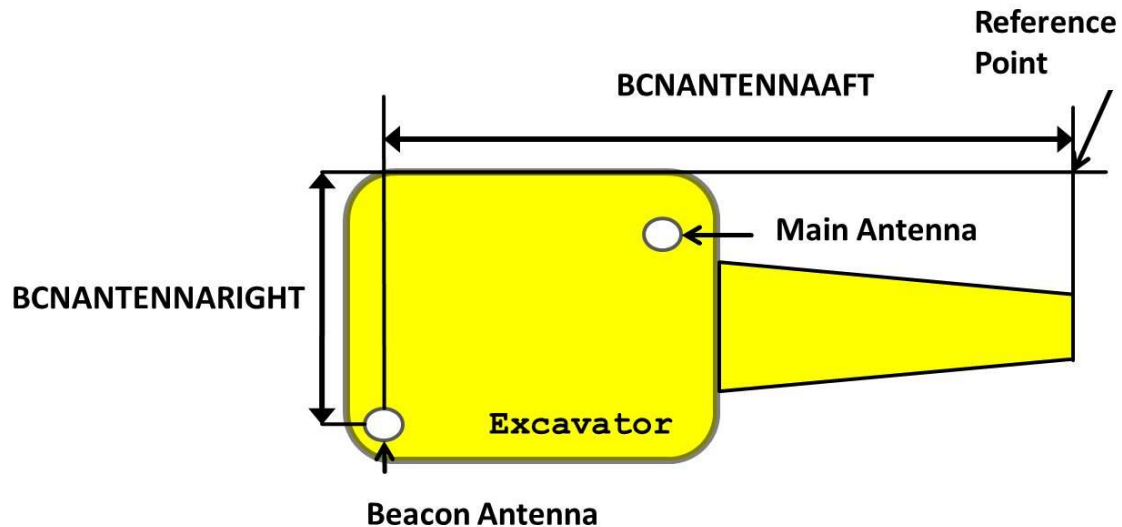
9.2.3.2 Software Configuration

For the system to operate properly, the principal unit needs to recognize the beacon unit. This is accomplished by including the beacon unit serial number in the configuration file of the main unit.

Parameter	Description	Unit	Range	Default	Example
BEACON	Beacon serial number	N/A	11 numbers	N/A	70011855000
BCNANTENNAFT	distance measured from the front of the vehicle to the beacon antenna		0 - 655	0	22.1
BCNANTENNARIGHT	distance measured from the left side of the vehicle to the beacon antenna		0 - 655	0	1.4
BCNANTENNAUP	distance measured from the ground level to the beacon antenna		0 - 05	0	7.3



The position of the beacon antenna is stored in the principal unit. By knowing the position of the principal and beacon antennas and the distance and angle between the two, the heading of the vehicle can easily and accurately be determined.



The following must be added to the standard configuration file of the **principal unit**:

```
BEACON = # Add serial number
BCNANTENNAFT = 12.4 # Example in meters
BCNANTENNARIGHT = 3.4 # Example in meters
BCNANTENNAUP = 0.0 # Example in meters
```

It is essential that both the main and the beacon unit have their antenna positions programmed accurately for proper operation!

Add the following to the configuration file of the **beacon unit**:

```
VEHICLETYPE = 100
```

9.2.4 Operation and testing

The LED of the beacon unit will flash green at 1Hz, 50% duty cycle, and the "reverse" LED is always off.

However, the main unit's "Reverse" LED will flash red if no valid beacon signal is received.

9.2.5 Limitations

The center of rotation is assumed to be in the middle of the vehicle for the rotation prediction. If there is a significant difference between the true axis of rotation and the center a slight positional error will result.

9.3 Stockpile Collision Avoidance

Special modes are available to support stockpile collision avoidance system application. This includes warnings for stackers, reclaimers, coal valves and vehicles operating on the stockpile. Please contact SAFEmine for additional information.

10 Additional SAFEmine device capabilities

In addition to CAS (Collision Avoidance System) certain devices can be configured to act for different purposes: SyncStation, Boom Gate.

10.1 SyncStation

A SyncStation can be used to update the surrounding SAFEmine units. Depending on the settings firmware, configuration files and obstacle files can be updated. The SyncStation will automatically update the vehicles within range.

Devices with remote accessibility (QC240 or QC250) must be used for SyncStations.

A SyncStation isn't a vehicle type. Any vehicle can be configured as a SyncStation once the functionality is purchased and enabled by SAFEmine.

10.1.1 Automatic Trickle Upload Features (v2.41, build 2096 and newer)

Below some of the most important features:

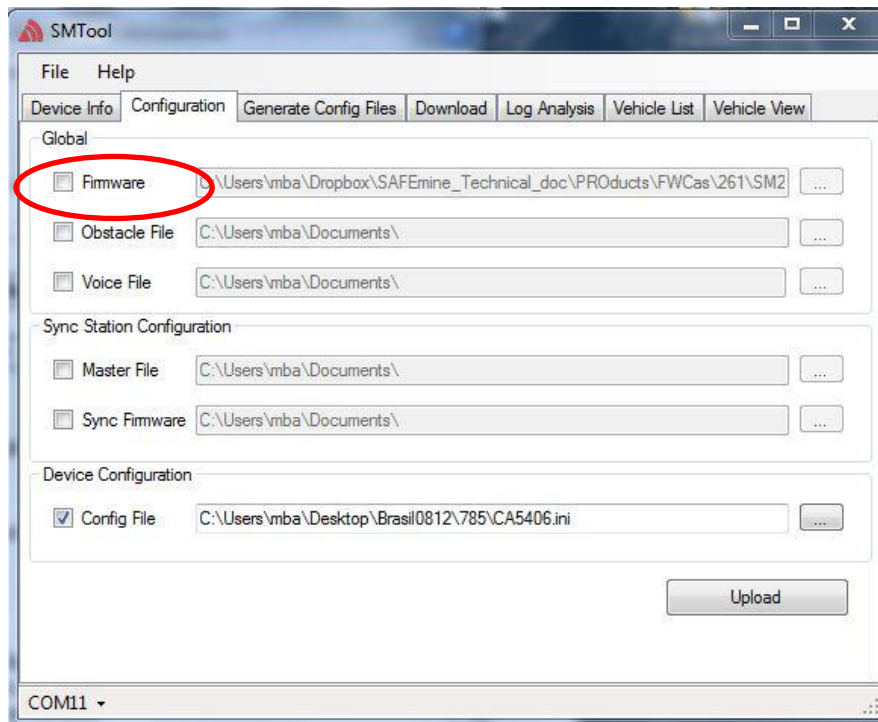
- Automatic, unattended upload of firmware, and other files to vehicles.
- Uploads at about 10 kbytes per minute → very slow for firmware and voice files, but not critical since it is unattended!
- Will update units with lower firmware version numbers (however, does NOT pay attention to BUILD #).
- Will update units in range concurrently (e.g. not one after the other)
- Records successfully updated serial # in the log file.

10.1.2 Step by step instructions

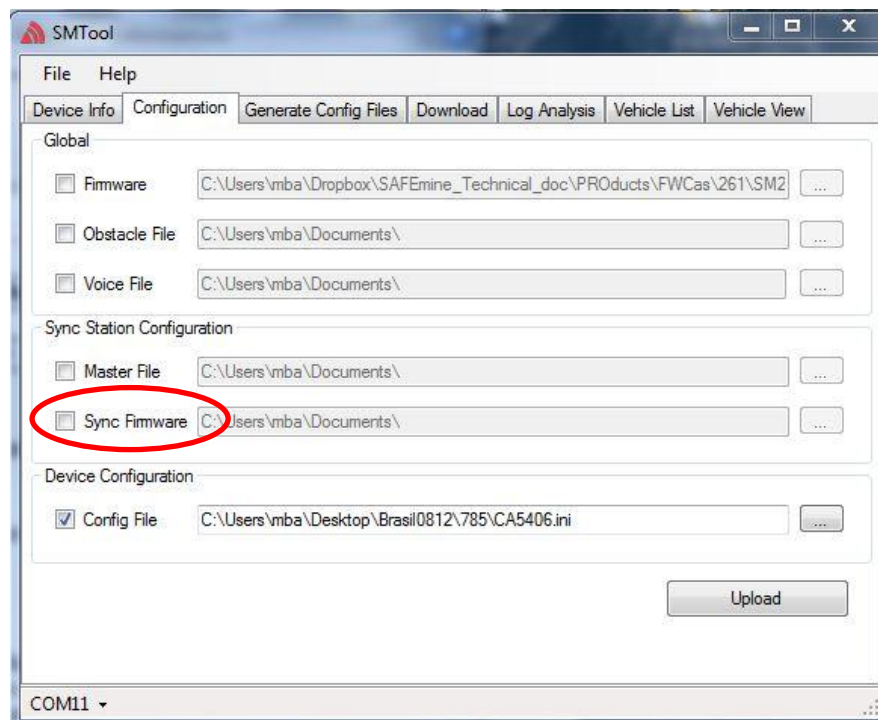
Parameter	Description	Unit	Range	Default	Example
RFUPDATE	RF update	N/A	0 – 0xffff	0	1
RFUPDATELOGINT	RfUpdate log interval	min	5 - 1440	60	

The instructions below assume SMTTool is installed.

1. Update **Sync Station's own firmware** with SMTTool → Configuration Tab select Firmware (see picture below). The Sync Station firmware must be version 2.61, build 2096, or higher.



2. Upload **files to be automatically distributed** with SMTTool → Configuration Tab, select Sync Firmware (see picture below). **Always upload the Firmware file.**



SyncStations can distribute:

- Firmware files supplied by SAFEmine (SMx.yz_build.fw)
Note that you can safely upload a firmware file as in picture above without affecting the firmware version that your Sync Station is currently running.
- The Master File (master.ini, see the chapter '10.1.3 Configuration updates' below)
- The Obstacle File (obst.ini)

3. The SyncStation can update several types of files. This is configured with `RFUPDATE`

- RFUPDATE supports the following options:

1	Firmware updates only
2	Configuration updates only
3	Firmware and configuration updates
4	Obstacle updates only
5	Firmware and obstacle updates
6	Configuration and obstacle updates
7	Firmware, configuration and obstacle update

- RFUPDATE must be added to the configuration file.
- Add the following lines to the **SyncStation Configuration File for all updates**:
`RFUPDATE = 1`

When updating a firmware also add:

`UPDATEFILE = SM2.61_3195.fw`

Note:

- The firmware indicated in `UPDATEFILE` must be identical to the firmware uploaded in step 2 above.

4. Connect to a terminal program (e.g. HTerm).

5. Enter `$PFLAR` and watch for any unexpected errors.

6. Enter `$PFLAC, S, DEBUG, 8000001`

This lets you watch the operation. Look for the following messages (the “% done” will show the percentage of updated vehicles)

```
301.0294 : Selected peer 70001828200 / DX230, firmware: 2.0.0,
connection    quality 49%
301.0395 : Connection established to peer 70001828200
301.0395 : Starting firmware upload
302.0192 : Created remote file __sm.fw
302.0892 : Wrote 128 bytes at 128, 0% done
303.0794 : Wrote 128 bytes at 256, 0% done
```

7. When done, enter `$PFLAC, S, DEBUG, 0`

This removes debug messages.

8. After a few hours of operation, download the log file, convert it to CSV and look for RFUPDATE messages.

10.1.3 Configuration updates

Target vehicles are first checked to make certain that they are at the level (or newer) indicated by the “UPDATEFILE” parameter in the SyncStation Configuration file. If this not the case, the target vehicle configuration file will NOT be updated.

The file master.ini is basically a concatenation of the all the new configuration files for all of the target vehicles to be updated.

- Master Files must always be generated with the Vehicle Register

The vehicle register is a tool provided by SAFEmine used to assist with the configuration management. Together with the SMTTool it will generate all the configuration files needed for the mine.

More information on the vehicle register and it's usage can be found in the following document: Vehicle_Register_Instructions(PRO_UTI_CON_120528).pdf

Each configuration file must also contain a vehicle ID of up to 6 characters "VEHID". If not, or if the "VEHID" is not present, the configuration file will not be updated. **It is mandatory to configure a unique vehicle ID** as the master.ini file will use the first configuration file that contains a particular vehicle ID for all remaining vehicles with the *same* vehicle ID. Refer to the below.

10.2 I/O Connections

10.2.1 GPIO (General Purpose Input/Output) Configuration

Please see the SAFEmine GPIO Application Note :

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.2 I/O Application: Test Station

10.2.2.1 Operation principle

In order to do a self-check of the unit a SAFEmine unit purchased with the option QP141 will act as a Test Station. The Test Station can control a light indicating to the driver that his device is operational.

Any SAFEmine equipped vehicle within the defined range of the Test Station will cause the digital output to go high. The output will remain high until the vehicle is again out of range. The approaching vehicle will have its LED flash red along with a buzzer alarm when it is within its DISTNEAR setting.

Test stations are ideal to be used as SyncStations. If such is the case a QC240 or QC250 device must be used to allow remote access.

To assist during installation the 'Mode' LED will turn Red to indicate that the digital output has gone high.



10.2.2.2 Hardware configuration

A digital output from the SAFEmine units of type QC230, QC235 and QC240/50 may be used. Please see the SAFEmine GPIO Application Note:

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.2.3 Firmware configuration values

Please see the SAFEmine GPIO Application Note:

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.2.4 Examples

GPIO Settings

Together with the other settings for a Test Station the settings below can be used. The settings below can power a strobe light from the blue wire (IO1)

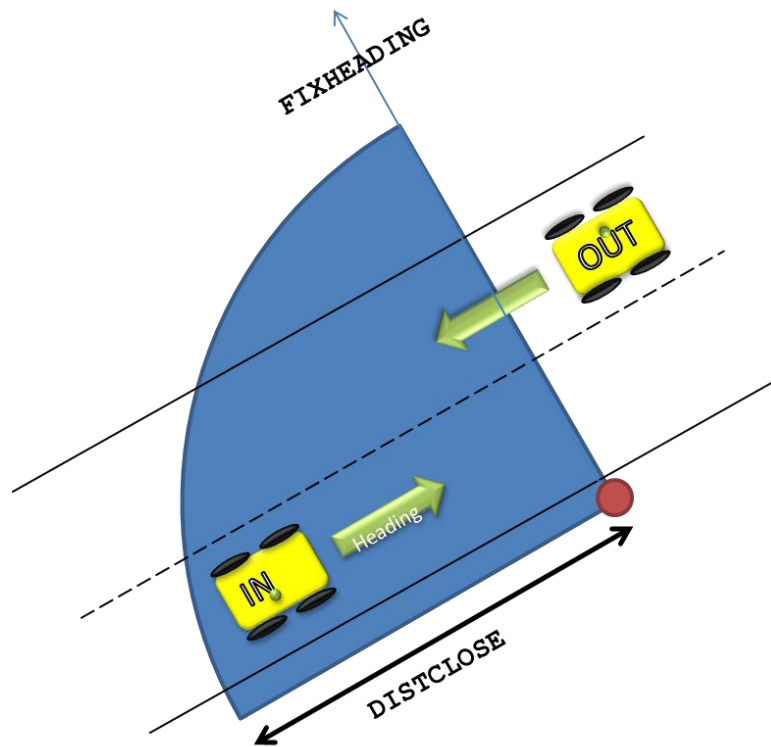
```
io1_direction = output  
io1_driver = source  
io1_function = alarm;signal:high
```

Right hand traffic

(Traffic keeps to the right side of the road)

The example below uses the following parameters:

```
VEHMOD = from left  
FIXHEADING = 330  
DISTCLOSE = 50
```



10.2.2.5 Left hand traffic

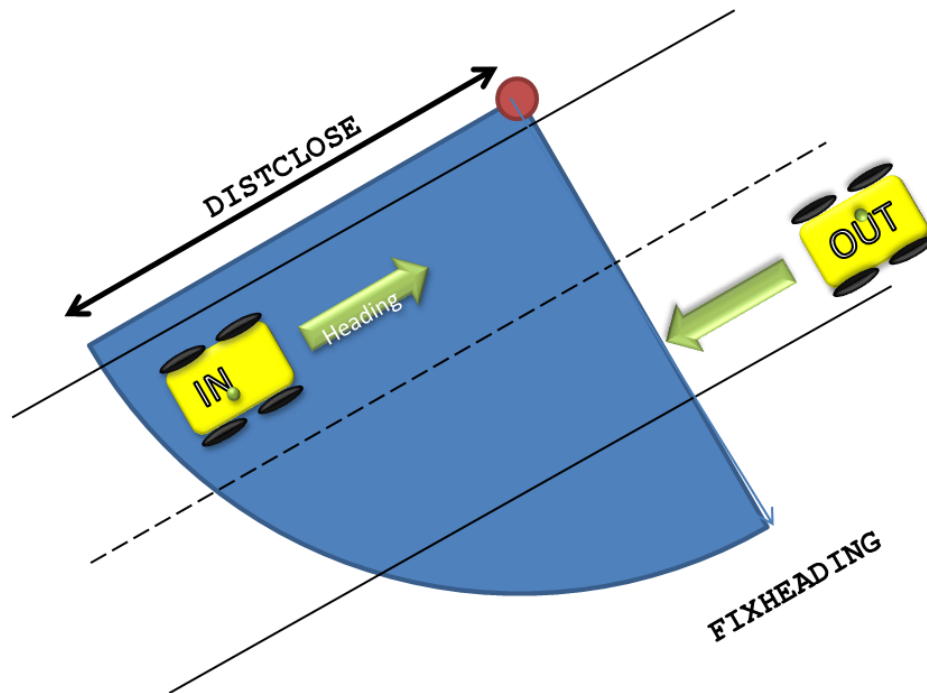
(traffic keeps to the left side of the road)

The example below uses the following parameters:

VEHMOD = from right

FIXHEADING = 150

DISTCLOSE = 50



10.2.3 I/O Application: Automated Boom gate

Similar to Test Stations, automated Boom Gates can be installed to ensure all vehicles in an area are equipped with an operating SAFEmine unit. This also gives mines an instrument to identify and isolate vehicles with faulty or missing SAFEmine installations.

Boom gates are ideal to be used as Sync Stations (see Chapter '10.1 SyncStation')

Please see the SAFEmine GPIO Application Note:

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.3.1 Operation principle

A SAFEmine unit purchased with option QP141 may be configured to act as a Boom Gate. In this mode and when configured correctly, the unit will identify vehicles moving towards the boom based on their position and heading.

The closing of the Boom Gate MUST be controlled by conventional means. (e.g. a photo cell or loop detector). The absence of a signal from the SAFEmine unit must not be interpreted as a vehicle having passed safely beyond the Boom Gate. Never use the signal from the SAFEmine unit to trigger the closing circuit!

Please see the SAFEmine GPIO Application Note:

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.3.2 Hardware configuration

A digital output from the SAFEmine units of type QC230, QC235 and QC240/50 may be used. Please see the SAFEmine GPIO Application Note:

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.3.3 Firmware configuration values

Firmware with version numbers 2.61 or higher is required.

Please see the SAFEmine GPIO Application Note:

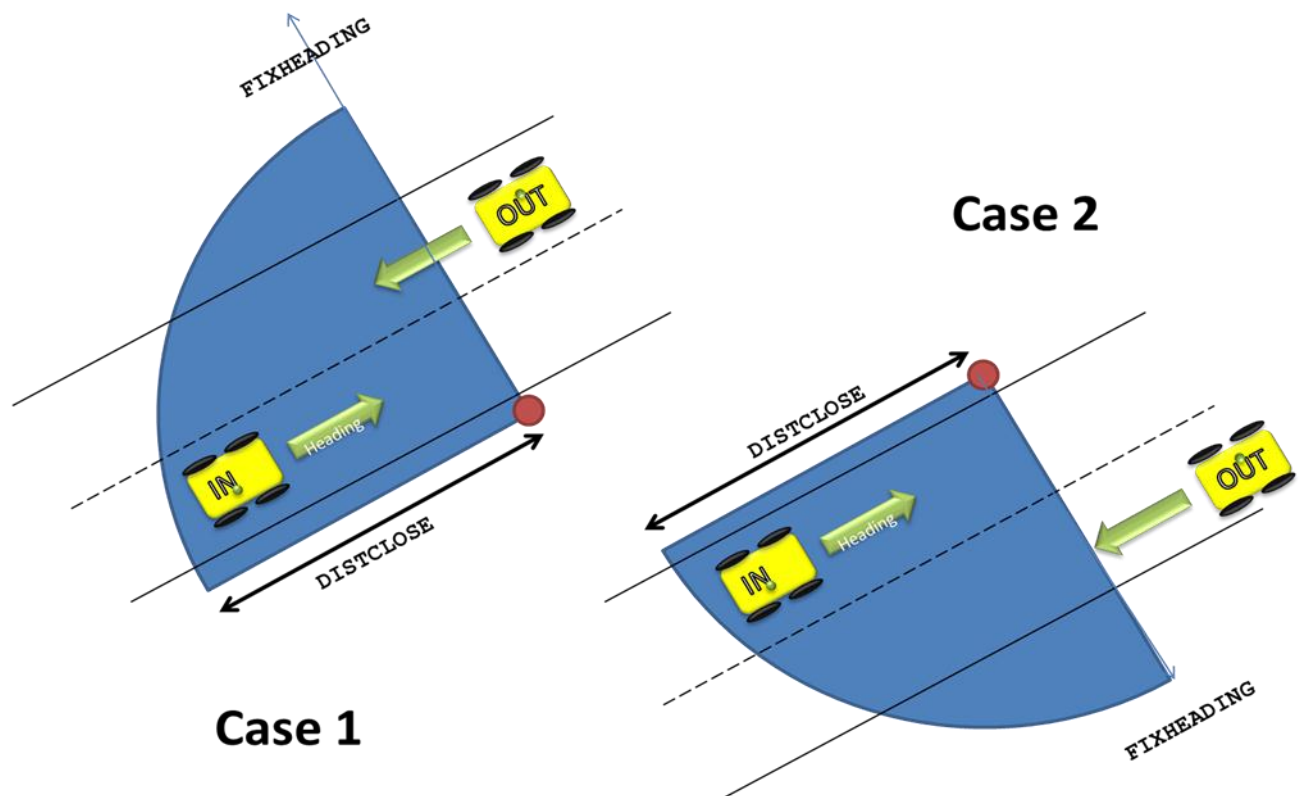
SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information.

10.2.3.4 Examples

GPIO settings

To trigger an automated boom gate, the IO-connectors blue wire can be connected to the boom gate's triggering relay. In such case the following lines must be added to the configuration (pulse length and interval may vary) in addition to the other Boom Gate specific commands:

```
io1_direction = output  
io1_driver = source  
io1_function = alarm;signal:high;pulse:500;interval:9500
```



Case one

Right hand traffic (traffic keeps to the right side of the road)

The example above uses the following parameters:

VEHMOD = from left

FIXHEADING = 330

DISTCLOSE = 4

Case two

Left hand traffic (traffic keeps to the left side of the road)

The example above uses the following parameters:

VEHMOD = from right

FIXHEADING = 150

DISTCLOSE = 4

Pulse length and interval will be configurable in future implementations

10.2.4 I/O Application: Reverse Gear

SAFEmine recommends connecting the reverse gear of all the heavy and tracked equipment to the SAFEmine unit.

Please see the SAFEmine GPIO Application Note:

SAFEmine_GPIO_AN_V11(PRO_CAS_QC2_120320).pdf for complete information about the reverse gear feature.

11 SAFEmine TRACK (QC250/QC240/QC220)

11.1 Presentation

The presence of a GSM module (Wifi) in the SAFEmine TRACK QC240, (QC250) and QC220 devices allows real time tracking. SAFEmine TRACK will connect the device at start-up to a SAFEmine server to send position and other data. The position of the devices (vehicles) is accessible via a web-hosted application.

Other information coming from the Digital I/Os can be sent to the server. For more information please contact SAFEmine.

In order to enable the TRACK functionality of the QC250/QC240/QC220 some extra parameters must be added in the configuration file. All the configuration parameters for the Collision Avoidance functionality of the device must also be set as for any other device.

Wifi will be available with FW 2.8 and later. For complete instructions regarding the Wifi configuration please contact SAFEmine for the application note: AN_WifiSetup_1.5(PRO_CAS_QC2_121201).pdf.

The configuration setting for the Wifi will be available with FW2.8 release notes.

11.2 Configuration parameters

Parameter	Description	Range	Required /SAFEmine device
TRACKINT	The interval (in seconds) with which positions are stored and sent to the tracking server. Note that currently a vehicle will be marked "offline" 10 minutes after the last position has been received by the tracking server. Values greater than 540 are therefore not recommended. Example: # Tracking interval TRACKINT = 60	10 - 900	yes, defaults to 15 / for QC250/40/20
GSMPIN	If the SIM card is locked with a PIN, this setting must be used. It can be left undefined or set to some arbitrary setting if no PIN is defined on the SIM card. Note that the SAFEmine unit tries to apply the PIN code only once after power-up. If the given PIN code does not match and unit is power cycled multiple times, the SIM card will be locked and rendered inaccessible. In this case, the Personal Unlock Key (PUK) needs to be applied to the SIM, e.g. by placing it in a mobile phone. Example: # SIM PIN GSMPIN = 1234	any	If SIM card is locked/ QC240 and QC220 only

Parameter	Description	Range	Required /SAFEmine device
GSMAPN	This setting defines the APN used for GPRS packet communication. This depends on the carrier and SIM card used. Note that some carriers provide multiple APNs with differing feature sets. Example: # APN GSMAPN = gprs.swisscom.ch	any	If requested by network provider/ QC240 and QC220 only
GSMUSER	Username for GPRS access, provided by carrier. Example: # User GSMUSER = gprs	any	If requested by network provider / QC240 and QC220 only
GSMPASS	Password for GPRS access, provided by carrier. Example: # Pass GSMPASS = gprs	any	If requested by network provider/ QC240 and QC220 only
AVLVOLTAGEINT	The interval (in seconds) with which the supply voltage is sent to the tracking server. The supply voltage is always sent together with a position. Setting avlvoltageint to a value smaller than trackint will result in the supply voltage being sent with every position. For larger intervals, multiples of trackint are recommended. If avlvoltageint is 0, the supply voltage is never sent. Example: # Track supply voltage hourly AVLVOLTAGEINT = 3600	0 - 57600	no, defaults to 0/ for QC250/240/220
AVLROLLOVERINT	The interval (in seconds) with which the current vehicle roll angle is sent to the tracking server. The vehicle roll angle is always sent together with a position. Setting avlrolloverint to a value smaller than trackint will result in the supply voltage being sent with every position. For larger intervals, multiples of trackint are recommended. If avlrolloverint is 0, the vehicle roll angle is never sent. Sending the roll angle also depends on the configuration of the rollover angle. If rollover is 0, the vehicle roll angle is never sent. Example: # Alert Operator of rollover danger ROLLOVER = 30 # Send roll angle with every position AVLROLLOVERINT = 1	0 - 57600	no, defaults to 0/ for QC250/240/220

Parameter	Description	Range	Required /SAFEmine device
AVLANALOG1INT	The interval (in seconds) with which the value of analog input 1 is sent to the tracking server. This value is always sent together with a position. Setting avlanalog1int to a value smaller than trackint will result in the value of analog input 1 being sent with every position. For larger intervals, multiples of trackint are recommended. If avlanalog1int is 0, the value of analog input 1 is never sent. Example: <pre># Track fuel gauge every 2 hours AVLANALOG1INT = 7200</pre>	0 - 57600	no, defaults to 0 / for QC250/240/220

SECTION D Software maintenance

12 Advanced Troubleshooting

A complete troubleshooting guide (Troubleshooting_Guide(PRO_CAS_QC2_111025).pdf) is available upon request.

12.1 Error codes

The unit performs a self-test upon power up. Errors are indicated by all 4 status LEDs (left side of the display) glowing red, while the circular display shows the error code(s). More detailed error messages are sent to the serial port.

Debugging of error codes is best done with a PC running a terminal program (e.g. HTerm) connected to the serial port.



On first restart after updating a "non-fatal" error may be displayed for 30 seconds due to the additional configuration options (green flashing status lights and one green light on the compass display). Troubleshooting guide explains how to react to an error code.

Error code	LED #	Subsystem	Severity	Cause/Comment
01	1	Flash Memory	(Fatal)	Flash memory failure; non-fatal if operational, but data lost. Fatal if operation is not possible.
02	2	Serial	Fatal	Serial number invalid, contact support
03	2&1	Dataport error	Alert	Sending of Dataport Heartbeat message failed.
04	3	GPS receiver	Fatal	Unable to communicate with or configure GPS module
05	1 & 3	GPS Antenna	Fatal	GPS antenna defective or bad connection
08	4	Power	Fatal	Power supply defective or low/high voltage
16	5	User Interface	Fatal	No user interface connected.
32	6	Config	(Fatal)	Configuration file contains errors, or is not present.
64	7	Firmware	Fatal	Firmware corrupt, upload new firmware
128	8	Generic	Various	Generic error, currently not used
256	9	GPIO error	Fatal	GPIO configuration or hardware problem. See Terminal output for details.
4095	All	Unknown	Various	Not used.

12.2 HTerm

HTerm allows interacting with the device. Parameters can be read and set. Advanced debug information can be read.



Parameters modified by command line are overwritten by parameters in the configuration file at every reset or power-up!

Unless specified all the commands below are valid for FW 2.41 and higher. Many commands will work with FW lower than 2.41, however the command may have changed slightly i.e. the output might be different than the one described below.

Communication is established through means of a terminal emulator, such as HTerm, supplied as part of the SAFEmine Laptop setup. Default setting for the serial port is 57600 Baud, 8 bit, no parity, no flow control, 1 stop bit

12.3 HTerm commands

12.3.1 Generalized command structure

Description	Command	Response
Set Parameter	\$PFLAC,S,[Parameter],[Value]	\$PFLAC,A,[Parameter],[Value]
Read Parameter	\$PFLAC,R,[Parameter]	\$PFLAC,A,[Parameter],[Value]
Revert to Defaults	\$PFLAC,Defaults	Resets to Default Values*
Reset	\$PFLAR	Device restarts

Parameter examples:

- Read gsm setting \$pflac,r,gsm
- Set trackint to 20 seconds \$pflac,s,trackint, 20

12.3.2 General usage commands

12.3.2.1 Debug commands

Description	Command	Response/Comment
Show status and parameters (local only)	\$PFLAS	Shows all available parameters
Ping the connected unit (shortest way to ascertain that the connection is good)	\$PFLAP	
List surrounding vehicles S/N & Types	\$PFLAN,LIST	
List surrounding vehicles Version numbers & extended details	\$PFLAN,LIST2	Distance, vehid, fw version,x ,y \$PFLAN,LIST2,A,70001824360 ,Haul Truck,HVCON,2.4.0,2.0,96.8 81,281.308
Show current task list (Local only)	\$SCHED,LIST	
Reset scheduler statistics	\$SCHED,RESET	
Turn on debug for RF updates	\$PFLAC,S,DEBUG,8000001	
Turn debug off	\$PFLAC,S,DEBUG,0	More info regarding debug later in chapter
Set output ON for PC Monitor	\$pflac,s,dataport,0x1e1	For details, see dataport manual
Set output OFF for PC Monitor	\$pflac,s,dataport,0x0	

Description	Command	Response
Display general debug information	\$PFLAC,S,DEBUG,<debug_value>	

Possible values:

<debug_value>

Description	Bit Number (Position)	<debug_value> Hexadecimal value to enable single variable
ZONE_INIT (extra debug parameters)	0	1
ZONE_GPS	1	2
ZONE_DATAFLASH	2	4
ZONE_BARO	3	8
ZONE_MS5	4	10
ZONE_MS5_L	5	20
ZONE_PERSIST	6	40
ZONE_DIFFERENTIAL	7	80
ZONE_GENERAL	8	100
ZONE_SIM	9	200
ZONE_NRF	10	400
ZONE_MODBUS	11	800
ZONE_COLLISION	12	1000
ZONE_COM	13	2000
ZONE_COMMANDPARSER	14	4000
ZONE_COMPASS_ON	15	8000
ZONE_VOICEQUEUE	16	10000
ZONE_NORTH_MOV	17	20000
ZONE_RFTCP	18	40000
ZONE_FAKEGPS	19	80000
ZONE_FILTER	20	100000
ZONE_LOGGING	21	200000
ZONE_FORCEGPSOK	22	400000
ZONE_RF_SPAM	23	800000
ZONE_OBSTACLES	24	1000000
ZONE_AREAS_OFF	25	2000000
ZONE_GSM	26	4000000
ZONE_RFUPDATE	27	8000000
ZONE_DATAPORT	28	10000000
ZONE_ACCEL	29	20000000

Remark:

In order to enable several debug messages add the debug values in the table above

Example:

- To enable GPS debug data `$PFLAC,S,DEBUG, 0x2`
- To enable GSM and GPS debug data `$PFLAC,S,DEBUG, 0x4000002`
- Disable all debug info `$PFLAC,S,DEBUG,0`

12.3.2.2 File system commands

Use the following commands to operate on the internal file system:

Description	Command
List files	<code>\$FILE,LS</code>
Remove file	<code>\$FILE,RM,[Filename]</code>
Print file content	<code>\$FILE,CAT,[Filename]</code>
Dump the (base64-encoded) contents of a file to HTerm output	<code>\$FILE,CAT64,[Name]</code>
Format SAFEmine (Local only)	<code>\$FILE,FORMAT</code>

12.3.2.3 Simulation commands

Certain simulation scenarios can be run:

Description	Command
Start SAFEmine in demo mode	<code>\$SIM,start</code>
Play scene number [Num]	<code>\$SIM,scen,[Num]</code>
List simulation scenarios	<code>\$SIM,LIST</code>

12.3.3 Test stations and Boom gate

The new text command `$pflac,recommend,fixheading` can be used to determine the “fixheading” configuration option for Test stations and Boom gates

Description	Command
Determine fixheading configuration	<code>\$pflac,recommend,fixheading</code>

Preconditions:

- Test Station or Boom Gate is installed at the final location
- Configuration option “vehmod” includes “from left” or “from right”
- Second Vehicle with SAFEmine unit is stopped in the position where it is expected to trigger the Boom Gate or Test Station

Examples:

```
> $pflac,recommend,fixheading
$PFLAC,RECOMMEND,FIXHEADING,Missing direction in vehmod:
Lighting12V,ERROR
```

```
> $pflac,recommend,fixheading
$PFLAC,A,RECOMMEND,FIXHEADING,fixheading = 175 for 70005211715
```

12.3.4 Set of GPS commands

Use the following commands to interact with the GPS module:

12.3.4.1 GPS status

Description	Command	Response
Display status of GPS	<code>\$GPS, STATUS</code>	<code>\$GPS, STATUS, A, fix=<fix>, numsat=<numSat>, lat=<lat>, lon=<lon>, alti=<alti></code>

Displayed values:

<fix> Fix quality, 0..6.
<numSat> Number of satellites used for location solution.
<lat> Current latitude measurement in degrees, scaled by 1E7
<lon> Current longitude measurement in degrees, scaled by 1E7
<alti> Current altitude measurement, in meters above standard ellipsoid

Example:

```
> $gps, status
$GPS, STATUS, A, fix=5, numsat=9, lat=471955997, lon=85370293, alti=517
```

12.3.4.2 GPS satellite information

Description	Command	Response
Displays extended satellite information	<code>\$GPS, SAT</code>	<code>\$GPS, SAT, A, <hacc>, <cno1>, <cno2>, ..., <cno16></code>

Displayed values:

<hacc> Horizontal accuracy
<cno1>...<cno16> Carrier-to-noise density of the first 16 satellites

Example:

```
> $gps, sat
$GPS, SAT, A, Hacc=500,0,0,0,28,25,25,12,23,12,0,25,16,25,0,0,0
```

12.3.4.3 GPS navigation information

Description	Command	Response
Displays satellite information relevant for navigation	<code>\$GPS, NAV</code>	<code>\$GPS, NAV, A, <numSat>, <cno1>, <cno2>, ...<cnoN></code>

Displayed values:

.<numSat> Number of satellites used for location solution
<cno1>...<cnoN> Carrier-to-noise density of the satellites in use. 50 is excellent. Below 20 is very bad.

12.3.4.4 GPS connection command

The following command allows connecting transparently to the GPS module.

\$GPS,transp

There is no specific command to exit this mode. To exit the unit must go through a power-cycle.

12.3.5 Set of GSM commands (Q240 only)

Use the following commands to interact with the GSM module:

12.3.5.1 GSM modem status

Description	Command	Response
Displays dynamic status of GSM/GPRS modem	\$GSM, STATUS	\$GSM, STATUS, A, init=<initialized>, reg=<registered>, op=<operator>, sig=<rssi>, ber=<ber>, tx=<tx>, rx=<rx>, act=<activated>, ip=<IP>

Displayed values:

<initialized>	Set to 1 if modem is initialized, 0 otherwise. If 0, an additional error message will be shown at startup. Usual causes for this are SIM missing, wrong PIN code.
<registered>	If modem is registered to network. A value of 1 shows successful registration, values of 0 or 2 denote the modem is still searching for a network.
<operator>	Name of network operator / carrier.
<rssi>	Signal quality, 0..32
<ber>	Bit Error Rate
<tx>	Total sent bytes
<rx>	Total received bytes
<act>	GPRS profile is activated
<IP>	GPRS IP address of modem

Example:

```
> $gsm, status
$GSM, STATUS, A, init=1, reg=0, op=, sig=99, ber=99, tx=0, rx=0, act=0, ip=0.0.0.0
> $gsm, status
$GSM, STATUS, A, init=1, reg=1, op=Swisscom,
sig=17, ber=99, tx=51217, rx=21192, act=1, ip=10.118.155.169
```

12.3.5.2 GSM modem information

Description	Command	Response
Displays static info on GSM/GPRS modem	\$GSM, INFO	\$GSM, INFO, A, 1, <mfg>, <model>, <imei>, <fw rev>

Displayed values:

<mfg>	Modem manufacturer
<model>	Modem type
<imei>	IMEI of modem. This value is needed to properly set up the AVL server!
<fw rev>	Revision of modem firmware

Example:

```
> $gsm,info
$GSM,INFO,A,1,mfg=u-blox,model=LEON-G100,imei=357852031917357,
rev=07.40.01
```

12.3.5.3 GSM reset command

\$GSM,RESET

12.3.5.4 GSM connection command

This command allows connecting transparently to the GSM modem.

\$GSM,transp

There is no specific command to exit this mode. To exit the unit must go through a power-cycle.

12.3.6 GPIO Commands

The GPIO configuration can be tested with the GPIO command using HTerm.

The reading command is:

Description	Command	Example
Reading of the GPIO status	\$GPIO,R,function	\$GPIO,R,GEAR

SAFEmine will return the state of the GPIO : '1' or '0' if a digital input is read.

SAFEmine will return the voltage level if IO0 is read

SAFEmine will return: 'voltage * gain + offset' if an analog input is read.

The overriding command is:

Description	Command	Example
Override of a GPIO status.	\$GPIO,R,function	\$GPIO,R,GEAR

\$GPIO,O,function,value_to_assign,time_in_seconds

Example

\$GPIO,O,ALARM,1,7

The command above will switch the alarm signal to 1 for the duration of 7 seconds.

12.3.7 Status messages

12.3.7.1 Internal memory information

Description	Command	Response
Displays stack usage information	\$MEM, STATUS	\$MEM, STATUS, A, STACKSIZE=<total size>, USED=<used>, FREE=<free>

Displayed values:

<total size> Total available stack size
<used> Number of used bytes in the stack
<free> Number of unused bytes in the stack

Example:

\$MEM, STATUS, A, STACKSIZE=4096B, USED=2128B, FREE=1968B

12.3.7.2 Power supply level

Description	Command	Response
Displays the current supply voltage.	\$POWER, STATUS	\$POWER, STATUS, A, <supply voltage>

Displayed values:

<Supply voltage> Supply voltage level in volts

Example:

\$POWER, STATUS, A, 11.97V

12.3.7.3 Radio channel information

Description	Command	Response
Displays radio channel status information. Averages are taken since the last \$RF, STATUS command.	\$RF, STATUS	\$RF, STATUS, A, CD=<cd>, AM=<am>, TX=<tx>, RX=<rx>, Dropped=<dropped> \$RF, STATUS, A, RX=<trx>, DELAY, MIN=<rxmin>, MAX=<rxmax>, AVG=<rxavg>, 5MS=<rx5ms> \$RF, STATUS, A, TX=<ttx>, DELAY, MIN=<txmin>, MAX=<txmax>, AVG=<txavg>, 5MS=<tx5ms>

Displayed values:

<cd> Carrier Detect: percentage of time a carrier signal was detected on the configured channel
<am > Address match: percentage of time the carrier signal could be decoded to a valid RF frame
<tx> Number of sent frames per second
<rx> Number of received frames per second
<dropped> Number of dropped rx-frames per second
<trx> Total of received frames since the last measurement
<rxmin> Minimal delay (in ms) between reception of a frame and further processing

<rxmax>	Maximal delay (in ms) between reception of a frame and further processing
<rxavg>	Average delay (in ms) between reception of a frame and further processing
<rxt>	Length of the tail: percentage of frames that were processed more than 5ms after reception
<ttx>	Total of sent frames since the last measurement
<txmin>	Minimal delay (in ms) between scheduling of a frame and transmission
<txmax>	Maximal delay (in ms) between scheduling of a frame and transmission
<txavg>	Average delay (in ms) between scheduling of a frame and transmission
<txt>	Length of the tail: percentage of frames that were transmit more than 5ms after scheduling

Example:

```
$RF, STATUS, A, CD=0.5%, AM=0.4%, TX=1.0/s, RX=1.0/s, Dropped=0.0/s
$RF, STATUS, A, RX=238878, DELAY, MIN=0, MAX=6073, AVG=2.5, 5MS=1.5%
$RF, STATUS, A, TX=242450, DELAY, MIN=1, MAX=393, AVG=2.2, 5MS=1.1%
```

12.3.7.4 Update status. (SYNC stations only)

Description	Command	Response
Displays current trickle upload status information. This information is also logged, averages are taken since the last log-entry..	\$RFUPDATE, STATUS	\$RFUPDATE, STATUS, A, R=<upload speed>, B=<total>, T=<ticks>

Displayed values:

<upload speed>	Average upload speed in kB/h
<total>	Total Bytes uploaded
<ticks>	Number of milliseconds over which the total and average are taken.

Example:

```
$RFUPDATE, STATUS, A, R=0.0KB/h, B=0B, T=239937.219s
```

12.3.7.5 Interface status

The command below

Description	Command	Response
Displays buffer health information for interfaces RS232, RS485, and GPSIO	\$UART, STATUS, <interface> (or \$UART, STATUS for default serial interface)	\$UART, STATUS, <interface>, A, TxFree=<txFree>, TxCount=<txCount>, TxUsage=<txUsage>, RxFree=<rxFree>, RxCount=<rxCount>, RxUsage=<rxUsage>, RxError=<rxError>

Command values:

<interface> Relevant interface (RS232, RS485, GPSIO)
Null will display default serial interface. Ex: \$UART,STATUS

Displayed values:

<interface> Relevant interface (RS232, RS485, GPSIO)
<txFree> Free bytes in transmit buffer
<txCount> Bytes currently occupied in transmit buffer
<txUsage> Maximum usage of transmit buffer
<rxFree> Free bytes in receive buffer
<rxCount> Bytes currently occupied in receive buffer
<rxUsage> Maximum usage of receive buffer
<rxError> Number of receive errors

Examples:

```
$UART,STATUS,RS232,A,TxFree=511,TxCount=0,TxUsage=511,  
RxFree=510,RxCount=1,RxUsage=20,RxError=0  
$UART,STATUS,GPSIO,A,TxFree=127,TxCount=0,TxUsage=71,  
RxFree=126,RxCount=1,RxUsage=127,RxError=0
```

13 Limitations

- Voice output is only lightly tested and has very limited error handling. This feature may only be used for testing and demonstration, never for operation.
- Distance to obstacles is calculated from the GPS antenna of the vehicle, no vehicle dimensions and antenna locations are considered! This will be improved in future releases.

Appendix A Declaration of conformity

SAFEmine Ltd., CH-6340 Baar, Switzerland, declares that in typical configuration the Hardware Version 1 meets the requirements of the CE Mark.

The radio conforms with the requirements of EN 300 220-3:2000 (Power Class 9). The EMC conforms with EN 301 489-3:2002-08 for a Class 3 SRD Device (equipment type I). It is a Class 1 item of radio equipment as defined by R&TTE Directive. The necessary tests and certification were undertaken by TRAC-KTL, Unit E, South Orbital Trading Park, Hedon Road, Hull, HU9 1NJ, UK.

These documents may be inspected at the premises of SAFEmine Ltd. by arrangement through: info@safe-mine.com

Schwyz, September 2008



Appendix B Specifications (QC 230/235)

Parameter	Conditions ¹	
Dimensions	excl. connectors	81 x 30 x 98 mm
	Overall	81 x 30 x 108 mm
Weight	without cables	210 g
Power Supply	Nominal	12 - 28 VDC
Power Supply Range	min / max	9.5 / 31 VDC
Power Consumption	typical @12 V	< 55 mA
	peak @12 V	< 180 mA
	standby @12 V	< 35 mA
Processor		ARM7, 32bit @ 60 MHz
GPS		50 channel GPS L1, ISO/TS 16949 qualified, GALILEO ready
Time to operation after power-up	Typical	50 s
Time to operation from "hot" standby	Max	2 s
Traffic alert range	Typical	500m
Maximum number of moving units in range	Typical	50
Direction of Targets Updated	Typical	4 Hz
Average Latency	Typical	250 ms
Operating Conditions ²		
Operating temperature		-40°C to +60°C ³
Storage temperature		-40°C to +60°C ³
Humidity		85%, non condensing
Vibration		IEC 68-2-6 10-500 Hz; 2 hours/axis; 5g
Shock	no function	IEC 68-2-27 30g/11ms (halfsine); 3 Shock/axis
Protection rating	IEC 60529	IP54
Connectors		
Power		M12, male, 8 contacts (IP67)

¹ All specification are at an ambient temperature of 25°C.

² Operation beyond the "Operating Conditions" is not recommended and exposure beyond the "Operating Conditions" may affect device reliability.

³ SAFEmine devices are designed to run at 85°C. For operator safety reasons the device must not be run at temperatures above 60°C

GPS		SMA Female, color coded
RF		SMA Female, color coded
Remote Display		M8, female, 4 contacts (IP67)

Appendix C Specifications (QC240/QC220)

Parameter	Conditions ¹	
Dimensions	excl. connectors	81 x 30 x 126 mm
Weight	excl cables	260 g
Power Supply	Nominal	12 to 28 VDC
Power Consumption (@ 12 V)	typical	< 100 mA
Processor		ARM7, 32bit @ 60 MHz
GPS		50 channel GPS L1, ISO/TS 16949 qualified, GALILEO ready
GSM		GSM 850/900/1800/1900 MHz GPRS Class 10
	Sensitivity (@ 25°C)	-110 dBm (typ) @ 850/900
		-109 dBm (typ) @ 1800/1900
Traffic alert range	Typical	500m (1/3 mile)
Refresh Rate	Typical	4 Hz
Traffic alert range	Typical	500m
Operating temperature		-40°C to +60°C ²
Humidity		95%, non condensing
Protection rating	IEC 60529	IP54

¹ All specification are at an ambient temperature of 25°C.

² SAFEmine devices are designed to run at 85°C. For operator safety reasons the device must not be run at temperatures above 60°C

Appendix D Specifications (QC250)

Parameter	Conditions ¹	
Dimensions	excl. connectors	81 x 30 x 126 mm ³ (3.2 x 1.2 x 5.0 in ³)
Weight	excl cables	260 g (0.57lb)
Power Supply	Nominal	12 to 28 VDC
Power Consumption (@ 12 V)	typical	< 80 mA
	Max peak	< 150 mA
	Max standby	< 40 mA
Input/Output	Digital	3x, configurable
Input	Digital	2x, low < 2.2V, high > 8.7V
Processor	Analog	2x, 0 to 24V
GPS		50 channel GPS L1, ISO/TS 16949 qualified, GALILEO ready
WiFi	Network standard	IEEE 802.11 b/g/n
	Frequency band	2.412 GHz – 2.484 GHz
	Security	802.11i (AES, TKIP, WPA, WPA 2)
	Typ. Transmit power	17dBm @ 1 Mbps, 15 dBm for 802.11 g/n
	Sensitivity	-97dBm @ 1 Mbps to -71 dBm @ 65 Mbps
	Data rates	802.11n: 65 Mbps; OFDM: 6,9,12,18,24,36,48,54 Mbps
Traffic alert range	Typical	500m (1/3 mile)
Refresh Rate	Typical	4 Hz
Traffic alert range	Typical	500m
Operating temperature		-40°C to +60°C ²
Humidity		95%, non condensing
Protection rating	IEC 60529	IP54

¹ All specification are at an ambient temperature of 25°C.

² SAFEmine devices are designed to run at 85°C. For operator safety reasons the device must not be run at temperatures above 60°C

Appendix E Specifications (QD 200: Remote display)

Parameter	Conditions	
Dimensions	excl. connectors	80 x 30 x 20 mm ³
	Overall	80 x 30 x 30 mm ³
Weight	without cables	60 g
Power Supply		from Transceiver CG1-S
Connector		M8, male, 4 contacts (IP67)
Operating temperature		-40°C to +85°C
Storage temperature		-40°C to +85°C
Vibration		IEC 68-2-6 10-500 Hz; 2 hours/axis; 5g
Shock		IEC 68-2-27 30g/11ms (halfsine) 3 Shock/axis; no function
Protection rating		IP54
Construction		Anodized aluminum with plastic end-bezels, all connectors on the back side.
Max length of cable (QD221)		15 meters

Appendix F Specifications (QD204: Scope Screen)

Parameter	Conditions	
Dimensions	excl. connectors	167 x 90 x 37 mm ³ (6.6 x 3.5 x 1.5 in ³)
Weight	without cables	460 g (1.0 lb)
Power Supply	Nominal	6 to 32 VDC
Power Consumption (@12V)	Typical	< 400mA
Screen resolution		480x 272 TFT color WQVGA LCD
Screen size		109mm (4.3 in) diagonal
Screen brightness		600 nits
Screen type		Analog resistive
Mount		Standard 'RAM' mount
Operating temperature		-40°C to +70°C (-4°F to + 160°F)
Humidity	Max	95%. Non-condensing
Accessories		IEC 68-2-6 10-500 Hz; 2 hours/axis; 5g
Remote Display Cable		Remote display cable QD221
Options		
Various FW options		

Appendix G Recommended parts

These parts have been tested by SAFEmine and allow an installation with highest reliability.

Please consult with SAFEmine before substituting with non-listed parts

- **3M "Dual Lock"**

Type 3550 / 51 / 52

- **Heat shrink tubing**

HellermannTyton HISA-9/3-PEX-BK

- **Self-Fusing Silicone Rubber Electrical Tape**

3M Scotch® 70

- **Braided Sleeving**

Polyamide

HellermannTyton TMEGA10MM

Clean Cut PET Expandable Sleeving

Techflex CCP0.50

- **Low loss 50Ohm coaxial cable**

RF-195 / LMR-195 / HDF195 / CFD 195 / LMR-200 /
LMR 400 (for more details consult chapter '4.5 Antenna cables')

- **SMA connectors**

SMA connectors, crimp and strip tools are specific to the cable type. Information below is for the HDF195 cable.

Male: Wellshow P/N C01AA31058A04A

Female: Wellshow P/N C02AA31058A12

Crimp tool: .213 Hex

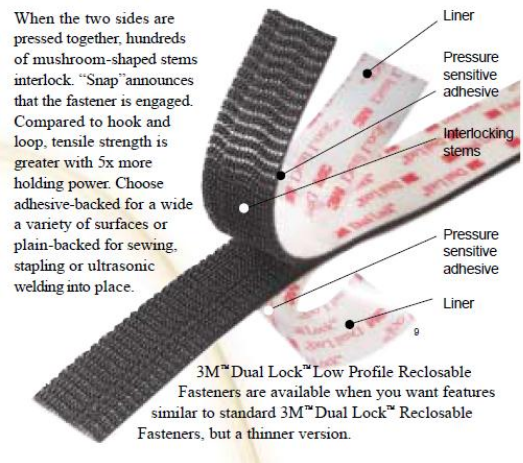
Strip tool: Paladin CST Vario 3-Stage Coax Cable Stripper

Solder - .5mm or 23 gauge 60/40 Rosin Core

- **Small Torch**

For shrink tubing

3M™ Dual Lock™ Reclosable Fasteners family for hundreds of closures with greater holding power



Appendix H Configuration example for areas

```
...
...

% area settings:

[areatype] % parking place
name       = parking
maxspeed   = 30
distfar    = 40
distnear   = 20
distclose  = 10

[areatype] % haul truck garage
name       = htgarage
maxspeed   = 20

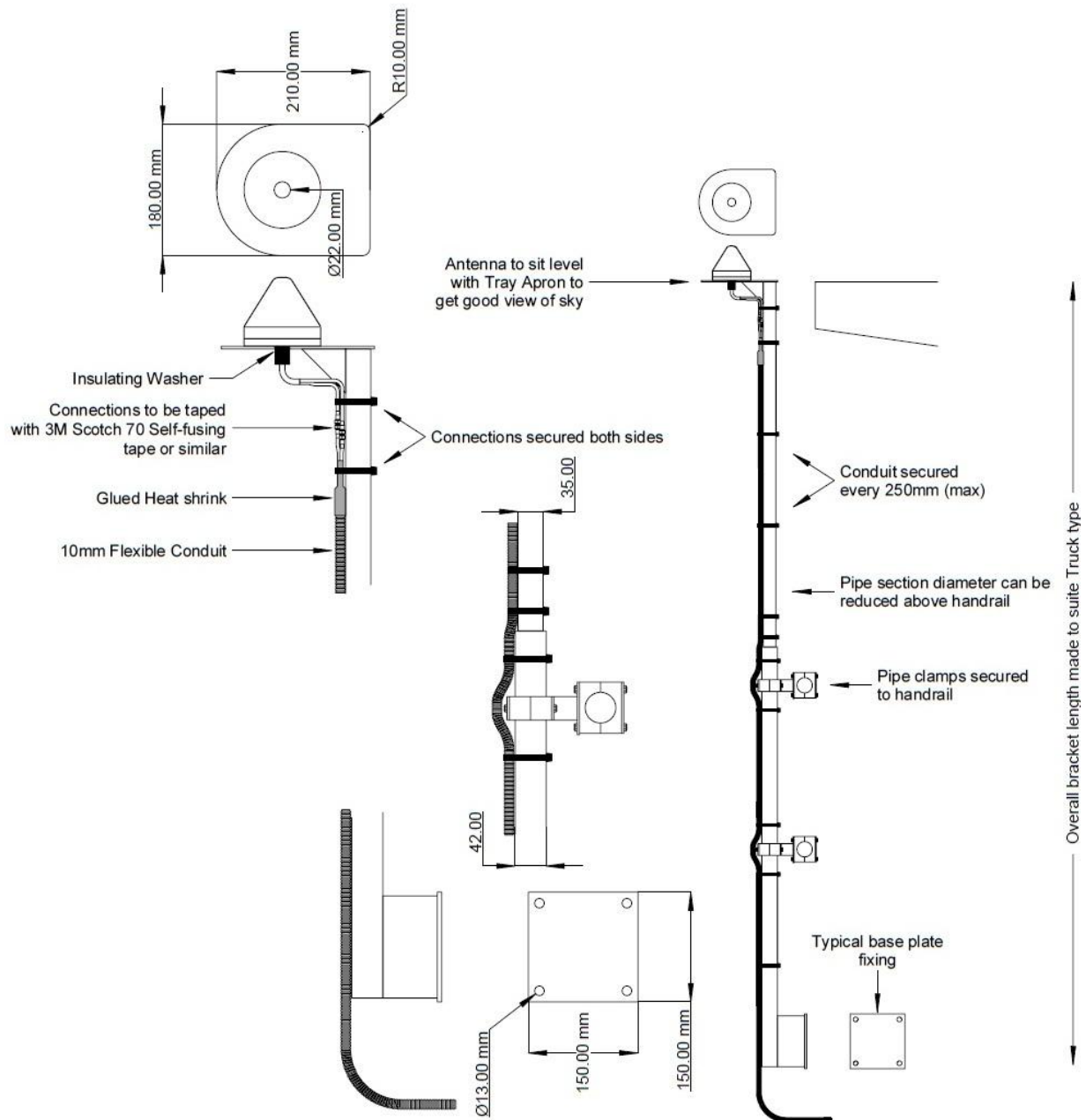
[area] % parking place 1
type       = parking
coord      = 47.0010n;-8.0010w % -8.0010w is equal to 8.0010e
coord      = 47.0020n;-8.0010w
coord      = 47.0020n;-7.9990w
coord      = 47.0010n;-7.9990w
volume     = 10

[area] % area with special distance settings
coord      = 8.0010e;47.0030n % switching the order of n and e is
allowed
coord      = 8.0010e;47.0040n
coord      = 7.9990e;47.0040n
coord      = 7.9990e;47.0030n
distfar    = 150
distnear   = 100
distclose  = 50

[area] % haul truck garage 1
coord      = 47.0050N;8.0010E % upper case N and E are allowed
coord      = 47.0060N;8.0010E
coord      = 47.0060N;7.9990E
coord      = 47.0050N;7.9990E
type       = htgarage
```

Appendix I Additional figures and drawings

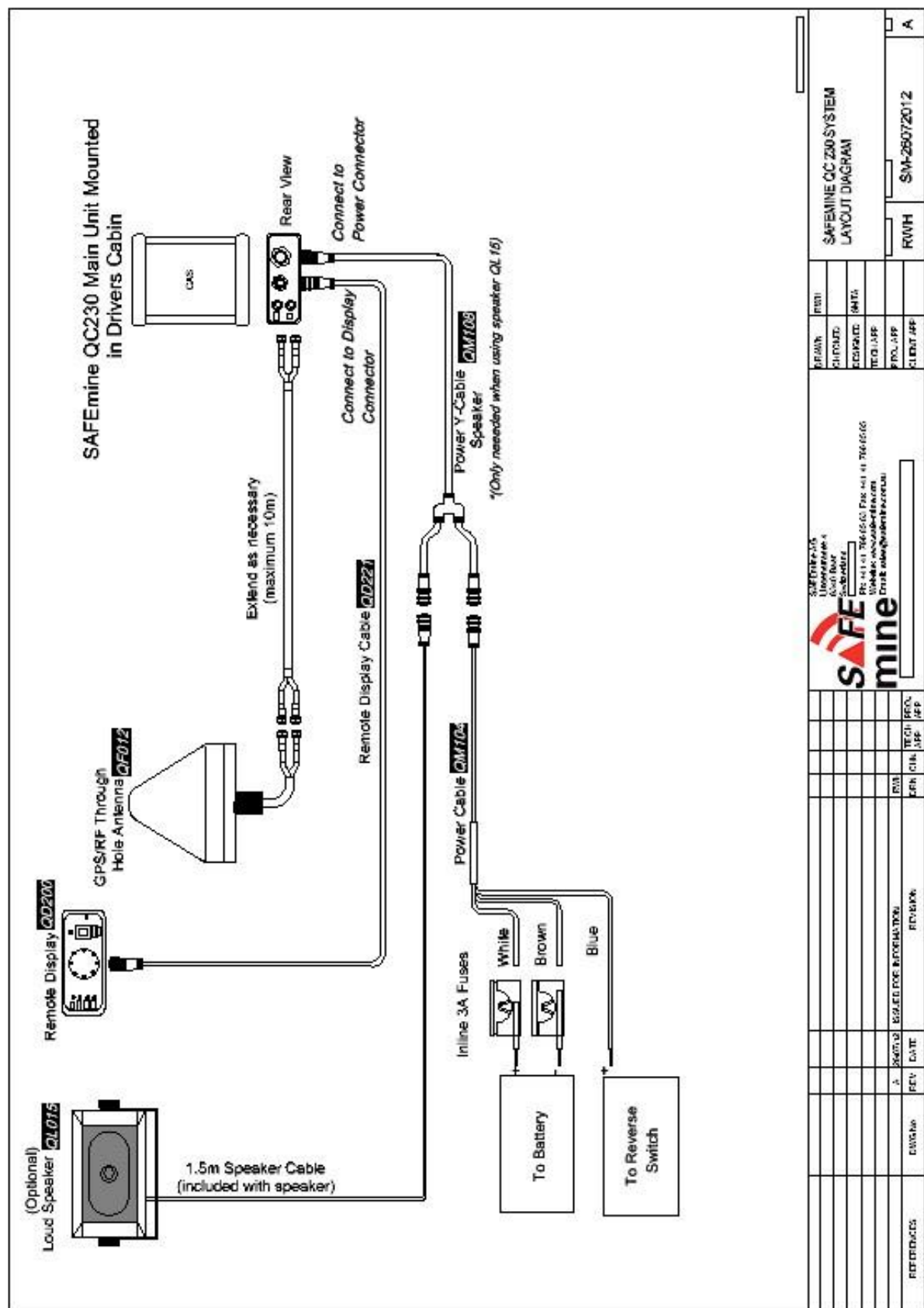
Antenna Pole



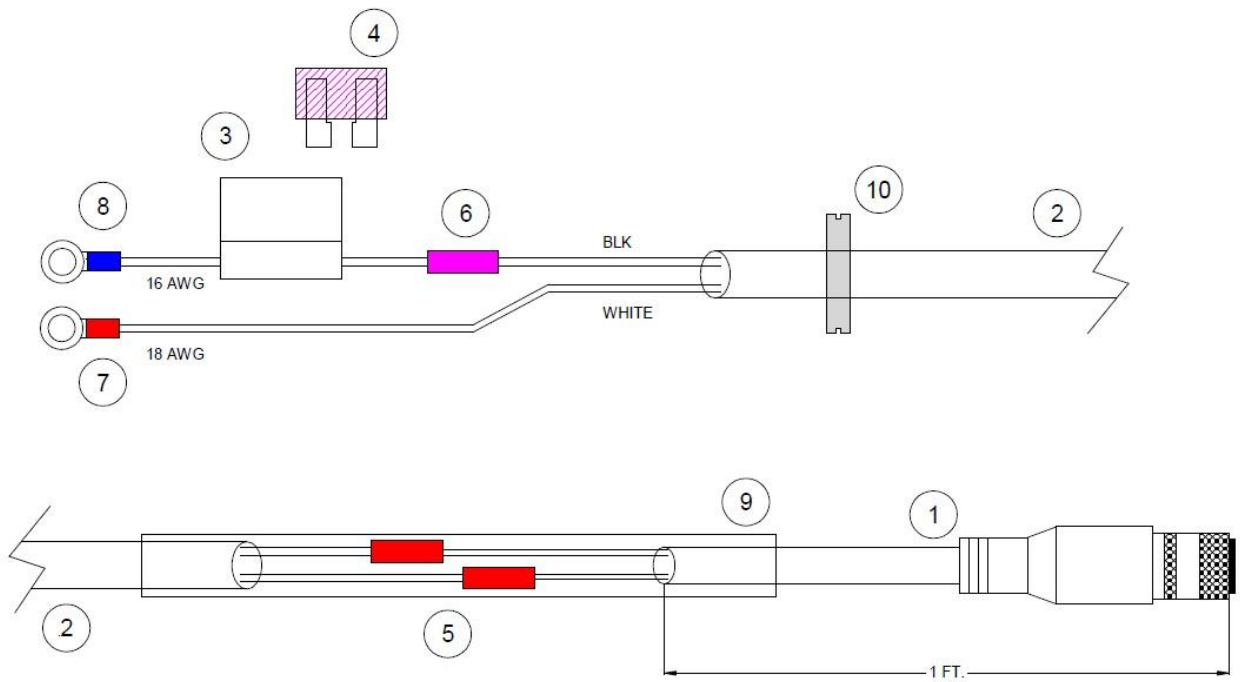
Minimum steel pole wall thickness is 2.5mm for lower section, 2mm above

Rubber pipe clamps are highly recommended, e.g. Stauff (www.stauffusa.com)

Typical installation



Battery Cable



NOTES

1. Optional Grommet (item 10) requires a 27/32 inch. drill

Appendix J Installation Checklist

DATE:	VEHICLE MODEL:
SITE:	VEHICLE ID:
TECHNICIAN:	SAFEMINE MAIN UNIT:
ANTENNA TYPE :	MAIN UNIT SERIAL NO:
CONFIG FILE RECEIVED FROM:	

	PARAMETERS	YES	NO	COMMENT
MAIN DEVICE	INSULATED FROM GROUND			
	TWO 2 AMP FUSES ON POWER CABLE			
	FIRMWARE UPLOADED			
	CONFIG FILE UPLOADED			
	OTHER FILES UPLOADED			
	SIM CARD STICKER FOR QC240/220			
GPS/RF ANTENNA	FULL VIEW OF SKY			
	INSULATION WASHER			
	GROUND PLANE LARGER THAN ANTENNA			
	MOUNTED AS OTHER IDENTICAL MODELS			
ANTENNA CABLES	CENTER PIN IS CRIMPED			
	BENDING RADIUS IS 5CM OR BIGGER			
	ALL COAXIAL (RF/GPS) CABLE CONNECTIONS ARE WELL COVERED BY ADHESIVE LINED HEAT SHRINK AND/OR SILICONE TAPE			
	CONNECTORS AREN'T TOUCHING AN METAL			
	CABLE CUTTING DISTANCES ARE RESPECTED(11MM & 2,5MM rule)			
	BRAIDED SLEEVE IS PROTECTING THE CABLES			
GSM ANTENNA	5CM AWAY FROM METAL			
	1M AWAY FROM RADIO EQUIPMENT			
	INSTALLED INSIDE CABIN			
	INSTALLED VERTICALLY			

UNEXPECTED EVENTS:

SIGNATURE:

Appendix K Maintenance Checklist

To be performed before vehicle is released

Item		
Date checked		
Responsible		
Configuration technician		
SAFEmine serial number		
Firmware version loaded		
Configuration file loaded		
Vehicle Plant number		
	Initial	Comment
Check cables, abrasion, UV damage		
Visual inspection of housing for damage		
Firmware updated to latest version		
Buzzer (speaker if installed) unobstructed and working		
Ready LED green after <3 minutes (if vehicle is outside)		
Press button (> 5 seconds) for reset -> light, beep, self test		
Driven by test station		

Appendix L User guide for QN555

Preamble

This manual describes the battery equipped unit from SAFEmine. Before the system will be put into operation read this manual carefully.

Important Information

- Do not ship the unit with fully charged batteries. See chapter “
-
- Transportation/Shipping of the **Unit**” for more details how to ship the unit.
- The batteries must be switched OFF for shipping.
- The disposal of the batteries must be handled under the local valid regulations or via SAFEmine. The battery harms the environment if improperly disposed.

Transportation/Shipping of the Unit

The Unit is equipped with rechargeable batteries (NiMH-Accumulators).

For safety reasons the batteries of the Unit **MUST** be discharged for shipping. This ensures battery safety during delivery. The SOC (state of charge) must be below 35%. Inside containers the temperature should be below 35°C. The product holder is responsible for any possible loss/damage during delivery if the conditions above cannot be hold completely.



For safety reasons, the batteries of the Unit **MUST** be discharged for shipping.

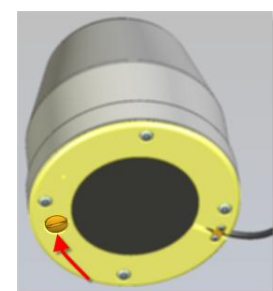
Discharging for shipping

Before shipping the units, switch the system **ON** for 48 hours without charging the Unit. This step discharges the batteries to less than 35% of the full capacity.

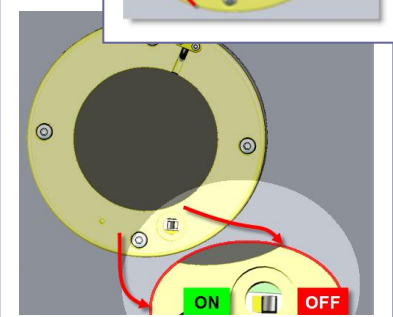
Prepare Unit for shipping:

1. Operate Unit for at least minimum 48 hours to discharge the batteries. This step is a **MUST** and very important for the safety during shipping.
2. Open the screw at the bottom of the unit to access the Power **ON-OFF** Switch under the screw with an appropriate screwdriver or coin. (marked with red arrow in Figure 1).
3. Hold the unit as shown in picture 2 then move the switch to the right

Figure 1:



Figure



side, **OFF-Position**, as marked in Figure 2.

4. Close the Power **ON-OFF** Switch with the screw again.
5. Disconnect the display from the Unit and prepare it appropriate for shipping

Prepare Unit for the first Operation

1. Unpack the unit.
2. Open the screw at the bottom of the unit to access the Power **ON-OFF** Switch under the screw (marked with red arrow in Figure 3).
3. Hold the unit as shown in picture 2 then move the switch to the **LEFT** side (**ON-Position**) as marked in Figure 4.
4. Close the switch with the screw again (Figure 3).

Figure 3: Screw

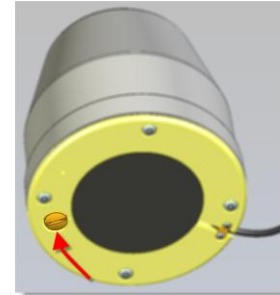
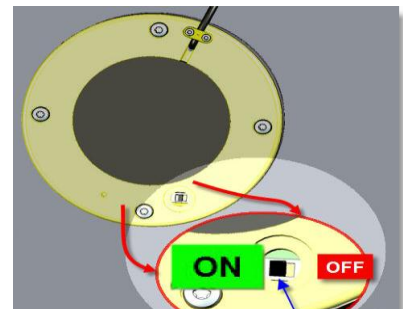


Figure 4: Power ON



5. Connect the display to the Unit for operation (Figure 5: Connect Display and Unit). If the display starts working let the system run until the display switches OFF. Now the

Figure 5: Connect Display and Unit



batteries are ready to be charged.

6. Connect the power supply to the charging connector on the Display. Then connect the power supply to the main-voltage. The display should start working after some seconds.

Charging TIME: 5 hours



Only charging devices and power supplies sourced by SAFEmine are to be used. Connecting the unit to other sources of power for charging or operation may damage the unit and voids warranty.

Technical Data of the Battery-Module		
Parameter	Value	
Voltage	9 .. 12 Volt	
Nominal Capacity	2000 mAh	
End Voltage after Operation	9 Volt	
Chemistry	Ni-MH Battery	
Discharging Current	100mA	
Life Cycles	>= 500 ^(*1)	
Operating temperature for charging	10°C +40°C	
Storage Temperature	-20°C +30°C	
Load Time	5 hours	
End of Life Time	When the operating time of the NI-MH batteries becomes much shorter than its initial operating time even after recharging, it should be replaced with a new set of batteries by SAFEmine.	
*1: under normal conditions (Temp-Range, Charging, Load ..).		
The disposal of chemicals (batteries) is regulated. Please check the regulations or ask your supplier of the Unit.		
	If the following points and precautions are not observed and handled carefully leakage of fluid (electrolyte), heat generation, explosion, fire and serious personal injury could happen.	
	• Never dispose the batteries (Ni-MH) in a fire or heat them up. • Do not connect the (+) positive and (-) negative terminals of Ni-MH batteries with electrically conductive materials together. • Do not transport or store NiMH batteries with their uncovered terminals or connected with a metal necklace or other electrically conductive material. • Charge the batteries using the specific charger which is part of the delivery. • Never disassemble (Ni-MH) batteries. Doing so may cause an internal or external short circuit or result in exposed material of battery reacting chemically with the air. It may generate heat, explosion and fire. It is as well is dangerous as it may cause splashing of alkaline fluid . • Never solder lead wires directly onto the batteries. • The gas release vent which release internal gas is located in the (+) positive terminal of the battery. For this reason, never deform this section or cover or obstruct its gas release structure. • NiMH batteries contain a strong colourless alkaline solution (electrolyte). The alkaline solution is extremely corrosive and will cause skin damage. If any fluid from a NiMH battery comes in contact with user's eyes, they should immediately flush their eyes and wash them thoroughly with clean water from the tap or another source and consult a doctor urgently. The strong alkaline solution can damage eyes and lead to permanent loss of eyesight. • Do not apply water, seawater or other oxidizing reagents to NiMH batteries.	

	as this can cause rust and heat generation. If a battery becomes rusted, the gas release vent may no longer operate, and can result in explosion. • When the operating time of a NI-MH battery becomes much shorter than its initial operating time even after recharging, a trained supplier of the equipment should replace it with a new set of batteries. • Do not use or store the unit at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of a heater. This may cause leakage of battery fluid. It could also impair performance and shorten operating life of NI-MH batteries.
--	--

Appendix M Scope FW update instructions

To update the Scope 1.3.0.1900 firmware:

1. Contact SAFEmine support for the firmware.
2. Rename 'SAFEmine.zup' to 'SAFEmine.zip'
(.zip is used to avoid problems with virus scanners and firewalls)
3. Unzip file and copy entire 'SAFEmine' folder onto top level of USB stick.
4. Slide the stick into the back of the Scope unit
5. Power cycle 'Scope'
6. Upon startup you should see an 'Update' button; select it
7. Click 'OK' on the verification prompt
8. Wait for unit to restart, remove USB stick
9. Verify new version and build number on Scope startup screen

Appendix N FCC compliance



This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The user shall be cautioned that changes/modifications not approved by the responsible party could void the user's authority to operate the equipment.

Appendix O Legal statement

WARNING OF PERSONAL INJURY

As with all traffic awareness and collision avoidance devices, SAFEmine products may not detect all threats within the detection window. SAFEmine products are intended as an additional tool in determining potential traffic threats, supporting an alert and conscientious driver. SAFEmine products are not designed as a substitute for proper safe driving and visual traffic scanning procedures; a vigilant effective lookout is required at all times. SAFEmine products only warn the operator of the presence of other vehicles that are also fitted with SAFEmine products or warn of obstacles that are stored in the internal database. SAFEmine products do not give any guidance on avoiding action. The operator of the vehicle remains fully responsible for operating the vehicle and ensuring the safety of passengers, pedestrians and other traffic. Never use SAFEmine products for applications other than their intended and authorized use. Never use SAFEmine products as emergency stop device or in any other application where failure of the products could result in personal injury. Before installing, handling, using or servicing SAFEmine products, consult the data sheet, manuals and application notes and make yourself thoroughly familiar with the operations and limitations. Failure to comply with these instructions could result in serious injury or death.

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SAFEmine Ltd.'s entire liability and customer's exclusive remedy for SAFEmine products that fail to conform to SAFEmine Ltd.'s limited warranty, shall be, at SAFEmine Ltd.'s sole option, either repair or replacement of the nonconforming products, or, if neither is practicable, a refund of the fees paid by customer to SAFEmine Ltd. for such products. The warranty for the repaired or replaced product is limited to the scope and remaining duration of the original warranty for the nonconforming product.

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If the customer uses SAFEmine products for any unintended or unauthorized application, the customer shall defend, indemnify and hold harmless SAFEmine Ltd. and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SAFEmine Ltd. shall be allegedly negligent with respect to the design or the manufacture of the product.

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