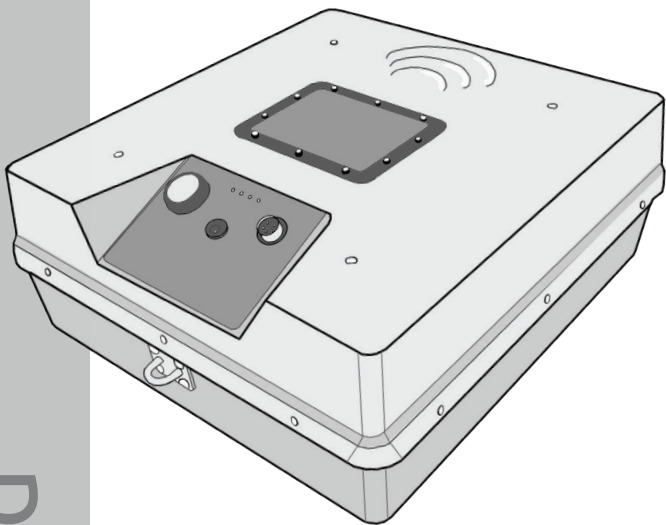


Scudo

Full System



USER MANUAL

Ground Penetrating Radar



Safety Information

Thank you for purchasing this Oerad equipment. Please read this User Manual carefully before connecting, operating or adjusting this product.

Electromagnetic radiation from GPR systems manufactured by Oerad Tech Ltd do not constitute a safety or health hazard under normal operating conditions.

WARNING

To reduce the risk of fire or annoying interference use only the recommended accessories and do not disassemble this product's modules. There are no user serviceable parts inside.

CAUTION

Danger of explosion if battery is incorrectly replaced. Replace only with the same or equivalent type recommended by the manufacturer. Dispose of batteries according to the manufacturer's instructions.

Information on Disposal

For private households: Information on Disposal for Users of WEEE

This symbol on the product and/or accompanying documents means that used electrical and electronic equipment (WEEE) should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product to designated collection points where it will be collected free of charge. Alternatively, in some countries, you may be able to return your product to your local retailer upon purchase of an equivalent new product.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

Please contact your local authority for further details of your nearest designated collection point.

Penalties may be applicable for incorrect disposal of this waste, in accordance with your national legislation.

For professional users in the EU

If you wish to discard electrical and electronic equipment (EEE), please contact your dealer or supplier for further information.

For disposal in countries outside of the EU

This symbol is only valid in the European Union. If you wish to discard this product please contact your local authority or dealer and ask for the correct method of disposal.



Please note that the actual controls and components, menu items, etc. of your Ground Penetrating Radar may look somewhat different from those shown in the illustrations in this User Manual.

What Scudo is

The Scudo is an Ultra-Wideband (UWB) shielded pulsed Ground Probing Radar (GPR) for non-destructive imaging of subsurface structures. It comprises of a transmitter and receiver boards and antennae, a controller board and a distance measurement device. The Scudo system is designed and manufactured by Oerad Ltd.

What Scudo is used for

The Scudo has a wide variety of usages including but not limited to underground utility detection, non-destructive archaeological surveys, underground water detection, road inspection, rock composition determination, cavities localization, ice thickness determination, geophysical research of underground layers, etc. It is designed to withstand the harsh conditions of outdoor surveys and construction sites.

This user manual contains the following sections:

- I. Before You Start
- II. Contents
- III. Technical Specifications
- IV. System Parts
- V. Assembly
- VI. Hardware Interface
- VII. Software Interface
- VIII. Startup & Calibration
- IX. Survey
- X. Read File
- XI. Working Conditions
- XII. Glossary
- XIII. Dielectrics Cheat Sheet

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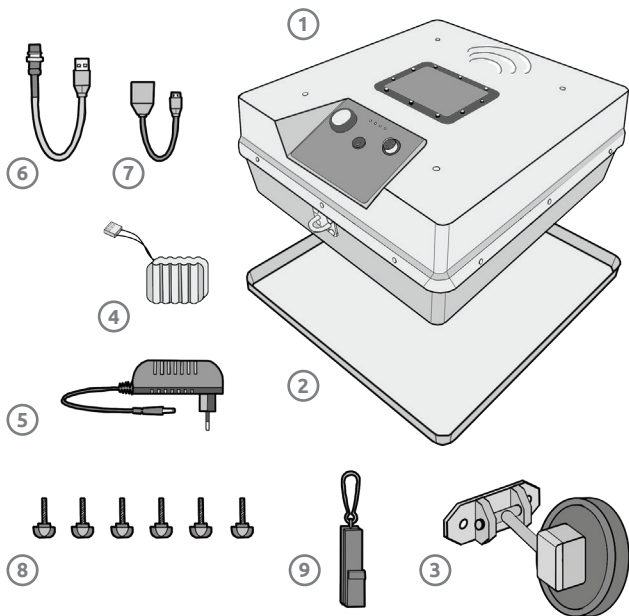
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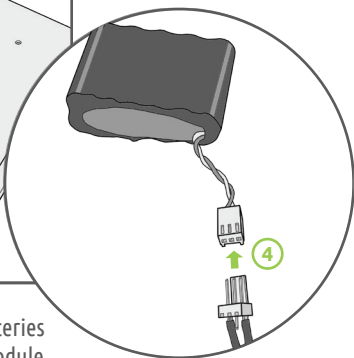
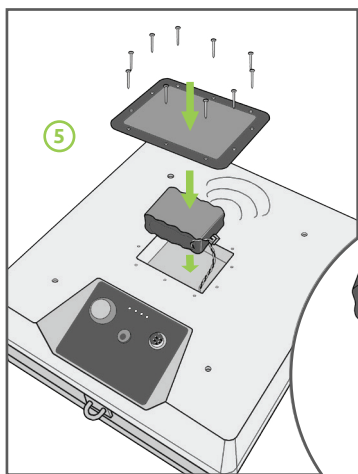
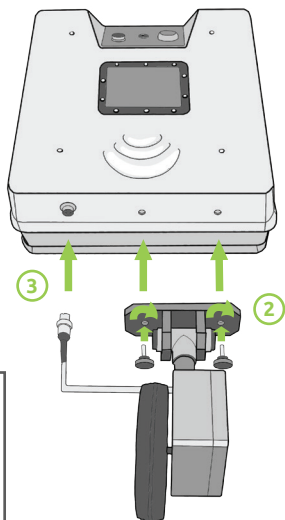
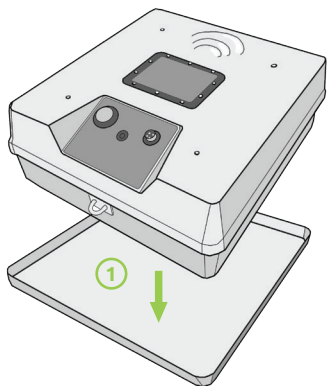
Technical Specifications

Frequency Bandwidth	30 MHz - 900 MHz
Central Frequency	500 MHz
Operating Time Windows	50 ns / 100 ns
Dynamic Range	120 dB min
Horizontal Resolution	0.1m
Vertical Resolution	0.05m
Pulse Repetition Frequency	75 kHz
Pulse Length	3 ns
Pulse Energy	600 V
Pulse Rise Time	1 ns
Average Tx Power	800 W
Power Consumption	270 mAh
Batteries	10 / 20 x 2.4 Ah NiMH 1.2 V
Autonomy with One Charge	7 h / 14 h
Charge Time	5 h / 10 h
ADC Range	8 bits
Data Acquisition Rate	18.2 traces/second
Samples Per Trace	585
GPR Interface	UART over USB
Operating Temperature Range	-5° C to 40° C
Water Resistance	IP 52
Size	38x35x15 cm
Weight	3 kg

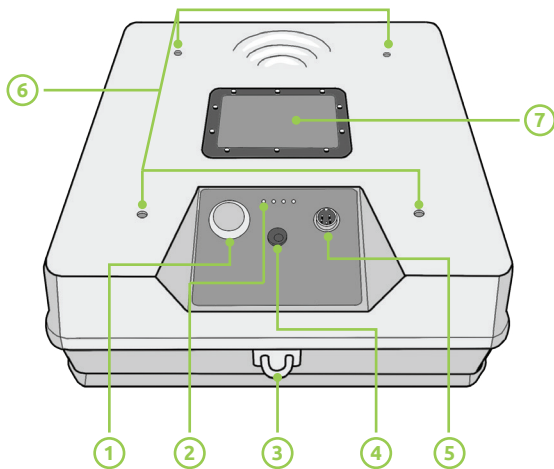


1. Scudo GPR Main Module
2. Rough Terrain Protector
3. Distance Measuring Wheel
4. Battery Pack 10x 3A Ni-MH
5. Battery Charger
6. USB Data Cable
7. USB OTG
8. Bolt M5 x 6
9. Handle

Assembly



* Scudo usually comes with batteries already inserted in the main module.

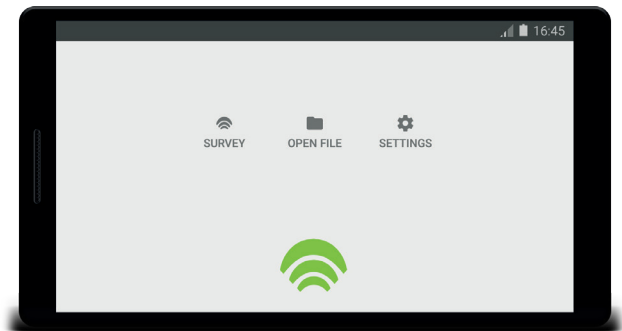


1. Power switch
2. Battery level indicator
3. T-Rods, handles or other forms of pulling devices can be attached here. Your Scudo system comes with a handle included.
4. Battery Charger Socket
5. USB Data Cable Socket. Your system should be connected in the following manner:

Scudo GPR main module -> USB Data Cable -> USB OTG -> Android tablet
OR

Scudo GPR main module -> USB Data Cable -> PC

6. Sockets for attaching Scudo to a cart, trolley or another transporting mechanism.
7. Sealed battery compartment. If you need to change your batteries with another pack, unscrew the bolts, gently remove the cover and the battery inside, and reassemble as shown in the Assembly section of this user manual.



General Information

- Make sure all cables are securely connecting the GPR and the tablet.
- Grant all permissions to Oerad App via your Android's 'Settings > Applications > Oerad > Permissions' menu.
- In order to avoid battery drainage and unnecessary signal transmission, turn off your GPR and disconnect it from your tablet when finished surveying.
- For further details on technical specification requirements, how to download, install and configure the Oerad App, please refer to the app's user manual available at <https://oerad.eu/software> .

Operating Modes

- **Survey**
Real time data visualization and recording. Live filter application.
- **Open File**
View recorded files and apply data filters to files.
- **Settings**
Recording options. Set radar as Scudo and choose your preferred distance measurement units. Manage dielectric constants.

Startup

- Assemble your system as shown in the Assembly section of this user manual.
- Attach all cables to GPR and Android device.
- Start up the Oerad Android app.
- Press the power switch on the GPR. Your GPR is running when the power level diodes light up.

Calibration

- Prepare a 1 or 2 meter long flat surface marking its beginning and end.
- Place GPR at beginning and start it up.
- Navigate to the Calibration menu in the Oerad app via settings or on its initial start up screen.
- Press Start and allow the Oerad App access to the USB device if prompted.
- When you reach the end of the surface press Stop and then Save
- Your distance measuring wheel is now calibrated.
- The step indicator shows you how many steps in the wheel encoder have been registered. If this value does not change when moving, reconnect the GPR and turn the power switch off and on again.

Calibrate Wheel Menu

Calibrate Wheel

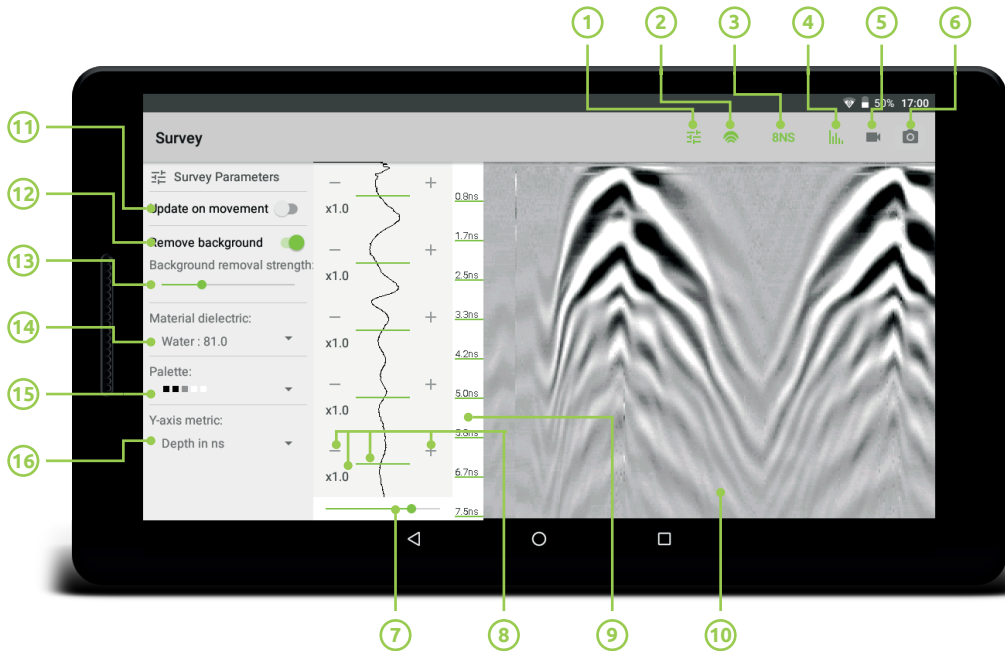
Connect your radar, press START and move it along a flat distance of length:

- 1 meter
 2 meters



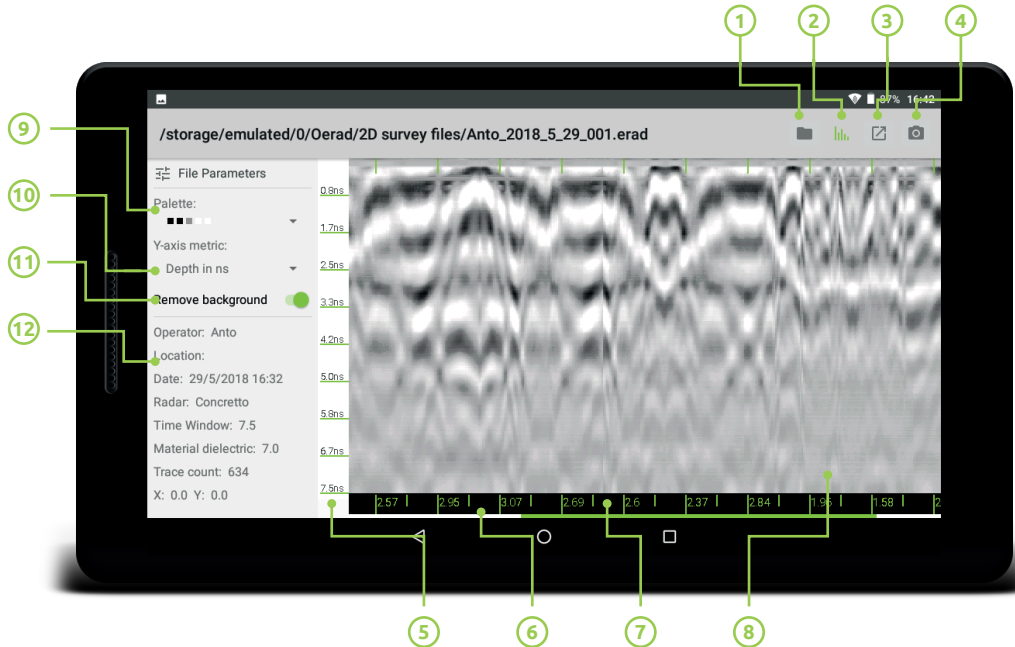
CANCEL SAVE

Survey



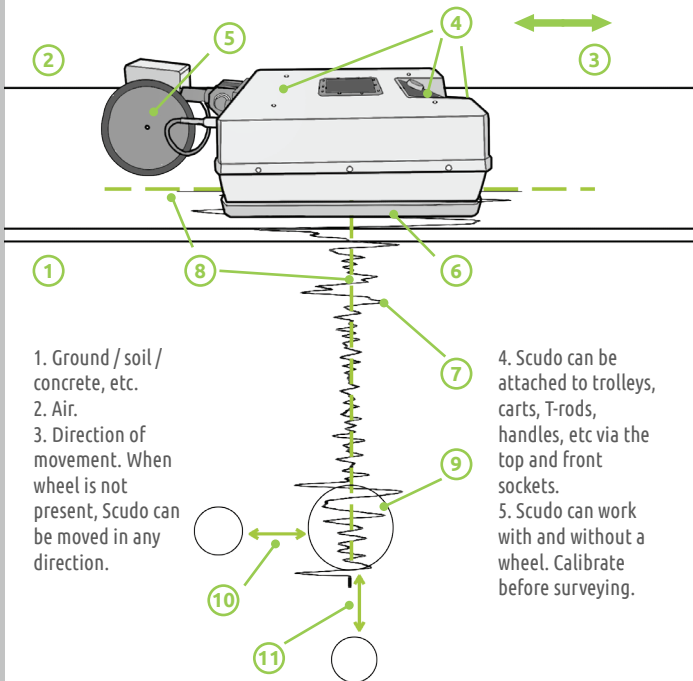
1. Survey parameters toggle - open / close the parameters menu on the left.
2. Pause / Resume survey.
3. Time window toggle - toggles between the GPR short and long operational time windows.
4. Apply background removal filter. It is recommended to have this filter on.
5. Record a SEG-Y or ERAD file for later viewing.
6. Take a screenshot of the current scene, saved as JPEG.
7. Hardware gain controller at five levels. Used to amplify the signal when the material does not allow good signal penetration.
8. Software gain control at five zones of the wave. Allows amplifying the signal locally at points of interest and reducing the signal strength elsewhere to reduce noise. -: reduce amplitude; +: amplify signal; **x1.0**: amplification factor; **green bar**: amplification factor.
9. Y-Axis showing penetration depth expressed in nanoseconds or meters/feet.
10. Radargram streaming live data from the GPR. Double tap anywhere on it to pause/resume surveying.
11. Update radargram on movement is only applicable to devices supporting a distance measuring wheel.
12. Apply Background removal filter. It is recommended to have this filter on.
13. Background removal strength toggle. It is recommended to have it set higher when moving slower or over greater distances.
14. Material dielectric helps calculate the penetration depth based on the surveyed material.
15. Change palettes to optimize anomaly detection.
16. Switch between nanoseconds or meters/feet as penetration depth measurement units.

Read File



1. Open new file. Files generated by Oerad are usually located in main storage in folder Oerad.
2. Apply background removal filter. It is recommended to view files with this feature turned on.
3. Export file to SEG-Y file format.
4. Take a screenshot of the current scene, saved as JPEG.
5. Y-Axis showing penetration depth of the recorded file in ns or in meters/feet.
6. Progress bar showing your current position within the file.
7. X-axis showing distance data when files are recorded with a distance measuring wheel. This feature is not yet available to Dipolo systems.
8. Radargram of the recorded sounding data. Tap and swipe right to navigate to the end of the file. Tap and swipe left to navigate to the beginning of the file.
9. Change palette of displayed file.
10. Change the penetration depth measurement unit displayed in the Y-axis.
11. Apply Background removal filter. It is recommended to view files with this feature turned on.
12. General information about recorded file. Includes: Operator, Location, Date of record; Dielectric constant of surveyed material; Device used for surveying; Time window at time of survey; Trace count in file; X & Y for files recorded with a distance measuring device.

Working Conditions



1. Ground / soil / concrete, etc.
2. Air.
3. Direction of movement. When wheel is not present, Scudo can be moved in any direction.

4. Scudo can be attached to trolleys, carts, T-rods, handles, etc via the top and front sockets.
5. Scudo can work with and without a wheel. Calibrate before surveying.

6. Scudo is a shielded GPR and its emission pattern requires close coupling with the ground.
 7. Typical signal from a Scudo system
 8. Signal center
 9. Detected object
 10. Minimum horizontal distance between two objects to be detected separately: 0.20m.
 11. Minimum vertical distance between two objects to be detected separately: 0.15m.
- Objects such as cellular towers, power lines or other EM wave emitting devices may cause interferences in the signal. This may result in radargram deterioration.
 - Scudo is suitable for all types of terrains.

Hz - Hertz, measurement unit for frequency.

Radio Wave - Electromagnetic wave with frequency ranging from 30Hz to 300GHz. For GPR from 10MHz up to 3GHz.

Radar - A system that uses radio waves to detect objects. Main components & signal flow: Transmitter ->Transmission antenna -> Receiver Antenna -> Receiver data processor.

Frequency Bandwidth - The spectrum of the radar's transmitted radio waves' frequencies.

Central Frequency - Transmitted waves at peak power (usually the centre of the frequency spectrum).

UWB - Ultra Wide Band radar that transmits over a frequency bandwidth > 500MHz.

GPR & Time-domain GPR - State-of-the-art high resolution radar with low power consumption.

Survey Sounding - The act of using GPR technology for object detection/determination.

Radargram - Image produced by a radar.

SEG-Y - General purpose file format for recording geophysical data from 1973.

ERAD - Oerad's open radar format optimized for small data storage.

Time Window - Operational window of the receiver antenna.

Penetration Depth - Theoretical maximum depth achieved during a given time window and a material's dielectric constant.

Dielectric Constant - Measure of a material's ability to store electrical energy in an electric field.

Attenuation - Reduction in GPR signal amplitude caused by energy dissipation in a material.

Dynamic Range - Ratio b/n the max amplitude signal recordable by GPR and its noise floor.

GPR Trace - Sequence of sample points collected by the receiver that indicate time variation of the amplitude of the recorded signal (in a given time window).

Resolution - Smallest detectable difference/object in a surveyed material/soil/wall.

Gain - Signal amplification.

Background Removal - Adaptive cancellation of the effects of a surveyed material.

DC Drift - Low frequency noise causing the signal to drift from the centre line.

Pulse - Energy packet emitted from the transmitter antenna. Its properties are **length**, **power** and **rise time** - a measurement of how fast a pulse achieves peak power.

Dielectrics Cheat Sheet

Material	Dielectric Constant	Max Depth at 50ns in meters	Max Depth at 100ns in meters
"Average soil"	16	1.88	3.75
Agricultural Land	15	1.94	3.87
Air	1	7.50	15.00
Asphalt	3 - 5	4.33 - 3.35	8.66 - 6.71
Basalt (wet)	8	2.65	5.30
Clay (dry)	3	4.33	8.66
Clay (wet)	8 - 15	2.65 - 1.94	5.30 - 3.87
Coal	4 - 5	3.75 - 3.35	7.50 - 6.71
Coastal sand (dry)	10	2.37	4.74
Concrete	6 - 8	3.06 - 2.65	6.12 - 5.30
Dolomite	6.8 - 8	2.88 - 2.65	5.75 - 5.30
Glass	5 - 10	3.35 - 2.37	6.71 - 4.74
Granite	5 - 8	3.35 - 2.65	6.71 - 5.30
Limestone	7 - 9	2.83 - 2.50	5.67 - 5.00
Marsh	12	2.17	4.33
Pastoral Land	13	2.08	4.16
Plexiglass	3.4	4.07	8.13
Polar Snow	1.4 - 3	6.34 - 4.33	12.68 - 8.66
Polyethylene	2.25	5.00	10.00
Pure Ice	3.2	4.19	8.39
PVC	3	4.33	8.66
Quartz	4.3	3.62	7.23
Sand (dry)	3 - 6	4.33 - 3.06	8.66 - 6.12
Sand (wet)	25 - 30	1.50 - 1.37	3.00 - 2.74
Sandstone (wet)	6	3.06	6.12
Shale (wet)	7	2.83	5.67
Silt (wet)	10	2.37	4.74
Water	81	0.83	1.67

The max depth of EM waves in the frequency range 10MHz - 1GHz:

$$D = \frac{c}{\sqrt{\epsilon}} \cdot t$$

where D - max depth; t - time window; ϵ - dielectric constant.

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