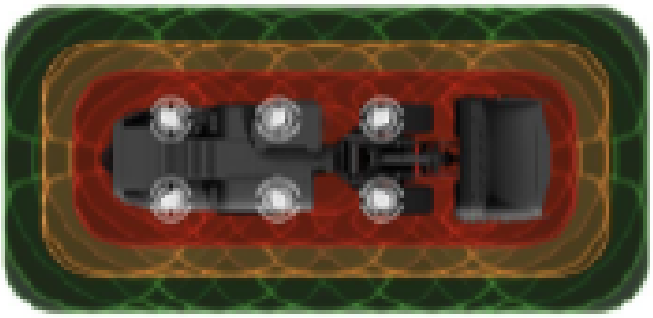
OptiMine®

Original instructions

Collision Warning/Avoidance System (CxS) Operator's Manual

v2023.4.12



⚠ WARNING

IGNORING INSTRUCTIONS HAZARD!

To avoid death or injury you MUST read, understand and follow operator's and maintenance manuals before installing, inspecting, operating, servicing, testing, cleaning, transporting, storing, dismantling or disposing of the product or a part or accessory of the product. Keep this publication for future reference.

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Table of Contents

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1 Introduction

1.1 General

Use this manual as a Collision Warning/Avoidance System-specific addendum to the Newtrax Vehicle Device (NVD) Operator’s Manual (NTX-NVD-OM-EN).

Refer to the NVD Operator’s Manual (NTX-NVD-OM-EN) for more information on the NVD generic components and other features that are not directly related to Collision Warning System (CWS) or Collision Avoidance System (CAS).

1.1.1 Collision Warning/Avoidance System

OptiMine® Proximity Detection and Collision Warning System improves operator awareness of vehicles and people, decreases downtime between vehicles, and helps manage interactions between vehicles and their environment in an underground mining operation.

Additionally, to increase safety in the mine, the solution can provide valuable information to improves the transparency of the underground mining process and optimize productivity.

In the following document, Collision Avoidance System (CAS) refers to a Collision Warning System (CWS) equipped with a Vehicle Intervention Controller (VIC). In order to refer to both systems interchangeably, the CxS abbreviation will be used throughout this document.

Note! ***For more information on the VIC, refer to the applicable section in this document and the manufacturer's manual.***

1.2 Purpose of these Instructions

The purpose of these instructions is intended as a guide for the intended use and maintenance of the product and to help the user to identify, avoid and reduce hazardous situations and related consequences.

These instructions must be followed along with any instructions given in local laws and regulations, any orders given by local authorities, and all protective measures specific for the site. When the instructions in this manual contradict site operating procedures, contact your supervisor.

Read and understand the complete manual carefully and follow given instructions strictly. If there is anything you do not understand, ask your supervisor or your local Newtrax representative to explain it. All sections of this manual contain information which is vital for your safety. This manual must be readily available to the Users and Administrators in either electronic or printed format. If you are using printed versions of the manual, they must be replaced immediately if lost, damaged, or unreadable. To replace the copies, please contact your local Newtrax representative.

When ordering replacement copies you must provide your Newtrax representative with the following information of the product:

- Product number
- Manual types
- Number of paper copies

- Language and version of the manuals
- Delivery address

The instructions set forth in the operator's and other manuals are to be used as a part of the training material during orientation. By following these instructions and local workplace safety regulations, safe practices will result, maintenance cost and downtime will be minimized, and the reliability and lifetime of the equipment will be optimized.

1.3 Disclaimer

Newtrax Technologies is committed to providing world class products, technologies and services. That commitment is underpinned by robust health, safety and welfare policies and procedures based upon, so far as is reasonably practicable, the reduction of risks and hazards while using the products and services for the purposes for which they are intended.

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1.5 Revision Summary

Date	Version	Comment
February 2023	2023-02-13	2022.3.1

1.6 Related Documents

Document type	Document number	Target group
NVD Operator’s Manual	NTX-NVD-OM-EN	End-User/Vehicle Operators
CxS Technical Manual	NTX-CXS-TM-EN	Newtrax regions application and technology specialists

1.7 Abbreviations

Abbreviation	Definition
BLE	Bluetooth Low Energy
CAN	Controller Area Network
CAS	Collision Avoidance System
CWS	Collision Warning System
CxS	Collision Warning/Avoidance System
FHB	Fixed Hazard Beacon
GUI	Graphic User Interface
ICD	Interface Control Document

Abbreviation	Definition
LO	Local Object
LTE	Long Term Evolution (Wireless broadband)
MET	Mobile Equipment Telemetry
MFD	Multi-Function Display
MRU	Mobile Recording Unit
NPD	Newtrax Personnel Device
NVD	Newtrax Vehicle Device
PDS	Proximity Detection System
PRS	Proximity Ranging Sensors
RF	Radio Frequency
RO	Remote Object
RSSI	Received Signal Strength Indicator
ToF	Time of Flight
UI	User Interface
USB	Universal Serial Bus
V2P	Vehicle to Pedestrian
V2V	Vehicle to Vehicle
VIC	Vehicle Intervention Controller
Wi-Fi	Wireless networking technology based on IEEE 802.11x

1.8 Terminology

Term	Definition
CxS Application	NVDs positioning module converts the raw ToF distance values collected by the PRS(es) into the 2D position of the ROs. It also manages the PRS firmware updates and configuration.
Mobile ID	An identifier that is unique to every vehicle, personnel, or location.
User/Operator	The person that operates the vehicle the CxS Application is installed in.

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2 Safety and Environmental Instructions

2.1 Safety labels, safety messages and signals

This section includes explanations of safety symbols, signs, signals and labels used on the product and in the information for use.

2.1.1 Signal words

The following signal words and symbols are used to identify safety messages in these instructions:

⚠ DANGER

The signal word, "DANGER", indicates a hazardous situation which, if not avoided, will result in death or severe injury.

⚠ WARNING

The signal word, "WARNING", indicates a hazardous situation which, if not avoided, could result in death or severe injury.

NOTICE

The signal word, "NOTICE", indicates a situation which, if not avoided, could result in damage to property or environment.

2.1.2 General hazard symbol

This general hazard symbol identifies important safety messages in this manual.

When you see this symbol, be alert; your safety is involved. Carefully read and understand the message that follows, and inform other users.

2.1.3 Hazard symbols

Hazard symbols are used to indicate the type of the hazard and the potential consequences. Hazard symbols are indicated by a yellow triangle with black symbols and black frames. All personnel working on or near the machine must understand and comply with information given in all hazard symbols.

Mechanical hazard symbols

Falling load hazard

Crushing hazard

Flying material hazard

Crushing hazard - feet

Crushing hazard - hands

Cutting hazard

Entanglement hazard

Entanglement hazard

Entanglement hazard

Entanglement hazard - rotating drill

Slipping hazard

Tripping hazard

Falling hazard

Skin injection hazard

High pressure injection hazard

Hanging load hazard

Run over hazard

Sideways tipping hazard

Forward/backward tipping hazard

Sideways tipping hazard, from level position

Sideways tipping hazard

Mechanical hazard symbols

Forward/backward tipping hazard

Sideways tipping hazard, from level position

Falling objects hazard

Remote controlled machinery hazard

Electrical hazard symbols

Electrical hazard

Dangerous electrical voltage

Electrical shock / Electrocution hazard

Overland line hazard

Thermal hazard symbols

Hot surface hazard

Hot coolant splashing hazard

Noise hazard symbols

Noise hazard

Radiation hazard symbols

Laser hazard

Radioactive hazard

Material/substance hazard symbols

Explosion hazard

Fire hazard

Hazardous/poisonous material hazard

Chemical burn hazard

Dust hazard

Environment pollution hazard

Battery hazard

Ergonomic hazard symbols

Lifting hazard

2.1.4 Mandatory action symbols

Mandatory action symbols specify actions to be taken to avoid a hazard. Mandatory actions are indicated by white symbols on a blue background. All personnel working on or near the machine must understand and comply with information given in all mandatory action symbols.

Wear protective gloves

Wear eye-protector

Wear safety helmet

Wear safety harness

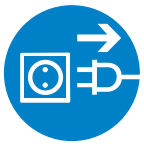
Wear hearing protectors

Wear safety footwear

Wear protective clothing

Wear high visibility clothing

Wear respirator



Disconnect from power source

Switch off and lockout equipment

Read the manual or instructions

Use cardboard for locating leaks in hoses

Use two-point belt

Use three-point belt

Read service and repair manual

Keep safe distance

Use walkways

Two persons for handling

General mandatory action symbol

2.1.5 Prohibited action symbols

Prohibited action symbols indicate actions which are prohibited in order to avoid a hazard. Prohibited actions are indicated by a red circle with a red diagonal line across the circle. The action which is prohibited will always be in black. All personnel working on or near the machine must understand and comply with information given in all prohibited action symbols.

No climbing

No smoking

No open flames

Do not touch

Limit or restrict access

Do not weld

Do not remove safety guard

Do not modify

General prohibited action symbol

Do not test for leak with hands

2.2 General Safety Instructions

⚠ DANGER	
	**PERSONAL INJURY HAZARD!** **If the machine and/or system are operated or serviced dangerously, incorrectly, or without sufficient safety procedures, this will result in death or severe injury.** **Operating, servicing, and adjustment procedures must be carried out by personnel with specialized operation and service training. All personnel who operate or drive the machine/system or carry out the maintenance or repair work must read and understand the operating and safety instructions before starting the work. Carefully plan your work beforehand to minimize the risk of damage or injury. Always obey the local laws and safety regulations.**

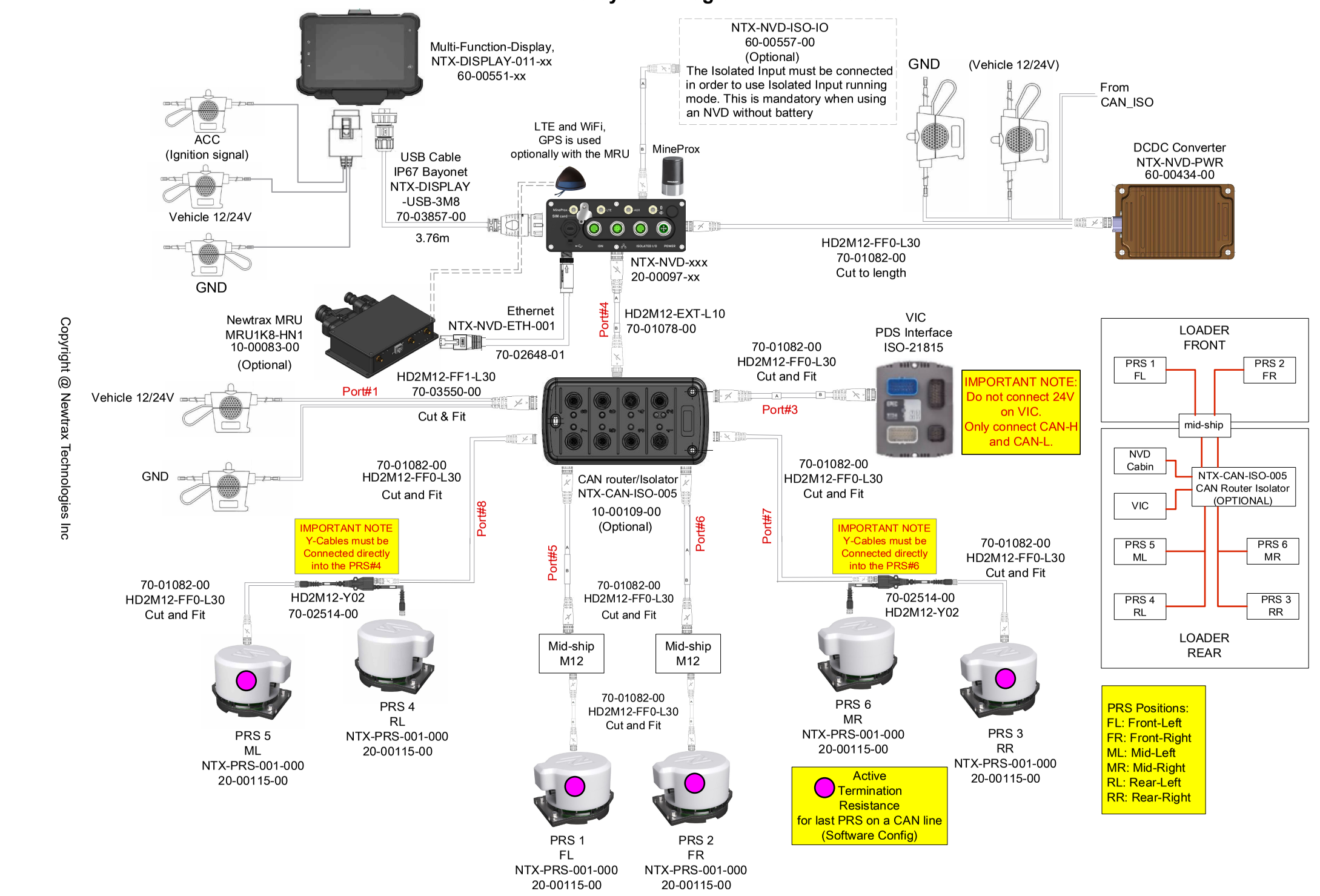
Due caution must always be observed when you are operating the system. Failure to do so can seriously endanger the safety of the operators and other personnel. All persons involved in operation or maintenance work must be aware of potential hazards and use safe working methods. Read the manufacturer's instructions and follow them before starting any maintenance or repair work.

Operators must understand how to use the system and the consequences of using it contrary to the instructions.

All production personnel with access to areas where Proximity Detection, Collision Warning and/or Collision Avoidance are in use, must be trained to recognize safety risks and learn how to get access to the area safely if necessary. Sufficient signs to instruct people must also be in place at each access area.

3 Kit Description

CxS System Diagram for the Loader



Note! ***The above image shows a typical CxS installation for a heavy vehicle with 6 PRSs. The image shown is for reference purposes only.***

3.1 NTX-NVD-CORE-xxx NVD Kit

Refer to Newtrax Vehicle Device (NVD) data sheet for more details and the NVD Manual for kit contents.

3.2 NTX-DISPLAY-011-xx MFD

Refer to Multi-Function Display (MFD) data sheet for more details.

3.3 MRU1K8-HN1 MRU (Optional)

Refer to Mobile Recording Unit (MRU) data sheet for more details.

3.4 NTX-PRS-001-00x Kit

NTX-PRS-001-006	Kit for a 6-PRS Installation
NTX-PRS-001-004	Kit for a 4-PRS Installation
NTX-PRS-001-002	Kit for a 2-PRS Installation
NTX-PRS-001-001	Kit for a 1-PRS Installation

Note! ***Contact your Newtrax representative to find which kit is suitable for your application.***

4 System Components

4.1 Vehicle Devices

⚠ WARNING	
	**RISK OF DAMAGE TO DEVICE!** **Care must be taken during installation as the power connection may differ.** **Work on electric equipment or materials must be done by qualified electricians or other professionals, or assistants under supervision and control. The local electric technical and electric safety regulations must always be observed. Replace the fuse with ones that provide the same over-current protections as the original fuses. Refer to the data sheet for more details.**

⚠ WARNING	
	**RISK OF ELECTROCUTION!** **Electrocution could cause death or severe injury.** **Work on electric equipment or materials must be done by qualified electricians or other professionals, or assistants under supervision and control. The local electric technical and electric safety regulations must always be observed.**

4.1.1 Newtrax Vehicle Device

Combining Newtrax MineProx® technology with the ranging distances acquired by the multiple PRSs installed on the vehicle to position in 2D the vehicles and pedestrians that are also equipped with Newtrax CxS-enabled devices also enables the following:

- Displays remote objects in the vicinity on its User Interface (UI) with the use of:
  - MineProx® RO count by type
  - CxS Bullseye that shows the distance of the nearest RO in its specific sector.
- Provides **Slowdown** and **Stop** advisory notifications on the UI when ROs are within the configured distance threshold
- Triggers vehicle-controlled Slowdown and Slow to stop interventions, with the use of ISO 21815-2 over CAN when ROs are within a certain distance threshold
- Stores and forwards significant MineProx® events over Wi-Fi and LTE back to OptiMine® Mining Data Platform (MDP) for reporting
- Provides notification when the link is lost with a PRS or with the VIC.

Note! ***Refer to NVD operator manual for more information on the NVD core components and other features which are not related to CxS.***

Note! ***Only trained personnel must use the NVD.***

4.1.2 Newtrax Multi-Function Display (MFD)

The Newtrax Multi-Function Display (MFD) is a tablet that runs the CxS situational awareness application and provides the following features:

- Remote Object (RO) types, counts, and their distance are entered into the expanded CxS Bullseye for a better user experience
- MineProx® RO type and count into the expanded CxS Bullseye for a better user experience
- MFD is connected to the Newtrax Vehicle Device (NVD) via a Universal Serial Bus (USB) connection

- Docking station and RAM mount for optimal positioning in the cabin
- Can be installed in landscape and portrait orientation
- Submenus that provide additional diagnostic information

For more information on the MFD, refer to NTX-Display-011 data sheet.

Note! ***Only trained personnel must use the MFD.***

Note! ***The operator must wait for the MFD to initialize before using the vehicle.***

4.1.3 Proximity Ranging Sensor (PRS)

⚠ WARNING	
	**RISK OF COLLISION!** **Damage to the Proximity Ranging Sensor (PRS) can put the operator and others at risk.** **The PRS detects CxS-enabled vehicles, pedestrians equipped with CxS-enabled cap lamps, and CxS-enabled fixed beacons. Each PRS must be checked regularly to make sure it is functioning properly. It is recommended to check at least once at the beginning of the shift and once during the shift.**

The PRS provides the following features:

- Dual RF technology measures the distance between the vehicle and remote object up to 100m with increased precision within 20 meters
- Line-of-sight visual indication of proximity to pedestrians and other equipment with integrated bright multicolored LEDs

- The PRSs are connected to the NVDs CAN port with or without the CAN isolator, which depends on the number of PRSs on the vehicle
- Up to 6 PRSs can be installed on the vehicle, depending on the size of the vehicle.

For more information on the PRS, refer to NTX-PRS-001-000 data sheet.

4.1.4 CAN Isolator

There are 4 CAN ports for the PRSs, 1 CAN port for the NVD, and 1 CAN port for a Vehicle Intervention Controller (VIC). The CAN Isolators have the following features:

- The Newtrax CAN Isolator forwards CAN messages between the 6 CAN ports based on a custom routing configuration with the use of M12 connections.
- The unit is designed to isolate the data from each CAN port and provide fast and bidirectional data between all the CAN ports.
- It also isolates power, so a short circuit on one CAN line does not affect all devices. This is achieved with an internal resettable fuse for each CAN port.

For more information on the CAN Isolator refer to NTX-CAN-ISO-005 data sheet.

4.1.4.1 Power Cable - CAN Isolator

- The CAN Isolator power cable (HD2M12-FF1-L30) is necessary to power the CAN Isolator and the PRSs connected to it.
  - Failure to use this specific cable will prevent the CAN Isolator from powering up as it uses 4 pins and 4 conductors to supply power.
- The end of the power cable is cut and installed in a fuse holder with a fuse to make a safe connection to the selected vehicles power source.

4.1.5 Vehicle Intervention Controller (VIC)

- Can intervene by inhibiting the action of the throttle pedal and slowing down the vehicle when a remote object is detected in the Slowdown Intervention zone
- Can intervene by inhibiting the action of the throttle pedal and applying the service brakes when a remote object is detected in the stop intervention zone
- Can intervene by inhibiting the action of the throttle pedal and applying the emergency brakes when a remote object is detected in the Stop Intervention zone.

Note! ***Interventions triggered by an NVD are signaled over CAN J1939/ ISO-21815-2.***

Note! ***A VIC is necessary to enable the Collision Avoidance System (CAS) mode functionalities. Refer to Modes of Operation section in the CxS Operators Manual for more information on the operating modes.***

Note! ***Only trained personnel must install and configure the Vehicle Intervention Controller (VIC).***

4.2 Personal Devices

4.2.1 NTX-NPD-L1x

The L1x Cap lamp is a Newtrax Personal Device (NPD) with digital safety features designed for underground mining operations. The Cap lamps have the following features:

- Functions as a unified platform for Ranging, Proximity Detection, Positioning and Communications services for workers in underground mines
- Can be detected by vehicles installed with the Newtrax Collision Warning/Avoidance System (CxS) solution
- Can be repaired in the field.

For more information, refer to the NTX-NPD-L1X data sheet.

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5 Operating Instructions

5.1 General

⚠ WARNING

RISK OF COLLISION!

If the NVD loses external power during operation, the vehicle will be shown as parked to other NVDs and will not be positioned on the Bullseye of other CxS-enabled vehicles.

The NVD must be configured and commissioned to enable the NVD LCD CxS Bullseye or MFD CxS Application. Only Newtrax certified personnel must configure and commission the NVD. Refer to CxS Technical Manual for instructions.

⚠ WARNING

RISK OF COLLISION!

Intentional or accidental damage to a part of the Proximity Detection System (PDS) or Collision Warning System (CWS) or Vehicle Intervention Controller (VIC) may compromise the ability to report any detection of remote objects that can put people and vehicles in the area at risk of a collision that could result in death or severe injury.

The system must be checked regularly to make sure that the device is functioning properly. It is recommended to check at least once at the beginning of the shift and once during the shift. For more information, refer to *System Verification and Maintenance (Page 86)*.

⚠ WARNING

RISK OF COLLISION!

Intentional or accidental damage to a part of the PDS or CxS may compromise the ability to report any detection of remote objects that can put people and vehicles in the area at risk of a collision that could result in death or severe injury.

The operator must wait for the User Interface (UI) to be initialized before using the vehicle. If a worker realizes that the system or any component is not working properly or if found damaged, then they must report it immediately. Mine safety working procedures must be followed. If there is no directive, then the vehicle must not be used in normal operation.

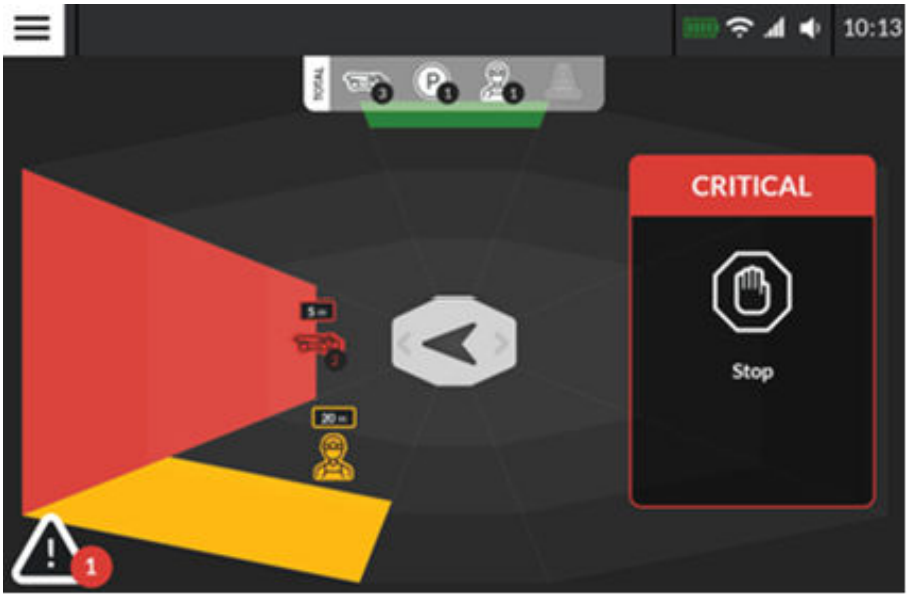
5.1.1 Modes of Operation

The Collision Warning System measures the distance and the position of light vehicles and heavy vehicles with respect to the Local Object (LO), by combining the measurements obtained by the Proximity Ranging Sensors

(PRS) that are installed on the equipment. The relative position and distance of the Remote Object are displayed on a 360-degree bullseye, on either the Newtrax Vehicle Device (NVD) or the Multi-Function Display (MFD).

These Remote Objects are prioritized on the display with three distance-based zones around the equipment that each have a corresponding color, depending on their severity, such as Green (Low), Yellow (Medium), and Red (High). As an additional visual indication of an oncoming Remote Object, the PRSs embedded LEDs blink the color of the most severely breached zone.

The CWS also gives audible and visible advisory notifications to Slowdown or Stop which depend on the distance and position of the Remote Object with respect to the traveling course of the equipment.



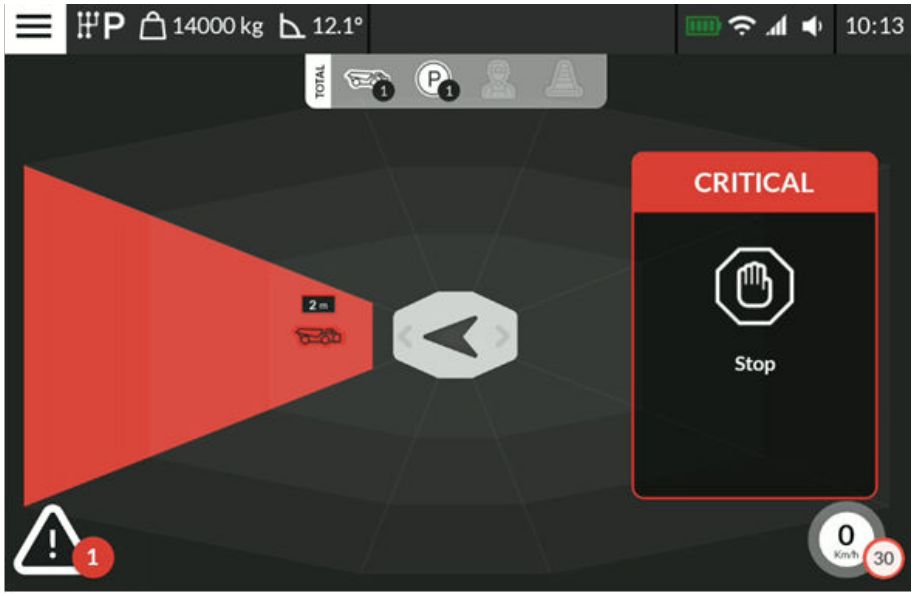
5.1.1.1 CWS Without Telemetry

The current solution has fixed-sized zones that are adapted to each model and designed by taking into consideration many factors, such as the maximum speed, maximum gear, braking performance of the equipment, and system delays.

5.1.1.2 CWS with Telemetry

Connecting the Collision Warning System (CWS) to the OptiMine® Mobile Equipment Telemetry (MET), which can give machine speed, speed limit, direction, and gear in real-time, allows the CWS to modulate the zone sizes and advisory notifications dynamically based on these inputs, therefore reduces the nuisance alarms.

Additionally, these telemetry parameters that are shared with the CWS are displayed on the Multi-Function Display (MFD), if installed.



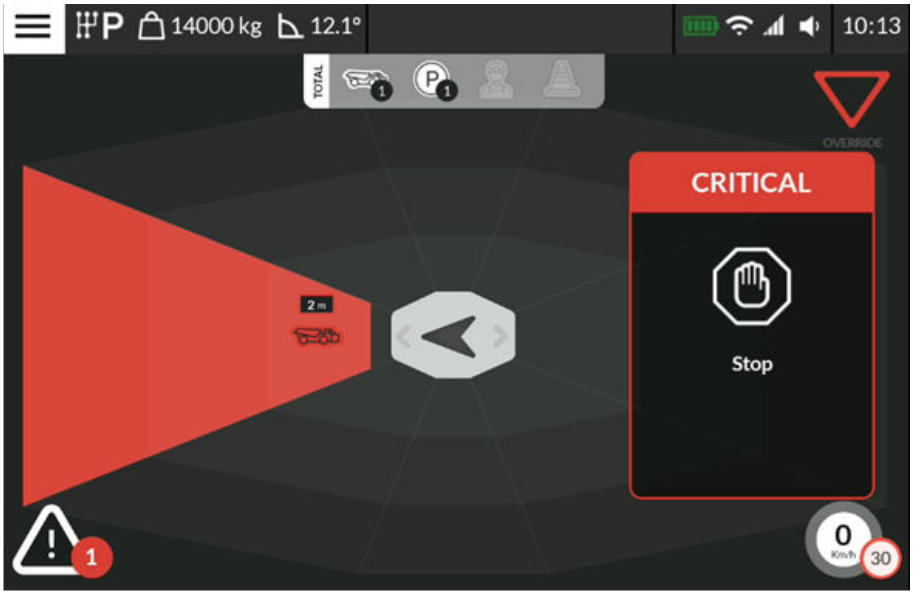
Note! ***This mode of operation is not available in the current release of the manual. Contact your Newtrax representative for more information.***

5.1.1.3 Collision Avoidance System (CAS)

The Collision Avoidance System capability can be unlocked by interfacing with an Intervention Controller that complies with the ISO21815-2 protocol - the standard Collision warning and avoidance communication interface for earth-moving machinery.

When the Remote Object breaches the most critical zones, the Collision Avoidance System (CAS) will send a signal to the Intervention Controller to request a controlled machine Slow-down or even a Slow-to-Stop, if the object is in extremely close proximity. It will also inhibit motion when the system detects a Remote Object in close proximity or if an anomaly with the system is detected.

Some Intervention Controllers could also be used as telemetry input if that system allows it. Enabling the CAS module also enables the Override button on the display (Only available on the MFD). The latter can be touched to override a Stop or Stand-Down signal requested by the CAS to the Intervention Controller.

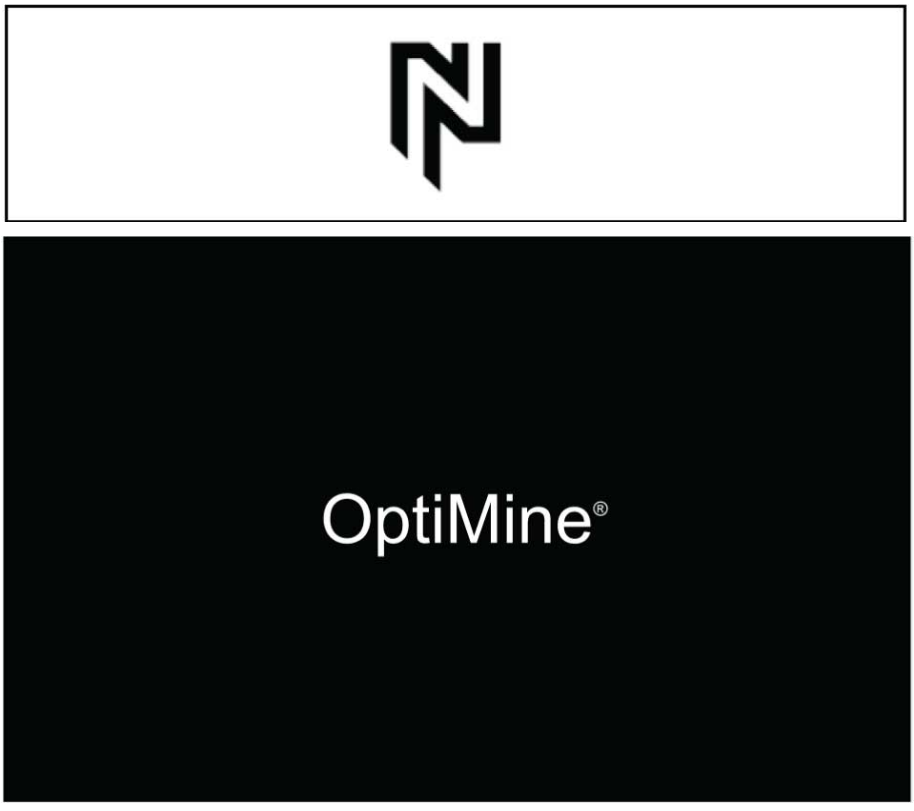


Note! ***This mode of operation is not available in the current release covered in this manual. Contact your Newtrax representative for more information.***

5.1.2 Initialization of Application

Note! ***Before operating the vehicle, the operator must wait for the screen to initialize.***

After the NVD was configured to perform CWS/CAS, the CxS Application initializes automatically on the NVD and the MFD (if equipped) at power-up.

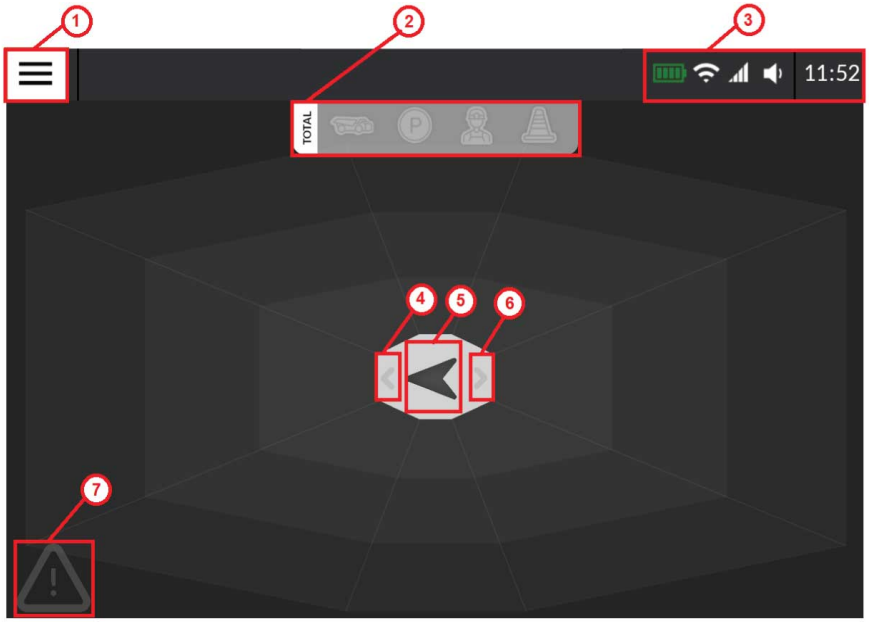


5.2 UI Fields

5.2.1 NVD User Interface (UI) Fields

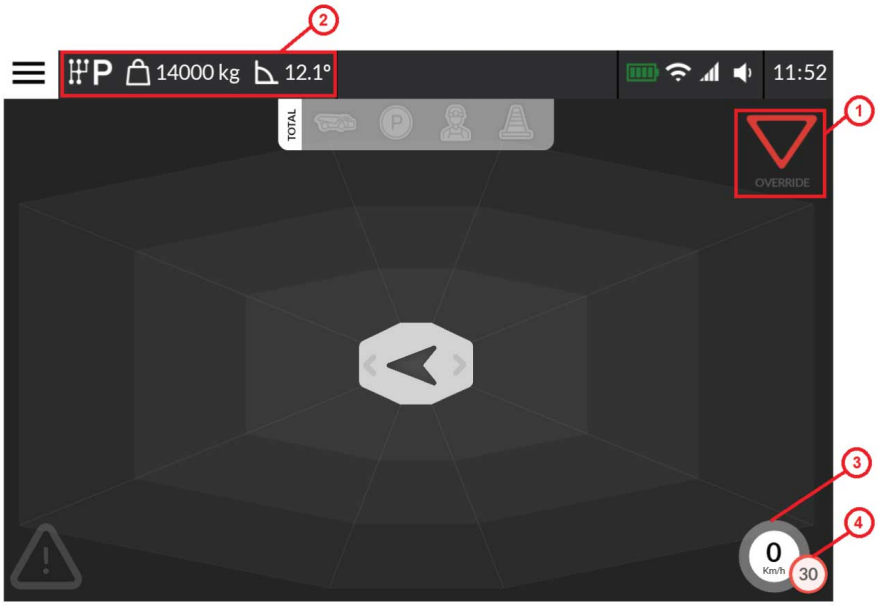
1. NVD status bar, from left to right:
   a) Current time - NVD
   b) Battery Status of the NVD
   c) Wi-Fi Status of the NVD
   d) LTE Status of the NVD
2. Units of distance, used in the Bullseye.
3. Orientation of the vehicle.
4. MineProx® RO types, from left to right:
   a) Vehicle in operation
   b) Vehicle parked
   c) Pedestrian wearing NPD
   d) Fixed Hazard Beacon
5. MineProx® RO count.
6. CxS Bullseye.
7. Alarms area.

5.2.2 MFD CxS UI Fields



1. Main menu.
2. MineProx® status bar.
3. MFD status bar, repeats the value from the NVD, from left to right:
   a) Battery status of the NVD.
   b) Wi-Fi status of the NVD.
   c) Status of the NVD LTE.
   d) Volume Level of the MFD.
   e) Current Time of the NVD.
4. Forward driving indicator, requires Telemetry input.
5. Orientation of the vehicle (e.g., LHD: pointing toward the bucket).
6. Reverse driving indicator is necessary for a Telemetry input.
7. Active Alarms/RO List table.

5.2.2.1 Telemetry Input and Collision Avoidance System (CAS) (Optional)



1. Local Override button.
2. Telemetry inputs, from left to right:
   a) Gear (D: Drive, N: Neutral, R: Reverse, P: Parked).
   b) Payload.
   c) Slope angle.
3. Telemetry input: Current speed of the vehicle.
4. Speed limit.

5.3 CxS Bullseye

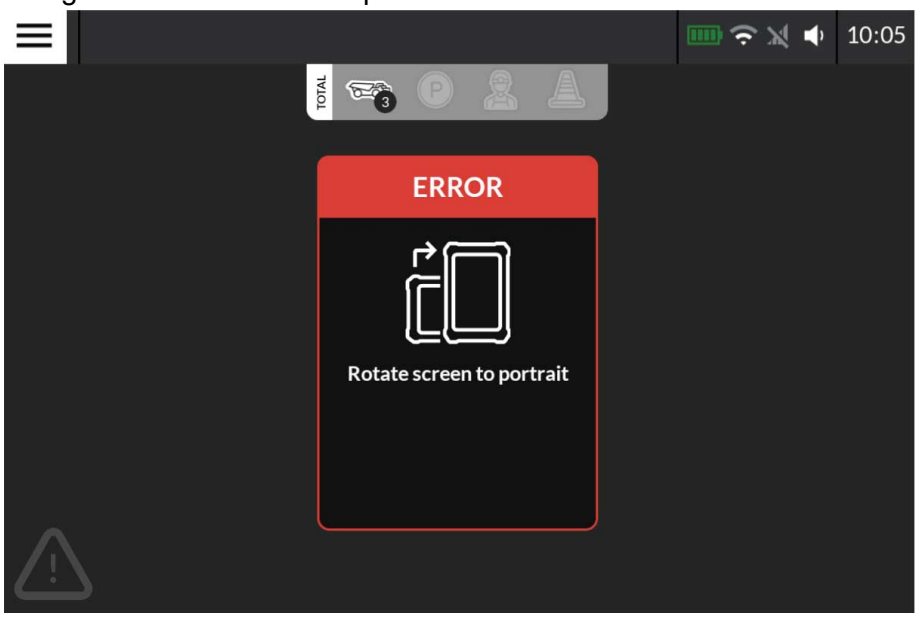
5.3.1 Orientation

⚠ WARNING	
	**RISK OF COLLISION!** **If the CxS system is used without the proper Multi-Function Display (MFD) configuration, this could lead to a collision that could result in death or severe injury. If you change the orientation of the Multi-Function Display (MFD) physically, it will shut the Bullseye and prompt an error message indicating that the MFD is not in the right orientation.** **The orientation must be configured by Newtrax certified personnel. The MFD must be oriented as it was configured.**

The MFD can be installed in either portrait or landscape orientation, which depends on where the front of the vehicle is:

- The MFD must be in front of the operator and set to portrait mode for a vehicle being driven forward direction with the operator sitting in the direction of driving, such as a haul truck.
- The MFD must be in front of the operator and in landscape orientation for a vehicle where the operator is seated sideways, such as a loader.

The image below is an example of MFD placed in landscape when it was configured to be oriented in portrait mode.



Note! ***Do not operate the vehicle with the MFD in the incorrect orientation.***

5.3.1.1 Portrait Orientation

Graphical Representation of the Vehicle

MFD Screen Shot

NVD LCD Bullseye Screenshot

5.3.1.2 Landscape Orientation

Graphical Representation of the Vehicle