



# **User Documentation Electric Transport Vehicle**

**23<sup>rd</sup> December 2020**

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## 1 INTENDED AUDIENCE

An output of the INDIRES project is user documentation for each of the products produced during the project. However, the status of the various products differs and, for this reason, the intended audience for the *User Documentation* will be different for each product. It is necessary, therefore, to indicate the type of user who will benefit from this particular *User Document*.

The Electric Transport Vehicle described here was fully prototyped and tested in a mine environment. As such, the information provided in this *User Document* could be utilised by end users who have a need for the exact functionality provided by the INDIRES prototypes. Such users can consider the instructions on how to use the Electric Transport Vehicle as definitive. For such users, this User Document provides:

- A description of the vehicle,
- Technical specifications,
- Operating instructions,
- Troubleshooting instructions,
- Directions on transport and maintenance,
- The delivery specification.

End users or developers who want to know more, and perhaps to discuss possible collaborative opportunities, are referred to *Section 10*.

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## 2 INDIRES ETV SPECIFICATIONS

### Dimensions

Length.....	2000mm
Width.....	1200mm
Height.....	800 mm
Ground clearance .....	180mm

### Dimensions of the cargo platform

Length.....	1560mm
Width.....	1200mm
Height (above the ETV).....	40mm

Mass (with/without the platform) ..... 795kg/760kg

Maximum load (at max. inclination/level ground) ..... 200kg/ 600kg

Ingress Protection rating.....IP54

### Speed

Intermediary.....	1.6km/h
Maximum .....	3.3km/h

Working time (max) ..... 40-4 min.  
(dependant on terrain type and load)

### Obstacle crossing

Steps .....	30 mm
Maximum inclination.....	20°
Wading depth.....	30 mm

Range of the remote control (mining conditions) ..... 2 m

Main battery charging time (per battery) ..... h

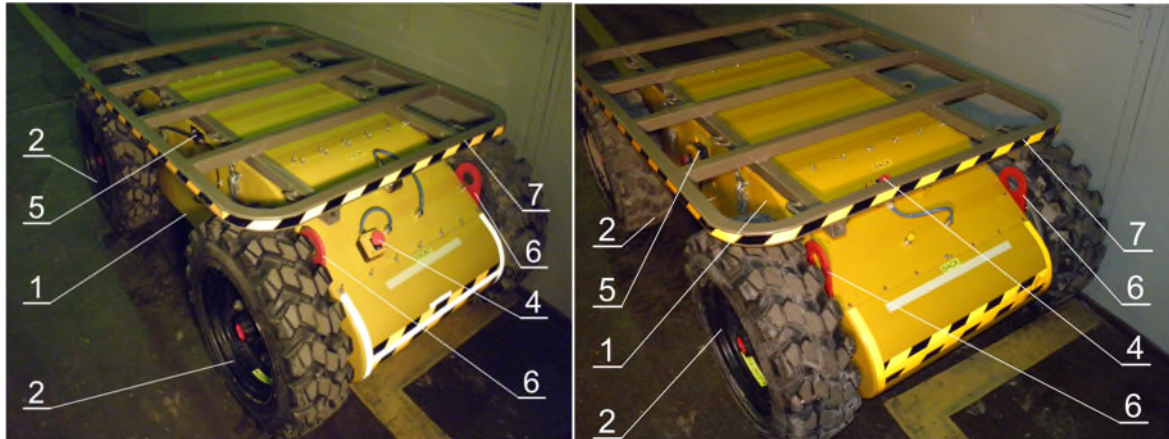
Auxiliary battery charging time (per battery)..... h

Operating temperature..... -20°C to +55°C

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### 3 INDIRES ELECTRIC TRANSPORT VEHICLE DESCRIPTION

INDIRES ETV (*Electrical Transport Vehicle*) is a vehicle designed to transport materials and equipment necessary during rescue operations in underground coal mines. The material is transported on a platform placed on the top cover of the vehicle and attached to its sides. The ETV is shown in *Figure 1*.



*Figure 1 – Overview of ETV*

1 – hull, 2 – driving wheels, 3 – main safety switch, 4 – auxiliary safety switches,  
5 – radio communication antenna, 6 – transport handles, 7 – transport platform.

The Electric Transport Vehicle construction is based on a steel frame, covered with steel plates (1). All the electric and electronic equipment is placed inside the ETV and is accessible by removing the covers. The front and rear covers give access to motor drivers, motors and gearboxes, and should only be removed by trained personnel for service purposes only. The top cover allows access to both main (propulsion) and auxiliary (control) batteries.

The ETV is a wheel-based vehicle, with all-wheel drive, with steel rims and enforced, skid-steer specific tyres (2). The wheels are equipped with free-wheel hubs, allowing for disengagement of the wheels from the gearbox shafts. The wheels are driven by brushless DC (BLDC) motors through a reductive transmission. Each of the motors and their dedicated drivers are powered from a separate, 37VDC, 16Ah Lithium-Polymer rechargeable propulsion battery. The control electronics (main controller, radio transceiver and DC connectors) are powered from four 14V, 4.8Ah Lithium-Polymer auxiliary rechargeable batteries. Both types of batteries are exchangeable, so discharged batteries can be replaced with charged ones.

The ETV is equipped with several safety features. The most important are the emergency stop buttons placed at both ends of the vehicle, and one placed on its side, which doubles as a main power switch. An additional emergency stop button is present on the remote controller. Two other safety features are present – a methane sensor (switching off the propulsion subsystems when the detected concentration is above 2% vol. CH<sub>4</sub>) and radio transceiver safety relays (stopping the vehicle when the remote controller is out of range). All the above features allow for immediate immobilization on the ETV.

The ETV is equipped with transport lugs for the purpose of transporting the ETV by means of lifting or towing. The load is transported on a detachable cargo platform, mounted on top of the ETV. The platform is held in place with four fasteners. The platform is a universal frame construction, but additional, more specialized platforms may be constructed if necessary.

The electric transport vehicle is controlled with a remote control console, equipped with two joysticks, each one controlling motors on one side of the vehicle, brakes engagement/disengagement switch, a directivity selector and an LCD display. Manoeuvring of the vehicle is carried out on the principle of skid steering. This means that, in order to change the path of the vehicle, the wheels on one side of the vehicle rotate with a different direction/speed with respect to the wheels on the other side.

## 4 INDIRES ETV REMOTE CONTROL CONSOLES

The ETV is controlled by radio commands. The control console is used to control and display the status of the vehicle. The appearance of the console is shown in *Figure 2*.



*Figure 2 – Control Console (Remote Control)*

1 – power switch, 2 – console activation button (ON/OFF), 3 – control mode switch, 4 – brake control switch, 5 – joysticks controlling the direction of rotation of the road wheels, 6 – LCD display.

The power switch is used to power on/off the console electronic system. The power is switched on by rotating the switch clockwise (the direction indicated by the arrows on the button). Pressing the button turns off the power.

After the power is switched on, it is possible to start the console. The console is started by pressing the green ON/OFF button (*Figure 2*, item 2).

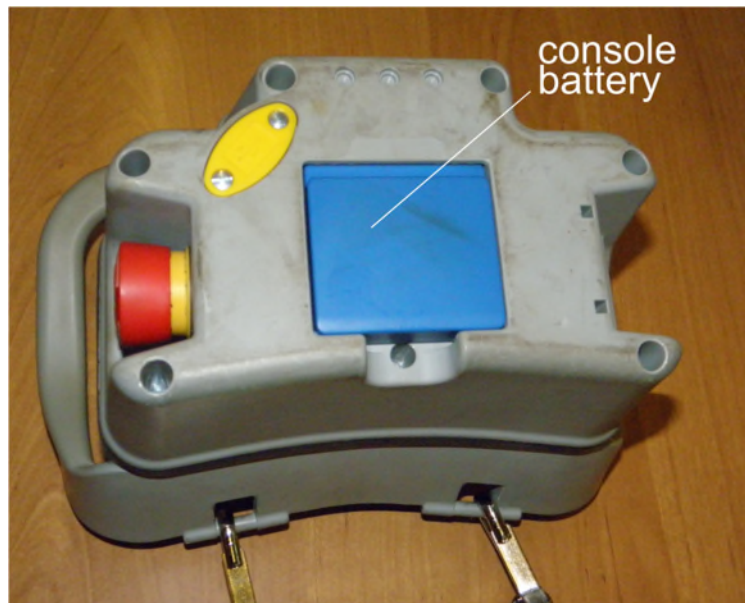
The control joysticks are intended to set the direction of rotation of a pair of wheels located on the same side of the vehicle. The assignment of the joysticks to the side depends on the position of the control mode switch (*Figure 2*, item 3).

The brake control switch is used to release the vehicle's electro-mechanical brakes (BRAKE OFF position) before starting driving, and to mechanically lock the wheel shafts (BRAKE ON position) after finished driving.

Detailed information on the operation of the remote control unit can be found in *Section 5*.

#### 4.1 Console Power

The console is battery powered. The battery is located in a slot on the bottom of the console housing (*Figure 3*).



*Figure 3 – Control Battery*

The battery charge status is shown on the console display (battery symbol). If you find that the battery is discharged, charge it. For this purpose use the charger supplied with the ETV (*Figure 4*).



*Figure 4 – Remote Controller Battery Charger and a Controller Battery*

#### 4.1.1 Remote Console Battery Charging

Charging of the remote controller's battery is performed with use of dedicated battery charger, delivered with the vehicle (Fig. 4).

To charge the battery, first remove it from the remote controller. Connect the charger to a standard 230VAC wall socket. The green LED indicator should turn on. Next, place the battery in the socket on the charger. The charging starts automatically. The red LED indicator will pulse, indicating the charging of the battery. When the LED turns off, the charging of the battery is finished and the battery is ready to use.

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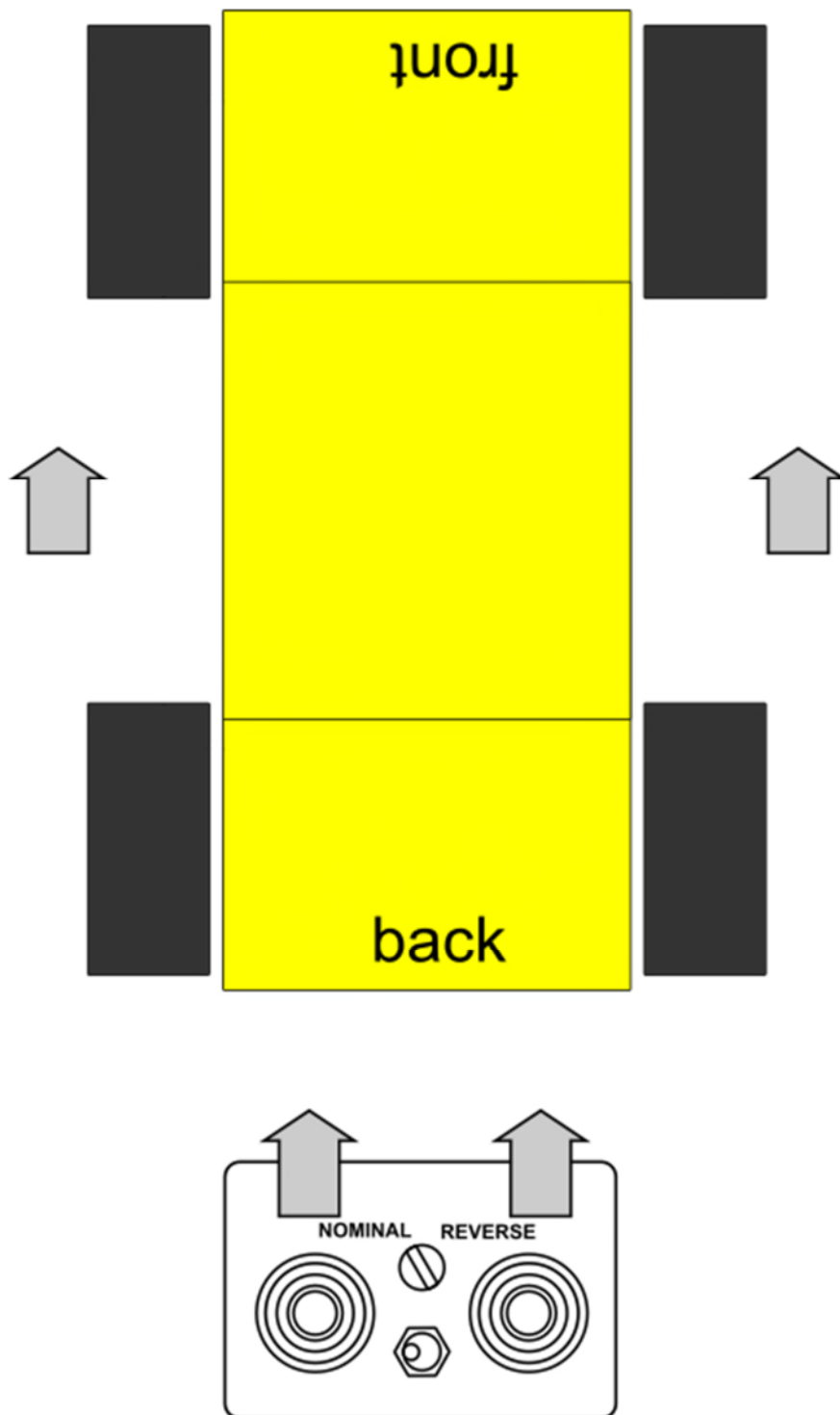
## 5 OPERATING THE INDIRES ELECTRIC TRANSPORT VEHICLE

The INDIRES ETV is generally symmetrical in terms of its exterior, i.e. it does not have a clearly distinguished front and rear. The only difference between the front and rear of the vehicle is the placement of a methane sensor in front. Additionally, there is a radio communication antenna on the right side. For clear distinguishing, “FRONT” and “BACK” are marked on the exterior covers of the ETV.

It is assumed that if the control mode switch is set to NOMINAL and the joysticks are pushed forward, towards the console's LCD (away from the operator) the vehicle moves forward. It is then considered that the right joystick controls the direction of rotation of the wheels of the right side of the vehicle, and the left one the left side. Pushing the joysticks in the opposite direction causes the movement back. In the middle position, the wheels of the vehicle do not rotate and the vehicle does not move.

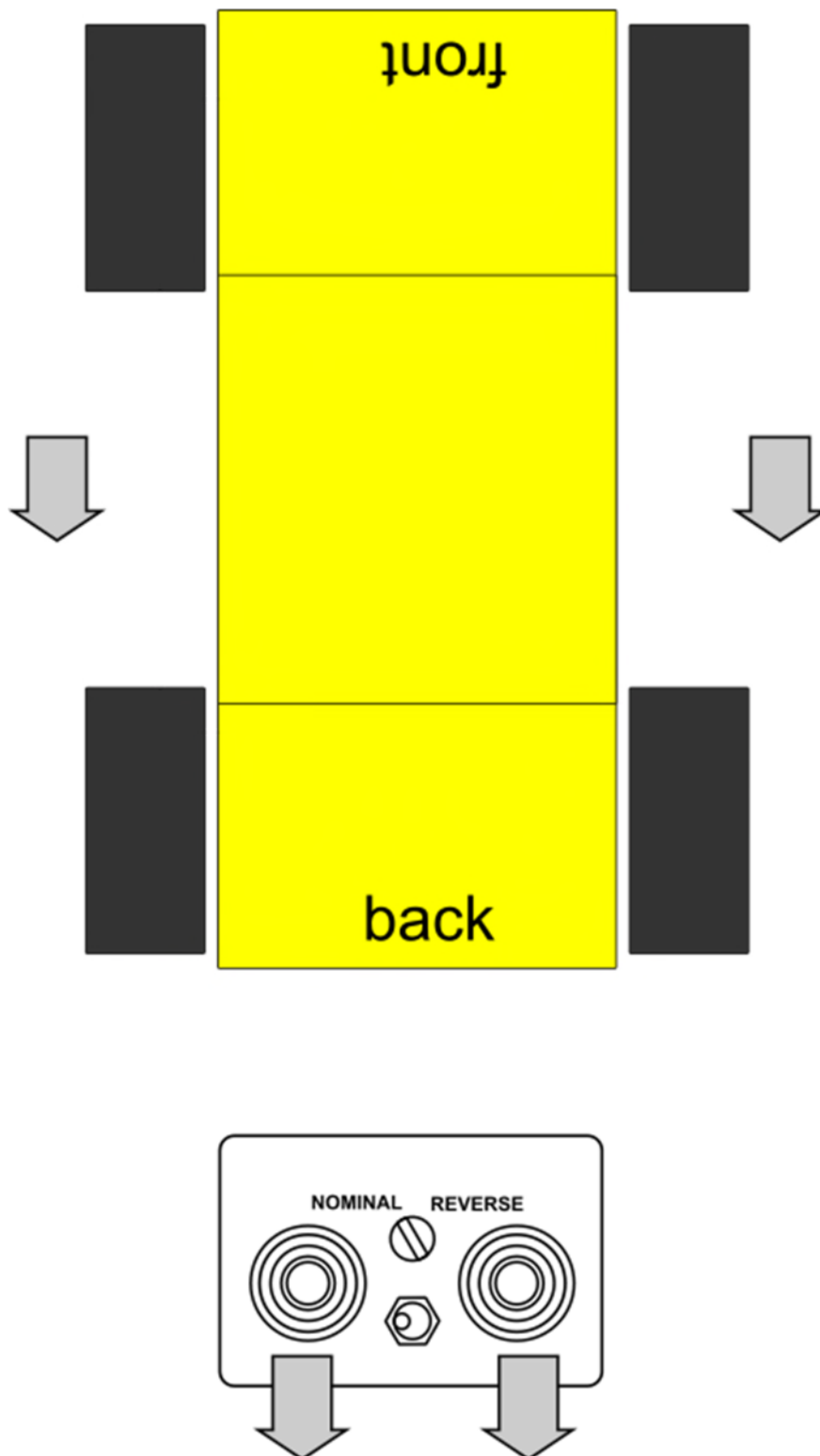
Setting the directivity selector to REVERSE position changes the joystick function, the left joystick controls the right side and the right joystick controls the left side, with direction of wheel rotation reversed. This function makes it easy to control the vehicle when reversing – the direction of the operator's sight and motion of the vehicle remain in accord with relative operation of the joysticks.

Pushing the joysticks forward (away from the operator) in NOMINAL directivity causes motion in the “front” direction of the ETV (*Figure 5*).



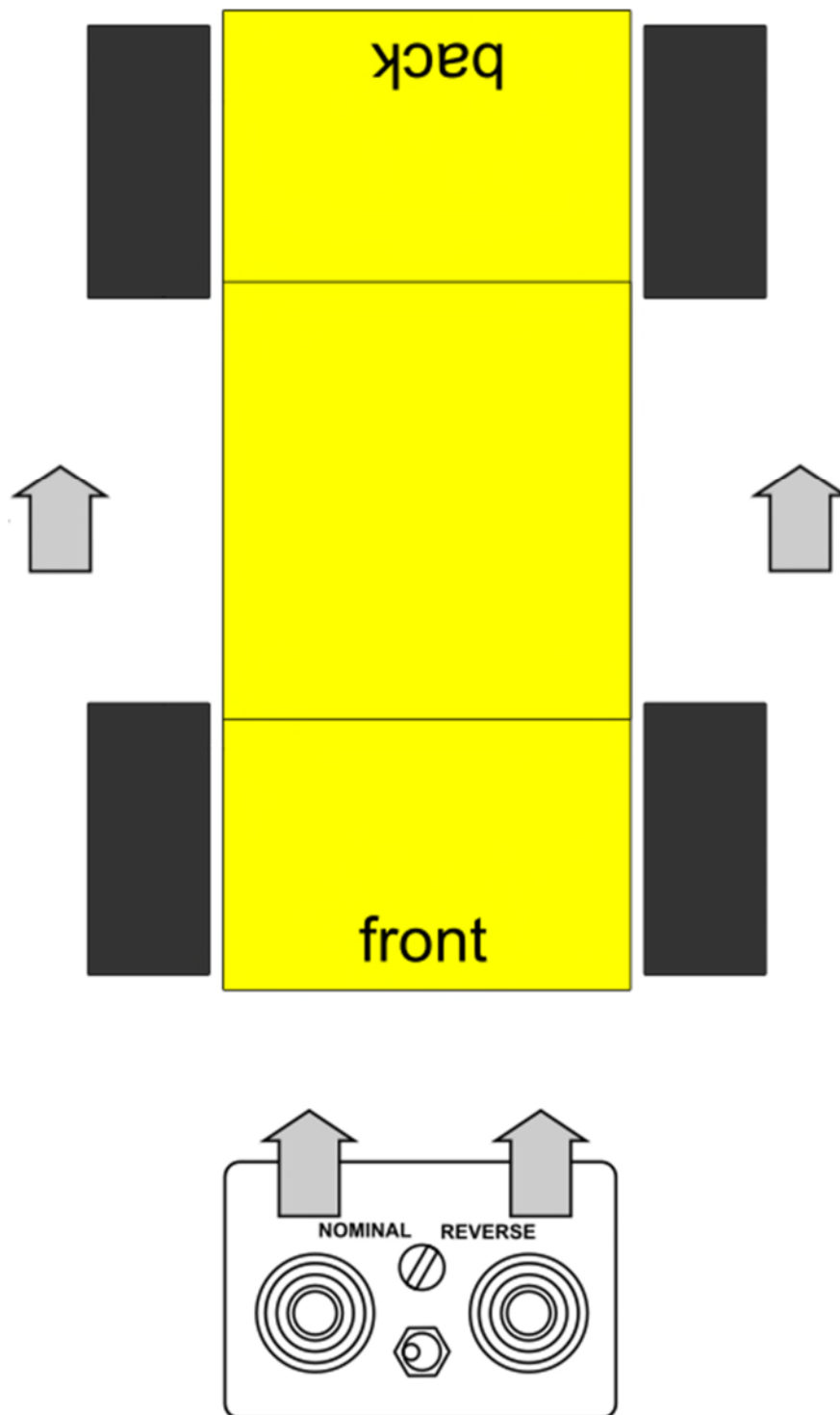
*Figure 5 – Moving the ETV Forward, NOMINAL Directivity*

Pushing the joysticks backwards (towards the operator) in NOMINAL directivity causes motion in the “back” direction of the ETV (*Figure 6*).



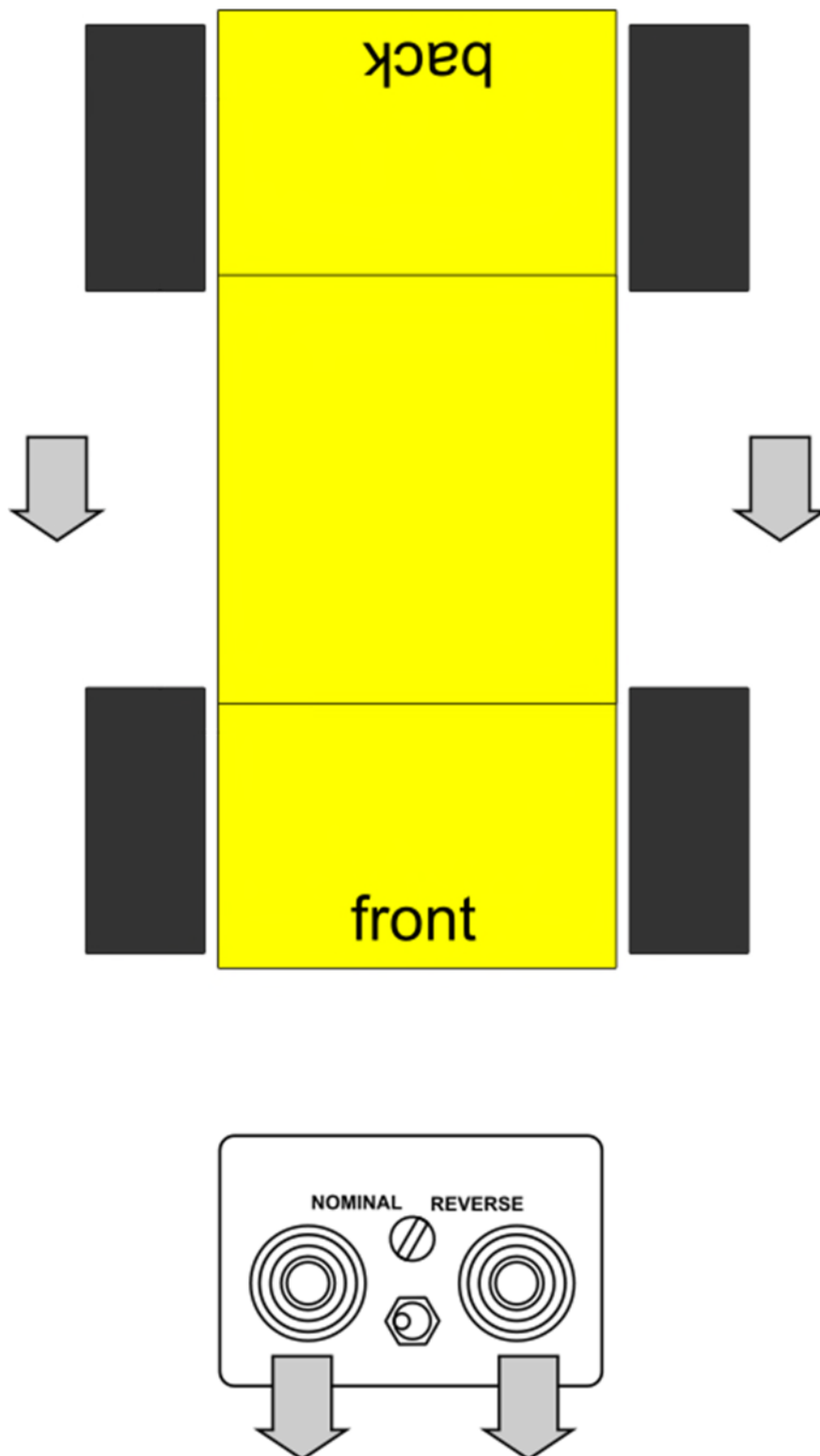
*Figure 6 – Moving the ETV Backward, NOMINAL Directivity*

Pushing the joysticks forward (away from the operator) in REVERSE directivity causes motion in the “back” direction of the ETV (*Figure 7*).



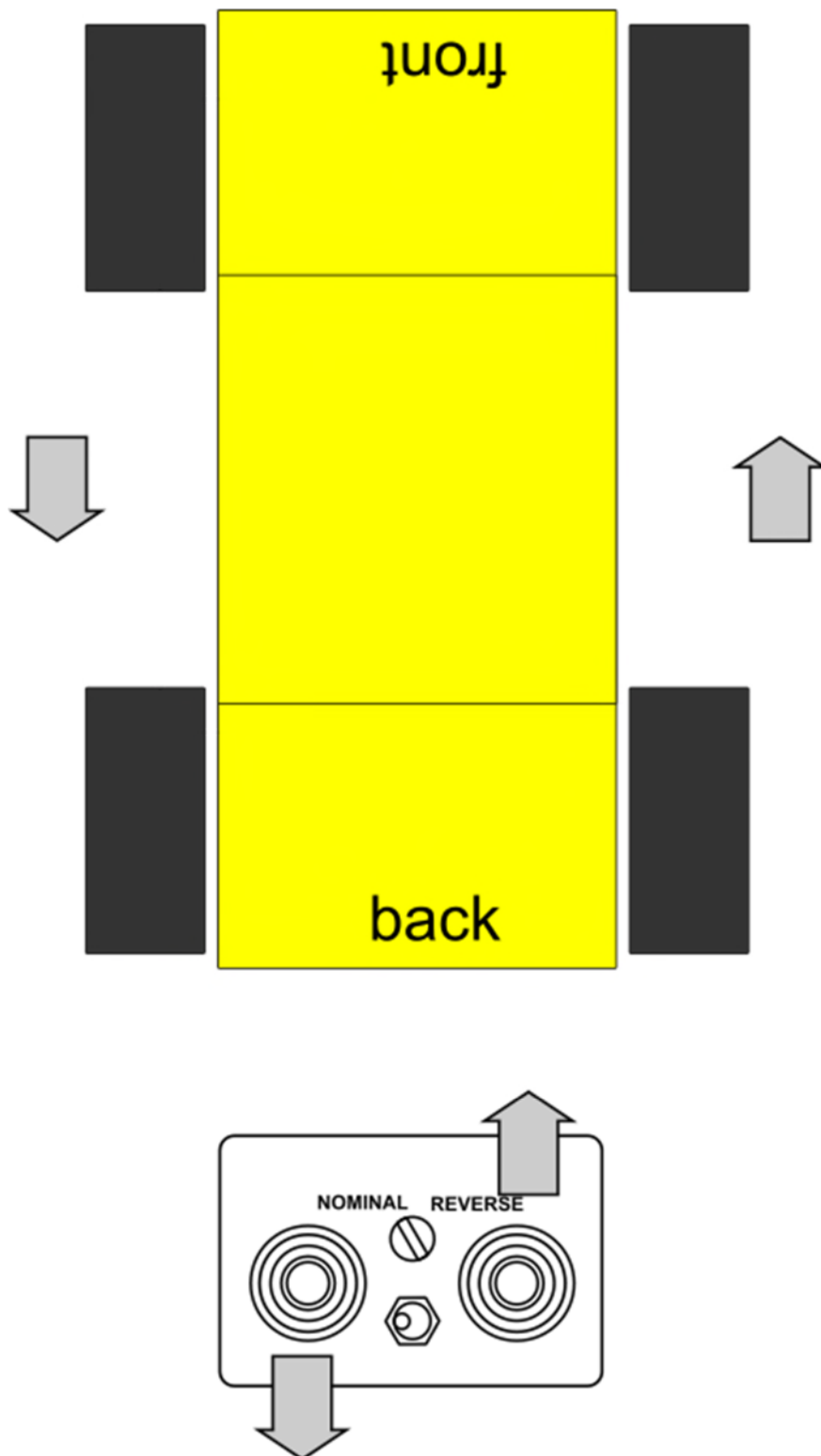
*Figure 7 – Moving the ETV Forward, REVERSE Directivity*

Pushing the joysticks backwards (towards the operator) in REVERSE directivity causes motion in the “front” direction of the ETV (*Figure 8*).



*Figure 8 – Moving the ETV Backward, REVERSE Directivity*

Pushing the joysticks in opposite directions causes change of direction / rotation of the ETV (*Figure 9 and Figure 10*). Please note the position of the directivity selector.



*Figure 9 – Rotating the ETV Left, NOMINAL Directivity*

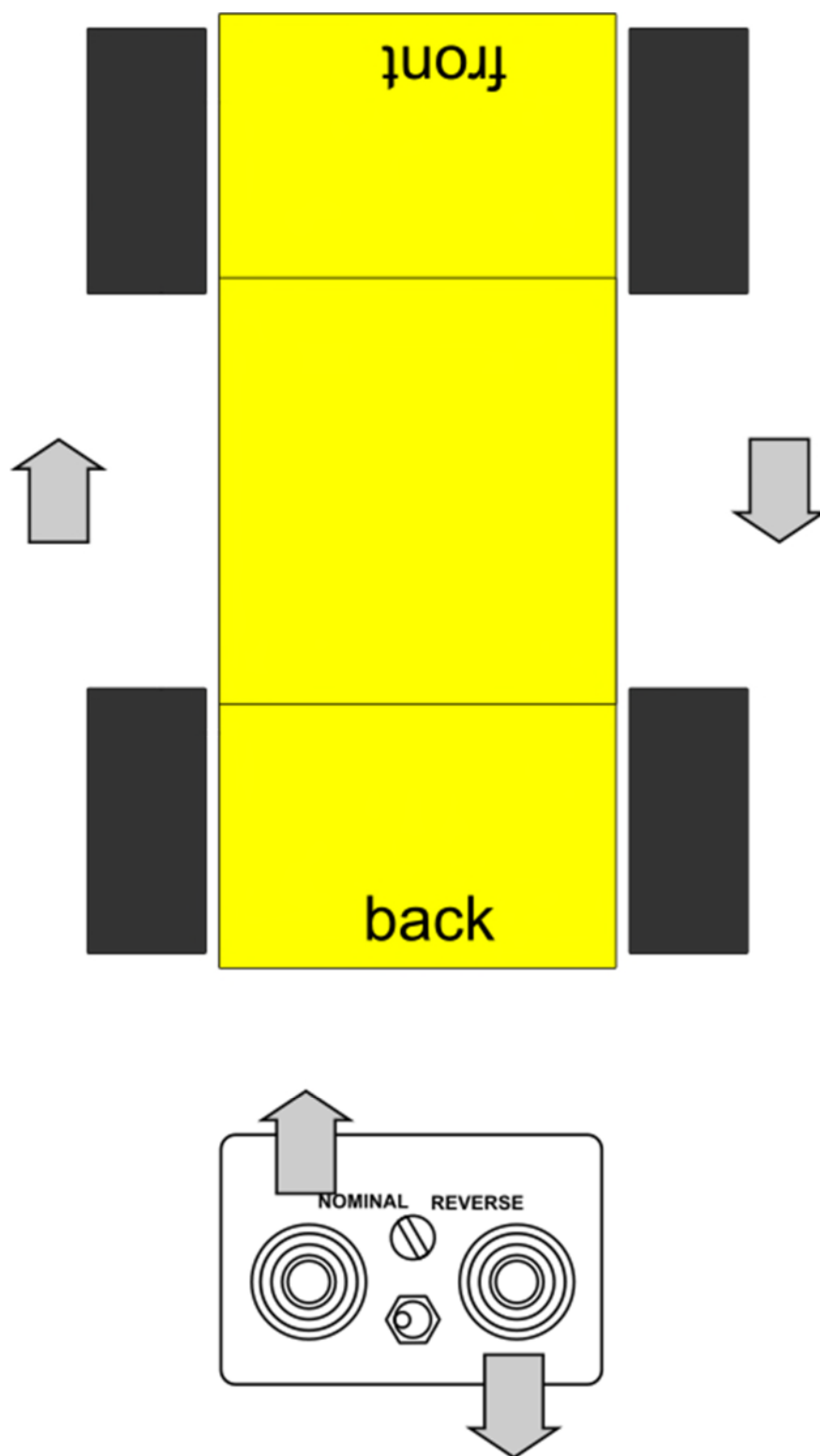


Figure 10 – Rotating the ETV Right, NOMINAL Directivity

## 5.1 Switching on the Vehicle

Before starting the vehicle, the free-wheel hubs (shown in *Figure 11*) should be engaged. The ETV is equipped with four hand-switched free-wheel hubs, one for each wheel.

Turning the free wheel hub lever clockwise engages the wheel hub with the drive shaft. Counter-clockwise rotation of the lever makes the hub and shaft disengaged and the wheel can turn independent of the shaft and respective motor/gearbox.

The procedure to turn on the ETV is as follows:

1. Switch on the remote control by rotating the emergency stop button (the brake control switch should be in the BRAKE ON position).
2. Start the console by pressing the ON/OFF button. The EMAG logo appears on the console display for a few seconds, followed by a list of options: *Start, Association, Setup* (*Figure 12*).
3. Release the main power switch of the vehicle (located on the left side) and confirm the *Start* option with the green button on the console. An attempt will be made to establish a connection between the console and the vehicle (*Figure 13*). After successful connection, the display shows information as shown in the *Figure 14*. If communication could not be established, the message *No link* would appear on the display (*Figure 15*). Confirming the *Validation* option allows the console to retry to communicate with the vehicle without turning off the power of the console.



Figure 11 – Free-wheel Hubs



Figure 12 – Appearance of LCD Screen After Starting the Console



*Figure 13 – Appearance of the LCD Display when Establishing a Connection Between the Console and the Vehicle*



*Figure 14 – Appearance of the LCD Display when the Connection Between the Console and the Vehicle is Established*



*Figure 15 – LCD Display in Case of Unsuccessful Connection Between the Console and the Vehicle*

4. Once connected to the vehicle, release both emergency stop buttons (located on the front and rear of the vehicle) and release the brakes with the brake control switch (BRAKE OFF position). The vehicle is ready to go.
5. Start driving by operating console joysticks. Moving both joysticks in the same direction causes forward / backward movement. Moving the joysticks in opposite directions forces the vehicle to rotate right / left. To stop the vehicle set the joysticks in the middle position.

The radio ensures communication between the console and the vehicle over a distance of up to 20m in typical mining conditions, dependant on the size of working/gallery and obstacles present. The radio signal level is presented on an ongoing basis on the console display. If the signal level is too low, communication will be interrupted, causing the vehicle to stop and the brake to be engaged. An appropriate message appears on the display console display (*Figure 16*).



Figure 16 – LCD Display when Communication is Interrupted

To reconnect, approach the vehicle. When the signal level is high enough, you can reconnect. First, you need to delete the failure message (transmission delay) by pressing the ON / OFF (green) button on the console shortly. Then by pressing shortly this button again, accept the start option, and thus start the procedure of establishing communication, which is similar to the process during turning on the ETV.

## 5.2 Switching off the Vehicle / Immobilisation of the Vehicle

After finishing the movement, it is recommended that you lock the wheels by switching on the brakes (brake control switch in the BRAKE ON position). In the event of prolonged immobilization of the vehicle:

1. When the brakes are switched on, disconnect the power supply to the motors by pressing both emergency stop buttons at the front and back of the vehicle.
2. Disconnect the power supply to the remaining circuits with the main power switch (push the Power ON/OFF button on the side of the vehicle)
3. Turn off the power to the control console (push the emergency stop button on the remote control console)

## 5.3 Emergency Immobilisation of the Vehicle

For safety purposes, the vehicle is equipped with three safety switches: one main (located on the side, cutting off the power to the vehicle controller and thus powering the other circuits) and two auxiliary (located at the front and rear, cutting off the power supply to motor controllers only). Emergency immobilization can be also achieved by engaging the emergency stop button on the remote controller. Detection of a concentrations of methane above 2% vol.CH<sub>4</sub> will also result in immobilization of the ETV until the methane concentration falls below 1.5% vol. CH<sub>4</sub>.

Forcing the activation of any of these actions causes an immediate stop of the motors (if the vehicle was in motion) and blocking of the wheels by the brakes, thus immobilizing the vehicle.

#### 5.4 Vehicle Power (Batteries)

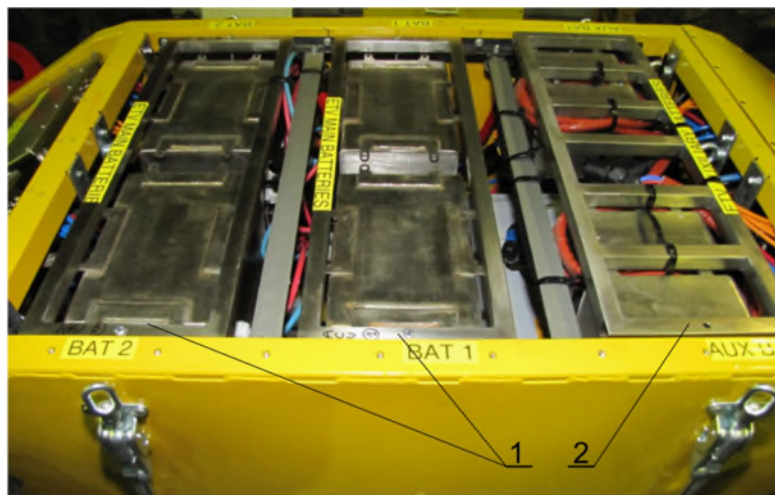
The ETV is an electric powered vehicle. Electric energy is used both to power the electronic modules, the electrical auxiliary circuits and the motors propelling the vehicle.

The ETV is equipped with four batteries supplying motors and motor controllers (one for each motor-controller unit) and four auxiliary batteries to power the vehicle's main controller, radio communication system and auxiliary circuits.

##### 5.4.1 Main Battery Charging

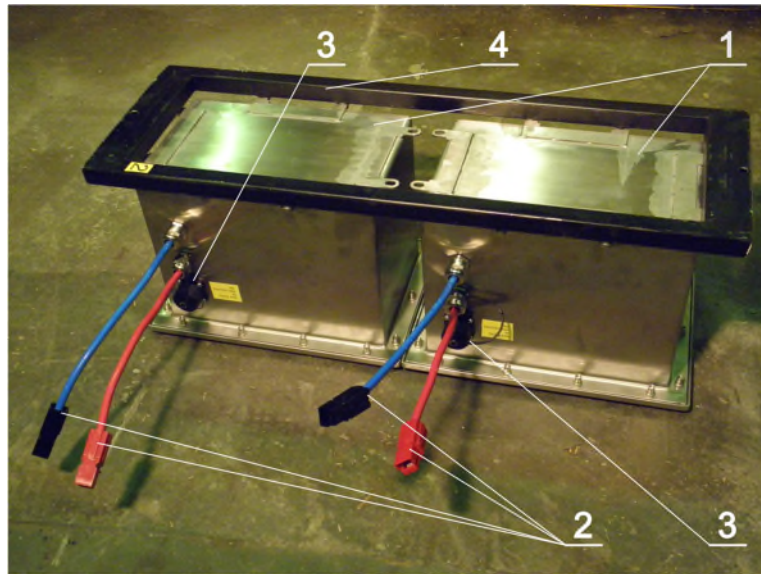
Batteries have to be charged periodically. Batteries should only be charged outside an explosion hazard zone using chargers supplied with the vehicle. During charging the vehicle has to be immobilized, the vehicle's power disconnected (the power switch buttons are pressed) and the brakes applied (if the batteries are charged without removing from the ETV).

Access to the batteries is possible after removing the transport platform and the top cover of the vehicle (*Figure 17*).



*Figure 17 – Location of the Batteries in the ETV (Top Cover Removed)*  
1 – main (propulsion), 2 – auxiliary batteries

The main batteries are mounted in pairs on two separate racks (BAT1 in *Figure 18*, and BAT2, 1 in *Figure 17*). Before charging, each rack with batteries should be removed from the vehicle. Next, connect the charge cable from the charger (*Figure 19, 2*) and connected it to the charging socket of the battery (*Figure 18, 3*) and connect the charger to a standard 230VAC wall socket. Turning on the charger is indicated by red LED turning on (*Figure 19, 5*). The status of the charging process is indicated by a two-colour LED indicator (*Figure 19, 4*). While charging, the indicator turns red. After charging has been finished, the indicator turns green.



*Figure 18 – One of Two Main Battery Racks Outside the Vehicle*  
 1 – batteries, 2 – output cables (red – positive terminal, blue/black – negative terminal),  
 3 – charging sockets, 4 – mounting frame



*Figure 19 – Main Battery Charger*  
 1 – charger, 2 – charging cable, 3 – power supply cable (230 VAC),  
 4 – charge status indicator, 5 – power supply indicator

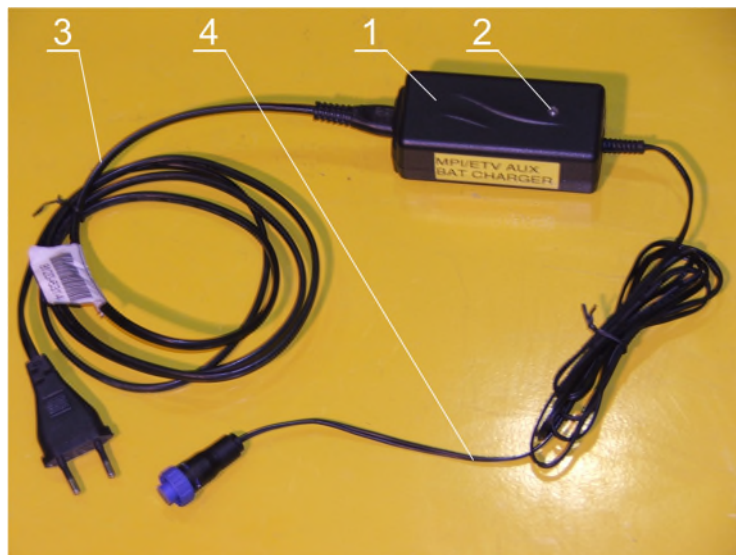
#### 5.4.2 Auxiliary Battery Charging

The auxiliary batteries can be charged without removing them from the vehicle – extension cables are connected to the batteries for this purpose. The cables are terminated with special plugs for connecting to the charger (*Figure 20*).



*Figure 20 – Auxiliary Battery Charging Plug*

In order to charge the batteries, connect the charger output cable (*Figure 21*, 4) to the battery and turn on the charger, by connecting to a standard 230VAC wall socket (*Figure 21*, 3). The charging process will start automatically. The state of the process is indicated by the LED on the charger housing (*Figure 21*, 2). During the charge, the indicator turns red. When charging is complete, the indicator light turns green. After charging is completed, disconnect the charger from the extension cable.



*Figure 21 – Auxiliary Battery Charger*

1 – charger, 2 – charging indicator,  
3 – power supply cable 230 VAC, 4 – charging cable

## 5.5 Transport Platform

Materials and equipment intended for transport by the ETV are placed on the cargo platform. The platform is mounted on top of the vehicle and attached to its sides with four hooks and buckles (*Figure 22*).



*Figure 22 – Cargo Platform Attachment on the Vehicle*

*1 – platform hook, 2 – buckle, 3 – buckle lock, 4 – buckle lever*

## 5.6 Disassembly and Assembly of the Transport Platform

The IETV is delivered with a transport platform fitted. It can be disassembled if necessary, e.g. when the batteries need to be recharged.

To remove the transport platform, first press and hold the lock button, pull the lever back and remove the buckle from the hook on the transport platform. Then remove the platform from the vehicle. To attach the platform back, proceed in the reverse order. If there is a problem with buckling the platform, check if the buckles aren't too tight, and loosen them if necessary by rotating them.

## 6 INSPECTIONS AND MAINTENANCE

Before each use of the ETV, the technical condition of the vehicle should be inspected. The inspection should take into account the completeness and tightness of the bolts fastening the covers, the wheels and free-wheel hubs, the degree of their tightening, the method of mounting the measuring platform, and the condition of the tyres. Before each use, make sure that the vehicle batteries and the control console battery are charged. Do not use a vehicle with visible mechanical damage, as this may cause further irreparable damage to vehicle components or cause danger to health or life.

User maintenance is limited to two aspects:

- Exchanging and charging of the main, auxiliary and remote controller batteries as described in earlier in this documentation.
- Cleaning of the vehicle and the controller.

Remove small dirt from the exterior of the vehicle with a damp soft cloth. In case of heavy dirt, it is permissible to washing the exterior of the vehicle with a jet of water (up to 12 dm<sup>3</sup>/min.). Particular attention should be paid to dirt accumulating in the spaces between the wheels and the sides of the vehicle, as this may increase resistance to movement and thus increase energy consumption and reduce the time of operation of the vehicle.

For the control panel, remove dirt with a damp cloth made of a soft material. In the event of dirt around the control buttons, power switch and battery socket, a brush with soft bristles may be used. Particular care should be taken when cleaning the display. The use of inappropriate (too rough) materials may lead to scratches and deterioration of the visibility of the information presented.

Other maintenance (including calibration of the methane sensor) and repairs are to be performed by specialized personnel only.

Do not attempt to inflate the tyres if deflated. Improper inflation of tyres may cause tyre explosion and dangerous debris. Tyres should be inflated only inside a safety cage.

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## 7 TROUBLESHOOTING

Below is a list of some possible vehicle malfunctions and methods of their corrections.

Lp.	Problem observed	Possible causes	Solutions
1	The remote control console does not turn on.	Discharge of the power battery.	Charge the battery or replace it with a spare battery.
		The console's emergency stop button is engaged.	Disengage the console's emergency stop button
2	No communication with the vehicle.	The power supply to the control systems of the vehicle is not switched on.	Turn on the vehicle power by turning the main power switch on.
		Too weak or no signal (out of range).	Decrease distance to the vehicle. Check and, if necessary, correct the seating of the antenna.
		Discharged auxiliary batteries of the vehicle.	Charge or exchange the auxiliary batteries.
3	Inability to release brakes.	The main power supply of the vehicle is not switched on.	Power the drive units (motors and motor controllers) by rotating the auxiliary power switch buttons.
		Discharged main batteries.	Replace the batteries with charged batteries. Charge discharged batteries.
4	Vehicle does not react to joystick	Brakes not released.	Set the brake control switch to BRAKE OFF.
		The emergency stop buttons are engaged.	Disengage emergency stop buttons.
		Discharged main batteries.	Replace the batteries with charged batteries. Charge discharged batteries.
		Drive wheel hubs and drive shafts disconnected.	Engage the free-wheel hubs.

*Table 1 – Troubleshooting List*

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## 8 DELIVERY SPECIFICATION

The INDIRES ETV is shipped with all accessories, required for normal use and user maintenance. The listing of the specific equipment is presented in the table below.

Item	Quantity	Notes
INDIRES Electric Transport Vehicle	1	
Main (propulsion) battery set	2	4 batteries each, one installed and one spare
Auxiliary battery set	1	4 batteries, installed in the vehicle
Cargo platform	1	
Main battery chargers	4	
Auxiliary battery charger	4	
Remote control console	1	
Remote control console batteries	2	
Console battery charger	1	
User documentation	1	
Transport accessories	n/a	Belt slings, cargo fastening belts

*Table 2 – Delivery Specification*

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## 9 STORAGE AND TRANSPORT

### 9.1 Storage

After delivery, the ETV should be stored in a closed room, free from dust, fumes and corrosive gases at a temperature of + 5°C to + 40°C. The relative humidity must not exceed 80%. Any heating devices should not directly affect the product.

Upon delivered, it is recommended that a check is carried out on the condition of the batteries and charge them if necessary. For information on charging the batteries, see *Section 5.4*.

The vehicle should be stored on even level surface so that all wheels have contact with the ground. Vehicle power should be disconnected. Additionally, it is recommended that the vehicle wheels are blocked with the wedges.

### 9.2 Transport

The Electric Transport Vehicle is intended to be transported to the operation site by means other than self-propulsion. Before and during transport follow the directions given below:

- Transport by lifts, gantries or similar means is permitted only with the use of the ETV's transport lugs or with belt slings.
- Use of the cargo platform as an attachment point for transporting the ETV is not allowed.
- A horizontal position for the ETV should be maintained if possible during the transport. If necessary, it is possible to transport the ETV in a position other than horizontal for short distances and with limited vibrations.
- Check the position of the Power ON/OFF button and the emergency stop buttons. All buttons must be pushed in and the vehicle must be powered off.
- It is possible to transport the vehicle, the batteries and the cargo platform separately if necessary.
- Avoid mechanical damage during the transport. Give special care to the wheels and wheel hubs.
- When towing, ensure the free-wheel hubs are disengaged
- Transport the vehicle at temperatures from -20°C to +55°C. If transported at other temperatures, give time to heat up/cool down to operating temperatures.

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## 10 FURTHER INFORMATION

Further information about the Electric Transport Vehicle is available from Łukasiewicz – Instytut Technik Innowacyjnych EMAG, 40-189 Katowice, ul. Leopolda 31, Poland. <http://www.ibemag.pl>.

Please contact Wojciech Korski at [Wojciech.Korski@emag.lukasiewicz.gov.pl](mailto:Wojciech.Korski@emag.lukasiewicz.gov.pl).

