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APPLICATION NOTE

SECURITY – PERIMETER INTRUSION DETECTION SOLUTIONS UTILISING DISTRIBUTED ACOUSTIC SENSING (DAS)

Bandweaver's range of advanced Distributed Acoustic Sensing (DAS) technology has a successful track record in providing Perimeter Intrusion Detection Systems (PIDS) to a wide variety of sectors all around the world. With a family of products that ensures the correct Detection Unit (DU) for any size asset. DAS sensing technology is especially suited to providing highly accurate location information of a perimeter breach along extended site boundaries.

INTRODUCTION

Perimeter Intruder Detection Systems (PIDS) act as a technology force multiplier, they keep a constant watch on a site's perimeter and offer the opportunity for early detection of an attack.

Perimeter detection solutions are a growing segment of physical security risk mitigation, without proper investment the perimeter can become a significant vulnerability. Long distances increase the potential for undetected entry. A properly designed perimeter should aid in deterring would be intruders, assisting in delaying, detecting, and denying hostile intent.

The PIDS market segment is growing due to a number of key drivers which include:

- Surge in infrastructure development
- Increased regulations and compliance – both governmental and insurance
- Increase threat of perimeter breach
- Move away from heavy security manpower requirements

Any perimeter detection system should focus on providing real time accurate location data with a minimum number of nuisance alarms to retain operator confidence.

The perimeter can be formed by various types of physical barrier, and it is common to have several types on a single site, these could include:

- Chain link fence
- Palisade fence
- Weld mesh fence
- Brick, block or concrete walls

In addition, there may be no physical barrier and the perimeter is marked by open ground with minimal/no site delineation. An effective perimeter section system should be able to encompass all the above perimeters and treat them all equally.

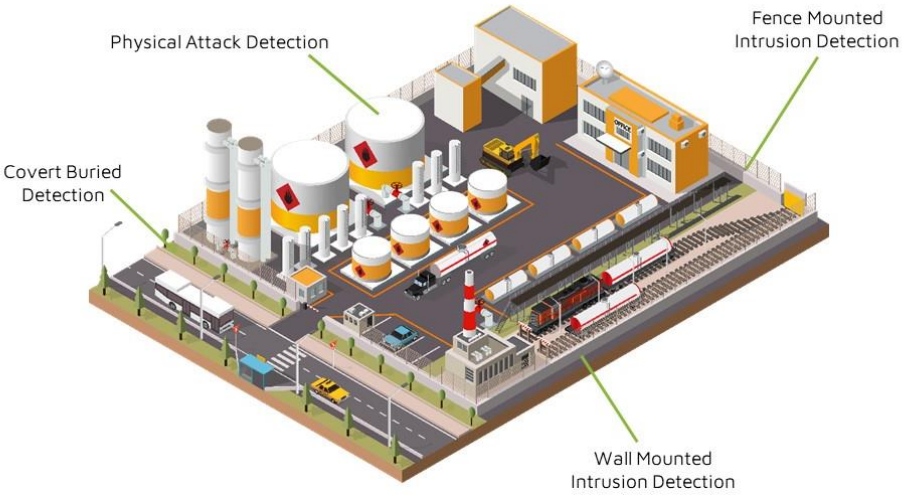

Figure 1 – Types of detection

Before deploying a perimeter intruder detection system, it is recommended that asset owners consider the requirements and any constraints to select the most appropriate technology, this is not an exhaustive list, but these include:

Risk factors:

- The threat profile for a perimeter breach – vehicle breach, fence climb, ladder climb, fence cut, tunnelling, etc.
- The consequence associated with this breach – this will drive investment and budget decisions.
- Risk of explosion or fire on site from a potential source of ignition

Physical/practical factors:

- Perimeter construction – fence, wall, open ground, etc.
- Access gates – quantity, type and frequency of use and how will they be protected.
- Perimeter lighting – how well-lit or dark sections of the perimeter may be
- Sources of potential nuisance alarms – radio frequency interference, EMI, etc.

Environmental factors:

- Geographical features – changes in ground height, dips, gulleys, etc.
- Site landscaping – bushes, trees, tall grass, and other foliage near to perimeter.
- Local climatic conditions – local weather features, wind, snow, etc.

Technical/operational factors:

- Power requirements – what power is needed and where.
- Infrastructure requirements – is there direct buried cabling or ducts, trenches, etc. required.
- Operator interface – how to demonstrate quickly and clearly the location of an alarm.
- Monitoring and response – who/where will the monitoring and response teams be located for any alarm activation.
- Requirements for 3rd party integration such as CCTV system or command and control central monitoring platform.

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PIDS Technology Overview

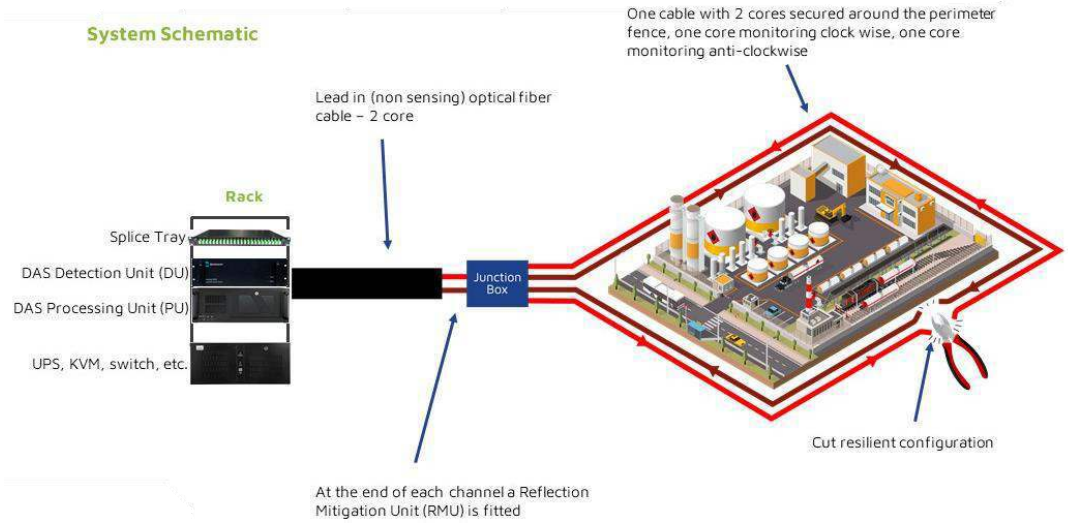
There are many different types of PIDS technology on the market, the table below shows a comparison on the most common type of detection. Some technologies are more suited to shorter range perimeters.

	Fence mounted Fiber Optic Cable	Buried Fiber Optic Cable	Radar	Active Infrared	Electric fence	Micro-wave	CCTV Video Motion Detection	Thermal Imaging Cameras
Line of sight detection required	No	No	Yes	Yes	No	Yes	Yes	Yes
HSE risk	No	No	No	No	High	No	No	No
Suitable for intrinsically safe sites	Yes	Yes	No	No	No	No	No	No
Affected by fog, heavy rain	Low	None	Low	High	Low	Low	Medium	Low
Impacted by changes in terrain	No	No	Yes	Yes	No	Yes	No	No
Requires power in field	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Impacted by vegetation/foliage	No	No	Yes	Yes	No	No	Yes	No
Installation & Commissioning	Simple	Simple	Complex	Simple	HSE Risk	Medium	Medium	Medium
Maintenance Requirements	Low	Low	High	Medium	Medium	Medium	High	High
Life span of detection sensor	Typically 25+ years	Typically 25+ years	Typically 3-5 years	Typically 3-5 years	Typically 3-5 years	Typically 3-5 years	Typically 3-5 years	Typically 3-5 years
Suitable for long range perimeters	Yes	Yes	Multiple Units	No	No	Multiple units	Multiple Units	Multiple Units
Infrastructure Investment Costs	Low	Low	High	High	Medium	High	High	High
System affected by EMI/RFI	No	No	Yes	Yes	No	Yes	Potential	Potential
System triggered by animals	Low	Low	Low	High	Low	Medium	High	Medium
System affected by rivers/water	No	No	Yes	No	No	Yes	No	No
Installed Cost	Low	Low	High	Low	Low	High	High	High
Whole Life Costs	Low	Low	High	Medium	Medium	High	High	High

The above table demonstrates that the selection of technology must be carefully considered. As you will see from the first two columns fiber optic cable detection has an excellent resilience to nuisance alarms while having a low installation cost together with low ongoing maintenance costs with exceptional whole life value.

There are several different types of sensing technology utilised for fiber optic cable PIDS, these include Fiber Bragg Gratings, Interferometry and Coherent Optical Time Domain Reflectometry (COTDR) Some systems report alarms in a zone-based fashion with typical zones of 100 meters and others with location accuracy of an event down to 1 meter. All sensing types typically utilises 9/125 single mode fiber.

The technology comparison table shown previously is based upon COTDR fiber optic cable sensing which, although it comes with a heavier price tag, is recognised as the leading technology for reliability, location accuracy and probability of detection. The added advantage of deploying a COTDR solution is its excellent resilience to cable cuts or damage, unlike alternative technologies COTDR detection will continue to work up to the point of cable cut and when wired in a two-channel loop configuration ensures system redundancy – please see figure 2.



The diagram (left) shows a resilient design to maintain detection capability in the event of a fiber cable cut or damage with only one cable required but 2 fiber cores and 2 channels required, one core monitoring clockwise and one core monitoring anti-clockwise.

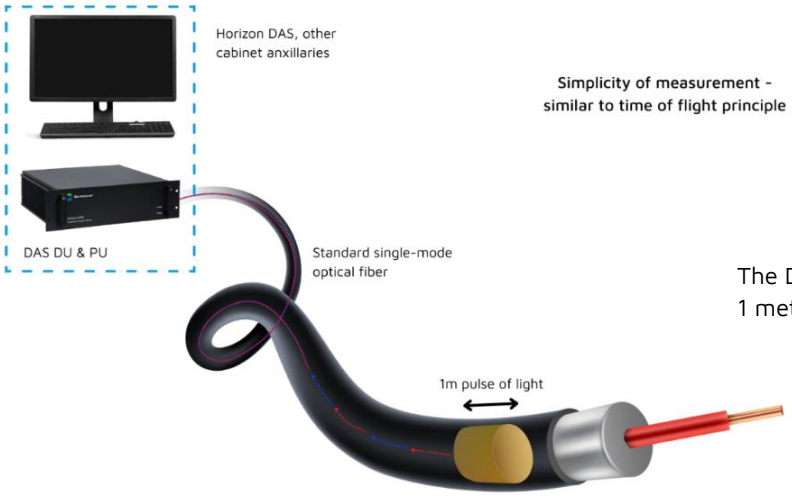
Figure 2 – Cut resistant configuration

COTDR based PIDS solutions have a number of key advantages over alternate technologies including:

- Consistent detection over long distances – up to 50km per channel
- Highly sensitive detection – producing excellent acoustic signal gathering.
- Leading location accuracy – identifying an intrusion down to 1 metre.
- Suitable for both fence/wall mounted and buried applications

How it works

The DAS Detection Unit (DU) sends an encoded light signal down a standard single mode fiber cable, this light will reflect back to the DU from micro imperfections in the side of the glass fiber (referred to as Rayleigh backscatter). When the cable is exposed to vibration the characteristics of the backscatter changes and the DAS PU analyses these changes against advanced algorithms. If a pattern is recognized an alarm event will be generated and a location will be identified based upon the length of time the light took to reflect back to the DU.



The DU will typically sample points every 1 meter down along the fiber optic cable.

Figure 3 – Simplicity of measurement

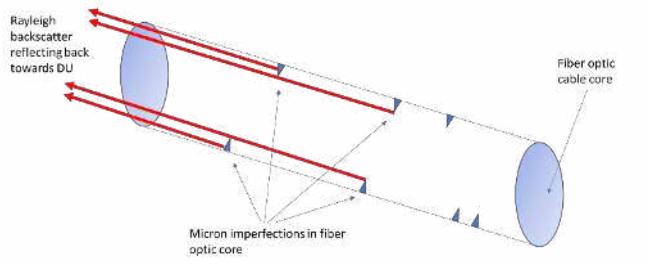


Figure 4 – Representation of Rayleigh backscatter

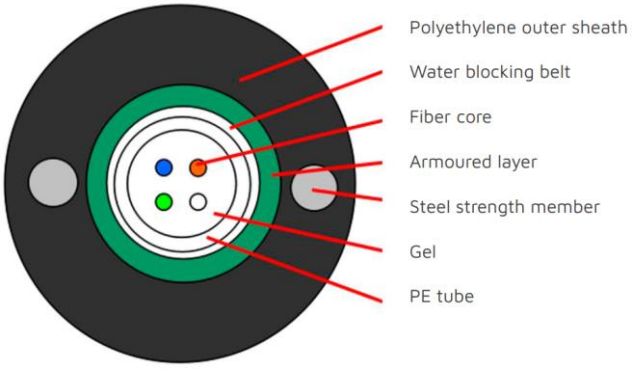


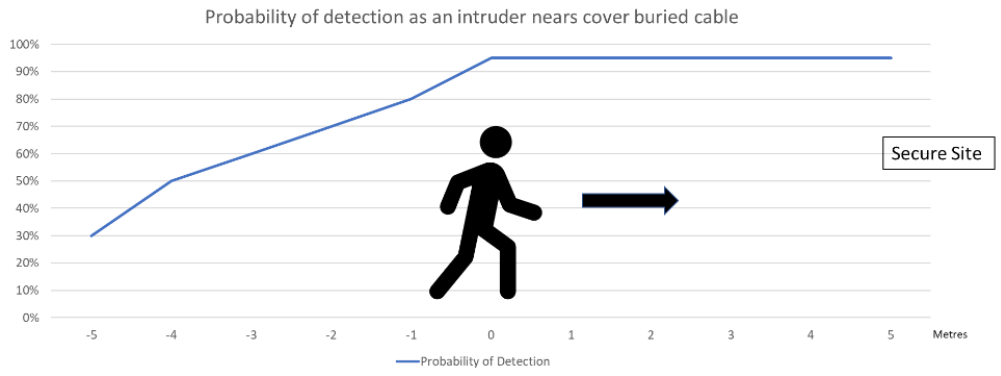
Figure 5 – Composition of fiber optic cable

The cable will be attached to the fence in a straight-line run using outside grade UV resistant cable ties as per the diagram on the left below and in a loop pattern on a gate as per the diagram on the right below.

Figure 6 – Fence mounted detection - patterns

For buried detection the cable can be installed at a depth of around 40-70 cm, this ensures reliable detection in most soil conditions whilst still providing a covert solution that will survive most environmental conditions. The cable ban be buried in either in a straight run pattern or a serpentine pattern dependent on the performance requirements, the serpentine pattern gives greater detection capability to detect crawling, planking, etc.

Figure 7 - Covert buried detection – patterns



Note: Exact detection capability is dependent on cable depth, soil type etc. when the system is setup for minimal nuisance alarms.

Figure 8 - Covert buried detection – Detection probability is typically 95%+

Notes:

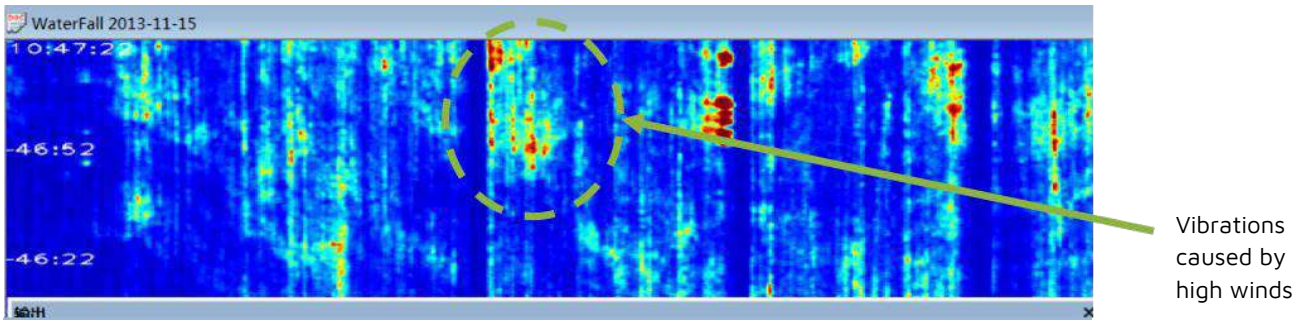
- Trench can be dug either by hand or by mechanical digging.
- Dependent on soil type, adding an additional layer of uniform crushed gravel or similar aggregate on top of the optical fiber cable provides good vibration transmission, especially in loose or sandy soil conditions.
- Landscape maintenance should be undertaken to ensure that the cable depth does not exceed 70cm in operational conditions.

Detection Algorithms

Fiber optic based PIDS utilise advanced machine learning to process signals to ensure a high probability of detection whilst reducing the risk of nuisance alarms, these can include pattern recognition, artificial intelligence, Deep Neural Networks (DNN), and Recurrent Neural Network (RNN) amongst others.

The raw data is processed via advanced environmental algorithms which can differentiate between environmental noise and real intrusion events as demonstrated below.

Without environmental correction algorithm:



Using environmental correction algorithm:

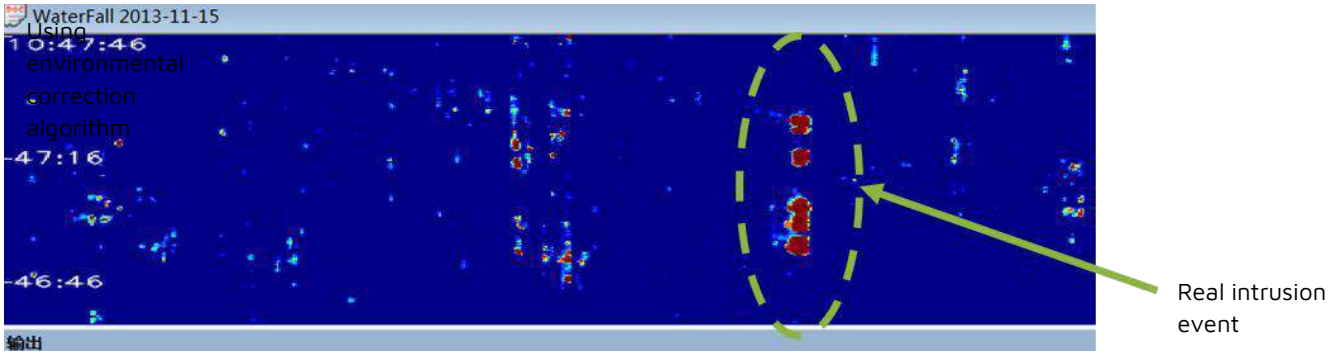


Figure 9 – Waterfall with and without environmental correction algorithm

Utilising the latest generation machine learning ensures that the PIDS solution will still detect an intrusion event even during the worst weather conditions; ensuring operator confidence remains high.

Fiber Optic PIDS as part of a wider security system

Typically a PIDS solution will be deployed as part of a wider site risk mitigation solution alongside other sub-systems such as CCTV, access control, screening and scanning equipment, etc. It is therefore vital that the PIDS solution fully integrates into any command and control system whether a PSIM, VMS, SMS, etc. Typical architecture is shown below:

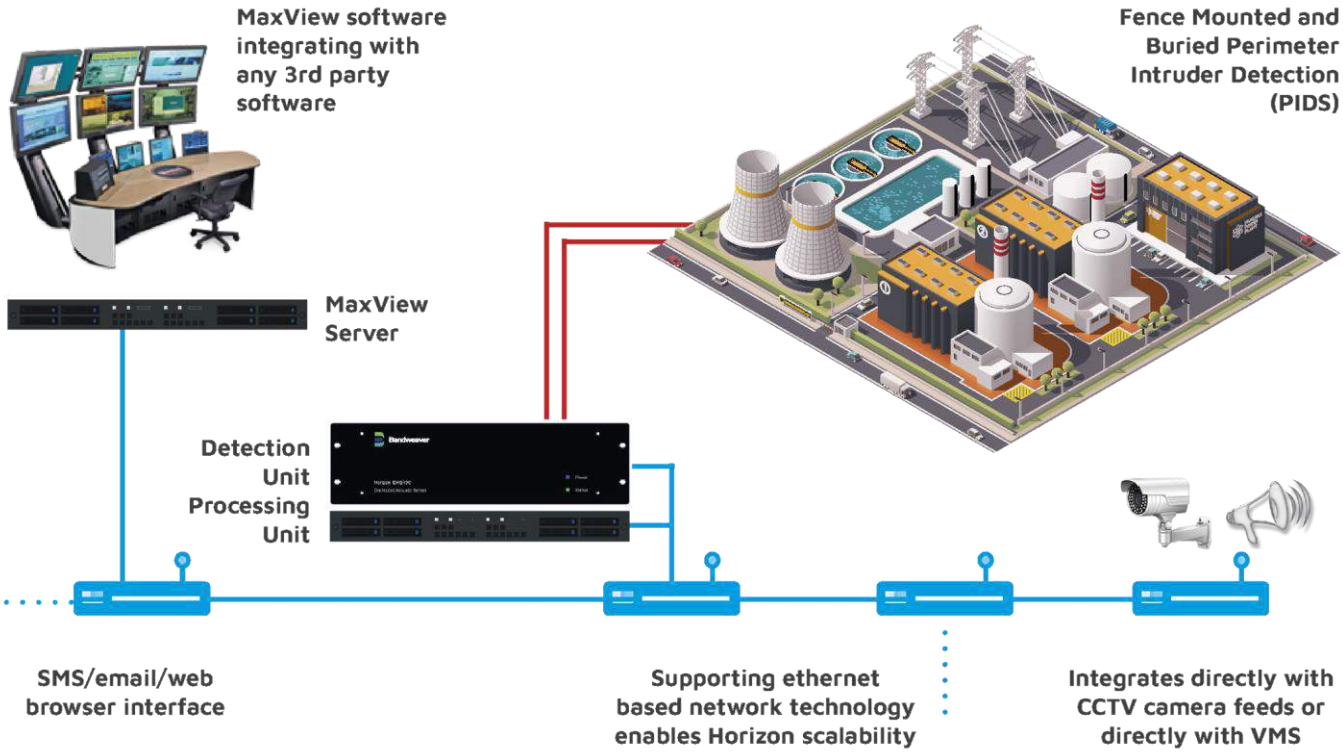
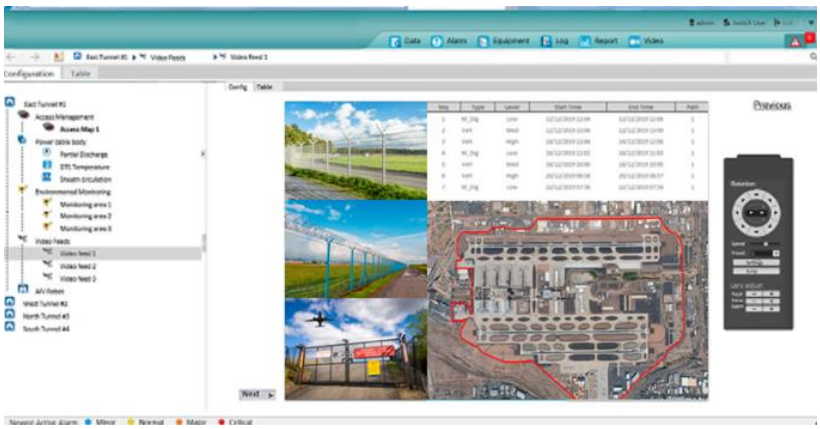


Fig 10 - Typical PIDS system architecture

Graphical User Interface

Typically the PIDS solution will be connected to a central server which will act as the human machine interface (HMI) where the operator can see a map view of their site and any alerts or alarms similar to the screenshot below. The GUI will display in real time any intrusion alerts together with the exact location on a map with GPS coordinates and where connected the feed form the most relevant CCTV camera, this ensure that the operator has all relevant information at their disposal to affect an appropriate response.



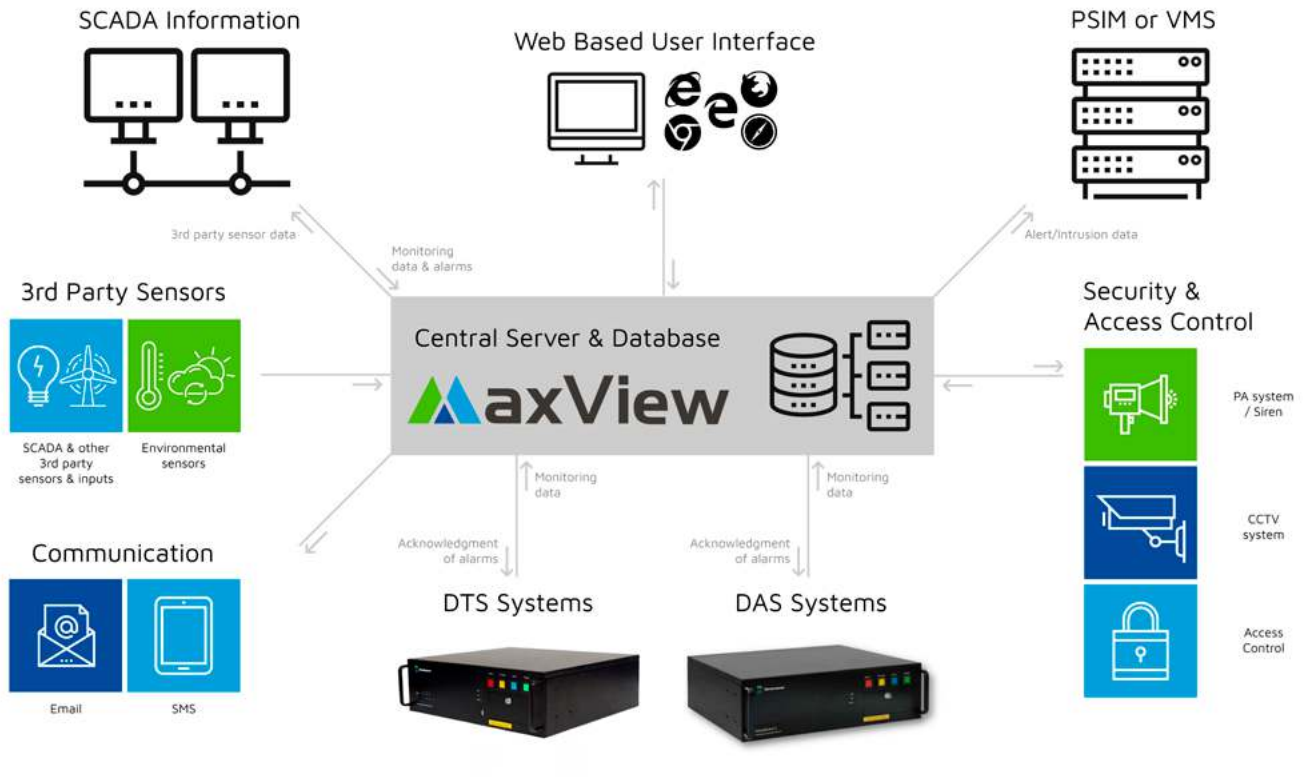


Fig 11 – MaxView interconnections

About Bandweaver Technologies

With an installed base of over 60,000km and 8,000 systems installed, Bandweaver's vision is to be the first choice for integrated distributed fiber optic sensing solutions across the globe. Since 2002, Bandweaver has been committed to delivering reliable, innovative, client-centric and value-added products and services, via a dedicated and talented team of people.

Bandweaver manufactures and distributes advanced fiber optic monitoring sensors and integrated technologies, enabling customers to monitor, secure and keep personnel and critical assets safe.

With quality and excellence as fundamental elements of Bandweaver's portfolio, the business is continuously developing its range of technologies, including Distributed Temperature Sensors (DTS), Distributed Acoustic Sensors (DAS) and integrated smart intelligent software solutions.

Utilising the latest technologies, Bandweaver provides solutions for Security, Fire, Power and Pipelines.

For further information please contact our global team at info@bandweaver.com