# **Praetorian** Fibre Optic Sensing

## Conveyor Idler Monitoring and Fire Detection >


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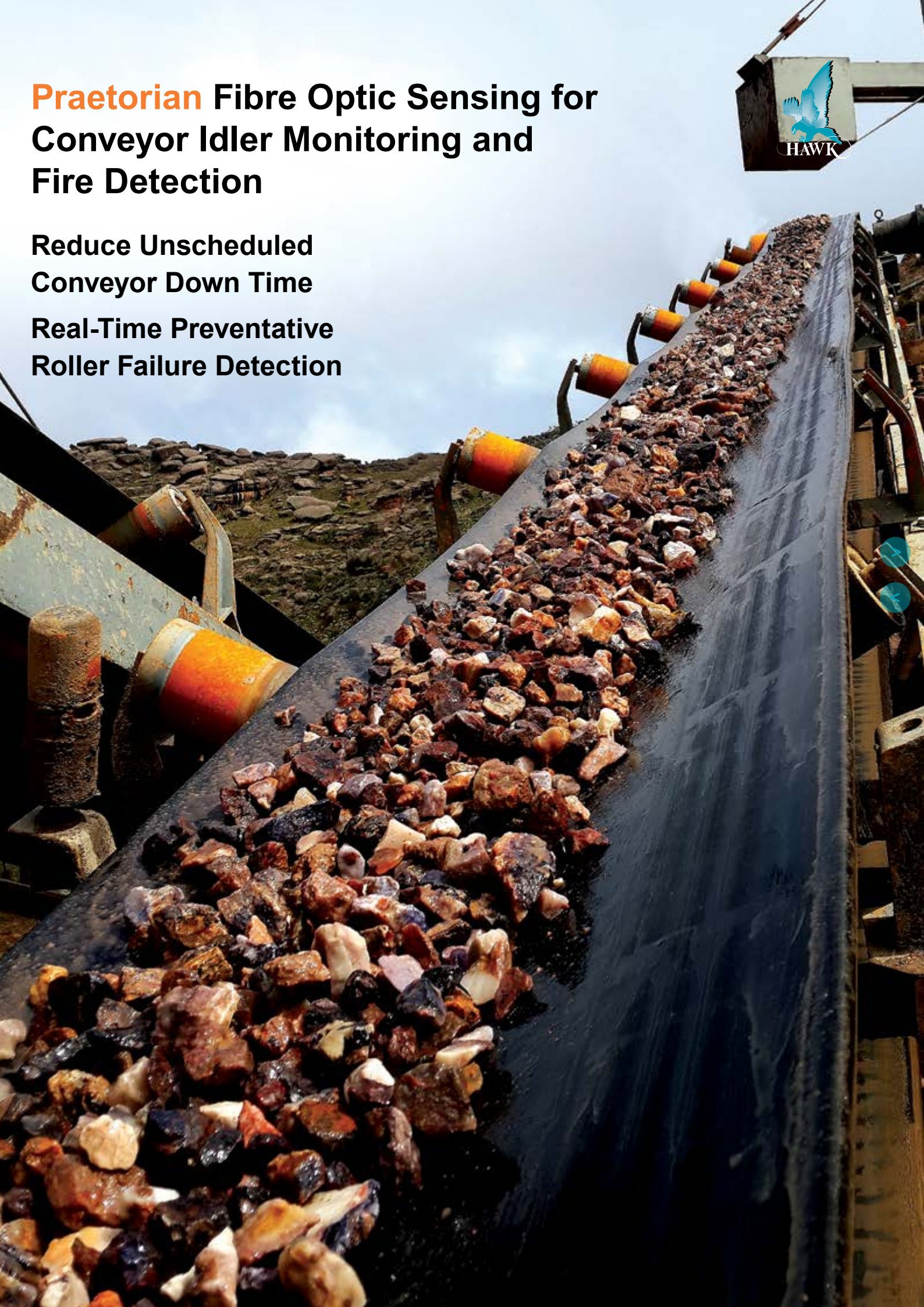
# Praetorian Fibre Optic Sensing for Conveyor Idler Monitoring and Fire Detection

## Reduce Unscheduled Conveyor Down Time

## Real-Time Preventative Roller Failure Detection



## Introduction

The mechanical nature of conveyors make them highly prone to wear and tear that can lead to failure of components and cause failures that can shut down the entire conveyor. Since conveyors are often the main form of locomotion for raw and saleable material within a plant; it follows that when a conveyor goes down so too does the profitability of an operation.

The Praetorian Conveyor Health Monitoring System (CHMS) provides a simple and reliable way to monitor each moving part of the conveyor for its running condition without the need for additional power or communications to be installed in the field. Praetorian's sensing capability is so great that even the slight variations in signal caused by wear and tear can be detected and a likely fault can be predicted and intercepted prior to failure, thereby reducing downtime and damage.

Due to its simple installation requirements, Praetorian and can be installed on new installations or retrofitted at a low cost per meter. With multi-channel capability Praetorian also has the capability to monitor multiple conveyors simultaneously such that a single system can be programmed to monitor an entire site.

## Function

Praetorian converts a fibre optic cable into a nearly infinite series of microphones and thermometers recording in real time. The system analyses an enormous amount of data using an ultrafast Field Programmable Gate Array (FPGA) architecture to give real time feedback on the likely origin and type of the disturbance. Utilizing proprietary pattern recognition software, Praetorian reduces the incidences of false positives normally associated with other Fibre Optic Sensors (FOS).

Using a series of pattern recognising algorithms Praetorian detects, identifies and reports failing and degrading bearings prior to catastrophic failure resulting in costly unscheduled downtime or safety risks.

Consisting of an Interrogator unit mounted in an indoor area (such as a server or control room) at one end of the conveyor, Praetorian can be configured to look after a single large conveyor or be routed around a plant to cover multiple conveyors at once. With a total fibre length of 80km per Interrogator it is possible for entire plant's worth of conveyors can be covered by a single Praetorian system.

As part of the commissioning system comparisons between "brand new" and "fully failed" idlers are made to allow the Praetorian to monitor the wear pattern on idlers and give a 0-100% "wear percentage" to operators. This allows preventative maintenance decisions about roller swap-outs to be made and allows asset and reliability managers to optimise roller lifespan preventing premature change out of rollers that still have usable lifespan remaining.

From an operation or systems integration approach Praetorian reports each conveyor leg stand covered by the system with a numerical value for wear percentage. Operators are then able to adjust alarm thresholds to suit their individual conveyor's behaviour utilising trend history gathered over the commissioning period. Each of these alarms and wear percentages are available via a number of digital communication protocols and by default Modbus TCP/IP is supplied. In the event that no SCADA or DCS is being used Praetorian can be directly controlled and monitored through its built in Graphical Human Machine Interface (HMI).

Praetorian's main advantage over traditional measurement methods is that signals are objectively observed, compared and referenced against predetermined and known good conditions in real time. Instead of relying on a manual audio/visual inspection that occurs once a shift. In addition, problems in inspection inaccuracies associated with operator fatigue, operator error and the natural loud sound response of the human ear (which reduces accurate aural responses) also is circumvented though the use of a Praetorian Fibre Optic Sensing system.

Another distinct advantage of using the Praetorian system over traditional periodic inspections is that detected failures can be tracked. This allows trends to be established giving operations the ability to make reasonable estimates of operation hours from detection of wear to complete failure of roller or other asset. This allows for targeted maintenance operations to be conducted during convenient production down times rather than stopping production when a roller is suspected of failing. This also removes the subjective nature of audio/visual inspection by different personnel.

Praetorian also Geo-tags alarms allowing operations or maintenance teams to respond immediately or plan maintenance activities to fit with existing schedules.

## Principle of Operation

The Praetorian system Interrogator unit is connected to one end of a fibre optic cable which is attached to the conveyor belt's static structure. The Interrogator produces rapidly pulsed laser light set at a precise frequency that excites the fibre and causes it to be responsive to physical changes around it. Some of this light is reflected back (backscattered) to the light source where the Interrogator records and analyses looking for changes to its colour relating to physical effects in the application.

Using a combination of Rayleigh backscatter, Brillouin backscatter and time of flight, Praetorian determines the presence, location, intensity and frequency of vibrations and temperature changes along the optical fibre in real time.

## Time of Flight

Locations of events are able to be accurately determined by a method called time of flight. Similar to radar, sonar and ultrasonic instruments, the amount of time from sending the laser pulse to receiving a return signal is recorded.

Due to the internal properties of a fibre optic core, the speed of light through a fibre is consistent at approximately two thirds of the speed of light through a vacuum (around 400 microseconds for a 40 Kilometre round trip). As speed is consistent, the return time can be used to calculate a distance on the fibre down to as accurately as 250 millimetres.

## Vibration Detection

In the Praetorian Interrogator, an optical effect called Rayleigh backscatter is used to observe vibrational effects on a fibre. In a fibre optic core, backscatter is the light that reflects off natural imperfections and polarizations within the fibre and returns to the light source. The return light gets diffracted into different frequencies similar to light moving through a prism and Rayleigh backscatter is one of these diffracted frequencies.

The amount of compression from vibration due to an environmental signal (or noise) on the core determines the strength of the Rayleigh component in the backscattered light. In this way the intensity and frequency of the vibration is measurable by recording the behaviors of the Rayleigh backscatter component. This change in intensity and frequency is used to determine the presence and position of a disturbance.

Rayleigh backscatter responds to physical vibrations imparted on the fibre by disturbances in the conveyor belt's normal vibrations. Traditionally the challenge of determining conveyor fault though sound has been to be able to remove the huge amounts of noise and vibration that are part of the normal running condition of the fibre.

HAWK'S signal analysis software allows Praetorian to quickly determine which signals are not consistent with the normal running sounds of the conveyor. Whilst monitoring and sampling over longer periods of time, it is possible for Praetorian to notice that signals occurring at a particular location have changed in a manner that indicates increased bearing wear. The system then reports the location of this worn idler or pulley to operators giving an advanced indication of impending roller failure.

To be classified as an alarm the duration, dominant frequencies and relative intensity of a signal all need to be present within pre-determined thresholds. This reduces the amount of false signals that move in to an alarm condition.

### Temperature Detection

At the same time the Interrogator is monitoring for vibration Praetorian will continuously hunt for temperature spikes along the belt's length. The main use of temperature in conveyor applications is for fire detection where an ignition has occurred.

Praetorian accomplishes this by scanning a separate fibre within the cable and looking for changes to another component of backscattered light called Brillouin refraction. The system can be calibrated to run very quickly (a few seconds) using lower accuracy (±1°C) scans of the fibre for temperature, or take a slower (30-60 seconds) more detailed scan for maximum accuracy (±0.25°C) of temperature to sense even the smallest changes.

Temperature as a primary sensing variable is not recommended as heat transfer from the bearing to the support and from the support to the fibre is minimal. Typically a temperature sensing fibre is connected to an overhead catenary wire that sits under the weather shield and monitors conveyor air temperature. In this way Distributed Temperature Sensing (DTS) can thereby be utilised for general fire protection duties of any linear infrastructure.

In normal conveyor belt configurations vibration acts as a primary sensing and detection variable used to schedule maintenance activities where temperature monitoring is used as an emergency condition detection method.

## Primary Areas of Applications

**Installation locations:**

- Coal Mines, Hazardous Area Suitable (No Infield Electronics)
- Hard Rock Mines
- Quarries
- Buildings
- Unmanned Material Handling Facilities
- Processing Plant Conveyors

**Possible applications:**

- Overland Conveyors
- Building Fire Detection
- Conveyor Fire Detection
- Remote or Rural Conveyors

## Features

Due to its utilisation of a Field Programmable Gate Array (FPGA) Praetorian is able to monitor every point along the fibre and constantly monitor for frequency changes in the individual conveyor idler leg stands and monitor changing conditions within the idler bearing.

Another distinct advantage with the Praetorian system is that it is able to work such that it is immune to the effects of a broken or cut fibre. The unit can be attached as a loop to both channels on independent fibres and in the event of a cut will report the damage, but continue to monitor the fibre on both sides up to the cut. Alternatively, if installed in a non-looped fashion Praetorian will monitor the position of the fibre end and check for any change. It can instantly identify a cut to the fibre.

In all distributed acoustic fibre sensors, the detected signal level has certain variations depending on the polarization state of the received signal which produces scattering of the signal. This scattering can be constructive interference or deconstructive interference, and to date there has been no ability to compensate for this scattering which is referred to as signal fading. HAWK has patented an effective solution to overcome signal fading, where small signals can be detected without fading.

Unlike systems restricted by Multimode LED light sources Praetorian uses a highly stable laser controlled to within ±0.04pm allowing the system to handle two independent sensing channels of up to 40km each without any loss of measurement in switching or time splicing.

## Technical Specifications

| Category | Parameter | Description |
|---|---|---|
| General | Sensing Element | Fibre Optic Sensing Cable |
| | Number of channels | 1 or 2 |
| | Interrogator operating Temperature | 0-50°C |
| | Unit operating Humidity (max) | 85% non-condensing |
| | Dimensions | 4RU 19” Rack Enclosure (190x600x490mm) |
| | Weight | 25kg |
| | Power Supply | 110-240VAC (50-60Hz), 24VDC |
| | Power consumption | <200W |
| DAS Performance | Sensing Range | Up to 40km per channel |
| | Spatial Resolution | 250 or 500mm |
| | Frequency Response | 1Hz-120kHz (Range Dependant) |
| | Dynamic Range | 50dB |
| | Temperature sensing range (cable) | -30°C to 200°C (special options for temps up to 800°C and down to -200°c available) |
| DTS Performance | Accuracy | ±0.25°C |
| | Resolution | 0.01°C |
| | Scan Time | 1-2 Minutes (Depending on Temperature Parameters) |
| | Temperature Sensing Range | -250°C to 700°C |
| Technical | Light Source | Laser (Infra red) Class 1M |
| | Laser Wave Length | 1550.12nm (nanometres) |
| | Laser Stability | ±5pm (picometers) |
| | Acquisition rate | 400MHz |
| | Processor Acquisition Rate | 64Bit (Ultra high speed) |
| | Operating System | Linux |
| | Output | Modbus Ethernet TCP/IP (Standard), Relay, USB, SCADA or User Specified |
| | Remote Interfacing | Ethernet and 3G/4G enabled |
| | Processer architecture | Field programmable gate array (FPGA) |
| | Data Storage (Removable) | 2x 2TB HDD (removable) |
| | Data Storage (Internal) | 128GB Solid State Drive |

## Other Uses

This document covers the use of the Praetorian Fibre Optic Sensing system utilising the underground cable protection and monitoring software suite and hardware. However there are a large number of other applications Praetorian is well suited to monitor.
These include but are not limited to:

- Perimeter Intrusion Detection System (PIDS) Security
- Pipeline Leak Detection System (LDS)
- High voltage power transmission or data Cable Monitoring Systems (CMS)
- Fire Detection
- Infrastructure Strain and Stress Monitoring
- Borehole Condition Monitoring

Praetorian can be installed with temperature, vibration and strain modules and expanded to suit a wide range of sensing application.

## Part Numbering

**Model**

**FOS** Praetorian Fibre Optic Sensing Interrogator

**Power Supply**

B 24VDC
U 110-240VAC

**Sensing Method**

AXX Distributed Acoustic Sensing
TXX Distributed Temperature Sensing
ATX Distributed Acoustic and Temperature Sensing

**Channel**

01 Single Channel
02 Dual Channel

**Mounting**

4R 4RU Rack Mount

**Communications**

M Modbus

**Software Options**

CON1 Conveyor Health Monitoring System

**Special**

X Not required

| FOS | U | ATX | 02 | 4R | M | CON1 | X |
|---|---|---|---|---|---|---|---|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Additional product warranty and application guarantees upon request.
Technical data subject to change without notice.

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