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Author:	AC

Newsteo TRE35 - TRE37 - TRE38
Product Specification

Revision history

Revision	Issue Date	Author	Comments
1.0	October 1st, 2012	AC	First specification.
1.1	October 2nd, 2012		Correction on accelerometer bandwidth
1.2	December 13th 2012	AC	Factory settings
2.0	October 6th, 2014	AC	Adding of 2 new references : TRE37 & TRE38
2.1	October 14th, 2014	FP	Technical add-ons
2.2	November 17th, 2014	AC	Adding of temperature and humidity long term drift and response time for TRE37 and TRE38
2.3	February 10th, 2017	AC	Adding of the detailed casing dimensions

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1   Introduction

This specification describes the operation of the TRE tracker.

Main features:
- Integrated sensors:
  - o TRE35 : 3 axis accelerometer + temperature sensor
  - o TRE37 : 3 axis accelerometer + temperature sensor + humidity sensor
  - o TRE38 : 3 axis accelerometer + temperature sensor + humidity sensor + luminosity sensor
- Measurements time stamped then stored in the Tracker flash memory
- Measurements can be downloaded to a Personal Computer through radio link. The PC has to be equipped with a Newsteo radio bridge (standard RF-to-USB Key) and the RF Monitor software.

	Accelerometer	Temperature	Humidity	Luminosity
TRE35	-16g to +16g on 3 axis	-40°C to 85°C	N.A.	N.A.
TRE37	-16g to +16g on 3 axis	-40°C to 85°C	0…100 % RH	N.A.
TRE38	-16g to +16g on 3 axis	-40°C to 85°C	0…100 % RH	0 to 220 Lux + low lux Opening detector + low lux casing opening detector

2   General TRE operation

The TRE is designed to record shocks suffered by a good during its transportation and climatic data.

It monitors the following parameters:
- Periodically (performed at a fixed frequency, same frequency for all the sensors, defined by the user) :
  - o Tilt (inclination of the product on 3 axis)
  - o Temperature
  - o Humidity (TRE37, TRE38)
  - o Luminosity (TRE38)

- As event occurs :
  - o Shocks: when the acceleration threshold is exceeded on any axis, the event is recorded into the tracker memory : shock intensity and Energy calculation on each axis
  - o Free fall: when a free fall is detected, the product calculates the height of a free fall. The resulting landing shock will be measured and energy integrated as a Shock.
  - o Luminosity (TRE38): when the TRE is that it has been suddenly lighted (from dark to luminous area, or lighted by a lamp. This event is then recorded. The aim is to detect the opening of the box in which the tracker has been put.
  - o Opening of the Tracker (TRE38): when the TRE is opened (access to battery compartment), the TRE38 is able to detect that it has been opened with an internal luminosity sensor.

2.1 *Periodic measurements (tilt, accelerations, temperature, humidity, ambient luminosity)*

The TRE periodically measures the climatic data and the accelerations on its 3 axis to calculate the tilt of the product. The period of this measurement is set by the user, using RF Monitor, before the campaign starts. During the campaign, in record mode all measurements are time stamped.

Measurements are recorded into the tracker memory with the following format:

YEAR	MONTH	DAY	HOUR	MIN	SEC	TEMP (°C)	X(G)	Y(G)	Z(G)	AngleX(°)	AngleY(°)	AngleZ(°)
2009	3	4	10	00	00	28	0	0	0	0	90	−90

Figure 1: Example of tilt measurement

NOTA: tilt and accelerations measurements inform as well the user of proper operation of the tracker during transportation. Upon delivery of transported goods, the user downloads the tracker contents and can check that periodic measurements are present, meaning that the tracker was actually monitoring potential shocks at any time, even if the report does not contain any of them.

2.1.1 TRE35 - Periodic recording
- Temperature
- Acceleration
- Tilt

YEAR	MONTH	DAY	HOUR	MIN	SEC	Ax(G)	Ay(G)	Az(G)	Angle X(°)	Angle Y(°)	Angle Z(°)	Temp (°C)
2014	10	6	15	16	22	−0.008	0.984	−0.055	−179.552	100.142	−3.135	26.52

Figure 2: Example of TRE35 periodic measurement

2.1.2 TRE37 - Periodic recording
- Temperature
- Humidity
- Acceleration
- Tilt

YEAR	MONTH	DAY	HOUR	MIN	SEC
2014	10	6	15	16	22

Ax(G)	Ay(G)	Az(G)	AngleX(°)	AngleY(°)	AngleZ(°)	Temperature(°C)	Humidity(%)
−0.008	0.984	−0.055	−179.552	100.142	−3.135	26.52	45.5

2.1.3 TRE38 - Periodic recording

- Temperature
- Humidity
- Luminosity
- Acceleration
- Tilt

YEAR	MONTH	DAY	HOUR	MIN	SEC
2014	10	6	15	16	22

Ax(G)	Ay(G)	Az(G)	AngleX(°)	AngleY(°)	AngleZ(°)
-0.008	0.984	-0.055	-179.552	100.142	-3.135

Temperature(°C)	Humidity(%)	Luminosity	Parcel Opening()	TRE Opening()
26.52	45.5	29.4	1	1

2.2 Shock measurement

This measurement is done by the internal 3 axis accelerometer. The measurement unit is the g (unitary gravitation).

The accelerometer sensor is constantly scanning at 3200Hz which guarantees that no shock can be missed. Once the user-defined threshold is exceeded, the following data are stored:

- Maximum shock level reached on each axis(g) and norm of the shock (g)
- Duration of the shock (ms)
- Energy on each axis (J / kg) and magnitude of the maximal acceleration vector (g)
- Current climatic data (depending on the TRE reference)

YEAR	MONTH	DAY	HOUR	MIN	SEC	TEMP	XMAX(G)	YMAX(G)	ZMAX(G)	Shock duration (ms)	Shock norm(G)	Ex(J/Kg)	Ey(J/Kg)	Ez(J/Kg)	Energy norm(J/Kg)
2009	3	4	10	52	48	28	8,1	7,6	6,575	1750	12,907	1650,1	884,744	1650,1	2495,682

Figure 3: Example of shock measurement

2.2.1 Earth's gravity

The 1g of earth gravity is kept and displayed on RF Monitor when the TRE is displayed in "Live mode". If a shock occurs, the firmware (embedded program of the product) cancels the 1g earth's gravity. It means that the threshold set on the shock is the same on the 3 axis; it is independent from the gravity, and then independent from the direction of fixing it on the good.

2.2.2 Scheme of the shock storage

NOTA: if the acceleration threshold is set at a too low level (example 1.5g), there will be many recorded schlock alerts which will quickly fill the tracker memory. By the way, the user will not get relevant information from this list of empty alerts.

To prevent this situation, the customer should make "shock tests" in live mode, with the TRE screwed in the final container, to determine a relevant threshold that should be used for long campaigns.
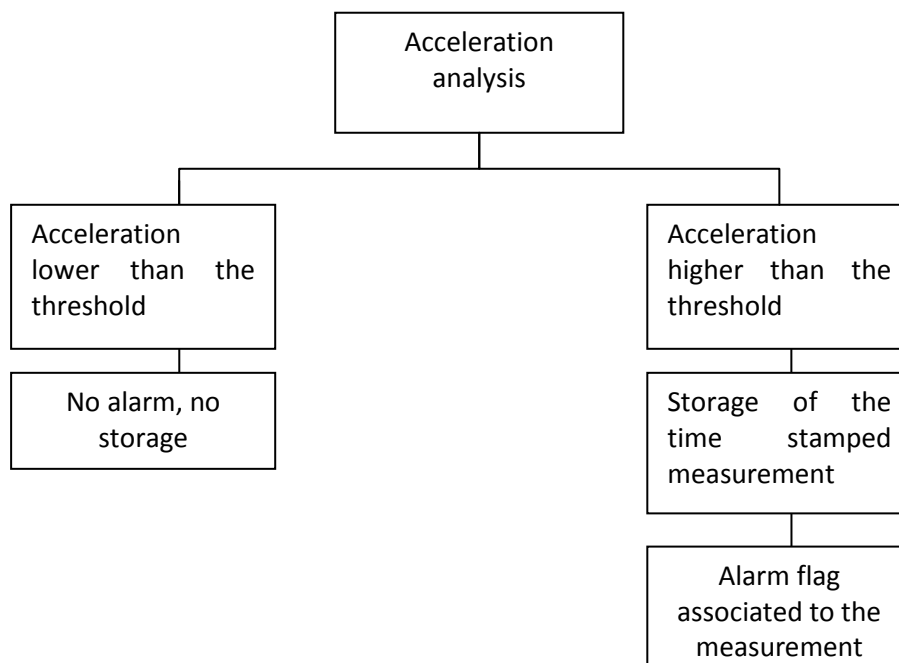
```
                    ┌─────────────────┐
                    │   Acceleration  │
                    │     analysis    │
                    └────────┬────────┘
              ┌──────────────┴──────────────┐
    ┌─────────────────┐            ┌─────────────────┐
    │  Acceleration   │            │  Acceleration   │
    │  lower than the │            │  higher than the│
    │  threshold      │            │  threshold      │
    └────────┬────────┘            └────────┬────────┘
    ┌─────────────────┐            ┌─────────────────┐
    │  No alarm, no   │            │  Storage of the │
    │  storage        │            │  time  stamped  │
    │                 │            │  measurement    │
    └─────────────────┘            └────────┬────────┘
                                   ┌─────────────────┐
                                   │   Alarm flag    │
                                   │ associated to the│
                                   │  measurement    │
                                   └─────────────────┘
```

Figure 4: Scheme of the shock storage

2.3 Free fall measurement

This measurement is done by the same 3 axis accelerometer. The measurement unit is the centimetre. During the duration of a free fall, the accelerometer detects "no acceleration". This duration enables the TRE to calculate the height of this free fall[1], assuming that the starting velocity is almost null.

2.4 Product settings

2.4.1 Operation modes

The product has two modes of operation:

- **Live / Record** (like a video recorder):
    - **This is the default recommended mode for TRE**
    - **In live mode, the user can "play with the product" and see measurements**
    - **Before sending the product for its campaign, the user activates the RECORD mode**
    - When record is activated, the TRE records the measurements in its memory.
    - During RECORD mode, the TRE is sending PRESENCE packets every minute, so the user can see the product on RF Monitor and send commands.
    - When the campaign is ended, the user stops the RECORD, and the product is back in live mode, sending measurements every 10s for example,
    - The user can download on the PC all the stored measurements when he asks.

Remark: in Record mode, the TRE sends a radio presence packet every minute. It allows detecting it on RF Monitor. It is also possible to start the record campaign in *silent mode*. Then, the TRE doesn't send any radio packet as soon as it starts recording.

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[1] White Paper available on demand

The Silent mode shall be used if a complete absence of radio transmission is needed (Ex: during air transportation). At the end of the recording period, to download the data, it is necessary in this case to use the function "*Find products in silent mode*" on RF Monitor in order to stop recording.

- **Monitoring** (real time monitoring applications):
    - The TRE sends in real time its measurements to the PC. If a measurement is not received by the PC, it stores it inside its internal memory and sends it to the PC on the next communication opportunity.

Changing the mode requires a PC with RF-to-USB Key and RF Monitor to send commands.

2.4.2 Settings

Configuration of the product must be done in Live mode or in Monitoring mode. The user has to set:
1. The Shock threshold (in g). An alarm will be recorded if an acceleration, on any one axis, is greater than this threshold.
2. The temperature thresholds (in °C). An alarm will be recorded if a measurement is smaller or greater than those thresholds
3. The humidity thresholds (in %), for TRE37 & TRE38. An alarm will be recorded if a measurement is smaller or greater than those thresholds
4. The periodic record frequency (From 1 minute up to 4 hours)
5. Set the tracker's time**. GMT time is recommended for international transportation. It is essential to set it**.

Other remarks

Only measurements that have already been downloaded to a PC can be removed.
When the memory is full, the Tracker stops recording to be sure not to erase the beginning of the campaign. In fact, the risk of losing parcels is higher at the end of transportation than at the departure.
Before starting a new campaign it is recommended to delete the measurements already stored (if any) in the Tracker.

2.4.3 Factory settings

The product is delivered in Record mode, in hibernation status.
The user has to sweep the magnet on the product, following a starting procedure (described below)
Factory record period:
- Record period : 15 min
- Live period: 10 seconds (to pass in Live period, the user has to stop the recording, through RF Monitor).

2.5 *Product start-up procedure*

The product is delivered with batteries inside, in hibernate mode.
To start the product, the user has to sweep 3 times a magnet on it and to check that the LED is properly blinking:
- First time the magnet is swept: the LED blinks red
- Second time : orange
- Third time : green

Then the TRE starts a recoding campaign.

If you stop this procedure at any step before the led signal, then the TRE will go back in hibernate mode.

2.6   LED status and indications

2.6.1 At product start up

See § *2.5 Product start-up.*

2.6.2 During operation

The LED blinks every minute and gives the status of the alert level:
- The product has never been on alert: blinks GREEN, one time
- The product is in alarm or has been in alarm since the last time the measurements have been downloaded on PC: blinks RED, one time

To avoid waiting 1 minute, the user can also sweep a magnet on the product to get an immediate status:
- The product has never been on alert: blinks GREEN, 5 times
- The product is in alarm : blinks RED, 5 times
- The product has been in alarm since the last time the measurements have been downloaded on PC, but is not in alarm anymore: blinks RED, 2 times

The status of the LED will be reset when the user will have downloaded the data.

2.7   Memory download

When the TRE is in LIVE mode or RECORD mode, the user can download the memory content, using the RF-to-USB KEY and RFMonitor software.

1. Click on Download on the RF Monitor software
2. All the measurements are then downloaded and available:
   a. In the database included in RF Monitor. It is then possible to use filters to sort the data.
   b. In a CSV file (compliant with Excel)
   c. In a PDF report

To start a new campaign, it is recommended to delete first the previous data and then to set the Tracker in Record mode.

If the user downloads the data while the TRE is in RECORD mode, then the report will contain intermediate data, and the campaign will go on as soon as the download finishes.

3 Technical characteristics

3.1 *General characteristics*

General characteristics	
RTC	Real Time Clock integrated for measurement time stamping. Resolution: 1s Maximum drift : 2 minutes / month at 25 °C The time is set in production.
Operating temperature range	-40°C to 60°C with lithium batteries, -10°C to +60°C with alkaline Recommended temperature range for maximizing product autonomy: +5°C to +35°C.
Flash memory	16 Mbits Flash meaning 129000 measure blocks (shocks takes 2 blocks) For example, it allows in a single measure campaign of 2 years: - 1 tilt and temperature measure every 15 minutes (70 080 records) - 29 000 shock records
Wireless communication	Operating on the ISM band, Short Range Device This device is designed for European market (uses 868MHz band).
Antenna	Internal antenna
RF range	100 meters in free space
ILS	Magnet sensor for user actions : - wakeup of the product in hibernate mode - take of a measure outside of the frequency measure set

3.2 Physical description

Figure 5: TRE35 picture

Casing				
Colour	Black			
Material	Plastic (ABS), the board is potted with transparent PU resin.			
Casing features	The casing integrates 2 holes for fixation on a wall or inside a parcel.			
Dimensions			Without flanged lid	Flanged lid included
		Length	84,80 mm	110,15 mm
		Width	56,00 mm	56,20 mm
		Height	22,00 mm	26,2 mm
Weight	About 160g (lithium batteries included)			
IP level	IP54			
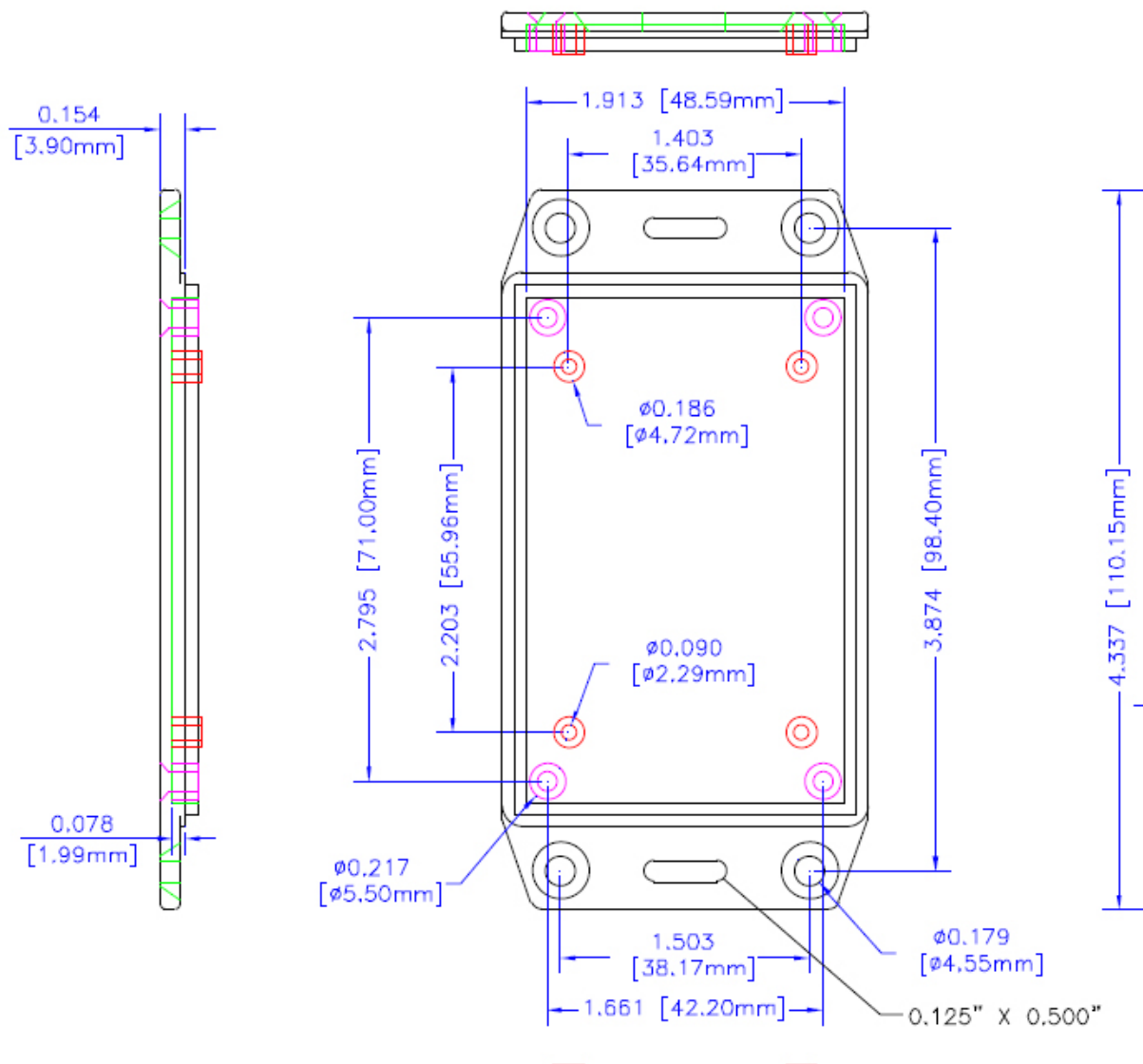
Figure 6: TRE3x dimensions

3.3 Performance of the accelerometer sensor

Accelerometer	
Sensor	1 accelerometer measuring 3 axis (XYZ)
Sensor range	Shock : -16g to +16g on each axis Tilt : -1g to +1g on each axis and corresponding angles
Resolution	14 bits – 3.9 mg
Accuracy at 25°C	± 0,5g from -16g to +16g (without crosstalk) If a shock is over this range, the TRE will clamp to 16g and store this measurement. Magnitude of vector's shock can be up to 22.6g
Noise	65 mg (typical)
Calibration	Calibration done in factory by the manufacturer
Drift of the accuracy	Possible drift of 10 mg / year on each axis for 4 years, not guaranteed after 4 years
Bandwidth	1600 Hz

3.4 TRE35: Performance of the temperature sensor

Temperature	
Sensor	1 temperature sensor
Sensor range	-40°C to 85°C
Accuracy	± 0,3°C from [-30°C … +70°C] ± 1°C from [- 40°C … -30°C] and [+70°C … +85°C]
Resolution	0.1 °C
Calibration	Calibration done in factory by the manufacturer
Long term dift	Smaller than the product resolution for a 4 years period of use
Response time	Less than 10 minutes in a ventilated area (ventilation of 1m/s) About 1 hour in a non-ventilated area

3.5 TRE37 – TRE38: Performance of the temperature and humidity sensor

| General characteristics	
Sensor	1 temperature & humidity sensor
Temperature sensor	Sensor range : -40°C to 85°C Accuracy : ±0.2°C (0 … 60 °C), see below Resolution : 0.015°C Response time t_{63}: < 10 seconds Long term drift: <0.05K / year
Humidity sensor	Sensor range : 0…100 % RH The maximum dew point is brought down to 80°C Dew formation resistant Accuracy @ 23°C : ±1.8% rH (0 ... 80% rH), see below Resolution : 0.03% rH Response time t_{63}: < 10 seconds Long term drift: < 0.5% rH / year
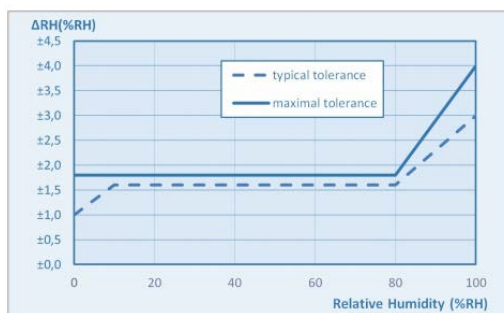
Figure 7: Relative humidity accuracy @ 23°C
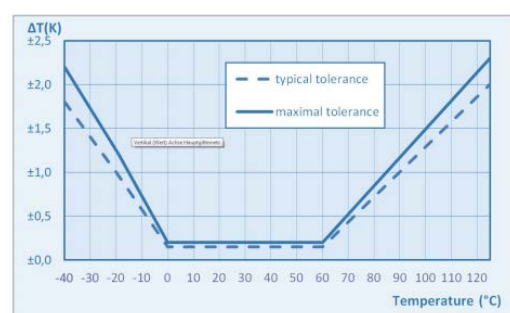
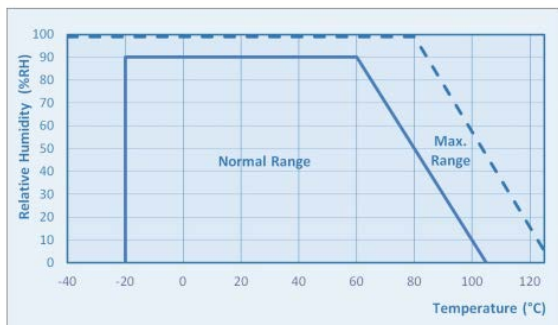**Figure 8: Temperature accuracy**

Figure 9: Operating temperature of the humidity sensor

To obtain a response time and desaturation time the fastest as possible, the sensor is particularly exposed.

Precautions of use:
- The sensor must not be scratched, touched by the finger, scratched with the nail or a tool (even a soft one).
- The sensor must not be subjected to projections of oil, paint or tight products (tars, resins etc.)
- The sensor must not be exposed to sandy winds, projections of muds or undergo deposits.
- The TRE must not be put down on the ground.

In case of spot, some distilled water must be used without sponge.

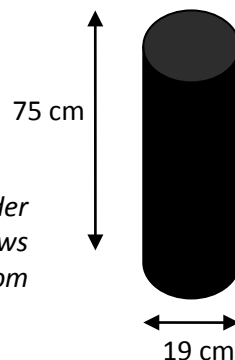## 3.6 TRE38: performance of the luminosity sensor

Light sensor	
Sensor range	0 to 220 Lux
Accuracy	± 30 Lux at 90° of incidence
Resolution	8 bits
Response time	<0,1s
Calibration	See below

Important remark on calibration of the light sensor:
The light sensor has been calibrated in accordance with the following installation:

Ambient Light at 90° of incidence (radiated into the cylinder)

75 cm

Empty cylinder without cover (allows light to enter from top)

At the bottom of the black cylinder, we put the TRK313 and a VOLTCRAFT LUXMETER MS-1300.

19 cm

3.7 Power supply / Autonomy

General characteristics	Wide Temperature	Ambient temperature
Power supply	1 x A size Thionyl Lithium Battery (3.6V) with connector	1 x AA size Alkaline battery (1.5V) in the battery holder
Operating Temp Range	-40 to +60°C (up to 85°C peak but the enclosure can be damaged)	-10°C to + 50°C
Autonomy	At 25°C: almost 2 years	At 25°C : around 1 year
Battery provider	Newsteo	Any provider (supermarket)
User replaceable	Yes, connector to plug	Yes, battery holder, respect polarity

To access the battery compartment, unscrew the 4 back flange lid screws.
After battery exchange, screw softly the flanged lid, and take care to prevent wires from been cut by the enclosure.

The product is delivered with **1 x Thionyl Lithium Battery, type A**, with connector.
The connector allows the battery to be well electrically connected, even if a shock occurs.

The TRE also includes a battery holder, in which a 1.5V **alkaline battery type AA** / LR6 can be put. The use of this battery will not reduce the product's performances, but only the autonomy. It can be useful as this battery type can easily be purchased in supermarkets anywhere.

4 Certifications

Products certified for radio use in Europe, on the frequency of 868 MHz (ISM band, Short Range Device). For use in another area, check with local authorities.