2P Square DAS之應用案例說明

APSensing簡介

- Leading distributed optical sensing solution provider (DTS, DAS)
- Over 35 years of optical measurement expertise based on HP/Agilent heritage
- Approved manufacturer by UL, FM, VdS, IECEx, ATEX
- ISO 9001, 14001, 45001 and 27001 certified
- Experienced and certified project managers and engineers, 365 days support, proven training programs

HEWLETT PACKARD

1939

Hewlett-Packard (HP) started as a test and measurement company.

1959

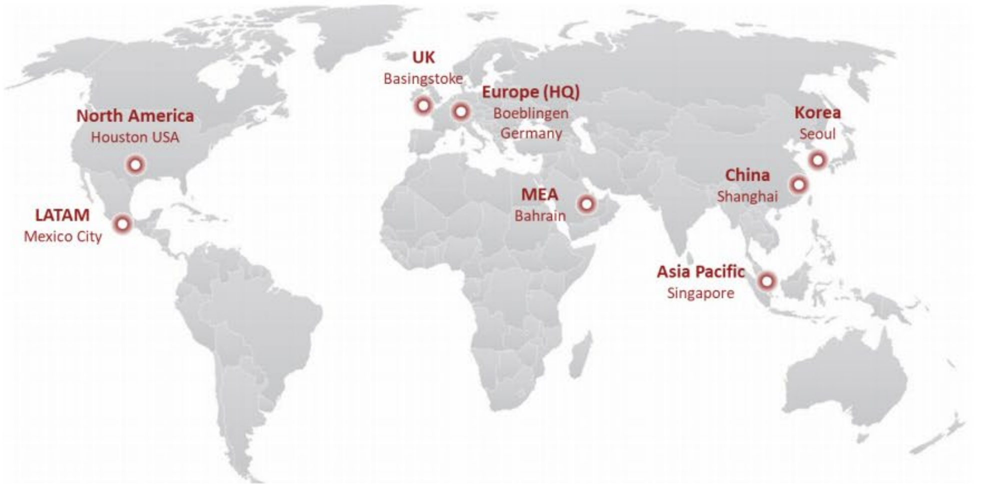
HP establishes its first production site outside of the US in Böblingen, Germany.

1999

Measurement business from HP is spun off into Agilent Technologies.

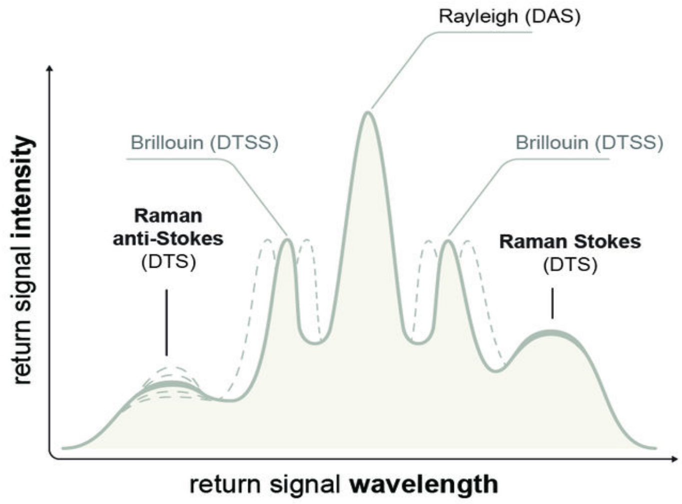
2007

Fiber optic sensing business is spun off into AP Sensing.


UK
Basingstoke
Europe (HQ)
Boeblingen
Germany
North America
Houston USA
Korea
Seoul
China
Shanghai
MEA
Bahrain
LATAM
Mexico City
Asia Pacific
Singapore

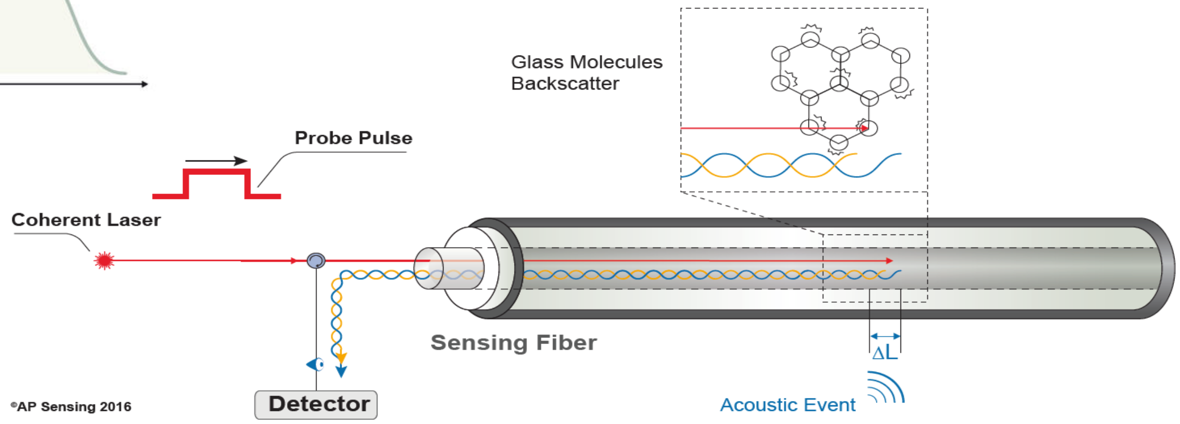
光纖分佈式聲波探(DAS)測系統簡介

DAS (Distributed Acoustic Sensing)
聲音測量概念及原理



DAS 利用跟DTS類似的背向散射技術。

雷利散射效應是光纖內因為聲音和振動活動而受到微小應力激發產生變化。傳回的信號經由分析會依據干擾程度以頻率和振幅形式來呈現。


Glass Molecules Backscatter
Probe Pulse
Coherent Laser
Sensing Fiber
ΔL
Acoustic Event
Detector
©AP Sensing 2016

聲音與震動的事件位置取決於測量光纖脈衝傳回的時間，類似雷達回波技術。

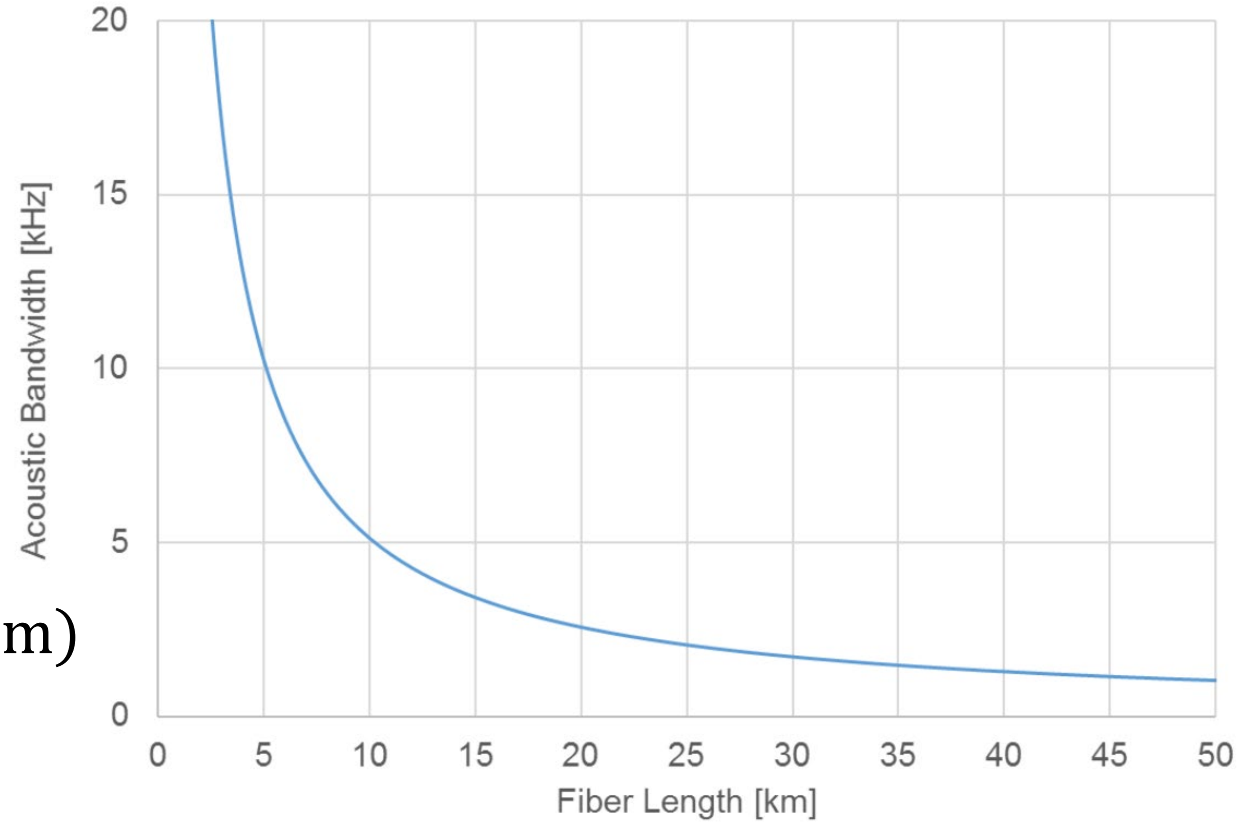
聲波頻率與光纖長度之關係

$$f_{max} = \frac{c_0/n}{2L}$$

$$c_0 = 3 \times 10^8\ m/sec$$

n = 1.4682

L = total fiber length (m)

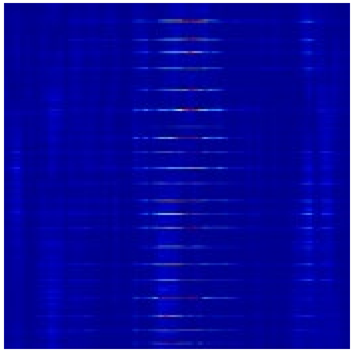


$$acoustic\ frequency = \frac{1}{2} \times f_{max} = \frac{c_0/n}{4L}$$

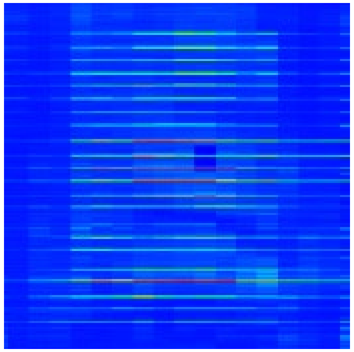
光纖分佈式聲波探測(DAS)系統簡介

DAS 應用領域

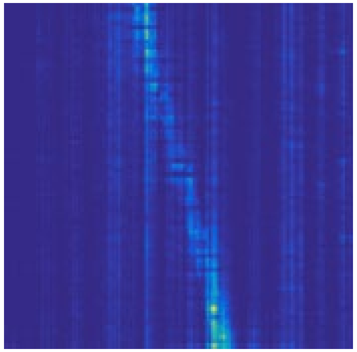
人工挖掘



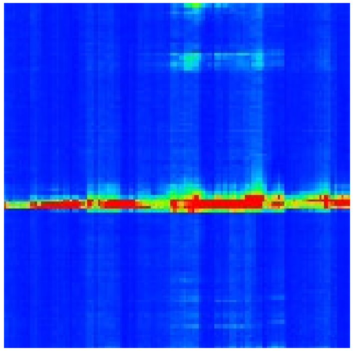
機械挖掘



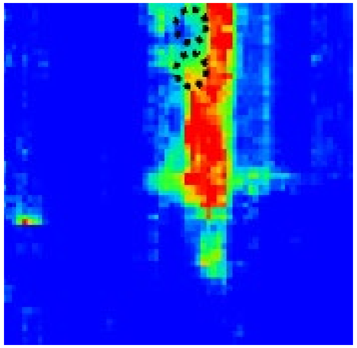
步行



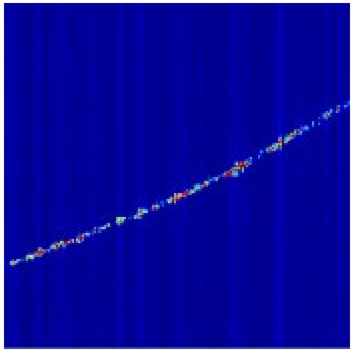
故障定位



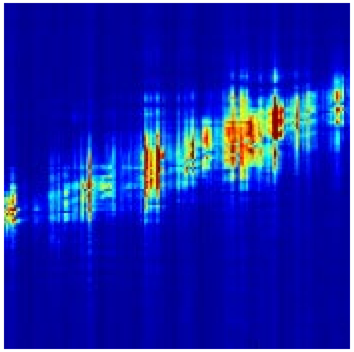
洩漏



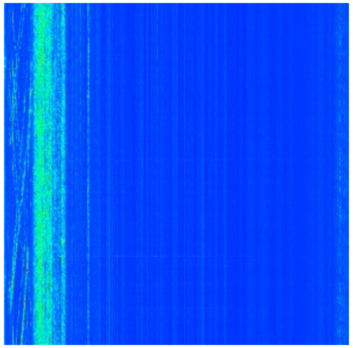
車輛



火車

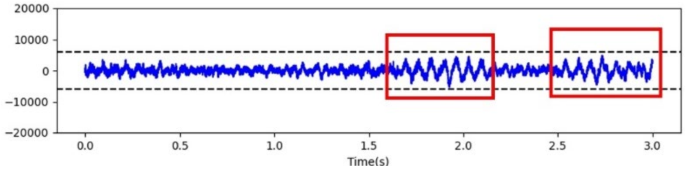


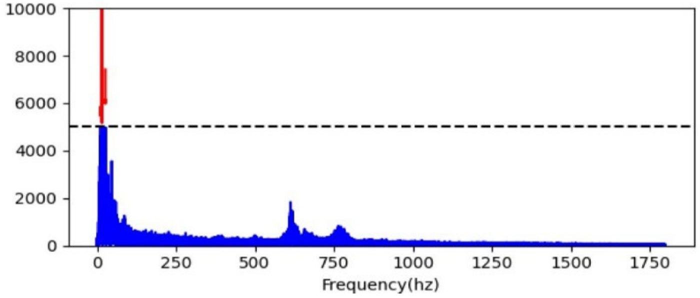
聲學分析

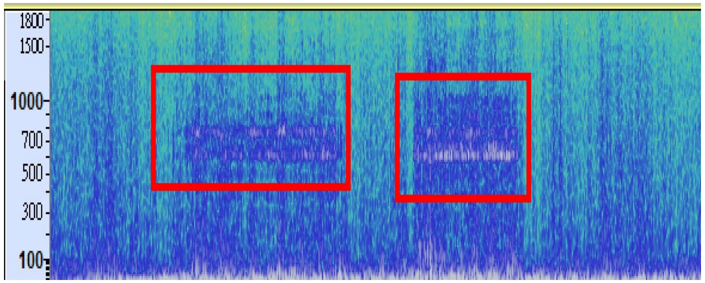


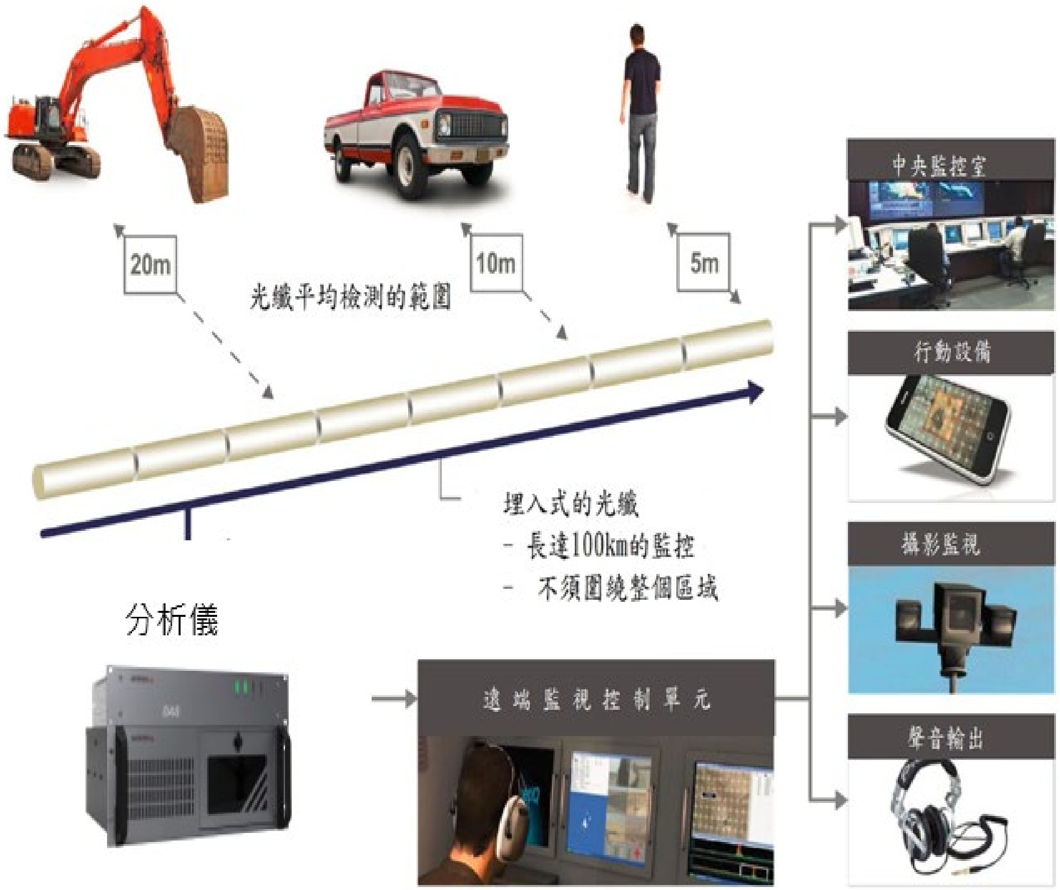
光纖分佈式聲波探測(DAS)系統簡介

DAS系統架構示意及事件檢測








20m
10m
5m
光纖平均檢測的範圍
埋入式的光纖
- 長達100km的監控
- 不須圍繞整個區域
分析儀
遠端監視控制單元
中央監控室
行動設備
攝影監視
聲音輸出

光纖分佈式聲波探測(DAS)系統簡介 (1)

Find the 5th Generation DAS designed for your infrastructure

	N5125B Series	N5225B Series	N5226B Series
Power Cable Monitoring	●	●	
Pipeline Leakage Detection	●	●	
Well & Reservoir Monitoring			●
Geo- & Hydrological Monitoring			●
Perimeter Monitoring	●	●	
Railway Monitoring		●	

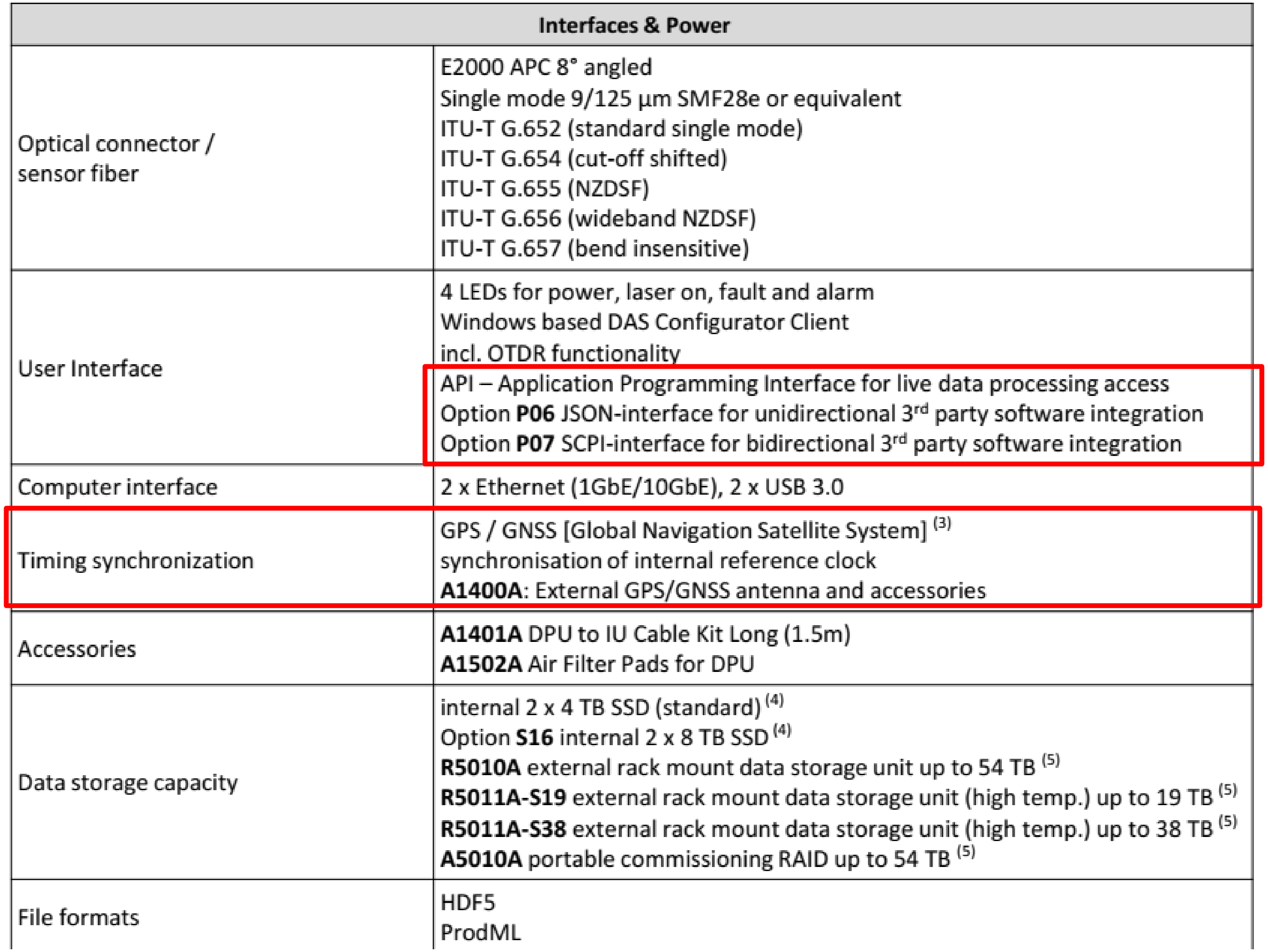
光纖分佈式聲波探測(DAS)系統簡介 (2)

DAS 系統主要規格

Functional Specifications					
Instrument option (1)	**R12**	**R20**	**R50**	**R70**	**R100**
Distance Range	12 km	20 km	50 km	70 km	100 km
Optical wavelength	1550 nm				
Optical channels (sequential)	Standard: 1 (**C01**) On request: 2 (**C02**), 4 (**C04**), 8 (**C08**)				
Spatial sampling interval (2)	1.25 m, 2.5 m, 5 m, 10 m, 20 m, 40 m				
Gauge length settings (2)	3.75 m, 5 m, 10 m, 20 m, 40 m, 80 m				
Pulse rate (depending on fiber length)	0.5 to 40 kHz				
Safety					
Laser safety class	Class 1 laser product (IEC 60825-1:2014; EN 60825-1: 2014; FDA 21CFR1040.10 + Laser Notice no.50)				

光纖分佈式聲波探測(DAS)系統簡介 (3)

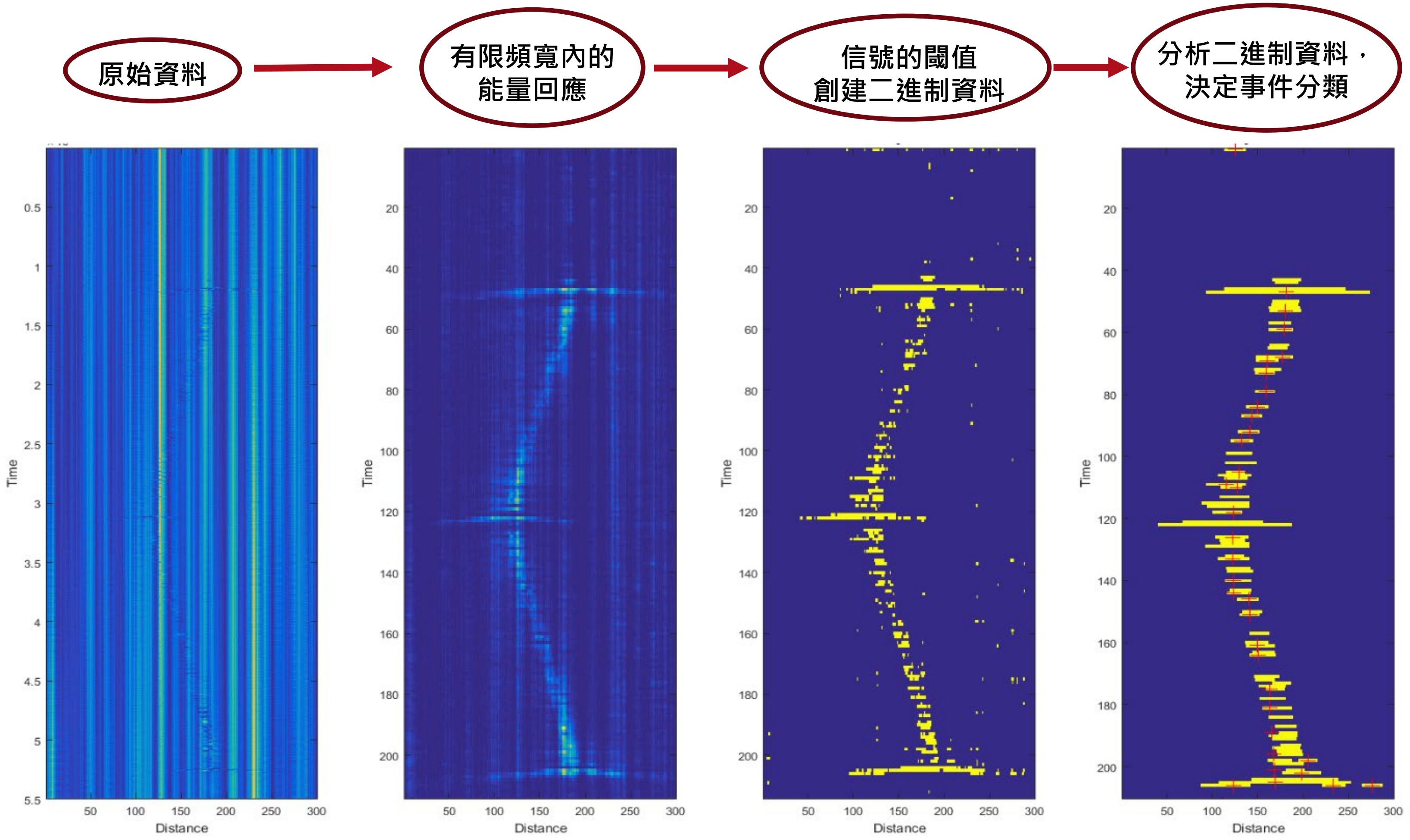
DAS 系統主要規格



Interfaces & Power	
Optical connector / sensor fiber	E2000 APC 8° angled Single mode 9/125 µm SMF28e or equivalent ITU-T G.652 (standard single mode) ITU-T G.654 (cut-off shifted) ITU-T G.655 (NZDSF) ITU-T G.656 (wideband NZDSF) ITU-T G.657 (bend insensitive)
User Interface	4 LEDs for power, laser on, fault and alarm Windows based DAS Configurator Client incl. OTDR functionality API – Application Programming Interface for live data processing access Option **P06** JSON-interface for unidirectional 3rd party software integration Option **P07** SCPI-interface for bidirectional 3rd party software integration
Computer interface	2 x Ethernet (1GbE/10GbE), 2 x USB 3.0
Timing synchronization	GPS / GNSS [Global Navigation Satellite System] (3) synchronisation of internal reference clock **A1400A**: External GPS/GNSS antenna and accessories
Accessories	**A1401A** DPU to IU Cable Kit Long (1.5m) **A1502A** Air Filter Pads for DPU
Data storage capacity	internal 2 x 4 TB SSD (standard) (4) Option **S16** internal 2 x 8 TB SSD (4) **R5010A** external rack mount data storage unit up to 54 TB (5) **R5011A-S19** external rack mount data storage unit (high temp.) up to 19 TB (5) **R5011A-S38** external rack mount data storage unit (high temp.) up to 38 TB (5) **A5010A** portable commissioning RAID up to 54 TB (5)
File formats	HDF5 ProdML

光纖分佈式聲波探測(DAS)系統簡介

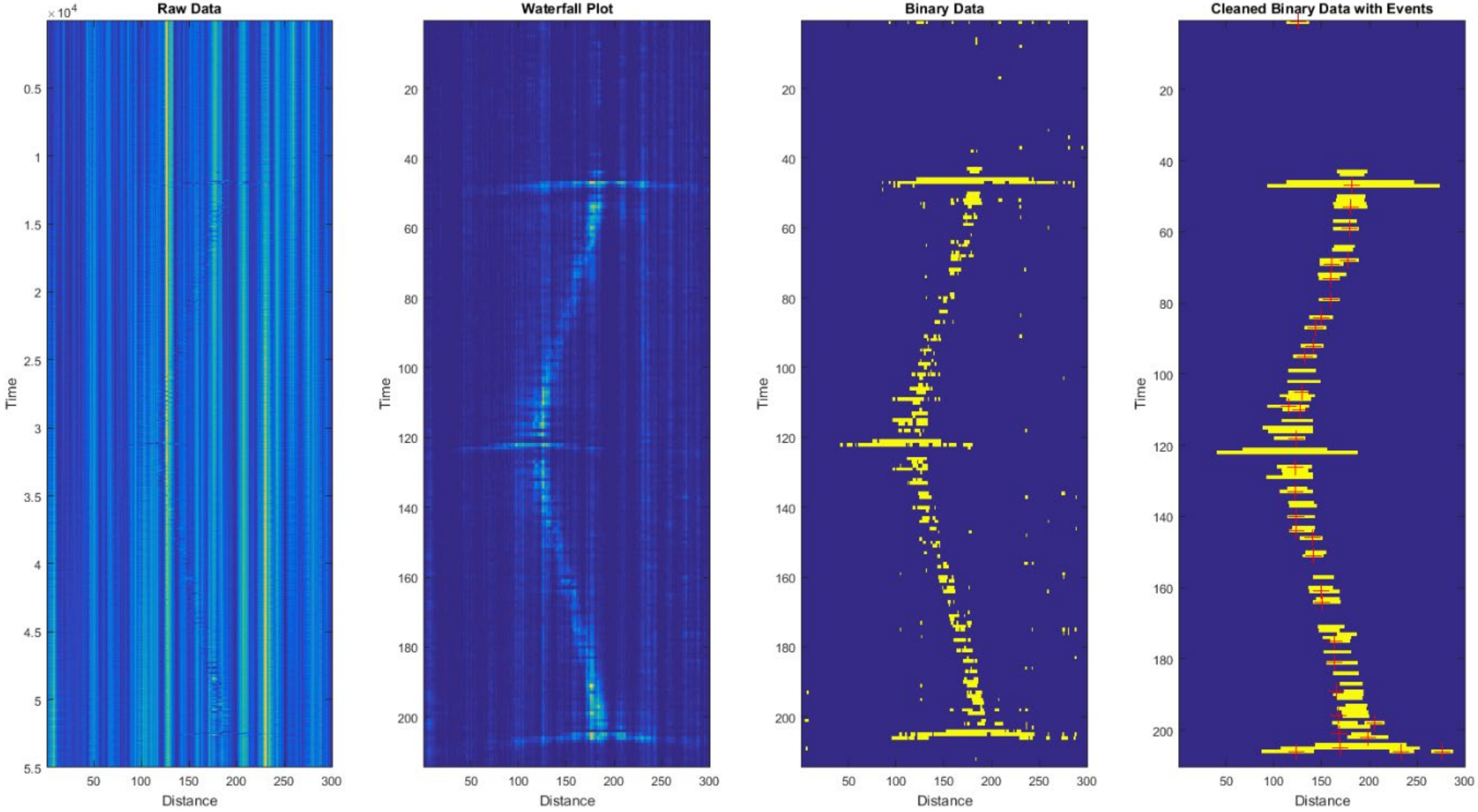
DAS 事件偵測流程



原始資料 → 有限頻寬內的能量回應 → 信號的閾值創建二進制資料 → 分析二進制資料，決定事件分類

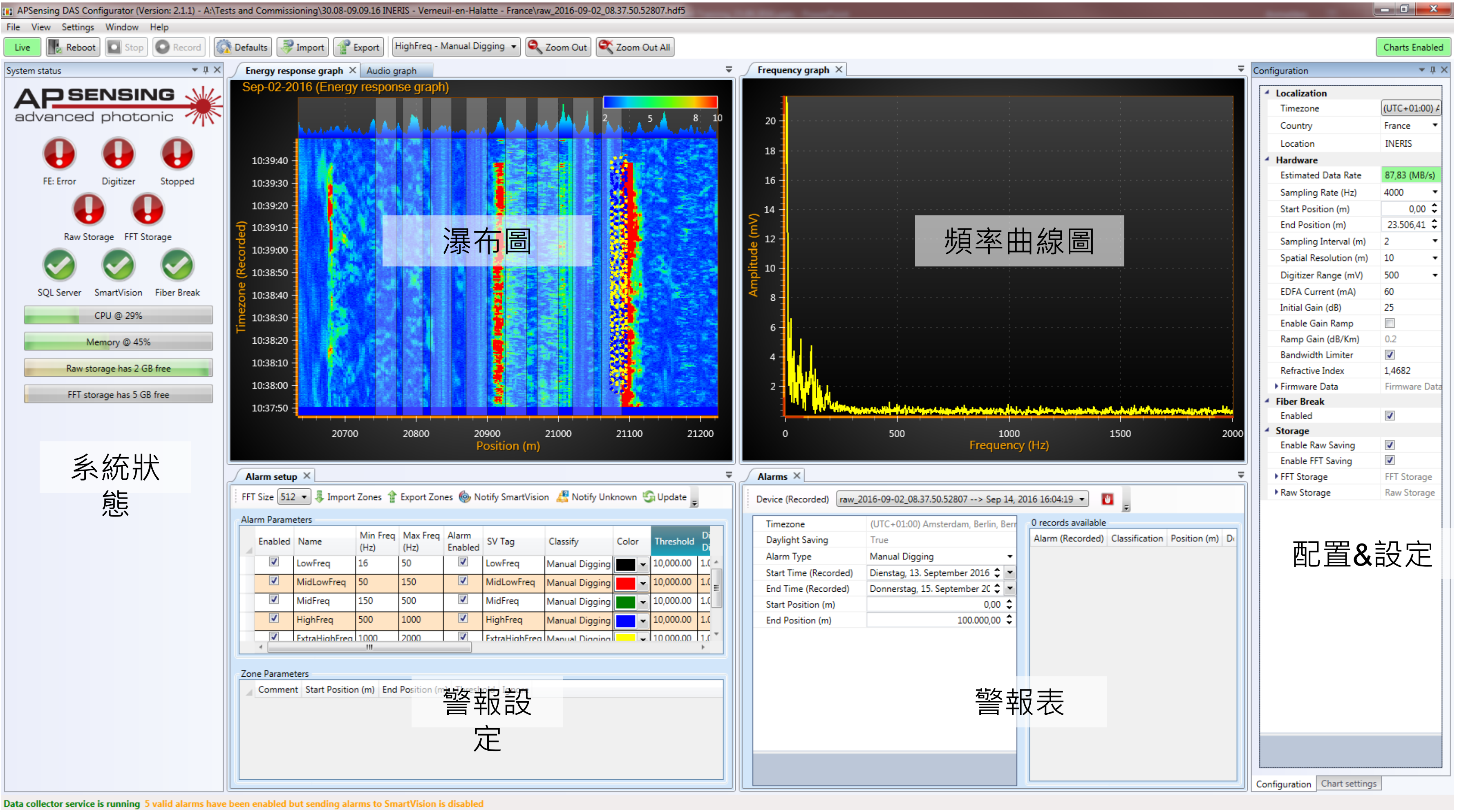
光纖分佈式聲波探測(DAS)系統簡介

DAS 事件偵測□ □ : □ □



光纖分佈式聲波探測(DAS)系統簡介

DAS 軟體 – DAS


APSensing DAS Configurator (Version: 2.1.1) - A:\Tests and Commissioning\30.08-09.09.16 INERIS - Verneuil-en-Halatte - France\raw_2016-09-02_08.37.50.52807.hdf5
File View Settings Window Help
Live
Reboot
Stop
Record
Defaults
Import
Export
HighFreq - Manual Digging
Zoom Out
Zoom Out All
Charts Enabled
System status
AP SENSING advanced photonic
FE: Error
Digitizer
Stopped
Raw Storage
FFT Storage
SQL Server
SmartVision
Fiber Break
CPU @ 29%
Memory @ 45%
Raw storage has 2 GB free
FFT storage has 5 GB free
Energy response graph
Audio graph
Sep-02-2016 (Energy response graph)
Timezone (Recorded)
Position (m)
Frequency graph
Amplitude (mV)
Frequency (Hz)
Alarm setup
Alarms
Configuration
Chart settings

瀑布圖

頻率曲線圖

系統狀態

警報設定

警報表

配置&設定

Alarm setup

FFT Size 512 | Import Zones | Export Zones | Notify SmartVision | Notify Unknown | Update

Alarm Parameters

Enabled	Name	Min Freq (Hz)	Max Freq (Hz)	Alarm Enabled	SV Tag	Classify	Color	Threshold
☑	LowFreq	16	50	☑	LowFreq	Manual Digging	■	10,000.00
☑	MidLowFreq	50	150	☑	MidLowFreq	Manual Digging	🟥	10,000.00
☑	MidFreq	150	500	☑	MidFreq	Manual Digging	🟩	10,000.00
☑	HighFreq	500	1000	☑	HighFreq	Manual Digging	🟦	10,000.00
☑	ExtraHighFreq	1000	2000	☑	ExtraHighFreq	Manual Digging	🟨	10,000.00

Zone Parameters

Comment	Start Position (m)	End Position (m)	Threshold	Ignore

Alarms

Device (Recorded) raw_2016-09-02_08.37.50.52807 --> Sep 14, 2016 16:04:19

Timezone	(UTC+01:00) Amsterdam, Berlin, Bern
Daylight Saving	True
Alarm Type	Manual Digging
Start Time (Recorded)	Dienstag, 13. September 2016
End Time (Recorded)	Donnerstag, 15. September 20
Start Position (m)	0,00
End Position (m)	100.000,00

0 records available

Alarm (Recorded)	Classification	Position (m)	De

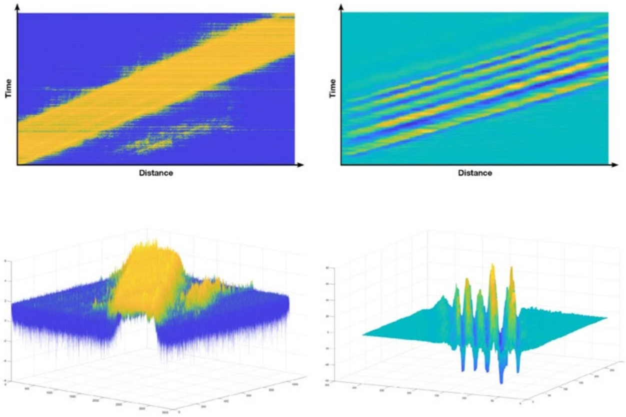
Configuration

Localization	
Timezone	(UTC+01:00) A
Country	France
Location	INERIS
Hardware	
Estimated Data Rate	87,83 (MB/s)
Sampling Rate (Hz)	4000
Start Position (m)	0,00
End Position (m)	23.506,41
Sampling Interval (m)	2
Spatial Resolution (m)	10
Digitizer Range (mV)	500
EDFA Current (mA)	60
Initial Gain (dB)	25
Enable Gain Ramp	☐
Ramp Gain (dB/Km)	0.2
Bandwidth Limiter	☑
Refractive Index	1,4682
Firmware Data	Firmware Data
Fiber Break	
Enabled	☑
Storage	
Enable Raw Saving	☑
Enable FFT Saving	☑
FFT Storage	FFT Storage
Raw Storage	Raw Storage

Data collector service is running 5 valid alarms have been enabled but sending alarms to SmartVision is disabled

光纖分佈式聲波探測(DAS)系統簡介

2P Square DAS 技術

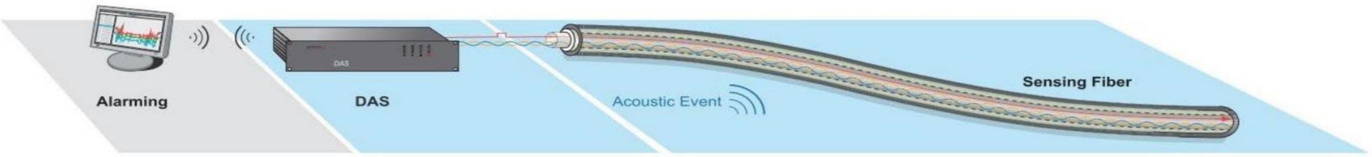


DAS 傳感器數據質量 "2P Squared DAS” 技術提供：

- ✓ 準確測量和定位信號的幅度、頻率和相位入射聲場
- ✓ 距離、時間和聲強的真正線性
- ✓ 以領先的信噪比實現信號質量
- ✓ 先進的 “2P Squared ” 光學技術提高了長測量範圍內的信號質量
- ✓ 世界領先的 100 公里測量範圍

優勢

- ✓ 以相同的靈敏度和 “特徵” 捕獲技術, 應用在光纖開頭和末端的聲學事件
- ✓ 優秀的原始數據是模式識別和機器學習算法的基礎

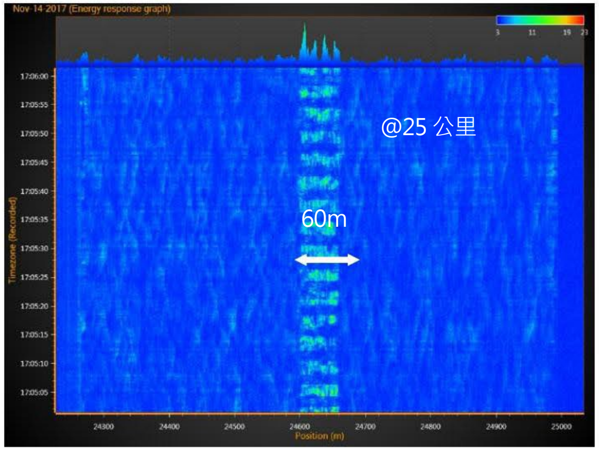

Alarming
DAS
DAS
Acoustic Event
Sensing Fiber

© AP Sensing 2018

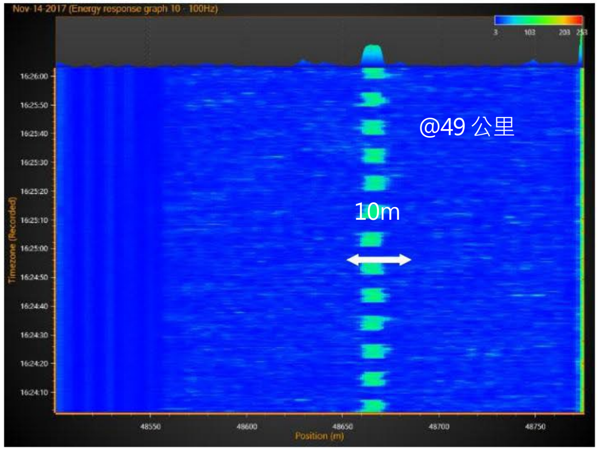
光纖分佈式聲波探測(DAS)系統簡介

DAS 性能比較

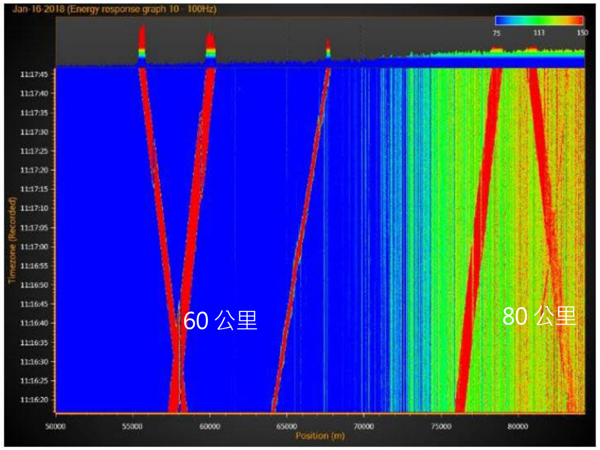
一般DAS



2P Squared DAS



2P Squared DAS



普通 DAS 系統

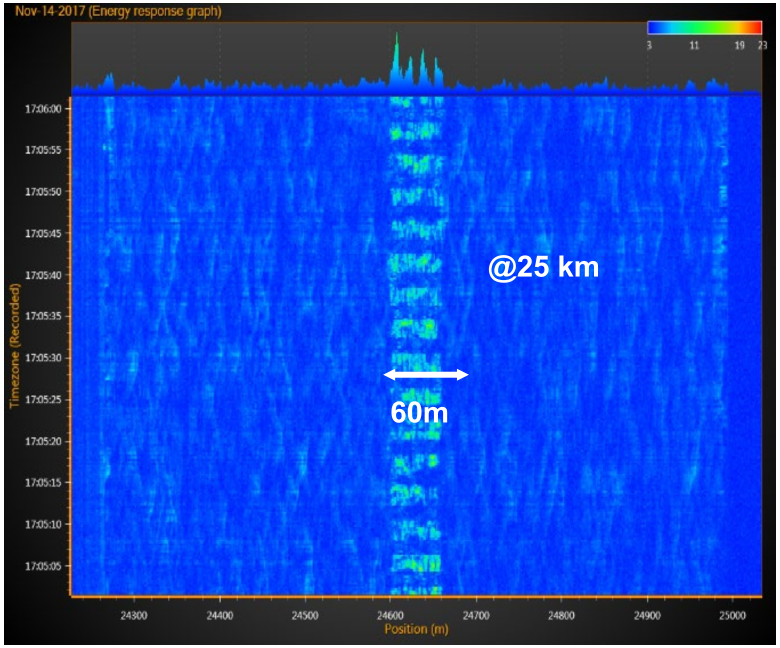
- 衰減，隨距離顯著退化
- 隨距離和聲強的非線性信號響應

2P Squared DAS

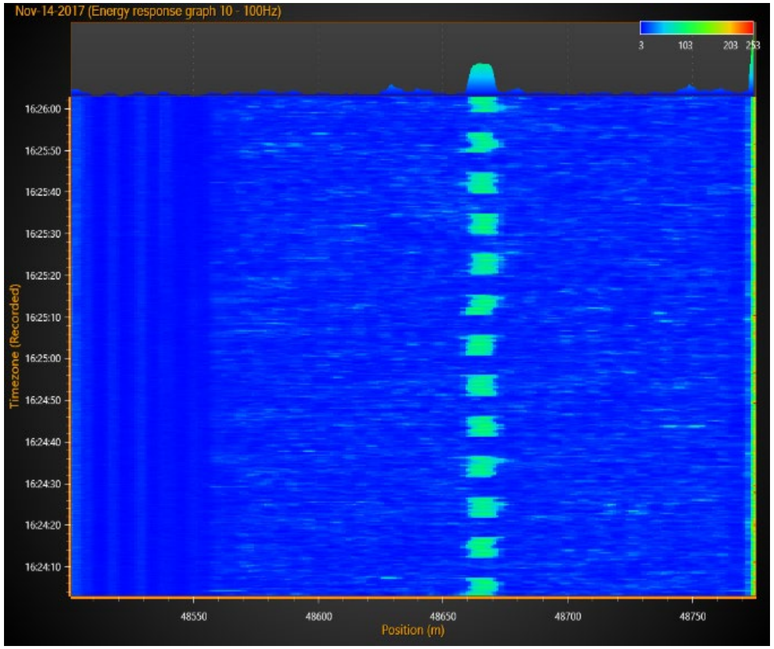
- 超過 70 公里測量範圍的高信噪比
- 對距離和信號強度的線性響應
- 可配置的空間分辨率

DAS 之間的性能比較

其他品牌DAS，如BW



2P Squared DAS



普通 DAS 系統

- 信號衰減嚴重，隨距離 顯著退化
- 在距離上不是線性的和信好強度

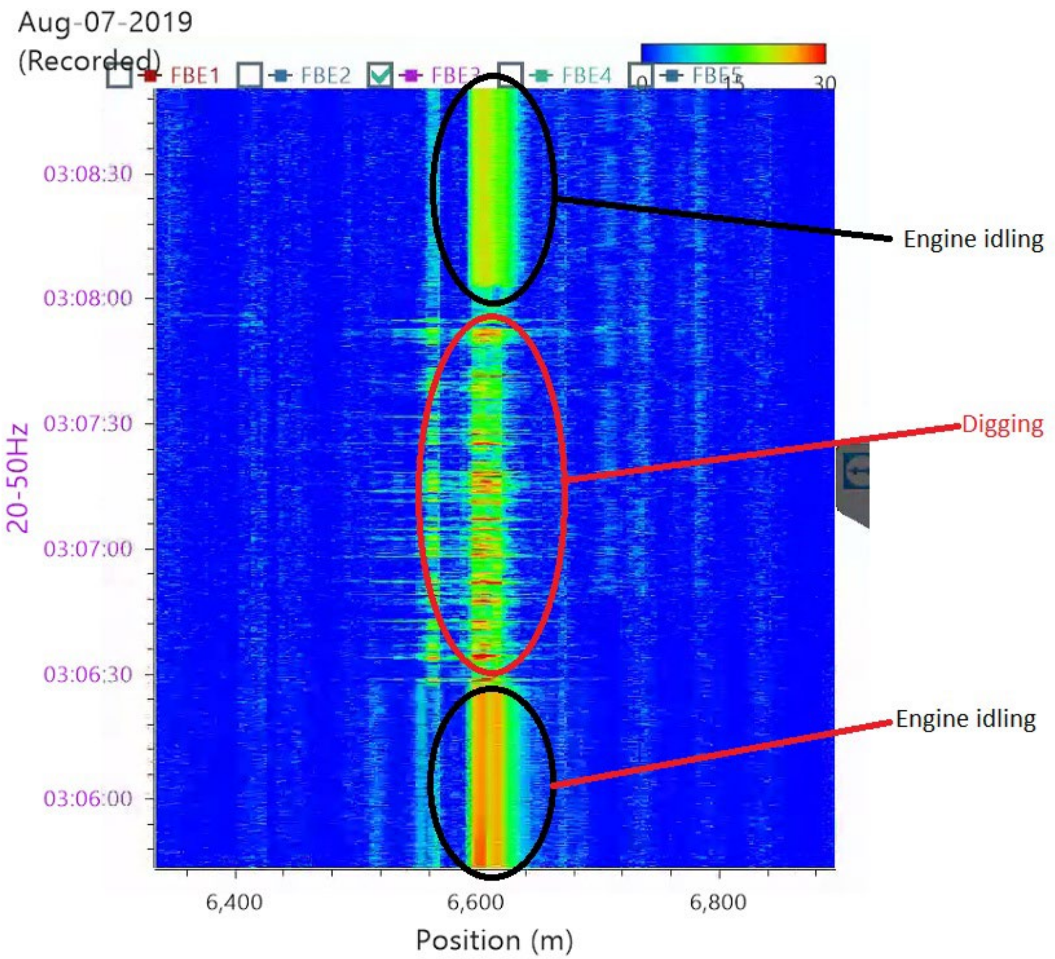
2P 平方 DAS

- 精細的空間分辨率. 超過 70 公里的高信噪比
- 距離和信號強度呈線性關係

機密的

光纖分佈式聲波探測(DAS)系統簡介

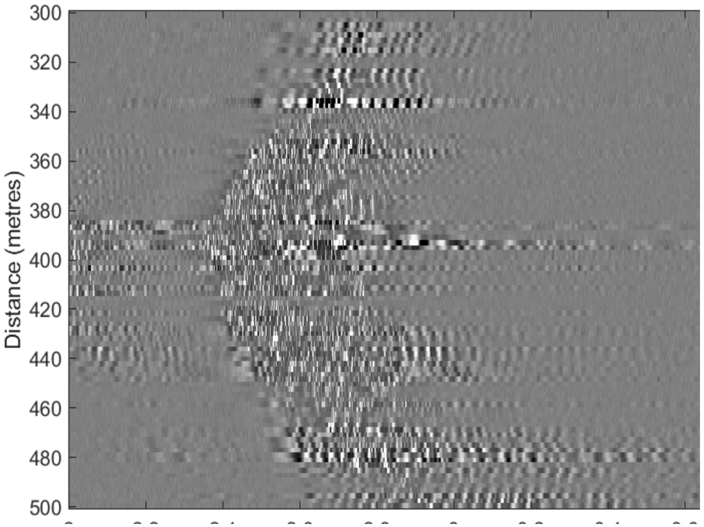
AP-aenaing DAS 優異性能



Ap-sensing 2P Squared DAS 除了偵測挖掘之外 還檢測到發動機怠速！

光纖分佈式聲波探測(DAS)系統簡介

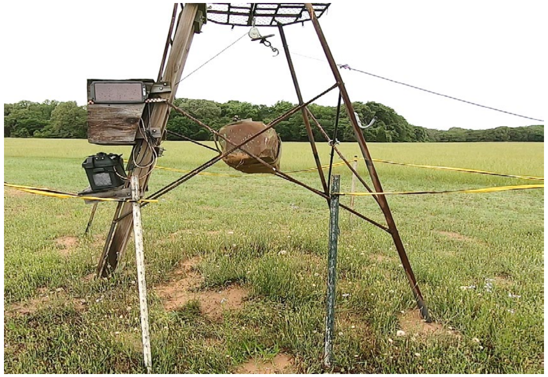
DAS 信號比較

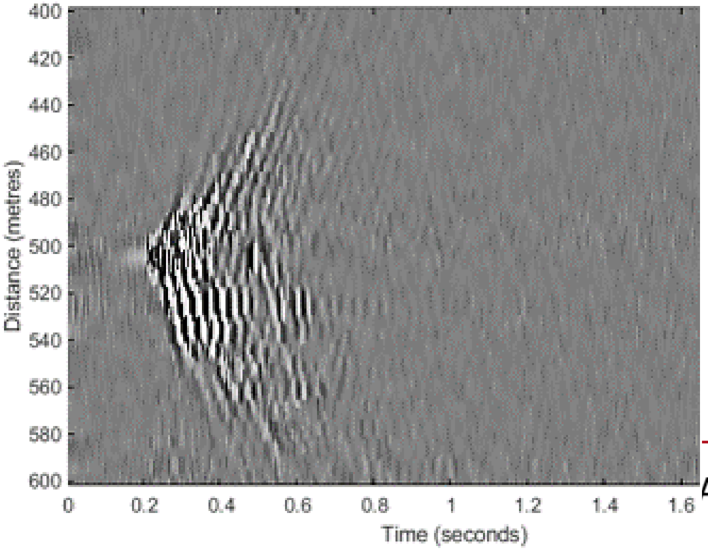


振幅測量，例如 BW

- 聲音信號產生了1D的斑點狀的干擾
- 干擾具有隨機的靈敏度和方向
- 適合定位事件，但不適合再現應用信號

重物下墜測試





AP SENSING advanced photonic 相位測量

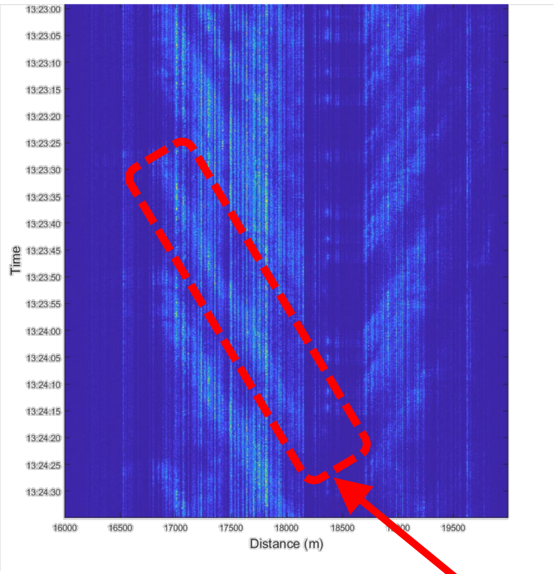
- 聲音信號產生1D的斑點狀的干擾
- 干擾具有已知且可重複的靈敏度和極性
- 允許進階信號處理/機器學習技術

光纖分佈式聲波探測(DAS)系統簡介

DAS性能比較

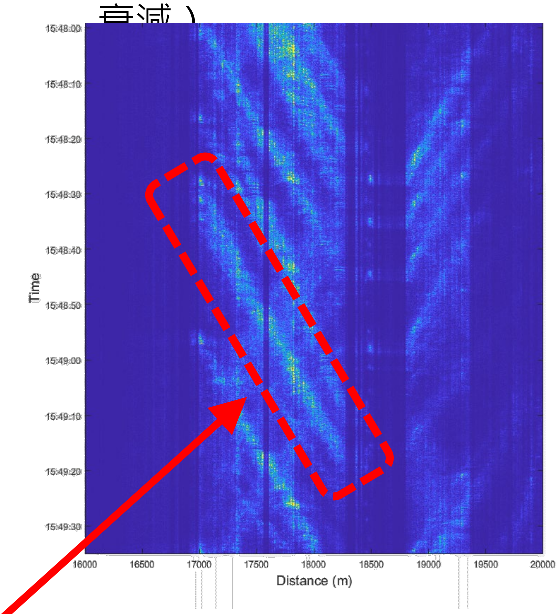
BW等一 般DAS

低 SNR – 褪色信號 衰落的通道
導致垂直線條的訊號干擾嚴重



2P Squared DAS

先進的2P Squared DAS SNR – 更
清晰的峰值· 衰減通道減少（由
於地面傳感器耦合而導致剩餘
衰減）



汽車沿著高速
公路行駛

光纖分佈式聲波探測(DAS)系統簡介

2P Squared-DAS N52 系列 –特色優勢總結

DAS
AP SENSING

特色

2P 平方 DAS 技術

·提高信噪比
·對應用信號的真正線性響應
· 100公里的世界領先範圍

先進的模塊化

信號處理架構，可滿足包括機器學習模塊在內的許多應用：
·洩漏檢測 (LDS)
·第三方入侵 (TPI)
·火車和航運監控

智能視覺平台

基於APSensing建立並受到尊重的數據可視化智能視覺平台

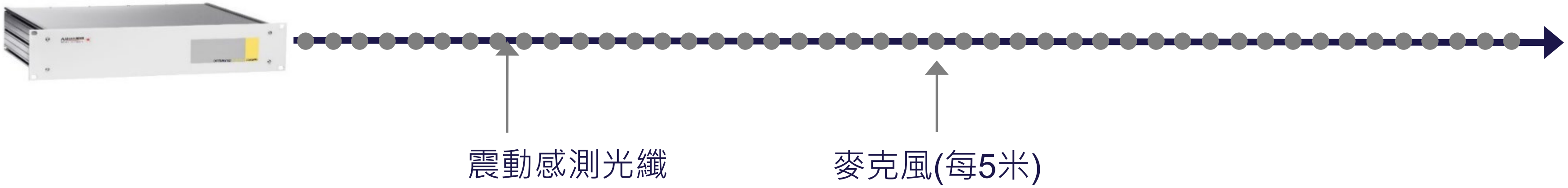
優勢

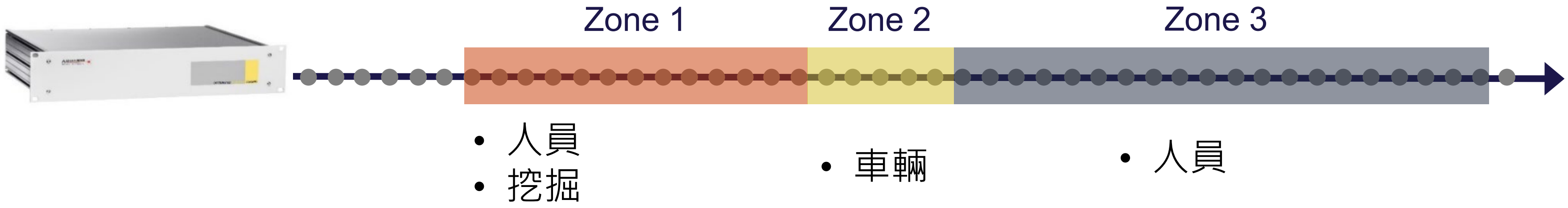
領先的性能

- 高信噪比, 高靈敏度
- 對距離和信號強度的優越線性響應
- 領先的測量範圍 ,可達 100公里
- 相干相位 OTDR技術 ,真正的線性度 ,最小衰落
- 長距離 5 m 的空間分辨率
- 領先的檢測和分 類算法和人工智能
- 質量領先

光纖分佈式聲波探測(DAS)系統簡介

DAS系統架構&探測分區規劃


震動感測光纖
麥克風(每5米)


Zone 1
Zone 2
Zone 3

- 人員
- 挖掘

- 車輛

- 人員

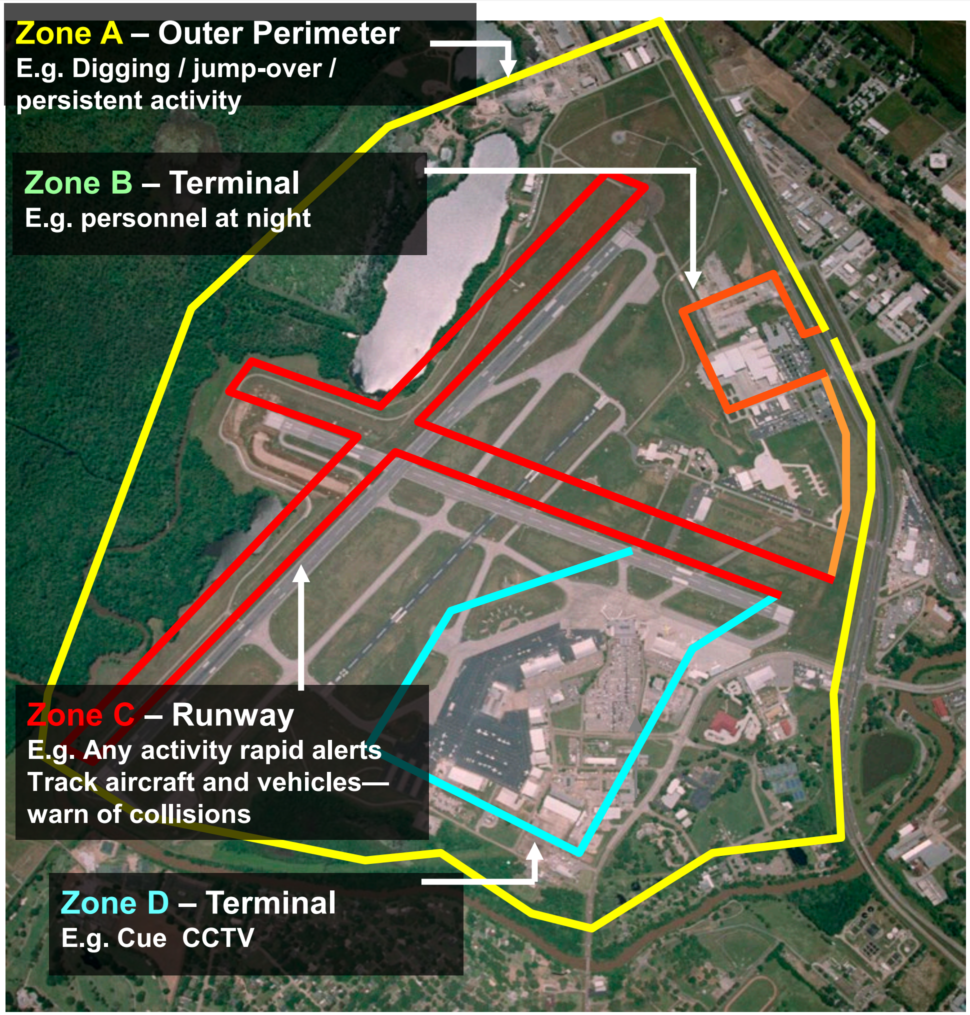
光纖分佈式聲波探測(DAS)系統簡介

AP SENSING advanced photonic

探測分區 Zones

- 每個 10m 部分（一個“通道”）獨立運行
- 可以創建區域以對任意數量的通道進行分組
- 可以為每個區域設置不同的警報類型挖掘，人員，車輛，所有等。
- 易於調整區域設置活動和威脅的季節性或每日時間變化（例如冬季的沼澤土壤，夜間使用更敏感的人員資料）
- 排除任何重大干擾噪音（例如道路、發電機）活動（例如，預期人員但不會挖掘進入圍欄）
- 系統可以一次處理多個警報為不同級別的用戶提供適當的探測'控制

每個區域都可以單獨配置以滿足不同的特定要求



Zone A – Outer Perimeter
E.g. Digging / jump-over / persistent activity

Zone B – Terminal
E.g. personnel at night

Zone C – Runway
E.g. Any activity rapid alerts
Track aircraft and vehicles—warn of collisions

Zone D – Terminal
E.g. Cue CCTV

光纖分佈式聲波探測(DAS)系統簡介

光纖圍籬檢測及優勢特色

檢測包括

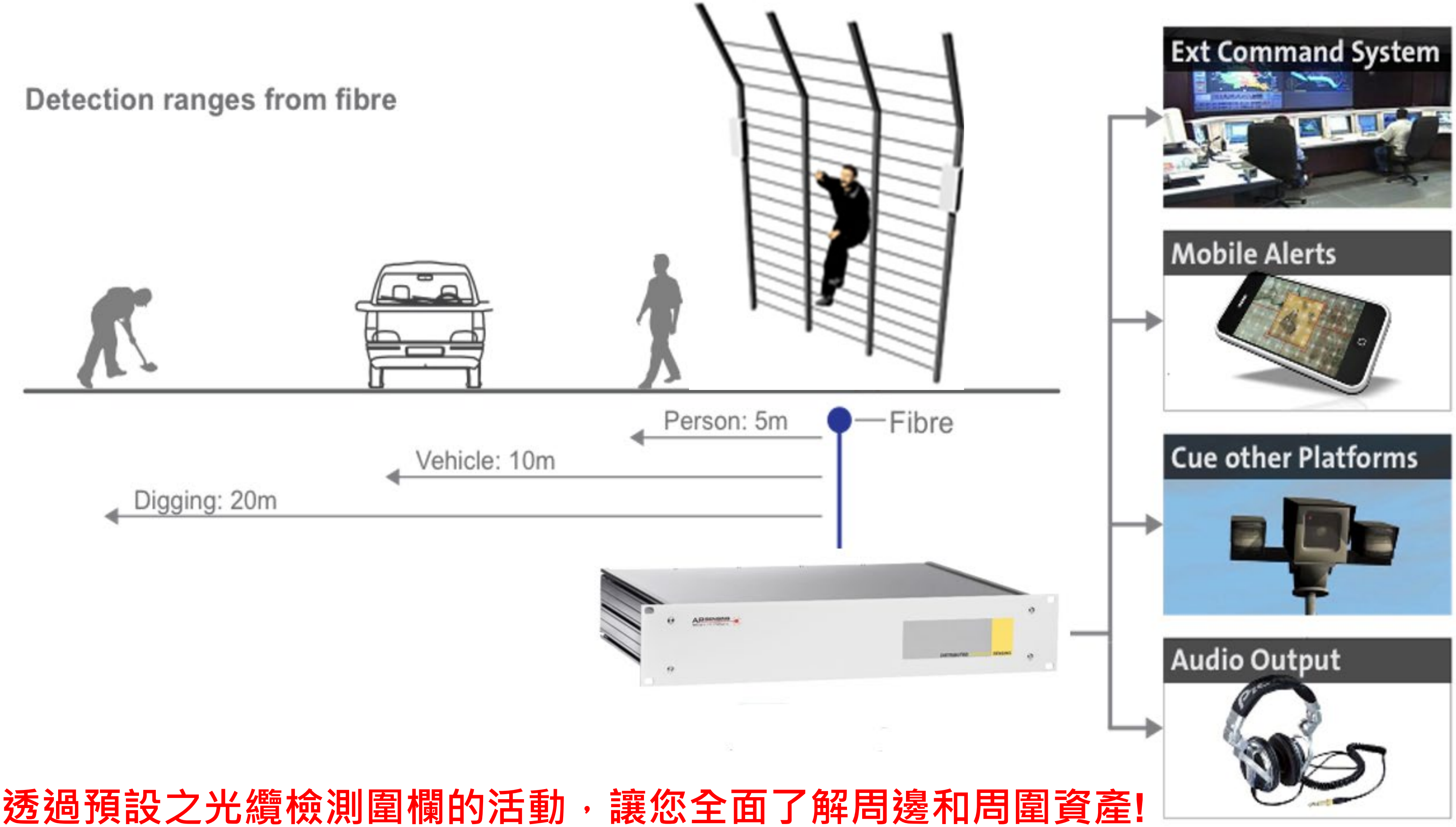
- 圍欄攀登
- 爬梯
- 圍欄切割/鋸切等

優勢特色

- 只需要一芯光纖，且可使用通訊光纜
- 先進的算法和數據分析，使誤報率極低

光纖分佈式聲波探測(DAS)系統簡介

圍籬周界安全監控系統示意總纜

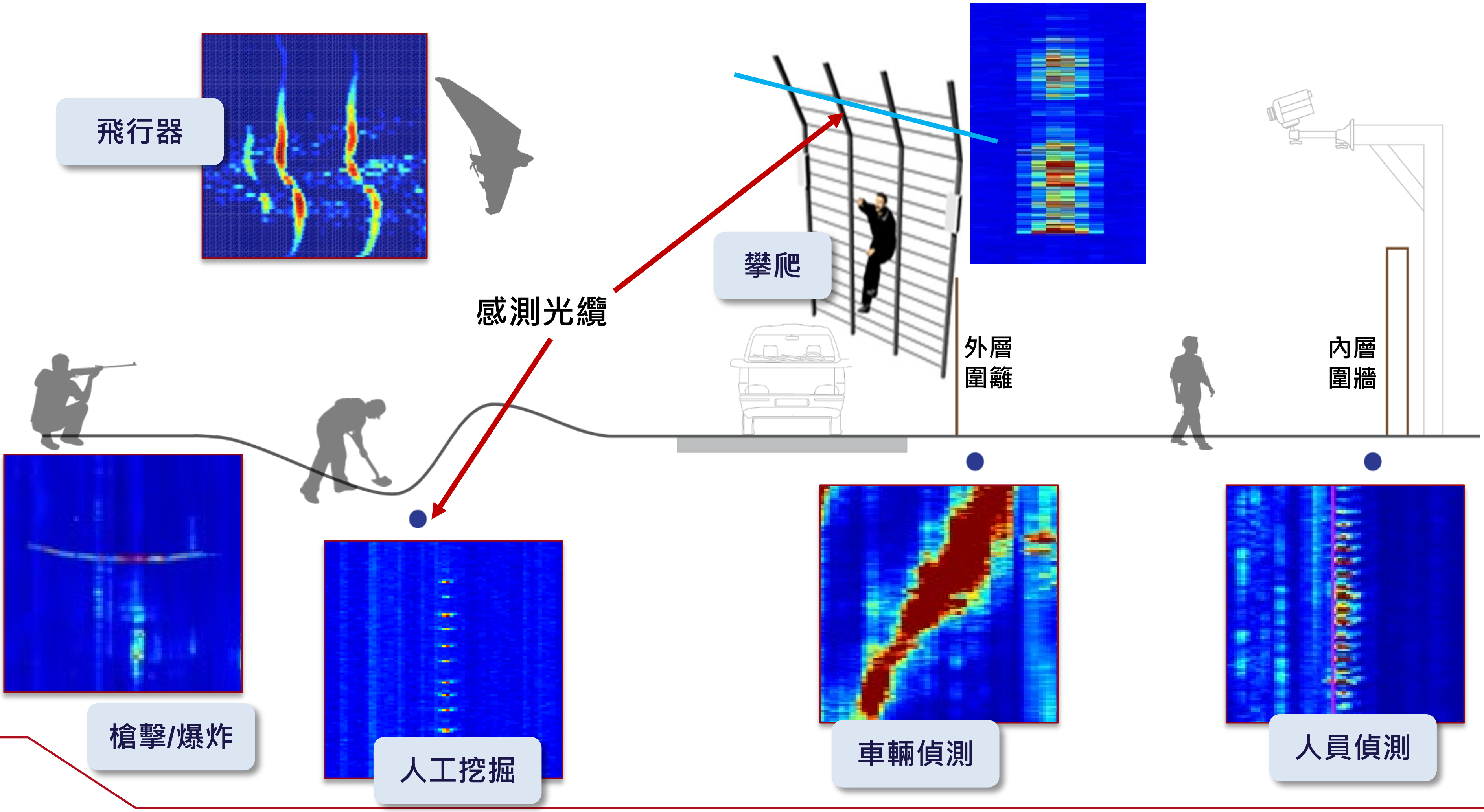


Detection ranges from fibre
Person: 5m
Fibre
Vehicle: 10m
Digging: 20m
Ext Command System
Mobile Alerts
Cue other Platforms
Audio Output

透過預設之光纜檢測圍欄的活動，讓您全面了解周邊和周圍資產!

光纖分佈式聲波探測(DAS)系統簡介

先進周邊保護的探測功能 有效防止地面、地下和地上的威脅!



飛行器

攀爬

感測光纜

外層
圍籬

內層
圍牆

槍擊/爆炸

人工挖掘

車輛偵測

人員偵測

圍籬震動光纜安裝示意圖

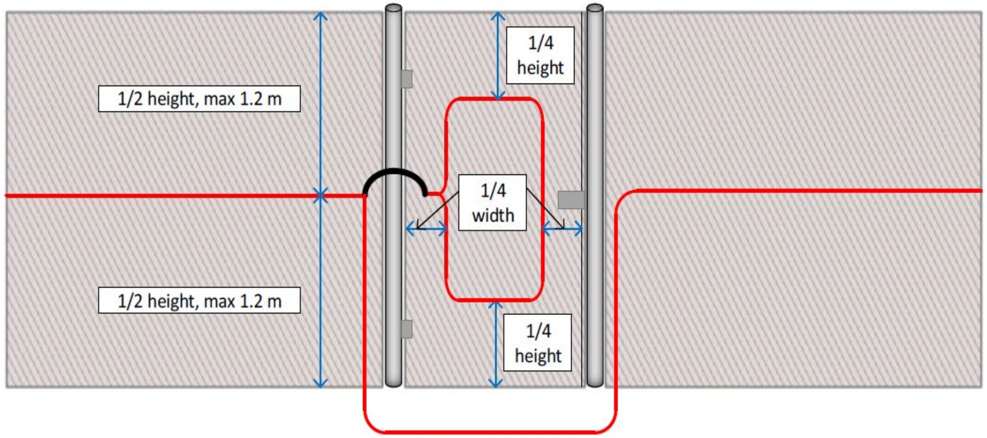
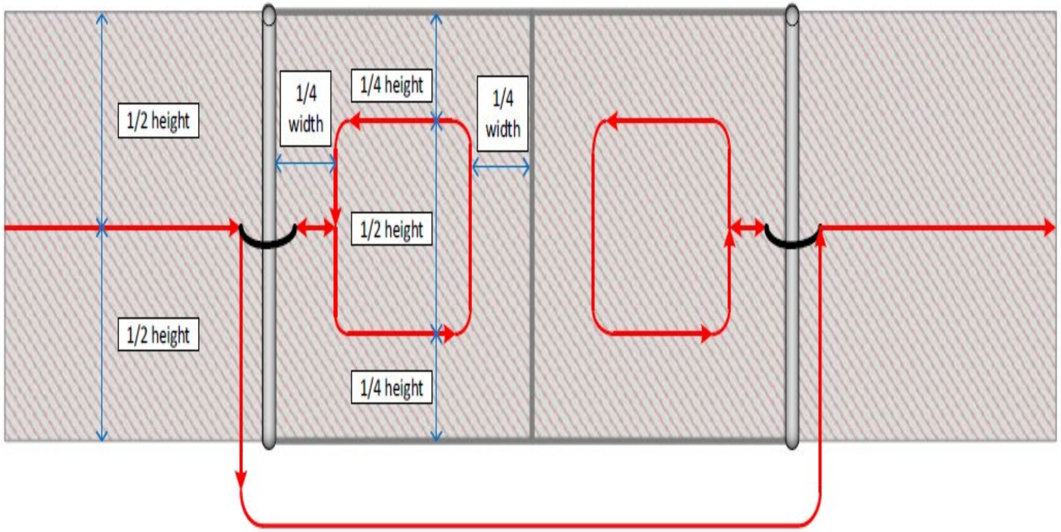
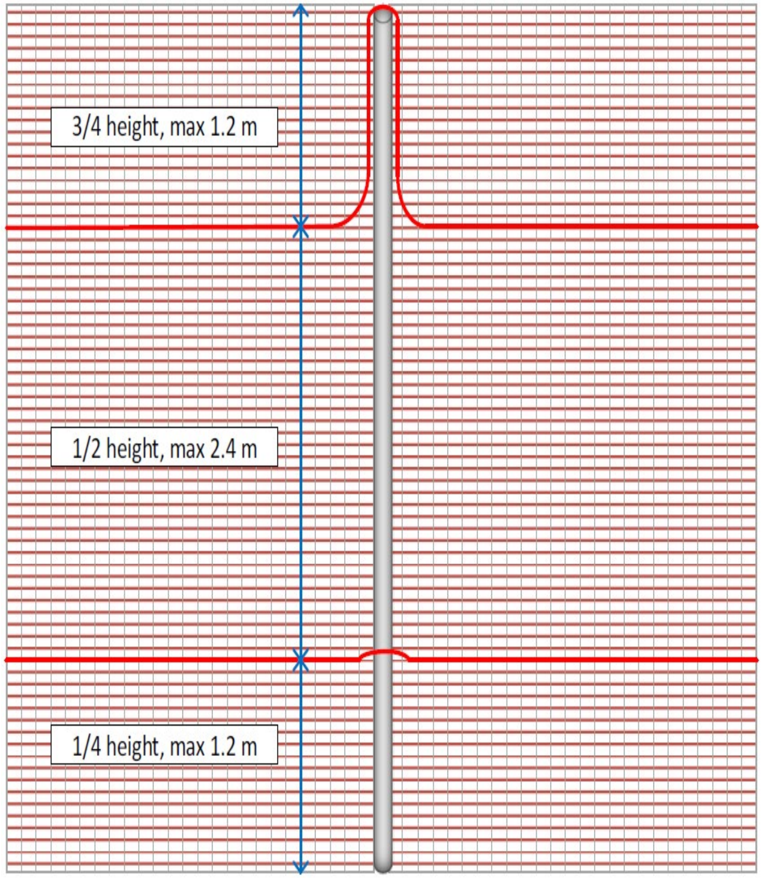

1/4
height
1/2 height, max 1.2 m
1/4
width
1/2 height, max 1.2 m
1/4
height

Figure 13: Fibre coverage of single personnel gates


1/4
width
1/4 height
1/4
width
1/2 height
1/2 height
1/2 height
1/4 height

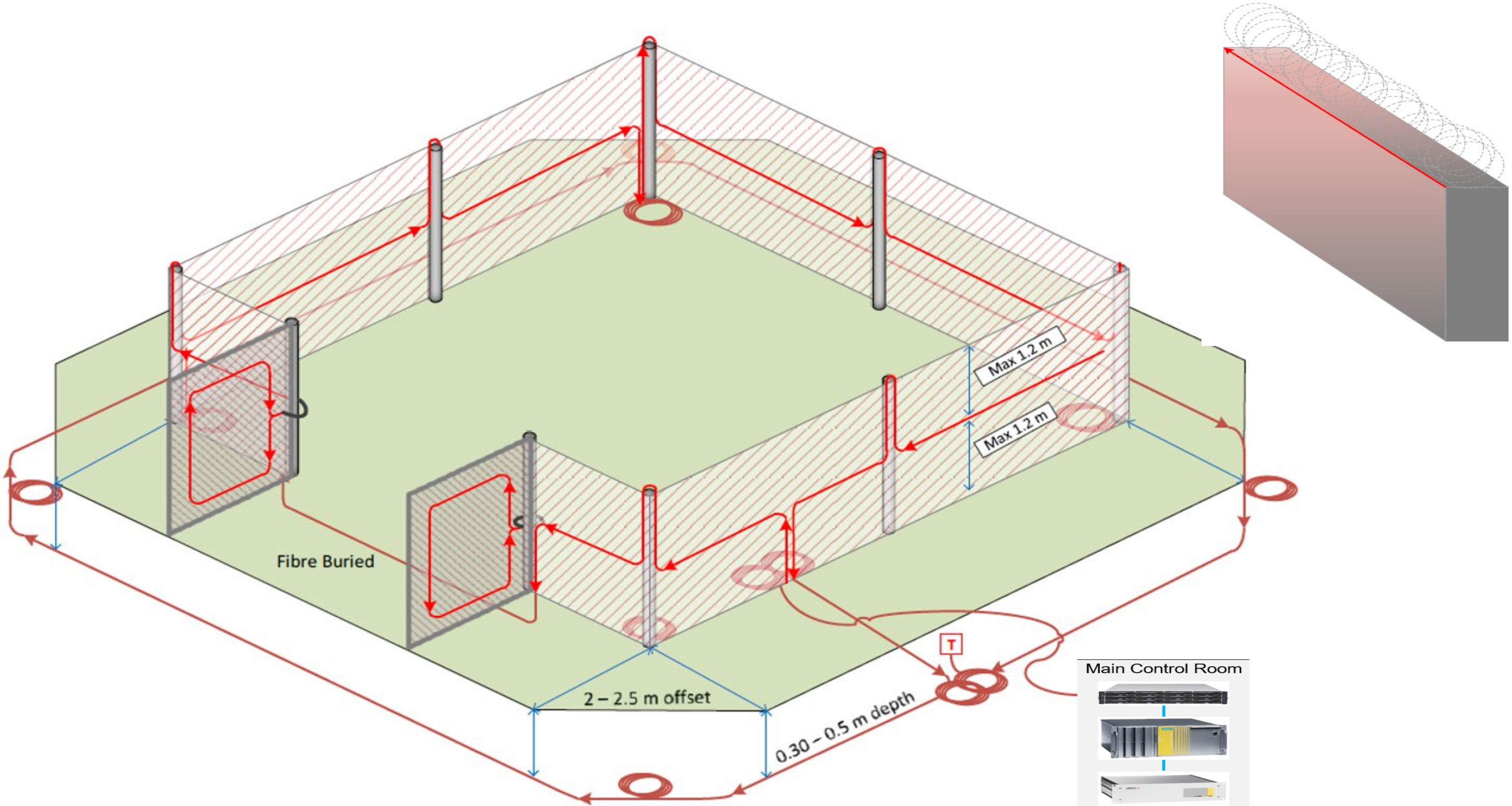
Buried fibre route under gate for
both configurations


3/4 height, max 1.2 m
1/2 height, max 2.4 m
1/4 height, max 1.2 m

光纖分佈式聲波探測(DAS)系統簡介

圍籬震動光纜安裝示意圖2

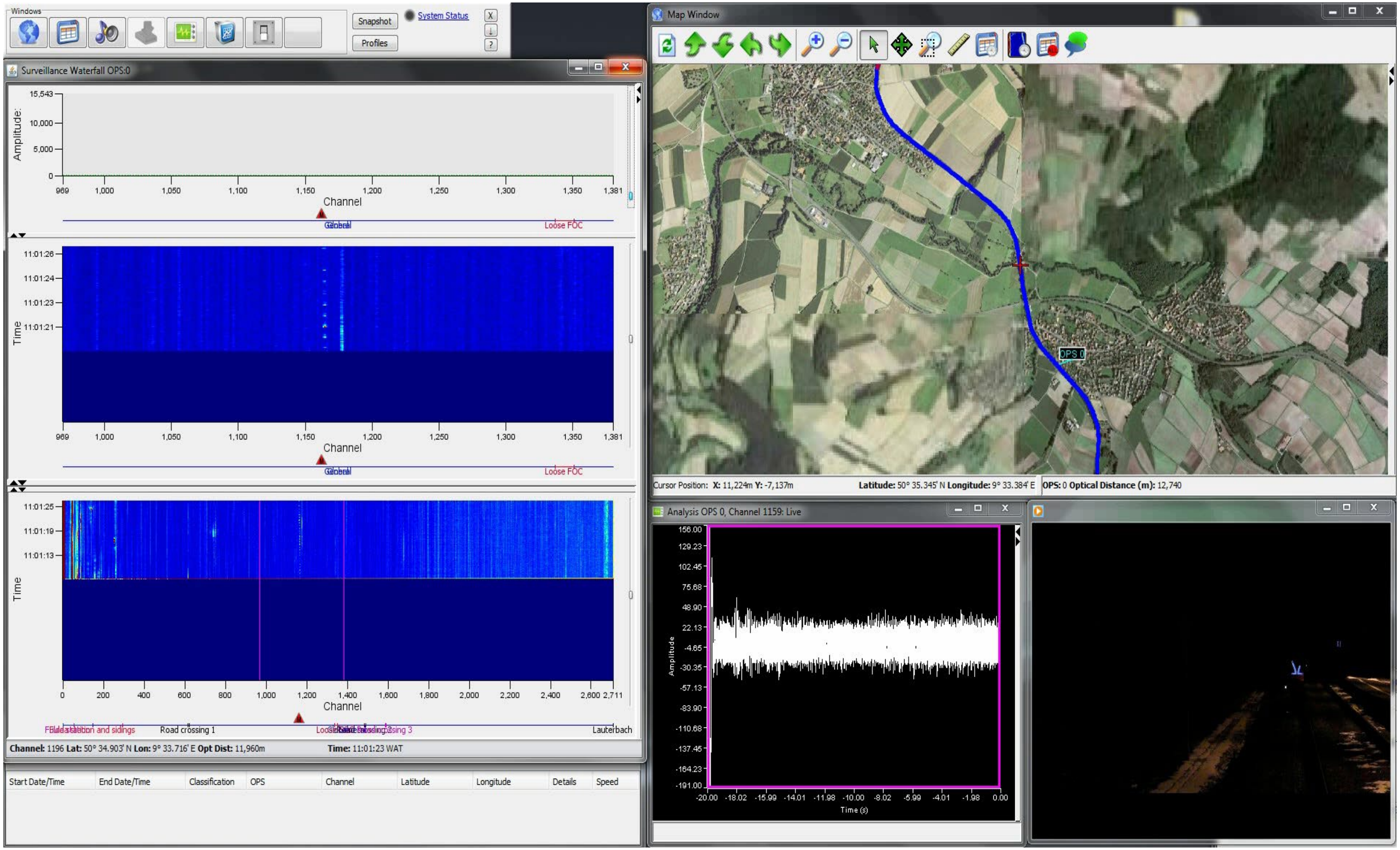
磚牆或混凝土牆


Max 1.2 m
Max 1.2 m
Fibre Buried
2 – 2.5 m offset
0.30 – 0.5 m depth
T
Main Control Room

DAS 測試影片和工程案例

DAS 人員車輛實測影片

DAS 軌道交通_銅竊盜測試影片


Windows
Snapshot
Profiles
System Status
Surveillance Waterfall OPS:0
Amplitude:
15,543
10,000
5,000
0
969
1,000
1,050
1,100
1,150
1,200
1,250
1,300
1,350
1,381
Channel
General
Loose FOC
Time
11:01:26
11:01:24
11:01:23
11:01:21
11:01:25
11:01:19
11:01:13
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
2,600
2,711
Road crossing 1
Lauterbach
Map Window
OPS 0
Analysis OPS 0, Channel 1159: Live
Amplitude
156.00
129.23
102.45
75.68
48.90
22.13
-4.65
-30.35
-57.13
-83.90
-110.68
-137.45
-164.23
-191.00
-20.00
-18.02
-15.99
-14.01
-11.98
-10.00
-8.02
-5.99
-4.01
-1.98
0.00
Time (s)

Cursor Position: **X:** 11,224m **Y:** -7,137m **Latitude:** 50° 35.345' N **Longitude:** 9° 33.384' E **OPS:** 0 **Optical Distance (m):** 12,740

Channel: 1196 **Lat:** 50° 34.903' N **Lon:** 9° 33.716' E **Opt Dist:** 11,960m **Time:** 11:01:23 WAT

Start Date/Time	End Date/Time	Classification	OPS	Channel	Latitude	Longitude	Details	Speed

DAS 軌道交通_銅竊盜成功案例

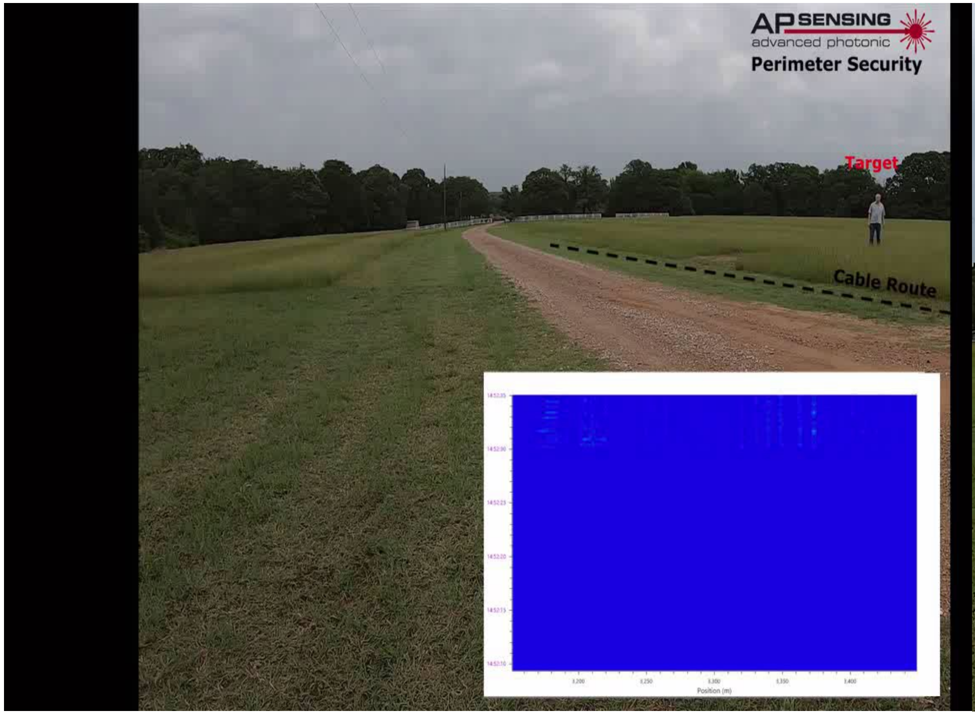
電纜盜竊案例

鐵路現場測試 – 德國 Rheydt 11/2018 DB，電纜盜竊

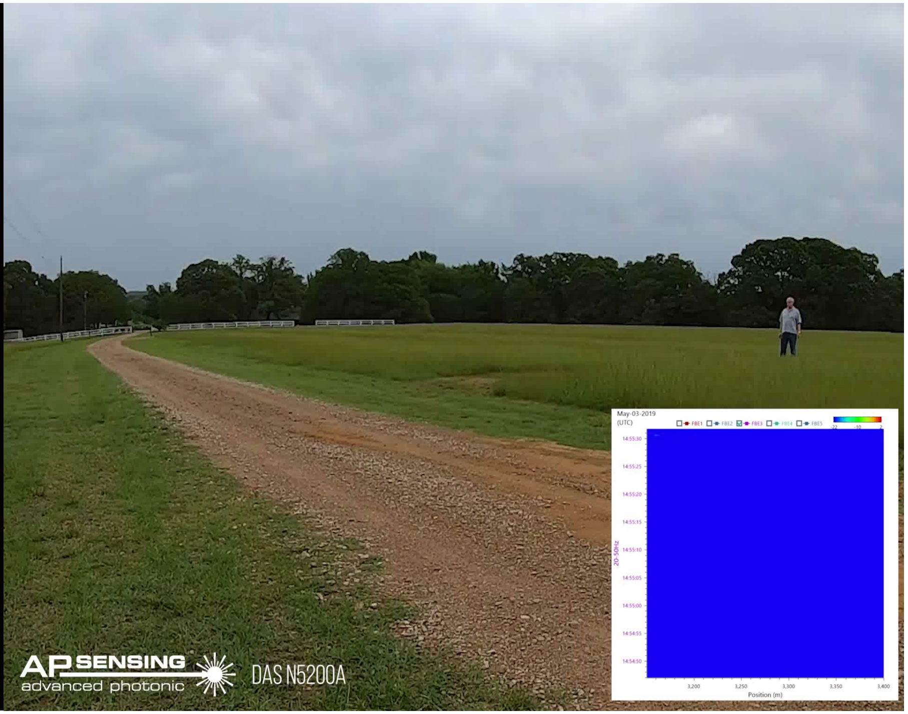
- 目標：捕獲電纜盜竊
- 地點：德國門興格拉德巴赫萊特
- 電纜長度：41 公里

DAS探測系統-人員移動偵測

人員嘗試穿越馬路


AP SENSING
advanced photonic
Perimeter Security
Target
Cable Route
Position (m)

道路附近的人類影響

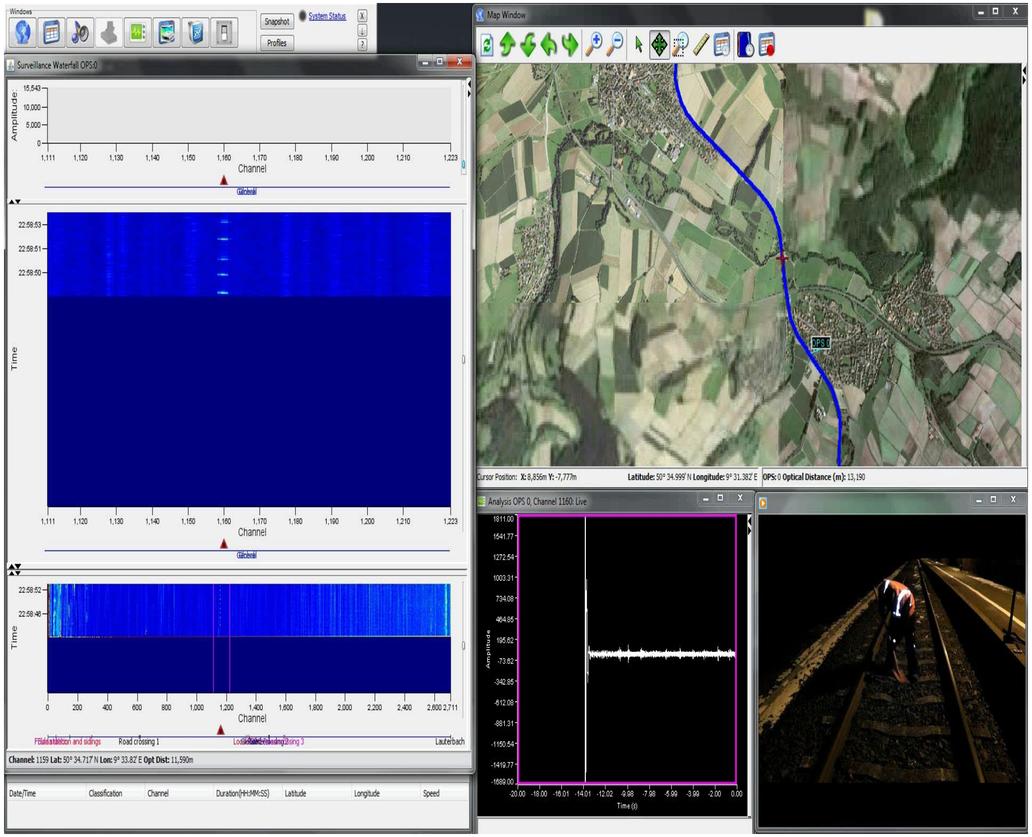

AP SENSING
advanced photonic
DAS N5200A
May-03-2019
(UTC)
Position (m)

DAS探測系統-人員攀爬、挖掘偵測

人員攀登圍欄的測試

AP SENSING
advanced photonic
DAS N5200A

人工挖掘


Windows
Snapshot
Profiles
System Status
Surveillance Waterfall OPS:0
Amplitude
Channel
Time
Map Window
OPS:0
Analysis OPS 0, Channel 1160: Live
Amplitude
Time (s)

Cursor Position: X: 8,856m Y: -7,777m Latitude: 50° 34.999' N Longitude: 9° 31.382' E OPS: 0 Optical Distance (m): 13,190

Channel: 1159 Lat: 50° 34.717 N Lon: 9° 33.82' E Opt Dist: 11,590m

Date/Time	Classification	Channel	Duration(HH:MM:SS)	Latitude	Longitude	Speed

謝謝聆聽與指教！