

# Kerberos™

## NM-GPR Subsystem User's Manual



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## Abbreviations

ETSI	European Telecommunications Standards Institute
GPR	Ground Penetrating Radar
HDMI	High-Definition Multimedia Interface
IC	Industry Canada
LiDAR	Light Detection and Ranging
M8	Metric, 8-millimeter
NM-GPR	Noise-Modulated Ground Penetrating Radar
PC	Personal computer
psi	Pounds per square inch
RF	Radio Frequency
RTK-GNSS	Real Time Kinematic Global Navigation Satellite System
Rx	Receiver
SMA	SubMiniature version A, a type of RF cable connector
Tx	Transmitter
USC	United States Code (of Federal Regulations)
V	Volts

# Introduction

Kerberos™ is a data collection platform capable of measuring various pavement properties at collection speeds of up to 100 kilometers per hour (62 Miles per hour). The system is modular and flexible, enabling hardware installation on variety of vehicle types or use on a dedicated trailer – see Figure 1

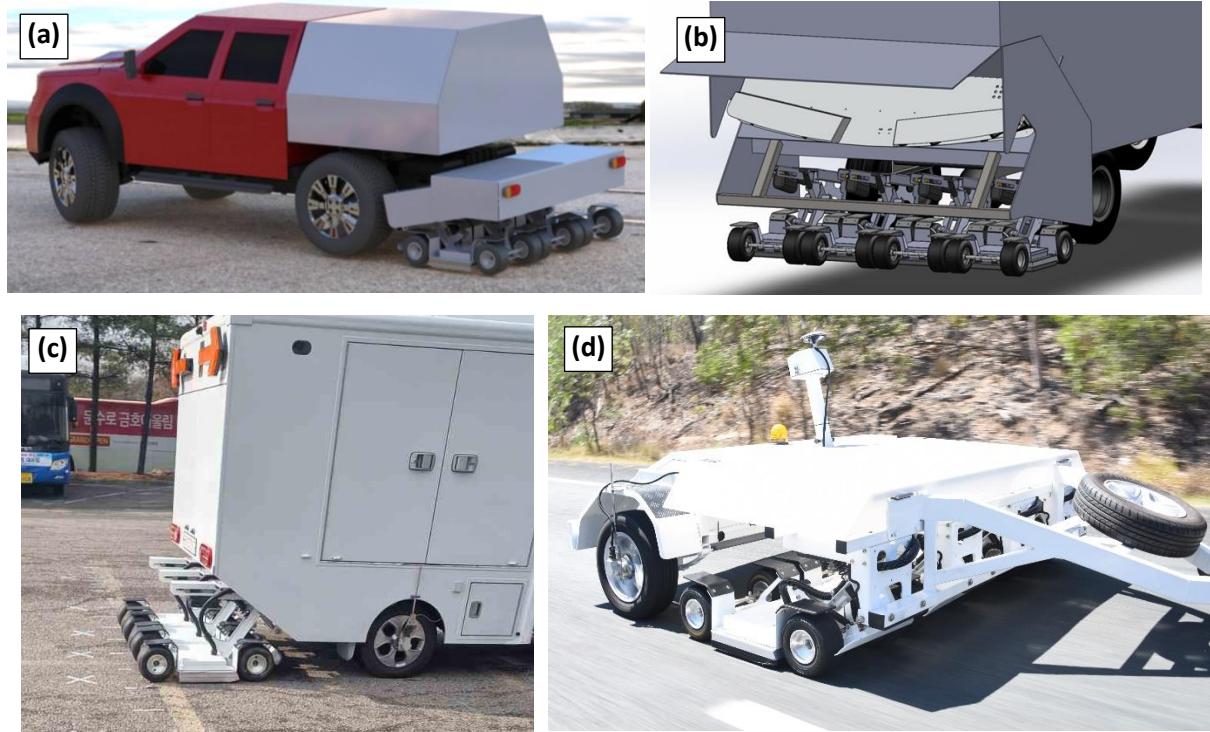


Figure 1: Kerberos™ NM-GPR subsystem installations. (a) Removable 3-pod system deployed on a utility or pickup vehicle; (b) A 4-pod system deployed below a collection truck, behind its rear wheel; (c) A vehicle-mounted 3-pod system that lifts and rotates pods to stow vertically beneath a rear cover; and (d) A dedicated 4-pod data collection trailer.

All Kerberos™ system installations include a **Power & Synchronization Subsystem** combined with one or more optional sensor subsystems. These include:

- **NM-GPR:** Adds advanced Noise-Modulated Ground Penetrating Radar (NM-GPR) technology and a modular ground-coupled array for traffic-speed subsurface imaging.
- **Surface imaging:** Adds a linescan camera for continuous surface imaging and (optional) lighting arrays, for nighttime operation and to reduce shadows during the day.
- **Transverse profiling:** Adds lasers and cameras to measure the profile across the road, to enable rut depth measurement.
- **Roughness:** Adds wheelpath lasers and inertial sensors to measure roughness in the direction of travel.
- **LiDAR:** Enables mobile cloud point capture of the surrounding environment.

This manual focusses on the **NM-GPR subsystem**. For details of other Kerberos™ subsystems, please contact Coded Radar.

# NM-GPR Subsystem

## Components & connections

The Keberos™ NM-GPR subsystem is supplied with preconfigured hardware and software. The hardware consists of a NM-GPR digitizer and a radio frequency (RF) switching matrix connected via RF cables to series antenna pods, each containing two Transmitting (Tx) and four Receiving antennas (Rx). Several pods operate side-by-side, forming a flexible ground-coupled array that can flex with and move over surface undulations. Most Kerberos™ installations use 3 or 4 antenna pods, producing arrays that are 1.8m or 2.4m wide and which measure on 22 or 30 adjacent GPR channels, respectively.

Figure 2 shows the NM-GPR V2.1 Digitiser & RF switch matrix. These components are typically installed within a protective toolbox or within the data collection vehicle. Figure 3 shows one of the antenna pods, which house and protect the GPR antennas within.

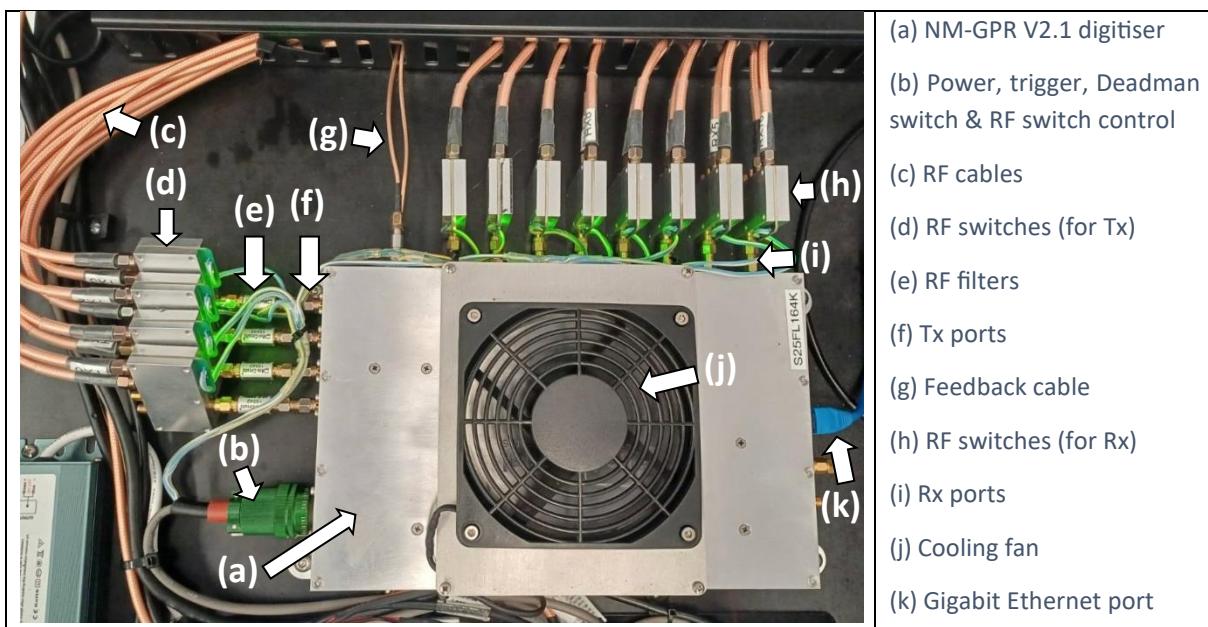


Figure 2: Digitiser & RF switch matrix components

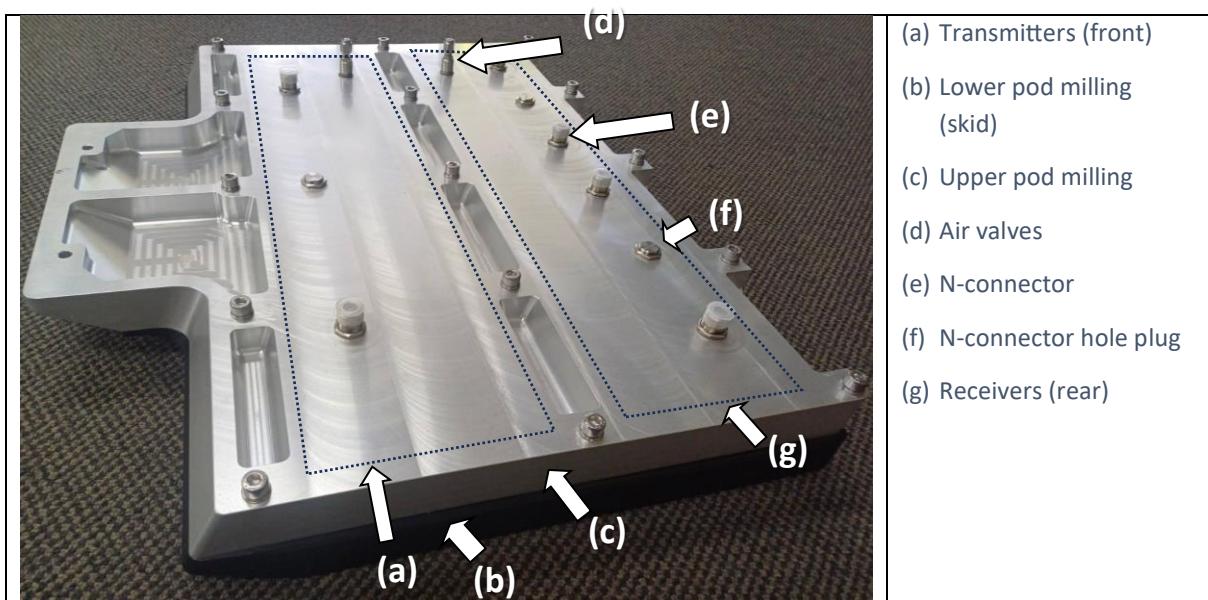


Figure 3: Kerberos™ antenna pod components

The antenna pod consists of an external shell with transmitter and receiver antenna modules within. The external shell consists of an upper metal milling and lower plastic lower milling, which are bolted together. The lower milling doubles as a replaceable wear skid. Rows of N-connectors from the antennas protrude through the top of the pod. The front row is attached to the transmitters, the rear row is attached to the receivers. Several RF cables, protected by metal covers and conduits, connect the antennas within the pods to the digitizer and switch matrix (Figure 4). Figure 5 shows the completed array during field operation.

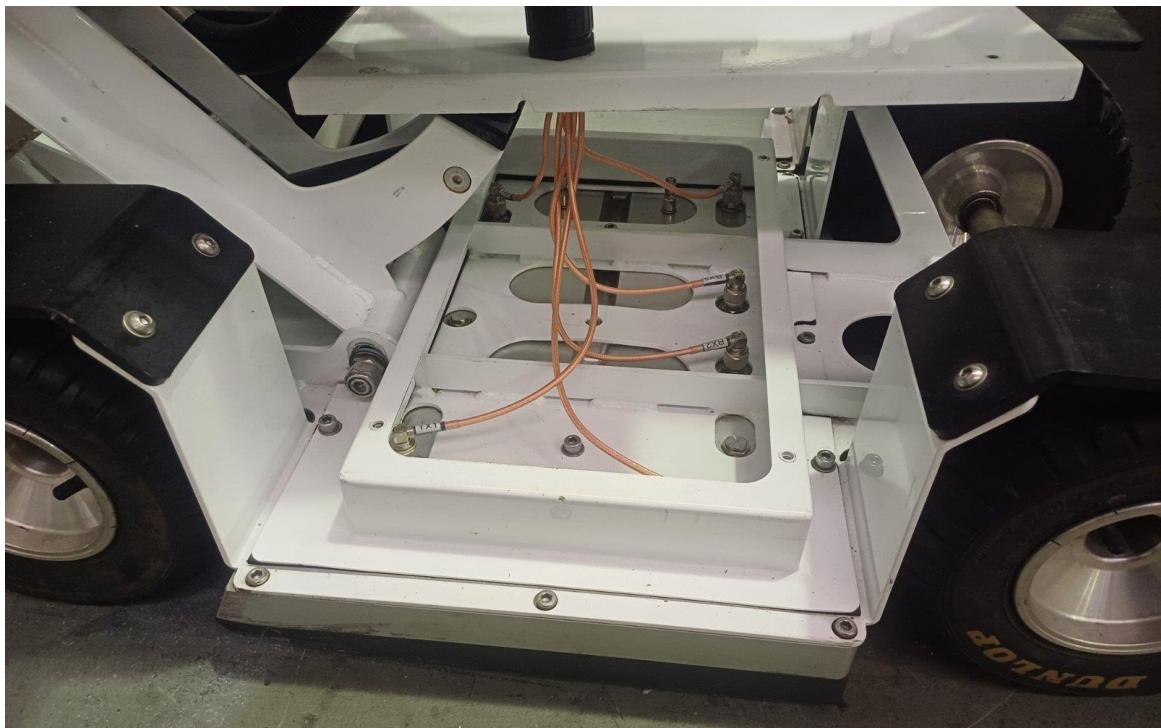


Figure 4: RF cables connected to antenna pod antennas



Figure 5: Assembled Kerberos™ array during operation.

# Operation

## Setup

Prior to scanning, find a safe location to park the Kerberos™ collection vehicle/trailer. Turn the system power on and start the data collection computer. Ensure all flashing lights and other safety devices are operating before commencing scans.

Launch the *EarthControl* software to enable monitoring of data from the various subsystems. When near the site, deploy (lower) the wheeled trolleys onto the ground surface using the supplied remote control.

**Note:** A “deadman switch” attached to one of the pod deployment arms (Figure 6) prevents transmitter operation when the pods are raised. The system will not produce useful GPR measurements until the pods are deployed.



Figure 6: The “Deadman switch” engages when the pods are raised (stowed) to prevent inadvertent GPR transmissions.

Figure 7 (a) shows the trolleys & pods in their fully deployed position. The roller bearing (Figure 7 (b)) will be positioned approximately midway along the slot when deployed. The roller bearing moves along the slot as the pod moves up and down over surface undulations.

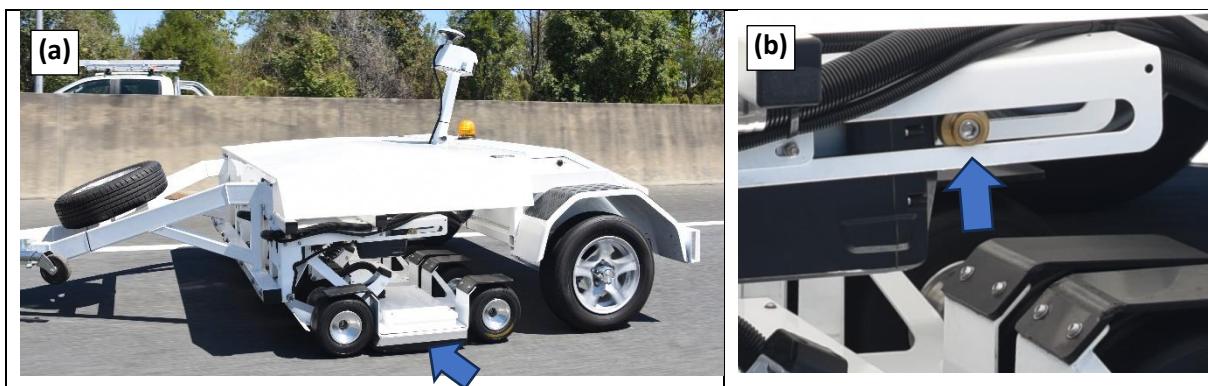


Figure 7: (a) Kerberos™ pods & wheeled trolleys in their deployed position; (b) The roller bearing is positioned approximately midway along the slot when the pods are fully deployed.

## Data collection & status monitoring

Within *EarthControl*, change into *data collection mode* by choosing “Mode” → “Select Mode”. Next, create a New Project (i.e. a folder) or choose an existing project where data are to be saved. Choose the desired systems settings file from the list in the upper box and press the “Connect” button. The NM-GPR equipment initializes using the settings file parameters.

Colored buttons at the bottom of screen provide a visual indication of subsystem status. The buttons start as red and change to green when data for that subsystem is received, except for the “GPS” button whose colour changes depending on depending on GPS fix quality. When all status buttons are dark green, the system is receiving data from each subsystem and GPS fix quality is the highest possible. Red buttons indicate no data received or there is some other type of system error.

Real time kinematic global navigation satellite system (RTK-GNSS) positioning data is often gathered alongside the 3D NM-GPR data. To use these capabilities, connect the data collection PC to the internet, enter the details of a nearby RTK base station within *EarthControl* (under Settings, NTRIP tab on bottom left of screen) and then press the “Connect RTK” button (main screen, right). If using a WIFI connection between a mobile phone and the PC, please ensure to connect using a 5GHz signal and not to 2.4GHz, to avoid adversely affecting the GPR.

To commence 3D NM-GPR data collection, press the “Start” button and drive along. The button’s label will change from “Start” to “Collecting”. To finish data collection, press the “Stop” button, whose label will change to “Stopped” when data collection has fully ceased. To commence the next scan, press the “Start” button, and so on.

When all scans have been completed, close *EarthControl* by selecting “Mode”, “Close Mode” and then “Mode” and “Exit”. You may then shut down the collection computer from within MS Windows. When the collection computer it is fully turned off, the rest of the Kerberos™ system components can be powered off by turning off the system power.

## Maintenance

### Antenna pod seal check

The antenna pods contain several environmental seals to prevent moisture ingress. It is recommended to regularly check seal integrity of the antenna pods, but **only when the pods are installed on the wheeled trolleys**. Testing prior to trolley installation is not recommended, as some bolts that hold the pod milling together pass through the trolley base.

To check seal integrity, use a hand pump (or similar) to apply a small amount of air pressure (5 psi max.) via the air valves that protrude through the top of each pod - Figure 3 (d). These connect to the cavities containing the Tx and Rx antenna modules. **Note: Do not overinflate beyond 5 psi** as this may damage internal antenna components. Applying the small amount of air pressure, wait 30 seconds and depress the valve core.

Listen if air comes out. If it does, the antenna cavity seal is intact. Alternatively, use a pressure gauge to monitor if air pressure within cavities is maintained over the waiting period. If air pressure was not maintained, check and tighten all the M8 cap head bolts on top of the pod and the nuts securing the N-connectors. **Note: Do not over tighten** the N-connector nuts or the M8 bolts as it may damage the antenna pod.

If the top surface bolts and nuts have been tightened but air pressure cannot be maintained, it may be necessary to replace the lower skid plate. If this is the case, please contact your local distributor or Coded Radar directly for further instructions.

#### Notes:

1. The purpose of the air pressure test is to detect major sealing problems that may lead to water ingress, not to detect gradual air leaks.
2. Please ensure that all excess air pressure has been removed after completing the seal integrity check by fully depressing each valve core.

## Regulatory requirements

Operation of GPR equipment is subject to certain jurisdiction-specific requirements.

Within the United States, the Federal Communication Commission (FCC) specifies the relevant requirements within Part 15, Title 47 of the US Code (U.S.C.) of Federal Regulations.

Within Canada, the relevant limits are specified by Industry Canada (IC) within RSS-220.

Within Europe, the requirements are stated in Harmonized European Standard ETSI EN 302 066, Parts 1 & 2.

**Warning: Users of this equipment are advised that changes or modifications not expressly approved by the party responsible for compliance could void the User's authority to operate the equipment.**

## Information for operators in the USA

This device complies with Part 15 of the Federal Communication Commission's (FCC) rules regarding Ultra-Wideband Transmission Systems. Operation of this device is subject to the following 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.

Operation of this device is restricted to law enforcement, fire and rescue officials, scientific research institutes, commercial mining companies and construction companies. Operation by any other party is a violation of 47 U.S.C. 301 and could subject the operator to serious legal penalties.

## Information for operators in Canada

This device complies with the requirements defined in RSS-220 – Devices Using Ultra-Wideband (UWB) Technology and RSS-Gen – General Requirements for Compliance of Radio Apparatus.

Operation of this device is subject to the following 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.

This Ground Penetrating Radar Device shall be operated only when in contact with or within 1m of the ground.

This Ground Penetrating Radar Devices shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

## Service & support

For service, repair or support please contact your local authorised distributor, or contact Coded Radar directly at: [info@codedradar.com](mailto:info@codedradar.com) or via phone on: +61 7 3192 5352