

出國報告（出國類別:其他）

107 年度「『離岸風電海氣象觀測與特性
分析』現場監測儀器採購赴原廠進行實
地教育訓練及作業技術操作」出國計畫

出國報告

服務機關：交通部運輸研究所

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派赴國家：英國、挪威、荷蘭

出國期間：107 年 3 月 22 日至 107 年 3 月 30 日

報告日期：107 年 6 月 8 日

「107年度」『離岸風電海氣象觀測與特性分析』現場監測儀器採購
赴原廠進行實地教育訓練及作業技術操作」出國計畫

交通部運輸研究所

摘要

行政院指派交通部協助風電產業開發事項，本所承辦相關計畫研究與技術發展，其中「離岸風電海氣象觀測與特性分析」工作項目，需採購現場觀測「水體濁度儀」、「潮波流監測儀」及「淘刷監測儀」等相關設備，經各層面詳細調查評估，目前國外研發之設備具有其功能優勢，國內暫無類似產品，遂採購國外現場觀測儀器，並派遣人員赴儀器原廠進行實地教育訓練及操作研習，提升我國海洋領域相關人才技術職能及研究能量，以執行離岸風電區海氣象觀測及特性分析等相關作業。

本次儀器原廠實地教育訓練及作業技術操作日期由 107 年 3 月 22 日~3 月 30 日共計 9 天，先後分別至英國倫敦 Aquatec 公司（AQUAlogger 310TY 水體濁度儀）、挪威奧斯陸 Nortek 總公司（超音波式表面波高波向與剖面海流儀 AWAC）及荷蘭阿姆斯特丹 Nortek B.V.公司（Scour Monitor 淘刷監測儀）等地，訓練課程相當扎實豐富，對自身本職學能提升助益良多，體會到自身仍須加強改善地方，瞭解唯有跳脫自身既有框架，才能發現不同思維脈絡及研究可能。

本次原廠實地教育訓練及作業技術操作，對於本國人才培訓可藉此增加國外專業職能學習機會，推廣臺灣海洋港灣領域成就能見度，落實國際間科技人員、研究技術實質上交流，針對我國現場海氣象觀測技術發展方面，可以直接獲得與儀器原廠工作人員面對面的指導說明和教育訓練，透過相互討論及意見交流，真正達到教學合一成效，對於促進國際學術交流及國外經驗吸取有相當大助益。

107 年度「『離岸風電海氣象觀測與特性分析』現場 監測儀器採購赴原廠進行實地教育訓練及作業技術操 作」出國計畫--出國報告

目次

摘要	I
目次	II
一、 目的.....	1
二、 教育訓練及行程紀要.....	2
三、 英國倫敦 Aquatec 公司.....	4
四、 挪威奧斯陸 Nortek 總公司.....	57
五、 荷蘭阿姆斯特丹 Nortek B.V.公司.....	105
六、 心得與建議事項.....	132

107 年度「『離岸風電海氣象觀測與特性分析』現場 監測儀器採購赴原廠進行實地教育訓練及作業技術操 作」出國計畫--出國報告

羅冠顯* 林受勳** 劉明鑫**

一、目的

行政院指派交通部協助風電產業開發事項，本所承辦相關計畫研究與技術發展，其中「離岸風電海氣象觀測與特性分析」工作項目，需採購現場觀測「水體濁度儀」、「潮波流監測儀」及「淘刷監測儀」等相關設備，經各層面詳細調查評估，目前國外研發之設備具有其功能優勢，國內暫無類似產品，遂採購國外現場觀測儀器，並派遣人員赴儀器原廠進行實地教育訓練及操作研習，提升我國海洋領域相關人才技術職能及研究能量，以執行離岸風電區海氣象觀測及特性分析等相關作業。

本案依據政府採購法辦理公開招標，得標廠商採用相關設備如下：

- (1)水體濁度儀：英國倫敦 Aquatec 公司所生產 AQUAlogger 310TY 水體濁度儀。
- (2)潮波流監測儀：挪威奧斯陸 Nortek 總公司所生產超音波式表面波高波向與剖面海流儀 AWAC (Acoustic Wave and Current profiler)。
- (3)淘刷監測儀：荷蘭阿姆斯特丹 Nortek B.V.公司所生產 Scour Monitor 淘刷監測儀。

本次原廠實地教育訓練及作業技術操作，對於本國人才培訓可藉此增加國外專業職能學習機會，推廣臺灣海洋港灣領域成就能見度，落實國際間科技人員、研究技術實質上交流。針對我國現場海氣象觀測技術發展方面，可以直接獲得與儀器原廠工作人員面對面的指導說明和教育訓練，透過相互討論及意見交流，真正達到教學合一成效。

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** 交通部運輸研究所港灣技術研究中心助理研究員

二、教育訓練及行程紀要

本次原廠實地教育訓練及作業技術操作日期為 107 年 3 月 22 日~3 月 30 日共計 9 天，為使本次教育訓練課程發揮最大成效，行程安排採早去晚回方式規劃，希望能爭取較多時間與儀器原廠人員直接面對面溝通討論，提升參訓人員對儀器操作熟稔度，厚植本所海氣象觀測、分析及研究能量，本次行程規劃如表 2.1 所示。

啟程，3 月 22 日一早便搭乘立榮航空（EVA Air BR 067）上午 8 點 50 分由臺北桃園機場（TPE）至英國倫敦（London）希斯洛機場（LHR）航班，飛行時間約 18 個小時，稍做休憩後即開始本次倫敦 Aquatec 公司訓練課程，於倫敦停留 4 日後便於 3 月 25 日轉搭 SAS 航空前往挪威奧斯陸（Oslo）Nortek 總公司，飛機抵達時間約為當地晚上 9 點，離開航廈即感受到迎面而來的刺骨寒意（當地氣溫接近 0 度），也發現滿地白雪，眼前景色與位處亞熱帶的臺灣決然不同，於下榻旅舍休息一晚後，次日 5 月 26 日即開始本次 Nortek 總公司實地訓練課程，幾日訓練課程結束後，便搭乘 KLM 航空前往本次實地訓練課程最後一站荷蘭阿姆斯特丹（Amsterdam）Nortek B.V.公司，整體訓練課程完成後，於 3 月 29 日晚上 9 點 40 分搭乘立榮航空（EVA Air BR 067）由荷蘭阿姆斯特丹機場（AMS）飛回臺灣桃園機場航班。

本次 9 天實地教育訓練課程雖然短暫但也非常充實，體會到自身仍須加強改善地方，瞭解唯有跳脫自身既有框架，才能發現不同思維脈絡及研究可能，本章謹針對此次出國行程規劃及課程安排等相關內容予以說明，有關儀器原廠實地教育訓練及作業技術操作課程有關內容，將於本報告第三章~第五章分別詳述。

表2.1 原廠教育訓練及作業技術操作行程規劃表

日期	地點	課程概述
3月22日(四)	臺灣 → 英國(倫敦)	搭機啟程抵達
3月23日(五)	英國(倫敦)	(1)儀器原廠簡介及產品介紹 (2)「水體濁度儀」量測原理說明 (3)實機操作及技術交流
3月24日(六)	英國(倫敦)	(1)「水體濁度儀」量測原理說明 (2)實機操作及技術交流 (3)儀器應用案例分享
3月25日(日)	英國(倫敦) → 挪威(奧斯陸)	(1)課程綜合討論 (2)相關經驗分享 (3)由倫敦搭機至挪威
3月26日(一)	挪威(奧斯陸)	(1)儀器原廠簡介及產品介紹 (2)「潮波流監測儀」量測原理說明 (3)實機操作及技術交流 (4)儀器應用案例分享
3月27日(二)	挪威(奧斯陸) → 荷蘭(阿姆斯特丹)	(1)「潮波流監測儀」量測原理說明 (2)課程綜合討論 (3)現場觀測經驗交流 (4)由挪威搭機至荷蘭
3月28日(三)	荷蘭(阿姆斯特丹)	(1)儀器原廠簡介及產品介紹 (2)「淘刷監測儀」量測原理說明 (3)SeaDarQ 雷達簡介及應用案例 (4)實機操作及技術交流
3月29日(四)	荷蘭(阿姆斯特丹) → 臺灣	(1)「淘刷監測儀」量測原理說明 (2)儀器應用案例分享 (3)課程綜合討論 (4)相關經驗分享交流 (5)搭機返程
3月30日(五)	荷蘭(阿姆斯特丹) → 臺灣	搭機返程

三、英國倫敦 Aquatec 公司

3.1 訓練單位介紹

Aquatec 總部位於英國英格蘭漢普郡東北部的小鎮貝辛斯托克 (Basingstoke)，由現任董事長 Andy Smerdon 於 1990 年創設，Aquatec 公司主要業務為開發、生產及製造海洋、海岸、港灣、海洋生物、河川及湖泊監測與調查儀器，其儀器之產製皆於該公司總部完成，該公司並提供水下測量、監測和通信等工程問題的解決方案，並符合 ISO9001 品質管理系統，具有一定之服務及品質管理系統，另該公司亦符合 ISO14001 國際環境管理系統認證，BS OHSAS 18001 職業安全衛生管理系統，為一取得國際性相關認證的公司。Aquatec 公司認為其核心價值為創新 (Innovation)，除了進行重要的內部研究和開發計劃之外，該公司並積極參與各國合作研究和開發計劃，並不斷發展突破性的新技術。



圖3.1 位於英國貝辛斯托克 AQUATEC 公司外觀照片

3.2 課程內容說明

本次教育訓練活動由 Aquatec 公司的執行長 Andy Smerdon 先生 與銷售及營銷總監 Elizabeth Paull 女士及為我們介紹海洋與環境監測儀器(如圖 3.2)，除了有關本所既有相關設備之操作說明及設定外，並介紹其他相關海洋儀器等設備，首先，Elizabeth Paull 女士先為我們介紹，目前本所既有之觀測設備濁度計(AQUALogger 310TY)如圖 3.3~圖 3.4，該濁度計可量測從 1,000FTU~10,000FTU，濁度計內建濁度 (Turbidity)、壓力 (Pressure) 及溫度 (Temperature) 感測器，其濁度感測器為一光學散射型式，其光源波長為 880nm，濁度感測器最多量測可達 10,000 FTU；壓力感測器最多達水下 6000M，其壓力感測器之準確度 (accuracy) 可達 $\pm 0.2\%$ ，其解析度為 $\pm 0.01\%$ ；另對於溫度感測器，於 $-2 \sim 35^{\circ}\text{C}$ 之範圍內，準確度可達 $\pm 0.05^{\circ}\text{C}$ ，解析度為 0.001°C 。

其操作介面上設計為簡單方便使用，有關操作特色上，包含可使用原廠所提供之啟動磁鐵，於設置完成後，只需要將啟動磁鐵於濁度計觀測儀器之本體滑動，即可啟動濁度計之觀測功能；另外，濁度計之狀態資訊，可將濁度計儀器本體，上下搖晃兩次，於濁度計儀器之顯示燈號可以判斷儀器之狀態資訊，綠色燈號為儀器正在進行觀測記錄中，藍色燈號為等待啟動，紅色燈號為濁度計之電池電量不足；AQUALogger 310TY 之供電方式，有別於一般觀測儀器供電系統的設計，該濁度計可使用 4 顆三號電池進行供電，其量測模式並可選擇觸發模式 (Burst) 或連續模式 (Continuous)，根據自身研究需求進行設置，概略介紹 AQUALogger 310TY 之相關規格後，便開始說明相關軟體之操作。



圖3.2 銷售及營銷總監 Elizabeth Paull、執行長 Andy Smerdon



(圖片來源：Aquatec公司官方網站)

圖3.3 AQUAlogger 310TY外觀照片



圖3.4 AQUAlogger 310TY通訊接頭外觀

表 3.1 AQUAlogger 310TY 規格說明

項目	規格
記憶體(Memory)	64MB可擴充至2GB
資料儲存年限(Data Retention)	>20年
測量模式(Sampling)	觸發模式(Burst)或連續模式(Continuous)
取樣頻率(Acquisition rate)	8Hz
通訊介面(Communication)	USB、RS232、RS422、無線傳輸
擴充裝置(External interfaces)	可相容之溝通模組 (Compatible comms modules):顯示器 (display)、光學式數據機(Optical modem)、聲波式數據機(Acoustic modem)
電池(Battery)	4顆三號電池(鹼性、鎳氫、鋰皆可)

項目	規格
操作軟體(Software)	AQUAtalk(可使用Aquatalk軟體進行設置、下載、懸浮質轉換)
最大耐深深度 (Maximum)	標準型:水下1000公尺深 水型:水下6000公尺
材質(Material)	標準型:Acetal 深 水型:Duplex
重量(Weight)	標準型<3kg 深水型<5kg
尺寸(Dimensions)	直徑60mm，長度360mm

AQUALogger 310TY 其量測所得之資料，可使用 USB、RS232、RS422 及無線傳輸等方式與電腦進行溝通，並配合 Aquatec 公司所開發之軟體 AQUAtalk 進行操作及分析繪製圖表，其操作介面如圖 3.5~圖 3.7 所示，為 AQUALogger 310TY 以 USB 溝通傳輸之方式操作畫面，該畫面為本所實際操作之狀況，由畫面可得知濁度計之儀器版本、溫度、壓力、深度、濁度及電池狀況等相關資訊。

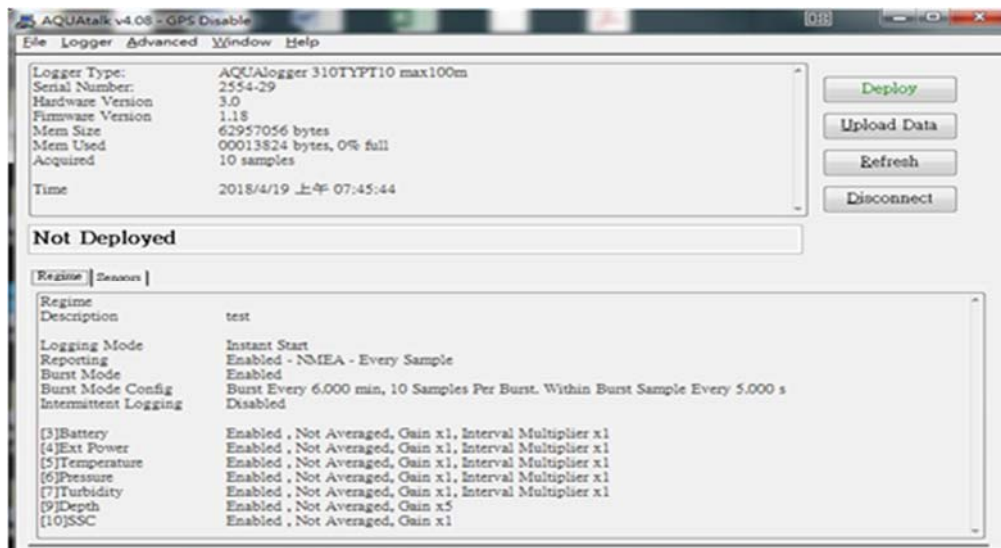


圖3.5 AQUAtalk 與 AQUALogger 310TY之操作畫面一

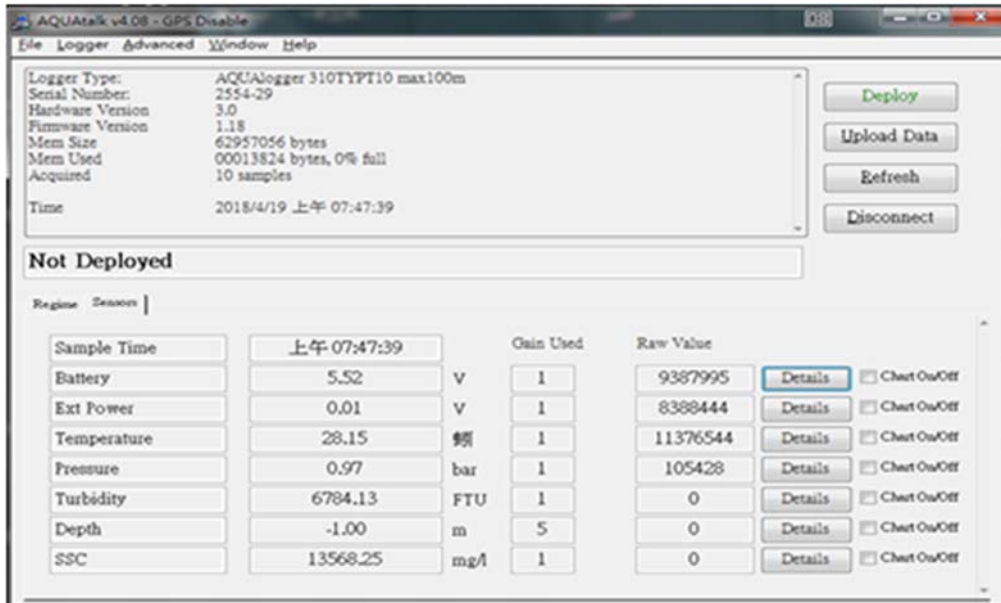


圖3.6 AQUAtalk 與 AQUAlogger 310TY之操作畫面二

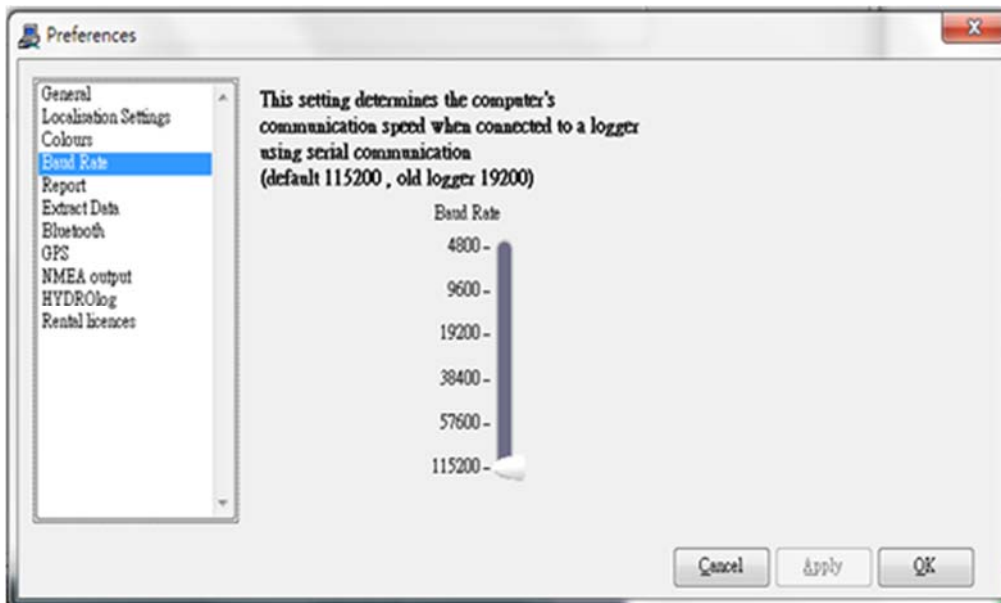


圖3.7 AQUAtalk 與 AQUAlogger 310TY之操作畫面三

Elizabeth Paull 女士並說明 AQUAlogger 310TY 除了以自記式的方式量測資料，亦可以即時傳輸（Real-time）的方式來量測記錄資料，而要在海洋觀測中進行即時傳輸的方式並不是一件容易的事情，除了於傳輸過程中常發生的海底纜線斷裂，亦有供電系統、海生物附著、惡劣天氣等等的問題，而對於水下的資料傳輸系統，Aquatec 公司亦有自己的一套解決方式，該公司開發了光學式數據

機 (optical modem) 及聲波式數據機 (acoustic modem)。光學式數據機主要可用於水下通訊傳輸資料之功能，該公司所開發之 The AQUAmodem Op2 optical modem，如圖 3.8，其主要功能為提供水下儀器與使用者之間利用光學方式傳輸資料，配合潛水人員或水下無人載具，於取得儀器之資料時，可以不須透過纜線傳輸，使得相關工作之進行更為順利、更具經濟及效率，並可於水下深度 3,500 m 進行操作。

除此之外，聲波式數據機亦有水下無線傳輸之功能，其相關水下聲波傳輸之技術 Aquatec 公司整合後於 1997 年首次產製，水下聲波傳輸需考量水下各種複雜的環境因子，包含水層結構 (water column structure)、氣泡 (bubble) 及雜訊 (noise) 等，因此 Aquatec 公司為了確保所進行監測流程之順利進行而提出之標準溝通流程如圖 3.9，以幫助監測研究單位確認其需求，另外，該公司亦推出相關聲波式數據機，AQUAmodem S500、AQUAmodem 500 及 AQUAmodem 1000，如圖 3.10，依據其使用之狀況，可進行雙向溝通，能夠發送和接收命令，並且能夠遠距離和深水地傳送數據，通過無線電、衛星或 GSM 等方式將結果傳遞給其他系統。由於此種技術的發展，可不需使用海底電纜，便能進行即時的觀測作業，未來可以發展並應用於我國海象觀測作業，節省人力讓讓相關作業能更順利進行。



(圖片來源：Aquatec公司官方網站)

圖 3.8 The AQUAmodem Op2 optical modem



(資料來源：Aquatec 公司官方網站)

圖3.9 標準溝通流程圖



(圖片來源：Aquatec公司官方網站)

圖3.10 左: AQUAmodem S500, 右: AQUAmodem 1000

除了前述水下傳輸通信技術之介紹外，由於觀測儀器置放於水下，而儀器放置於水下進行觀測時，隨者時間的推移進行，觀測儀器表面會有生物附著現象 (biofouling)，如藤壺、海蠟子、藻類及管蟲等海生物附著於觀測儀器上，造成儀器無法順利進行觀測或造成誤差過大，因此，海洋觀測研究人員需定期將附

著於觀測儀器上方的海生物清除，而這常常需要花費大量的時間、金錢成本，為了應對此種狀況，Aquatec 亦有海生物自動刷除器(automatic wiper)如圖 3.11，可安裝於觀測儀器上，將附著於觀測儀器感測器之海生物刷除，藉由此種方式，可大幅減少前往維護觀測儀器的各種成本，使得觀測作業更為經濟並具有效率，有關本次英國倫敦 Aquatec 公司教育訓練期間相關照片如圖 3.12 所示。




(圖片來源：Aquatec公司官方網站)

圖3.11 海生物自動刷除器



圖3.12 教育訓練期間相關照片

3.3 課程相關資料



OCEAN & ENVIRONMENTAL

Oceanographic & Environmental Instrumentation

Elizabeth Paull – Sales & Marketing Director

www.aquatecgroup.com



Aquatec Group Ltd

- Founded in 1990
- Headquartered in Basingstoke UK
- Design and manufacture all products and engineered solutions
- Products sold worldwide



QHSE

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- BS OHSAS 18001 Occupational Health and Safety Management

— FPAL —
empowered by Achilles



— Registered —

- **Design, manufacture and supply of subsea instrumentation, communications, and cathodic protection systems**



- **FPAL Advanced Registration**

Subsea Solutions

Consultancy • Measurement • Communication • Insight

- **Areas of Expertise**

- Sediment measurement
- Sensing underwater
- Data acquisition, processing and storage
- Through- and above-water communication
- Subsea packaging



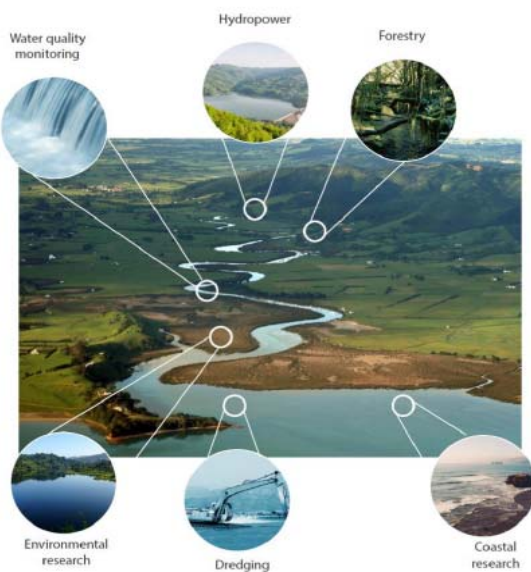
- **Technologies**

- Acoustics
- Optics
- Temperature & Pressure
- Motion and Attitude
- Cathodic Protection



Sediment? *Solved*

Sediment? *Solved*



A complete range of oceanographic and environmental instruments for observing and collecting sediment

Aquatec instrumentation for observing suspended sediment

KC-Denmark equipment for collecting suspended, bedload and deposited sediment

System design, bringing together *Sediment? Solved* products and Aquatec's extensive expertise in instrument, communication and system design

Sediment? Solved

Observing Suspended Sediment

- AQUAlogger 310TY Advanced turbidity logger
- AQUAscat 1000 range of acoustics suspended sediment profilers

- Secchi disc



Collecting Suspended Sediment

- Sediment traps, water samplers, Niskin bottles and rosettes



Collecting Deposited Sediment

- Grabs and corers



Suspended sediment

Coastal Studies

- Assessment of civil engineering works
- Erosion & deposition
- Quantify sediment flux
- Fate of pollutants
- Data for models
- Breakwater design
- New harbours
- Wind farm sites



Artificial embayments at
Sea Palling, Norfolk, England

Dredging

- Environmental impact assessment
- Dredge material fate
- Regulatory compliance



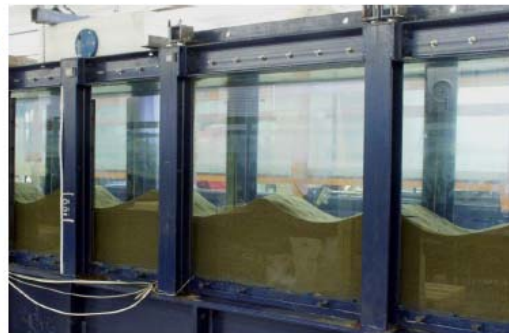
River Sediment Load

- Erosion/deposition
- Contaminant fate
- Water quality
- Aquaculture



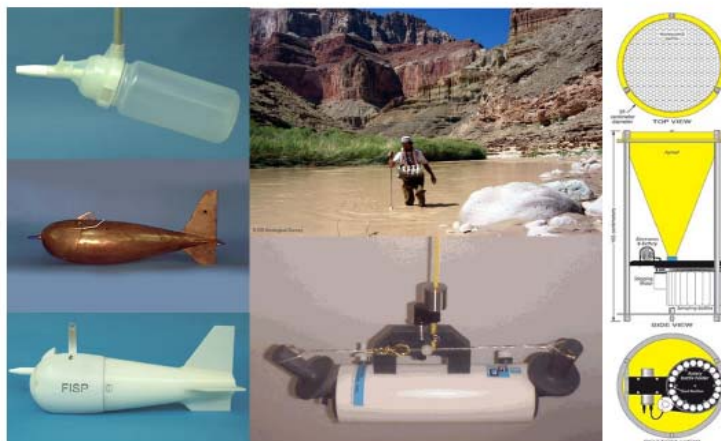
Process Studies

- Deposition and resuspension processes
- Sediment dynamic behaviour
- Interaction with currents
- Interaction with waves



Measurement options

Physical Sampling



Turbidity measurement

- Relies on optical scattering of infra-red light from suspended particles
- Instruments need to be calibrated using site samples to provide concentration values.
- Example is Aquatec's AQUAlogger 310TY



Acoustic measurement

- Scattering of sound from suspended particles using multiple frequencies
- Provides profiles of suspended sediment concentration
- Example is Aquatec's AQUAScat 1000



AQUAlogger 310TY

ADVANCED TURBIDITY LOGGER

www.aquatecgroup.com

AQUAlogger 310TY

SIMPLY ADVANCED

Observing sediment

- Turbidity to over 10,000FTU
- Suspended sediment concentration (with SSC Converter)

Visualise & communicate with field-swappable comms modules



User-friendly features

- Quick start
- Shake to show
- Off-the-shelf batteries
- Tablet compatible

Flexible sampling

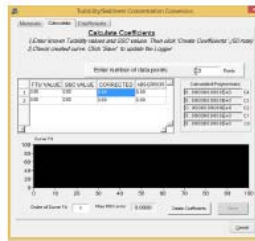
- Delayed start
- Continuous or burst sampling
- Sample averaging
- Variable sample rates for each sensor
- Advanced logging settings

AQUAlogger 310TY

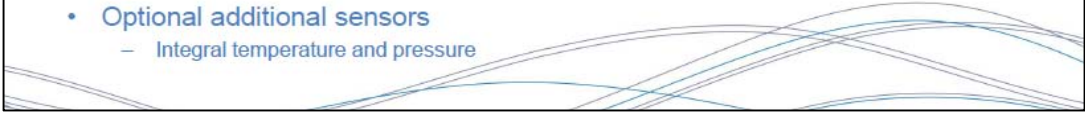
OBSERVING SEDIMENT

Now available!
Turbidity, SSC and depth
in real time

- New higher range
 - Turbidity to over 10,000FTU
- Measure suspended sediment concentration (SSC)
 - Use the SSC Converter to convert turbidity to SSC



- Optional additional sensors
 - Integral temperature and pressure



AQUAlogger 310TY

USER FRIENDLY FEATURES

- Quick start
 - Set up your logger in the lab, then swipe with our magnet in the field to start
- Shake to show
 - Shake your AQUAlogger 310 to check the status
 - Logging, not deployed, waiting to start, low battery
- Standard batteries
 - The AQUAlogger 310 uses standard off-the-shelf AA size batteries
 - Choose between alkaline, NiMH or lithium depending on your deployment
- Optional wireless communication
 - Remove the need for cables with the optional wireless functionality
- Use with a tablet
 - Set up, deploy and download data with a Windows tablet



AQUAlogger 310TY

FLEXIBLE SAMPLING

- Delayed start
 - Set up your logger to start at a specified date and time
- Continuous and burst sampling
 - Continuous sampling – sample at a set rate of up to 128Hz (depending on the sensor)
 - Burst sampling – set the logger to record bursts of data, sampling at a higher frequency within a burst
- Variable sample rates
 - Log each sensor/variable at different rates
- Averaging
 - Select which sensors to average data from within the logger
- Advanced logging settings
 - Set trigger input or output
 - Select intermittent sampling (e.g. only sample every Monday)



AQUAlogger 310TY

VISUALISE AND COMMUNICATE WITH SWAPPABLE MODULES

- Observe your data in real time with the subsea display



- Command and data download with the optical modem
- Transmit live data readings with the acoustic transmitter



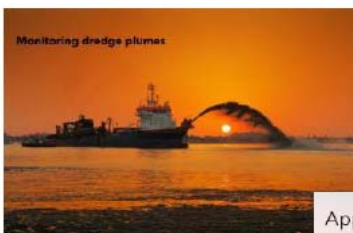
AQUAlogger 310TY

- Optional hydrowiper to combat biofouling



(photo courtesy of Fugro EMU)

AQUAlogger 310TY



Monitoring dredge plumes



Water quality monitoring for EIA and aquaculture



Applications

Oceanographic, environmental and coastal research



Turbidity monitoring during construction



Silt monitoring for hydropower plants

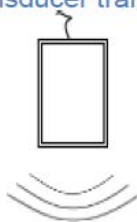
AQUA*scat* 1000

ACOUSTIC SUSPENDED SEDIMENT PROFILER

www.aquatecgroup.com

Acoustic Backscatter

Transducer transmits pulses of ultrasound equal in length to the bin: e.g. 13.33 μ s approximately equivalent to 1 cm bins



Sound waves travel through water



Sediment in water scatters sound, which is picked up by transducer. Different size sediment scatters sound more or less depending on frequency of sound

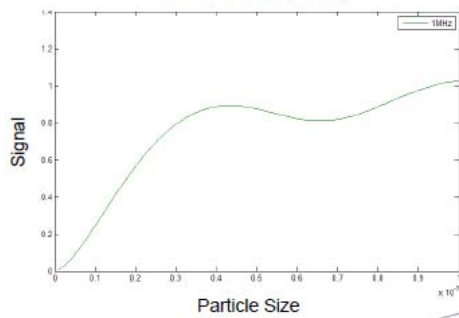


Frequencies

Single frequency

- Measured signal varies with particle size
- Requires physical samples to be taken

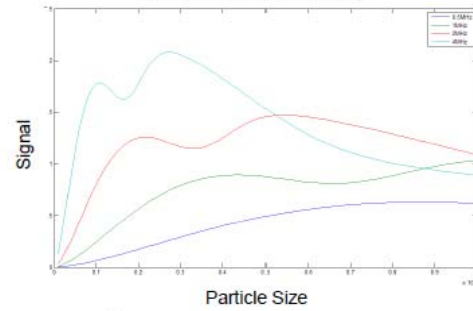
Measured signal vs Particle size: Fixed concentration (1MHz)



Multiple frequency

- Use the size dependent response to different frequencies to determine particle size.
- Calculate concentration using particle size information

Measured signal vs Particle Size: Fixed concentration (0.5 - 4MHz)



Backscatter Equation

• Measured signal

$$P = \frac{k_s k_t}{r^2} \sqrt{M} \cdot e^{-2r\alpha}$$

System constant (points to $k_s k_t$)
 Range from transducer (points to r)
 Attenuation (points to $e^{-2r\alpha}$)
 Range modification factor (points to r^2)
 Mass Concentration (points to \sqrt{M})

$$k_s = \left(\frac{F_m}{\sqrt{a_s \rho_s}} \right)$$

Form function (function of size and frequency) (points to F_m)
 Mean sediment radius (points to a_s)
 Sediment density (points to ρ_s)

Equations from papers by Thorne and Hardcastle 2002

Observation methods

Collection Method \ Function	Manual	Pump & traps	Turbidity	Acoustics
Flexible Sampling	No	No	Yes	Yes
Maintenance	Low	High	High	Low
Effect of Bio-fouling	Low	Low	High	Low
Online Capability	No	No	Yes	Yes
Unattended operation	No	Yes	Yes	Yes
Profiling	No	No	No	Yes
Reference Samples	No	No	Yes	Depends

AQUAscat 1000

- Multiple Frequency Acoustic Backscatter System
- Variable bin size from 2.5 mm to 4 cm
- 256 profile bins with ensemble averaging
- 4 Channels
- Frequency range from 300 kHz to 5 MHz
- Cabled or built in transducers
- Flexible deployments
- Large storage capacity 8 GB
- USB data download



AQUAscat 1000 – the range

- AQUAscat 1000R - *Research*

- 4 cabled transducers
- Can transmit and receive sound in any direction
- Choose between 7 frequencies (300 kHz, 500 kHz, 1 MHz, 2 MHz, 2.5 MHz, 4 MHz and 5 MHz)



- AQUAscat 1000S - *Survey*

- Survey
- Compact for simple and repeat deployments
- 4 integrated transducers (frequencies of 500 kHz, 1 MHz, 2 MHz and 4 MHz).

AQUAscat 1000 – the range

- AQUAscat 1000LT - *Lite*

- 2 integrated transducers (frequencies of 1 MHz and 4 MHz)
- Observe profiles of 2.5m
- Rechargeable battery



- AQUAscat 1000L - *Laboratory*

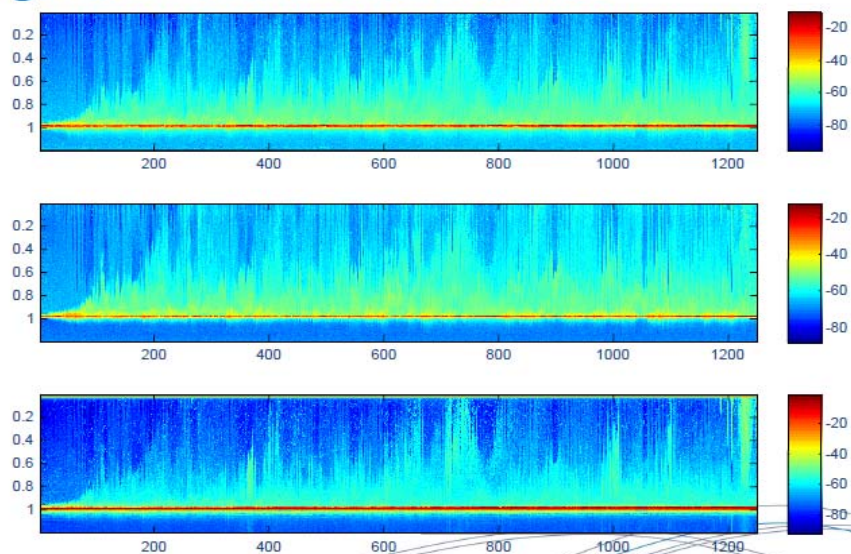
- Choose between 7 frequencies (300 kHz, 500 kHz, 1 MHz, 2 MHz, 2.5 MHz, 4 MHz and 5 MHz)
- Up to 4 cabled transducers providing flexibility in operation
- Can transmit and receive sound in any direction

Flume Tank Data

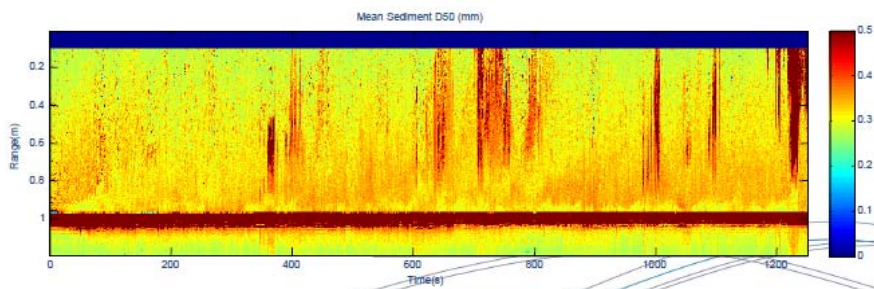
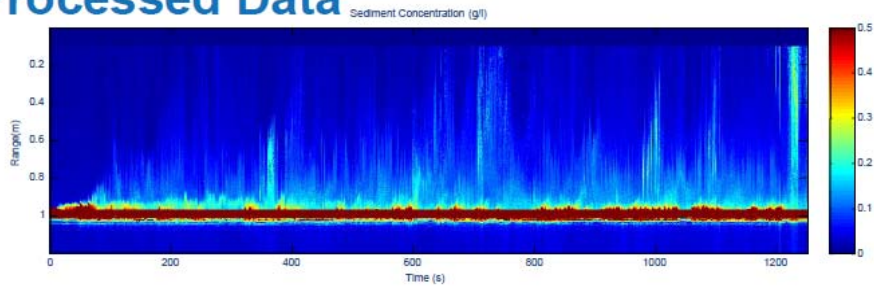
- Measurements in the Großer Wellenkanal at the Coastal Research Centre FZK in Hannover, Germany
- 2 MHz, 4 MHz & 1 MHz
- 64 Hz Ping Rate
- 32x Averaging
- 1 cm Bin Size
- 1 m from bed



Range Corrected Backscatter



Processed Data

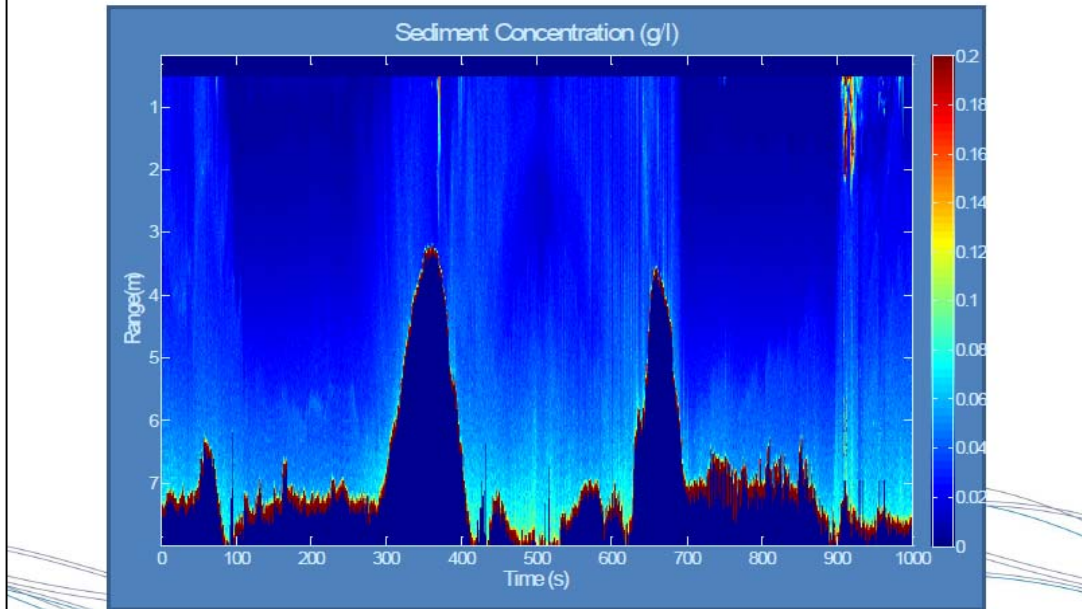


River Transect Data

- Measurements at Grimsby in the Humber Estuary, UK
- 1 MHz and 2 MHz Transducers
- 4 cm Bin Size



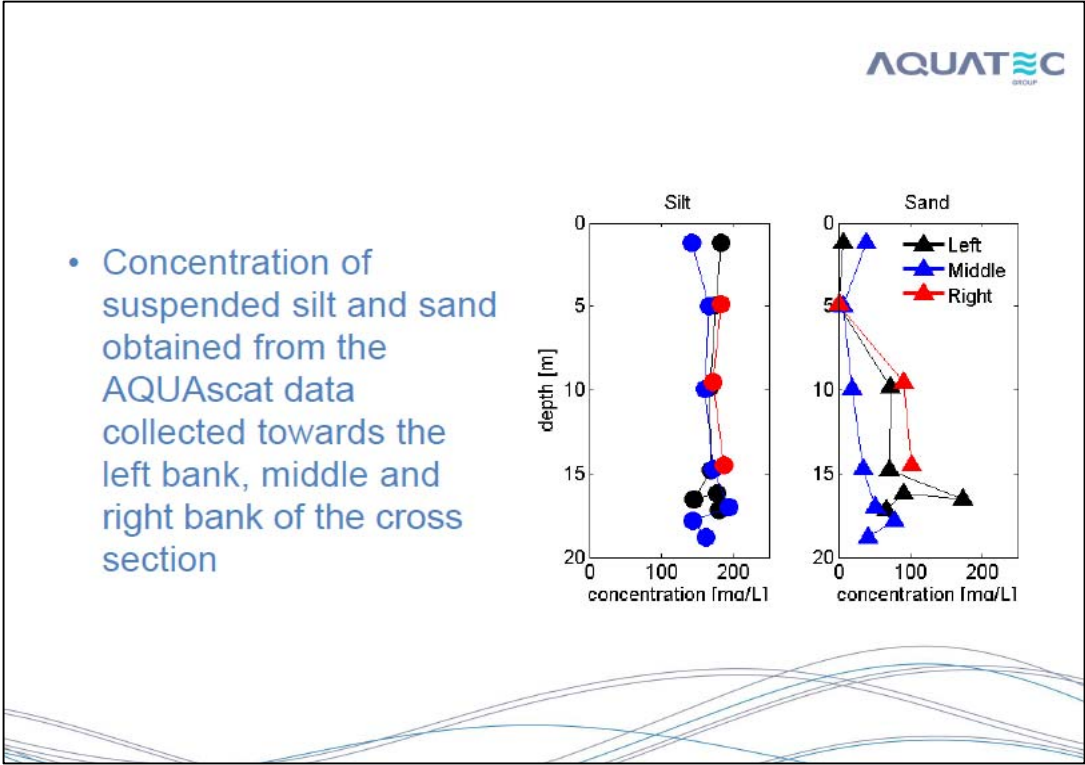
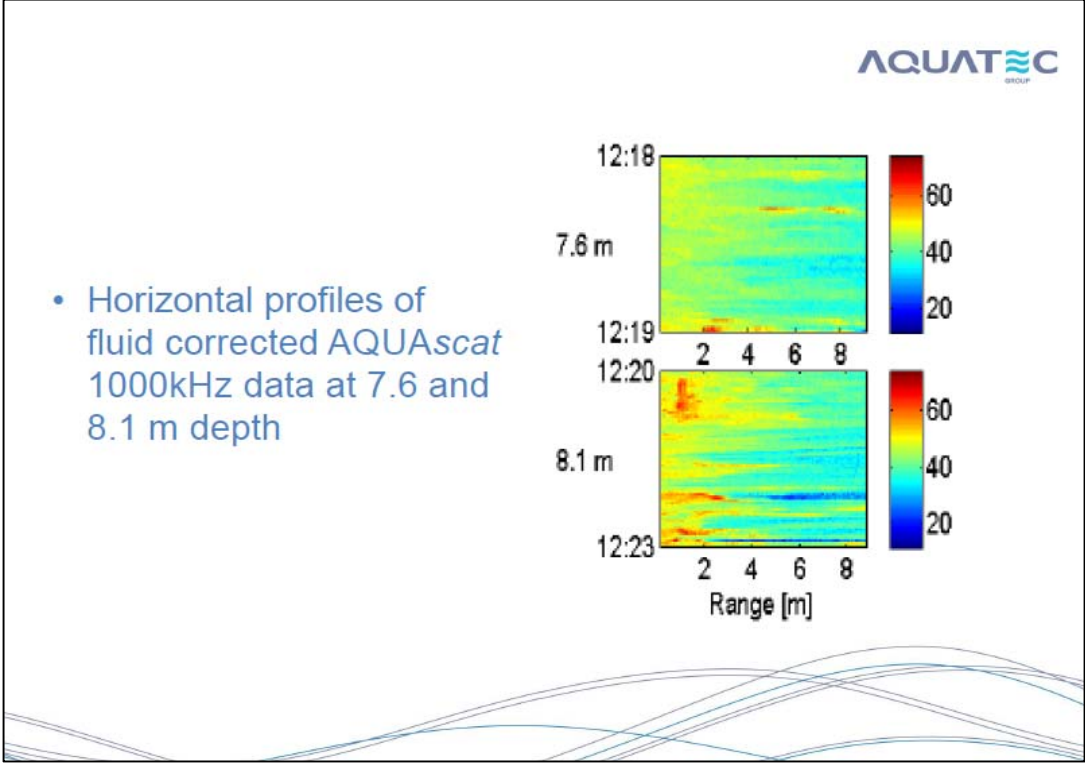
River Transect Data



Sediment fluxes in the Mekong River

- Study of the sediment fluxes of the Lower Mekong River
- Deployed horizontally in multiple across-stream positions at varying depths attached to a bed load sampler frame
- Used in conjunction with an ADCP, bed load sampler and water samples



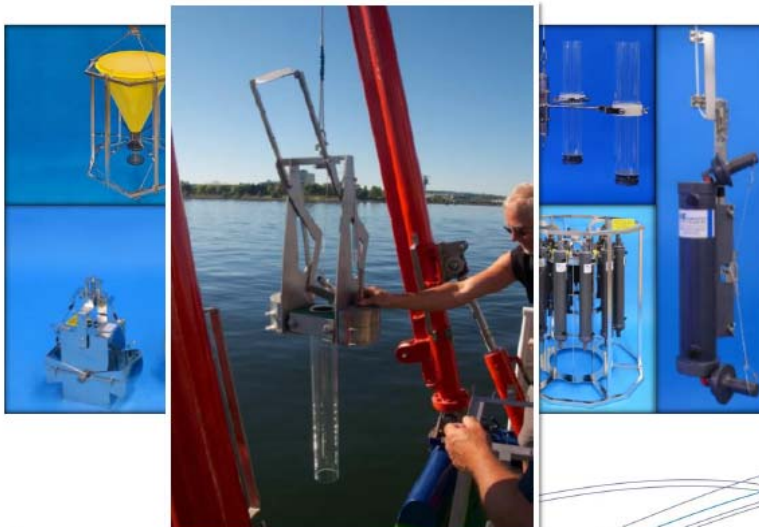


Aquatec Expert

- A **personal consultation** to discuss your deployment, what you want to measure, the expected sediment regime, your expectations, your client's expectations, and gathering an understanding of other co-located instruments.
- **Pre-deployment advice** comprising a performance capability prediction for the range of suspended sediments, covering trade-offs with power and sample regime; and a recommended configuration for your instrument, including advice on equipment mounting, battery provision, and synchronisation with any other instruments.
- **Post deployment report** to include:
 - a. Critical analysis of AQUAscat dataset
 - b. Deployment summary
 - c. Hand-tuned particle size and load profile inversions
 - d. Matlab or CSV processed dataset

	Bronze	Silver	Gold
Personal consultation	✓	✓	✓✓
Pre-deployment advice	✓	✓	✓✓
Post-deployment report		✓	✓✓

Beyond suspension...



- Sediment traps
- Water samplers
- Niskin bottles & rosettes
- Grabs
- Corers

Beyond suspension...



Voyager II sea flume

- Designed for in situ studies of threshold, erosion velocity and erosional behaviour of undisturbed marine muds

Cohesive Strength Meter

- Directly measures the surface erodibility of marine, fluvial and terrestrial sediments



Integrated systems

- Complete systems can be designed to measure sediment throughout the natural environment, bringing together Sediment? Solved products and Aquatec's extensive expertise in instrument, communication and system design.



Temperature & depth

Temperature and depth

- THE MINI LOGGER - AQUAlogger® 520

- Compact wireless design
- Up to 5 year battery life
- Continuous & burst sampling regimes
- Maximum 1000m depth



- THE WIRELESS LOGGER - AQUAlogger® 530

- Automatic transmission of data to a remote computer via wireless technology
- Automatic display of temperature and depth data

- THE ADVANCED LOGGER - AQUAlogger® 310

- Compact, self-contained logger
- Real time reporting capability as standard
- Depth rated to 6000m



AQUAlogger 520

- Compact, self contained logger
- Deployed and data downloaded via reader with inductive modem
- Up to 5 years battery life
- Depth options: 10m, 30m, 40m, 100m, 500m, 1000m
- Flexible sampling – burst and continuous

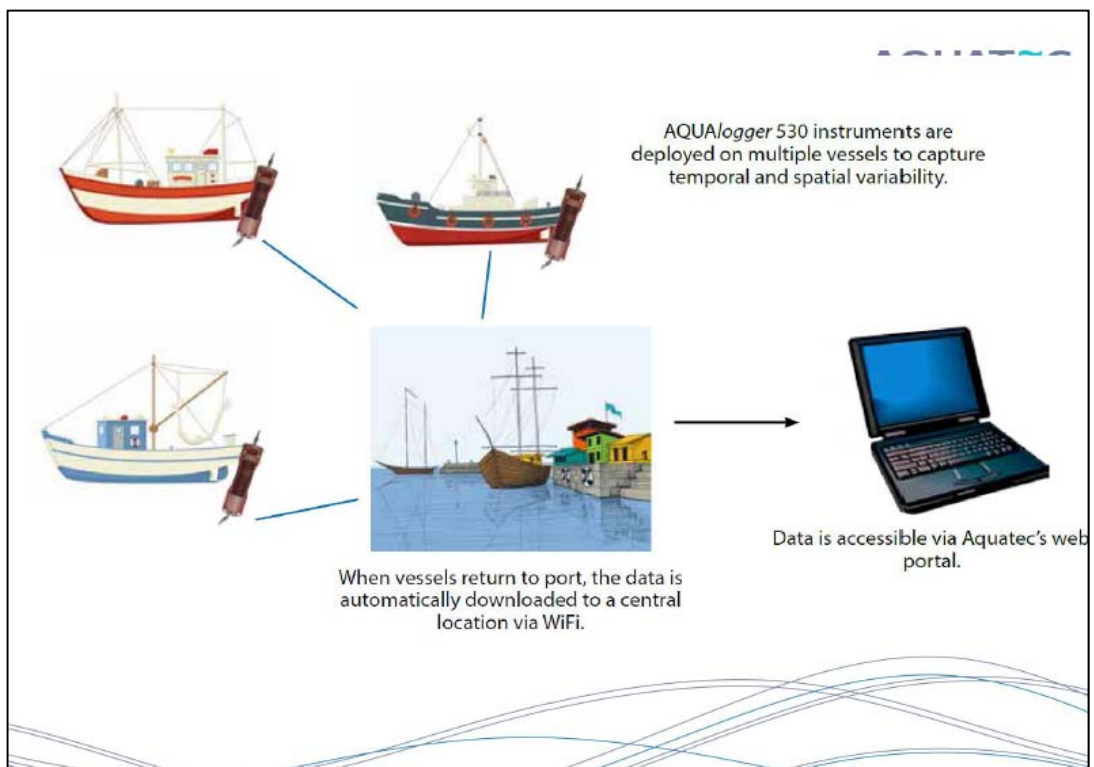
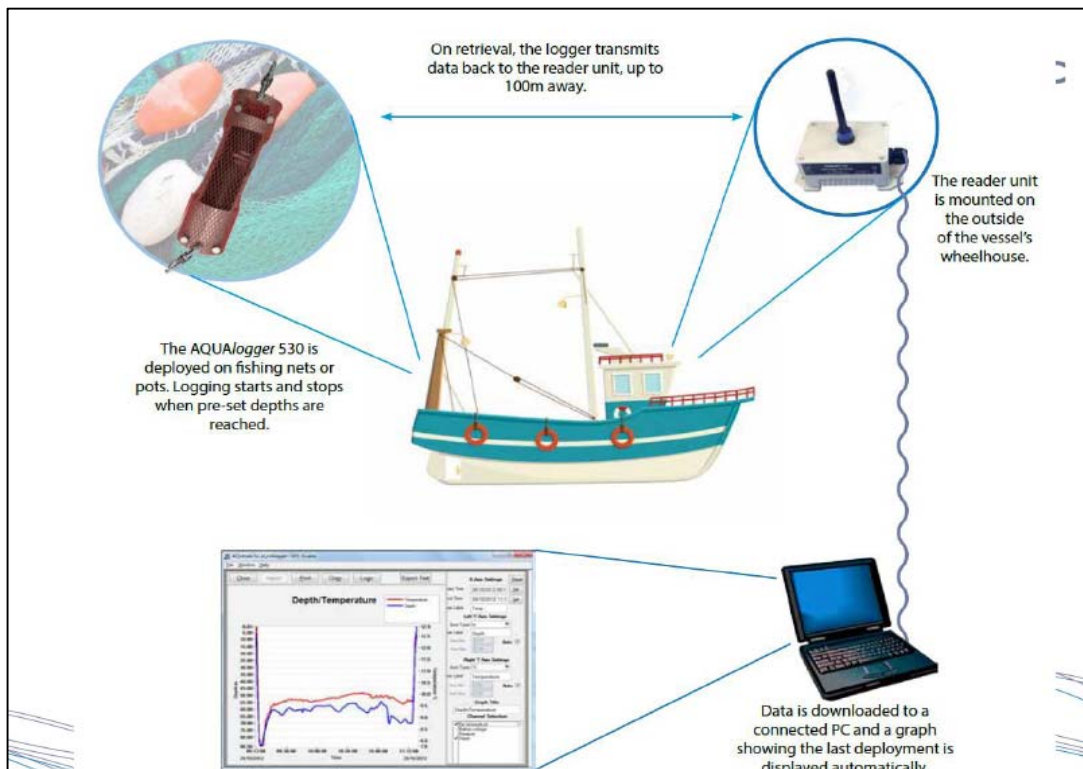
Model	Temperature sensor	Pressure sensor
AQUAlogger 520T	✓	
AQUAlogger 520PT	✓	✓



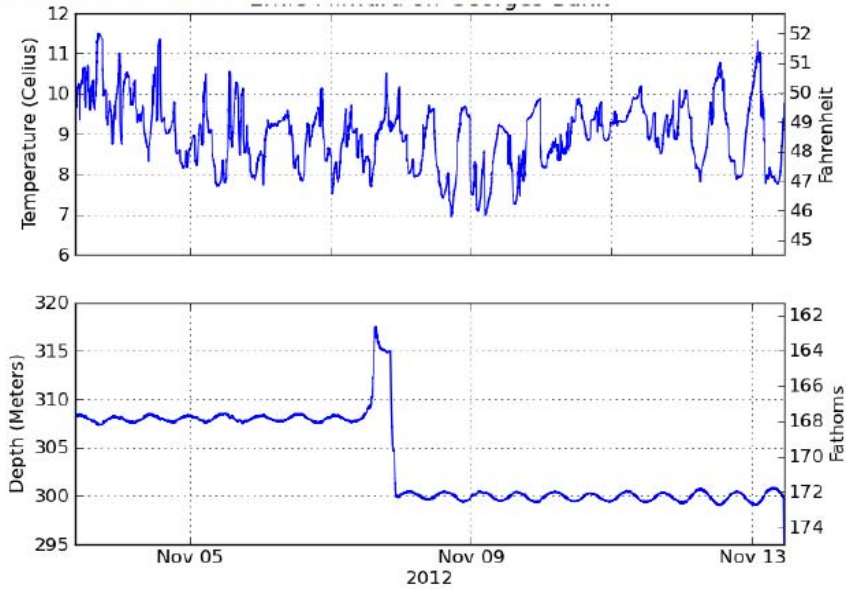
AQUAlogger 530WTD

- Standalone temperature and depth logger
- Use on commercial fishing vessels
- Stores data and displays graphs automatically via wireless technology
- No cabled connection
- System comprises:
 - Data logger
 - Reader unit, connected to PC

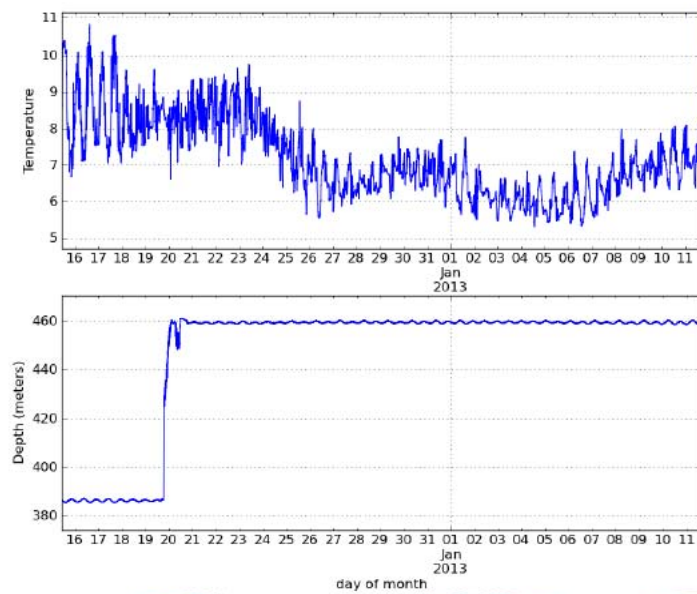




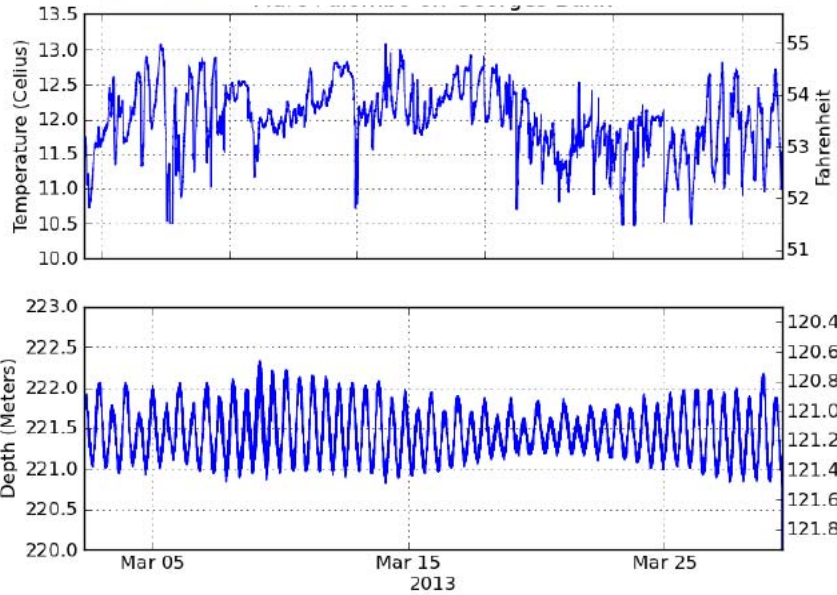
Fisheries Observations



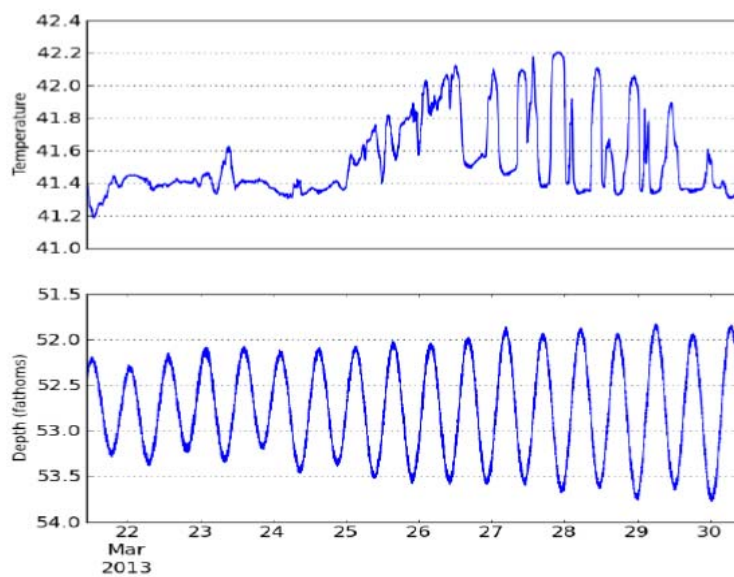
Fisheries Observations



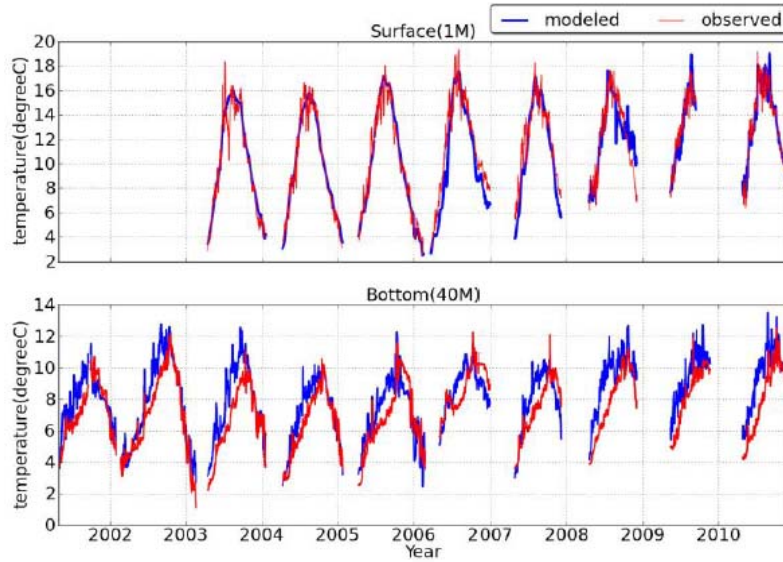
Oceanographic Observations



Oceanographic Observations



Model Improvement



Marine Mammal Deterrents

AQUAmark 848

- Programmable deterrent for research
- Available for rental in a pre-configured form
- Target species: porpoises, dolphins and similar toothed whales
- Effective range: up to 1500m depending on species and nature of interaction
- Rechargeable batteries: up to 1 week between charges
- Depth rating: 500m



AQUAmark 848

Frequency	Primary bandwidth 5 kHz to 30 kHz Harmonic energy to 120 kHz
Sound level	Typically 165 dB re 1 μ Pa @ 1 m peak
Deterrent signals	AQUAmark chirp repertoire for general deterrence Pseudo-clicks for echo-location confusion Pseudo-noise for echo-location masking Random composite of all modes



Underwater communication

Why transfer data?

OIL AND GAS INDUSTRY

- Typical Applications
 - Process control
 - e.g. valves, BOP control
 - Equipment and process monitoring
 - e.g. riser motion, pipeline temperature, hydrotest
 - Asset management
 - e.g. cathodic protection monitoring & control
 - Diagnostics and maintenance
 - e.g. subsea factory condition monitoring
- Data Retrieval from Subsea to...
 - Surface platforms
 - Subsea nodes
 - Surface gateways (buoys, ASVs)
 - ROVs
 - AUVs



Why transfer data?

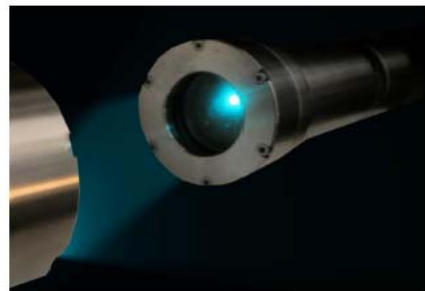
OCEAN AND ENVIRONMENTAL

- Access to data without retrieving instrumentation
- Maintenance and status checks
- React to events on shorter timescales
- Change sampling regimes



Options

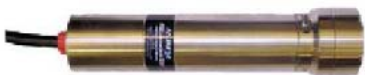
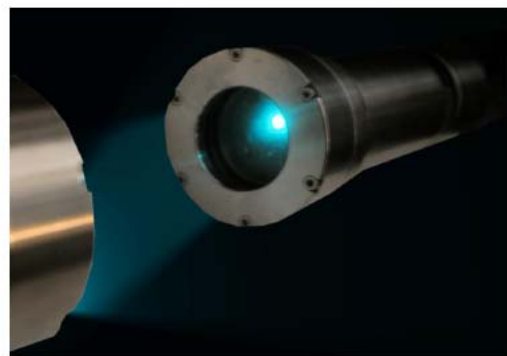
- Optical
- Acoustic
- Radio
- Displays

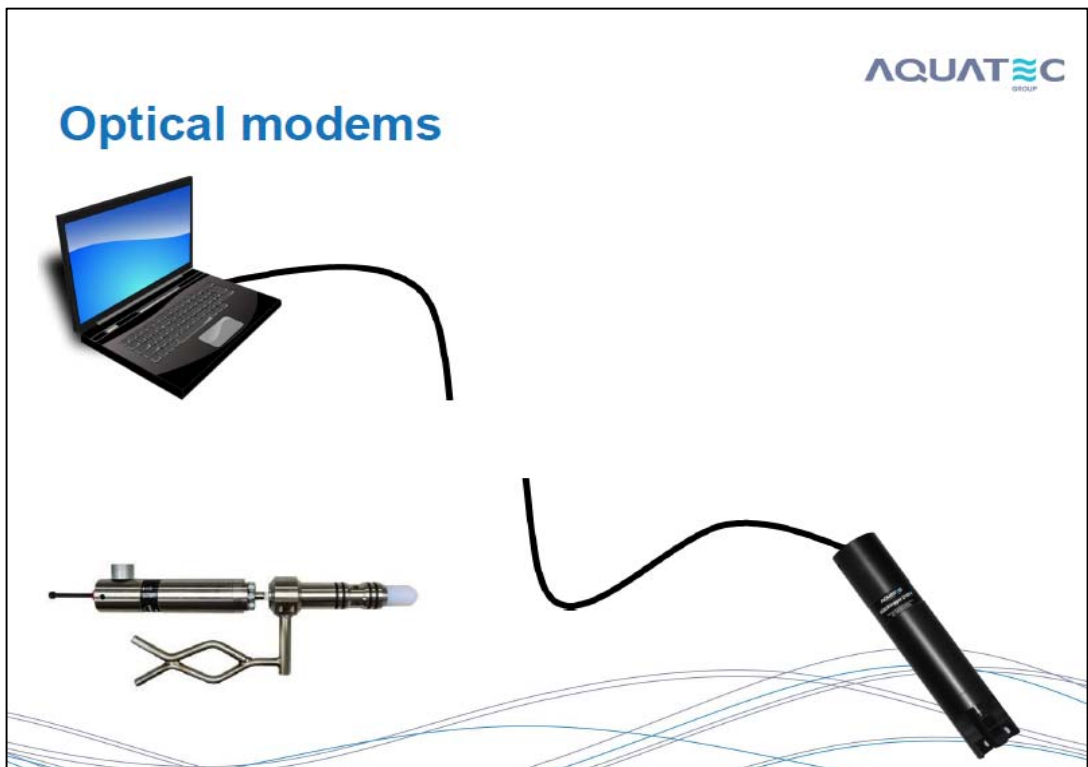
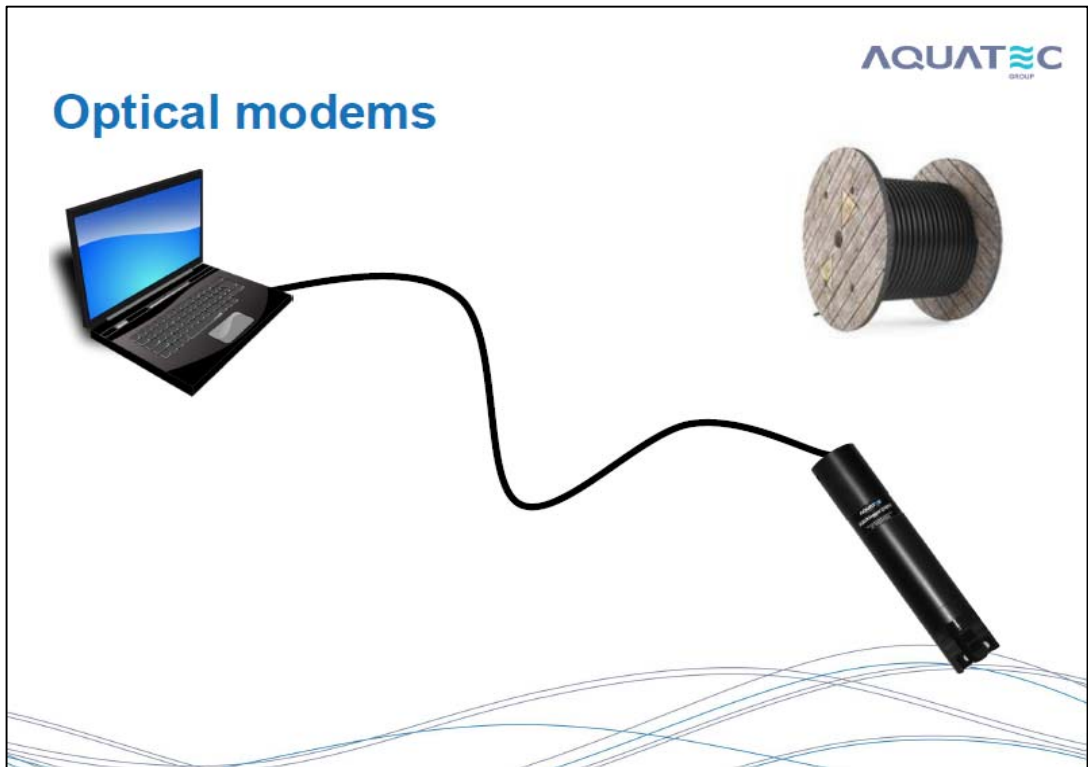


Optical communication

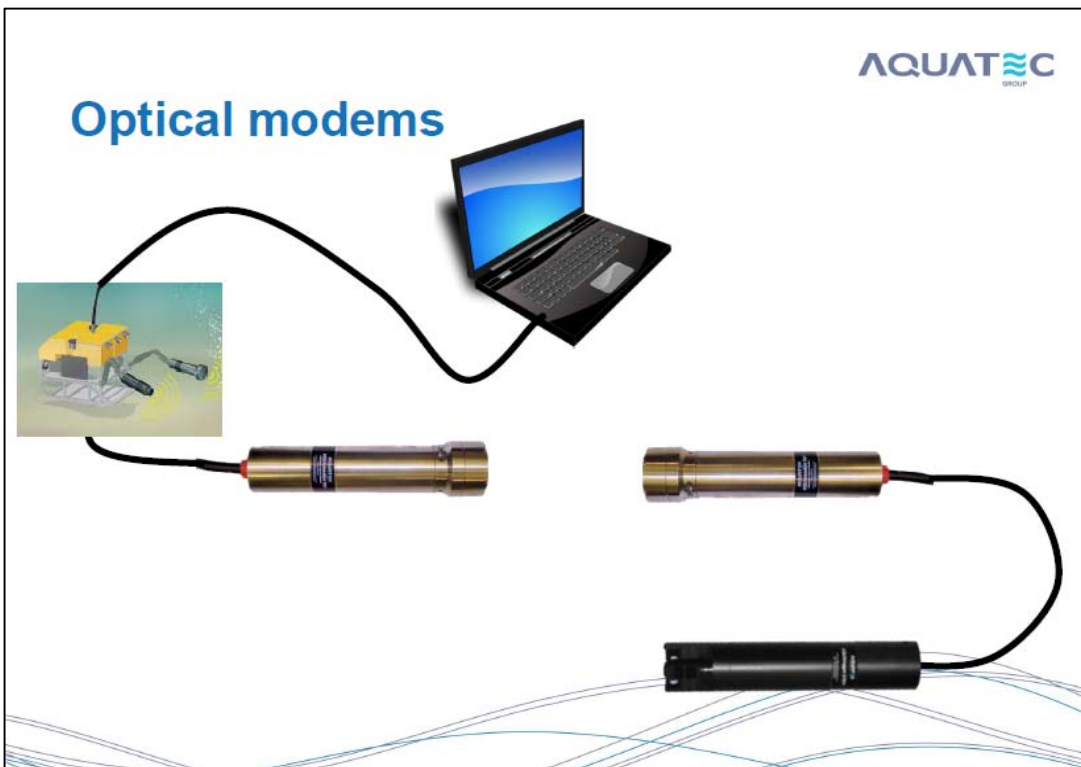
Optical modems

- Use light to transfer data through the water
- Cyan light
- Seamless link between instrument and PC





Optical modems



Optical modems

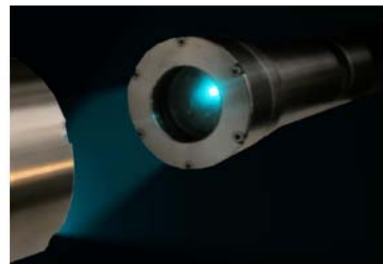


Why light?

- Alternative through-water communication methods
 - Acoustics
 - Radio
- Optics allow high speed communication over short distances
- Not affected by environmental conditions or bubbles as with acoustics
- Turbidity can have an impact

AQUAmodem Op2

- Seamless interface between subsea instruments & surface operator
- Transparent RS232 communication link
- 3500 m depth rating
- 1 m typical operating range
- 115 kbaud
- Addressable



Optical modem functionality

- Short range interrogation, commanding and data download
- RS232 serial interface
- Optical or serial wake up
- Unique/universal addressing
- Standard product



AQUAmodem Op2

FOR REAL TIME DATA AND DATA RECOVERY



AQUAmodem for AQUAlogger v3.02 - GPS Device

Logon Type: H3C@Key 2009P135-mad50m
 Serial Number: 24 0
 Hardware Version: 1.1
 Firmware Version: 2.5
 Mem Size: 512K Bytes
 Mem Used: 0 Bytes
 Samples Acquired: 0 samples
 Time: 21/02/140 18:27:17

NOT LOGGING

Sample Time: []
 Exit Temperature: 0 [] Details On/Off
 Pressure: 0.00 bar [] [] Details On/Off
 Battery: 0.00 V [] [] Details On/Off

Upload Progress: Data Uploading

Buttons: Deploy, Upload Data, Refresh, Disconnect



JVC

04/05/2016 08:52:09 Depth: 89.47 EP: 1.962 HDG(°): 213.43
 R: 430078.75 ALU: 0.65 BCC: 1.64 Pitch: 0.18
 W: 430089.48 Roll: -0.67 Yaw: 7.30

Company:
 Contractor:
 Vessel:

Pipeline Reinforcement
 Hydrostatic Strength Testing

7:30
 11.31
 594.24

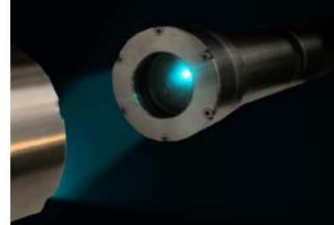
04/05/2016 15:15:71 Depth: 87.68 EP: 1.963 HDG(°): 110.81
 R: 430078.18 ALU: 0.44 BCC: 1.78 Pitch: 0.49
 W: 430089.18 Roll: 0.49 Yaw: 1.24

Pipeline Reinforcement
 Hydrostatic Strength Testing

AQUAmodem Op2L

- Lightweight optical modem
- 1m range
- Depth rated to 500m
- Ideal for use with small ROVs or by divers

- 3 times lighter than standard Op2



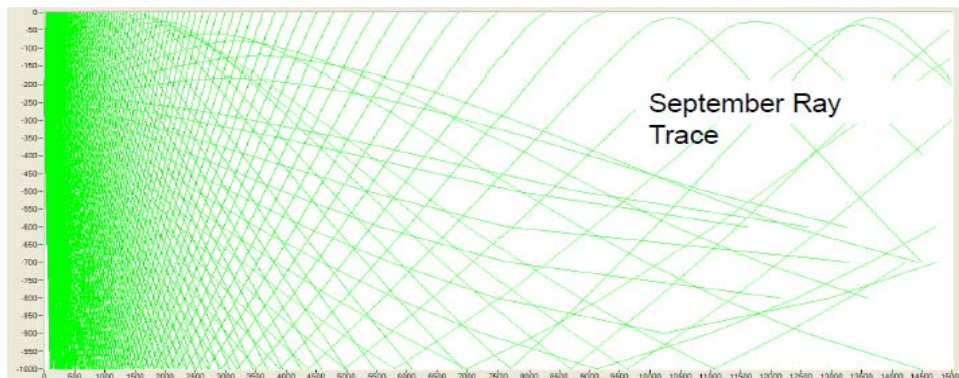
Acoustic communication

Acoustic Communications

Pros	Cons
Long range potential	Slower
Cheaper than long cable runs	Requires power
Cheaper to install than cable	Busy communication channel
Can be more robust than cable	Acoustic path can be problematic

Environmental Issues

- Ray bending due to temperature variations (see below example transmitting in Mediterranean at 250m depth)
- Bubbles (attenuate transmitted and received signals)
- Surface noise from thrusters, acoustic systems (mask received signals)



Acoustic comms: best practice



- Obtain seasonal CTD (Conductivity Temperature Depth) or Sound Velocity profiles for deployment region to allow modelling in advance
 - Part of environmental data set
 - Also gathered during sonar surveys
 - Aquatec can provide modelling service
- Place vessel mounted transducers as far from thrusters as possible
- Deploy overboard systems as deep as possible (min 30m, ideally 50 – 100m)
- Consider mounting on remote connected platforms e.g. ROV, dive bell

One way comms

- AQUAmodem 500 allows operates in “send and forget” mode
 - Low power
 - Periodic measure – acquire – send cycle
- Range from 200m to >1000m but dependent on environment
- AQUAmodem S500 for integrated modules



Two way comms

- **AQUAmodem 1000** allows commands to be sent to instrument to:
 - Change configuration
 - Request data
 - Carry out other operations e.g. trigger external equipment
- Range can be long but dependent on environment

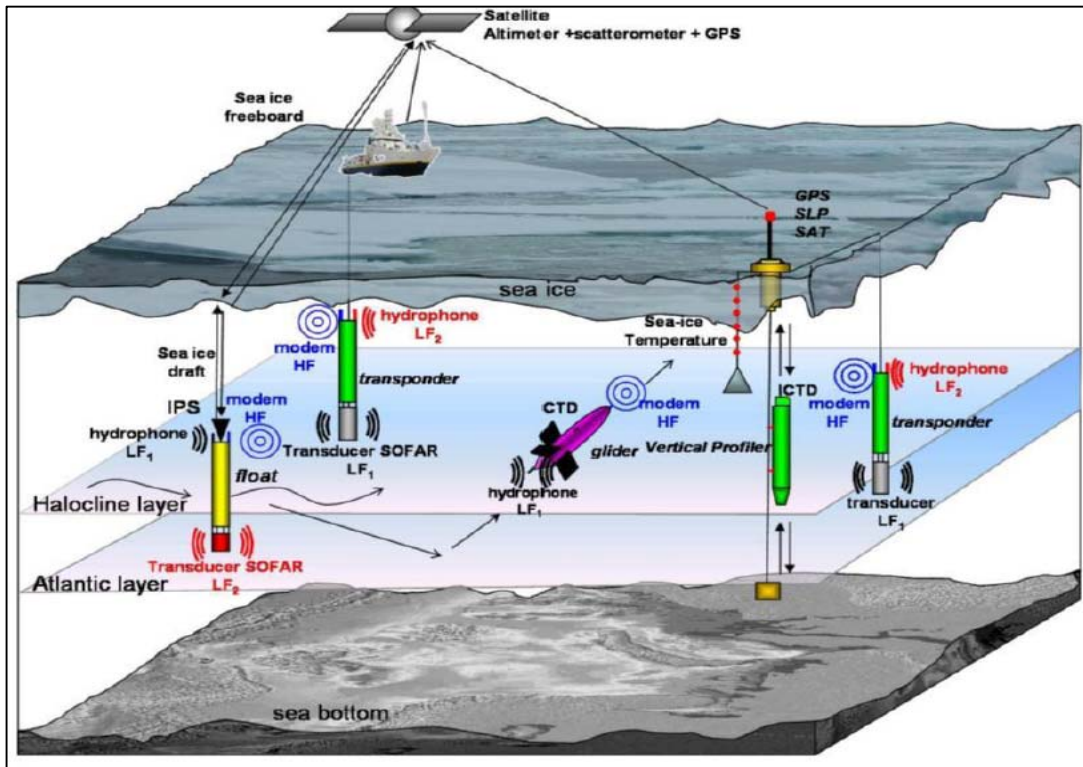
AQUATEC GROUP



CPguardian

AQUATEC GROUP






 OCEAN & ENVIRONMENTAL

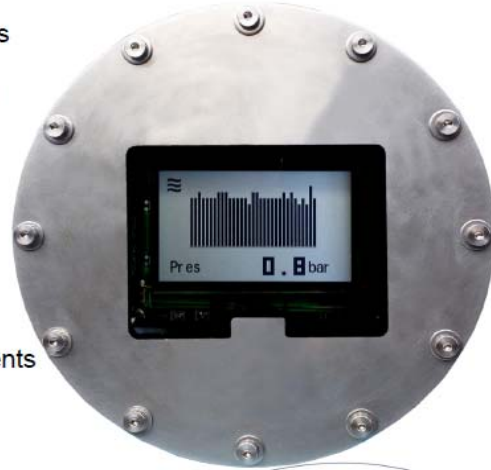
Subsea display

www.aquatecgroup.com

Supplementary Instruments

AQUAdisp SUBSEA DISPLAY

- Compatible with AQUAlogger instruments
- Displays up to 16 values over 4 screens
- Displays up to 16 graphs
- RS232 Interface
- Supports NMEA messages
- Custom configurations for other instruments
- Optional light activation



Any questions?

四、挪威奧斯陸 Nortek 總公司

4.1 訓練單位介紹

Nortek 為一國際化之公司，公司總部位於挪威奧斯陸 (Oslo)，由公司創辦人 Atle Lohrmann 先生於 1996 年創立，如圖 4.1~圖 4.3，目前於亞洲、美國、英國、法國、澳洲、及歐洲等地區均設有分公司。該公司主要以都普勒效應 (Doppler effect) 為基礎，設計開發水下聲學相關儀器，如本所使用之超音波式表面波高波向與剖面海流儀 Acoustic Wave and Current profiler (AWAC)。從產品設計開發、後端軟體編譯及儀器生產維修均由公司採一條龍方式辦理，且近幾年另創立行銷部門，將公司產品包裝推廣，是間相當具有系統性及前瞻性公司。



(圖片來源：google map)

圖 4.1 Nortek 挪威總公司地理位置



圖 4.2 Nortek 挪威總公司照片



圖 4.3 Nortek 總公司研發產品展示照片

4.2 課程內容說明

本次訓練課程分別由 Nortek 總公司首席銷售工程師 Ketil Horn 先生及技術支援工程師 Elin Bondevik 女士擔任講師，課程主要針對公司所生產儀器、儀器量測原理、軟體設定及儀器校正等進行解說，如圖 4.4~圖 4.5 所示。



圖 4.4 Nortek 總公司首席銷售工程師 Ketil Horn 先生

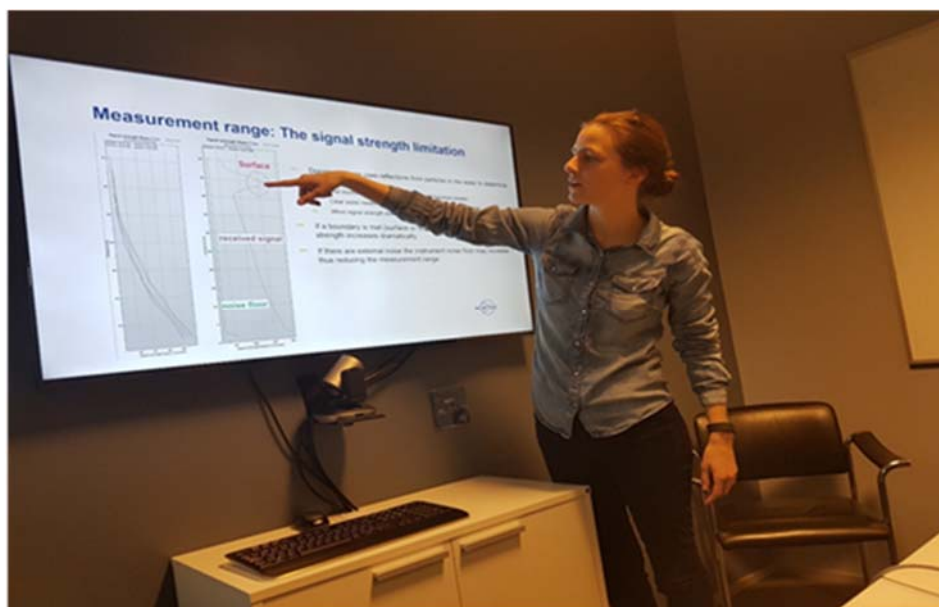
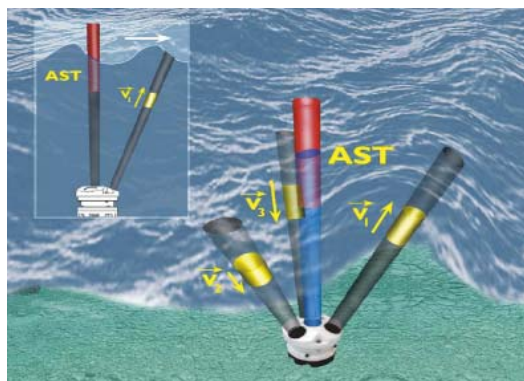


圖 4.5 Nortek 總公司技術支援工程師 Elin Bondevik 女士

本所目前現場波浪及海流觀測主要採用 Nortek 公司所開發生產表面波高波向與剖面海流儀 Acoustic Wave and Current profiler (AWAC)，依據音鼓發送頻率 (Transmit Frequency) 不同共分為 1MHz、600kHz 及 400kHz 三種，其原理係透過儀器上方音鼓量測設置地點波流及海流運動情形，如圖 4.6 所示。



(a) 超音波量測原理



(b) 1MHz AWAC



(c) 600kHz AWAC



(d) 400kHz AWAC

(圖片來源：Nortek 公司官方網站)

圖 4.6 表面波高波向與剖面海流儀 (AWAC)

AWAC 經 Nortek 公司多年研發改善，目前已具備即時傳輸功能，可透過傳輸元件 (如無線傳輸、有線網路及衛星) 將現場量測所得波流及海流等資料，即時傳輸至使用者指定位置，對於船舶調度、船隻航行及航線規劃等提供直接且即時海象資訊，為該產品一大特點。AWAC 依據型號不同，其最大所能量測波浪及海流深度亦有所不同，可依據使用者需求選擇不同型號儀器執行觀測作業，茲將前述三種型號儀器相關量測特性整理如表 4.1。

表 4.1 AWAC 不同型號儀器特性比較表

	1MHz	600kHz	400kHz
波浪最大量測範圍 (底床至水面距離)	35 公尺	60 公尺	100 公尺
海流最大量測範圍 (底床至水面距離)	25 公尺	50 公尺	90 公尺
量測功能	自記/即時	自記/即時	自記/即時
取樣率	1Hz、2Hz	1Hz	0.75Hz
樣本數	512、1024、1200、 2048、2400	512、1024、 1200、2048、2400	512、1024、 1200、2048、2400

接下來，Nortek 總公司繼續為我們介紹近幾年他們所開發新一代水下波流量測儀 Signature，依據音鼓發送頻率不同共分為 Signature 1000、Signature 500 及 Signature 250 三種型號，波浪及海流可量測最大範圍分別為 150 公尺與 200 公尺，提供使用者根據不同觀測水域及任務導向選擇採用，如圖 4.7 所示。



(a) Signature 1000



(b) Signature 500



(c) Signature 250

(圖片來源：Nortek 公司官方網站)

圖 4.7 Signature 波浪及海流儀

Signature 與 AWAC 於波流量測機制略有不同，AWAC 為海流量測模組優先執行，待海流量測作業完成後，接續執行波浪觀測作業，波浪與海流無法同時量測，惟其優勢是俱備觀測資料即時傳輸功能；反觀 Signature，其俱備波流可同時觀測之特性，惟因觀測資料量較為龐大，所以暫無即時傳輸功能，觀測資料暫存於儀器內建儲存空間，由使用者定期取回將資料下載分析，兩組儀器各有其，有關 AWAC 與 Signature 功能比較整理如表 4.2。

表 4.2 AWAC 與 Signature 功能比較表

	AWAC	Signature
波浪及海流觀測模組	波流無法同時觀測	波流可同時觀測
波浪最大量測範圍 (底床至水面距離)	100 公尺	150 公尺
海流最大量測範圍 (底床至水面距離)	90 公尺	200 公尺
即時傳輸功能	有	無

本所於基隆、蘇澳、花蓮、高雄、臺中、金門及馬祖等 12 個港域外海，均設有底碇式水下波流及海流觀測儀，資料傳輸方式係透過海底電纜將每小時觀測資料即時回傳儲存（如圖 4.8 所示），惟水下海底電纜常因違法底拖作業，造成海底電纜損壞，影響資料即時傳輸。本所藉由本次訓練課程，向 Nortek 總公司提出未來研發水下無線傳輸之可能性，並提出該系統可能面臨之挑戰，如水下氣泡、傳輸距離及傳輸容量等問題，總公司人員表示目前本所使用之 AWAC 已具備即時傳輸功能，未來將以 AWAC 為開發基礎，研發水下無線傳輸系統，待本套系統較為穩定後，在將此技術移轉至新一代波流儀 Signature，提升本所現場海氣

象觀測能量，有關本次挪威奧斯陸 Nortek 總公司教育訓練相關照片如圖 4.9 所示。

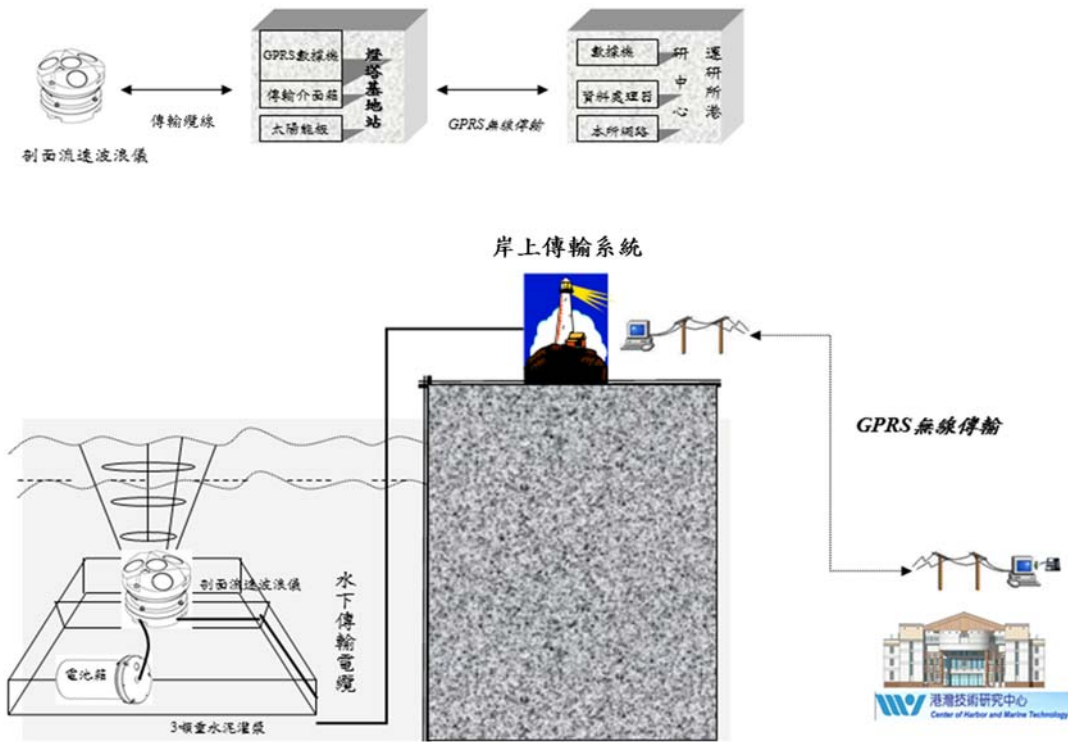
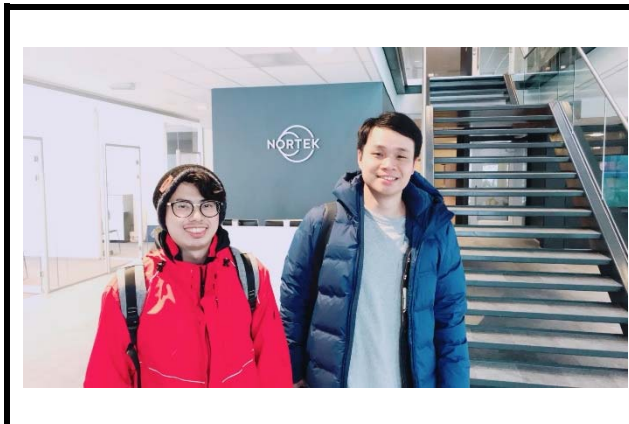


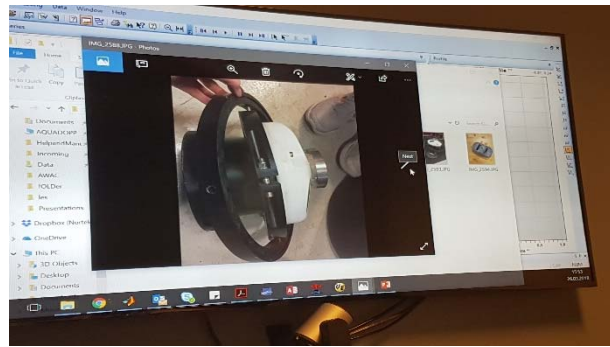
圖 4.8 底碇式水下波流及海流觀測系統



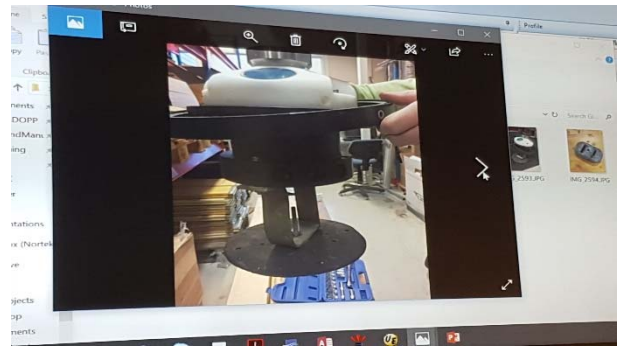
(a)



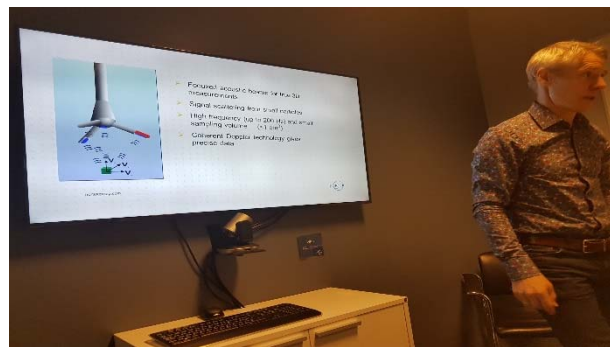
(b)



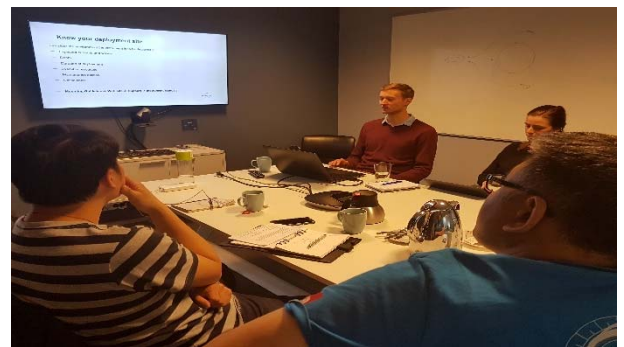
(c)



(d)



(e)



(f)

圖4.9 教育訓練期間相關照片

4.3 課程相關資料

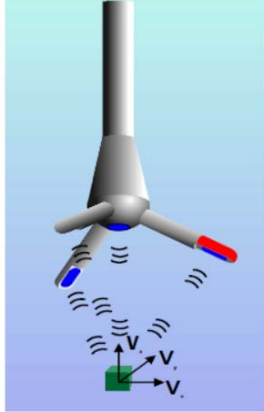
Products

<p>Velocimeters</p>	<p>Current Meters</p>	<p>Current Profilers</p>
<p>Wave Systems</p>	<p>External sensors</p>	<p>Online Systems</p>
<p>Vessel Mounted Profilers</p>	<p>Software</p>	<p>Turbulence</p>

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Velocimeters

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- Focused acoustic beams for true 3D measurements
- Signal scattering from small particles
- High frequency (up to 200 Hz) and small sampling volume ($<1 \text{ cm}^3$)
- Coherent Doppler technology gives precise data



Velocimeters are great because:

- No moving parts
- Calibration never needed
- No zero-point drift over time due to fouling
- Measurement volume remote with respect to sensor
- No physical structures in measuring volume
- Mechanically robust
- Insensitive to flow regime and water quality
- High sampling rate for turbulence measurements
- No minimum velocity, calibrated down to 1mm/s
- Measurements close to boundaries

nortekgroup.com



Vector applications



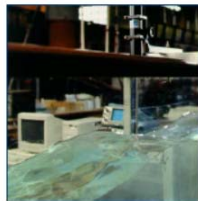
nortekgroup.com

- Process studies
- Orbital wave motion studies
- Surf-zone dynamics
- Boundary layer studies
- Natural low flow studies in lakes and marshes
- Turbulence measurements



The Vectrino lab velocimeter

- 200 Hz sampling rate
- 0.08 cm³ sampling volume
- Down to 3 mm from boundary
- High speed (10 Hz) sampling of distance to boundary
- Better SNR performance
- Non-multiplexing
- Smaller head → less flow disturbance
- Two independent vertical estimates for improved turbulence measurements
- ExploreV

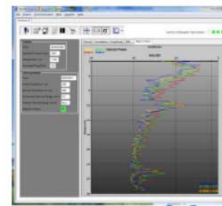
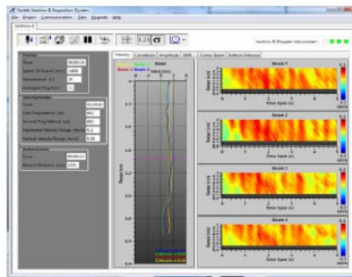
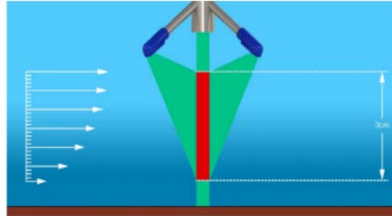


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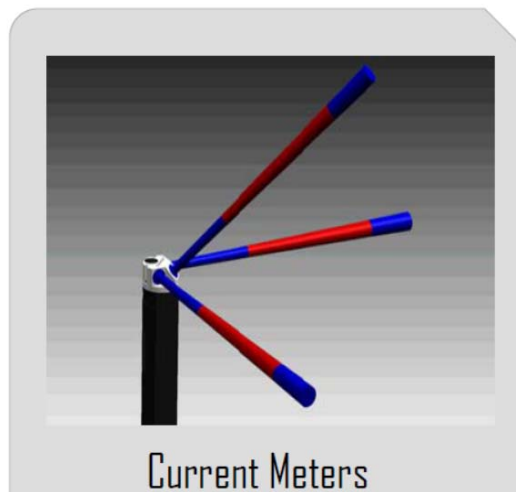
Vectrino Profiler

- 10 MHz pulse frequency
- 3-D velocity profiles
- Amplitude profiles
- Correlation profiles
- Range from 40-75 mm
- 1-4 mm cell size
- 60 dB+ dynamic range
- Temperature sensor for speed of sound calculations
- Up to 100 Hz sampling rate
- Interleaved bottom check to 10Hz
- Adaptive ping interval selection for acoustic interference reduction



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NORTEK



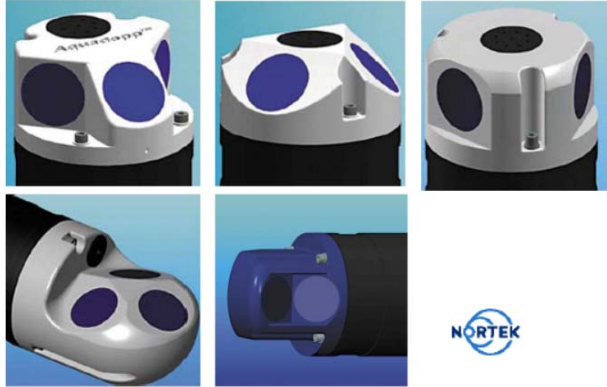
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NORTEK

Aquadopp single point current meter (300m depth rate)

Meas. cell position: 0.3 - 5 m
 Velocity range: ± 5 m/s
 Accuracy: 1% ± 0.5 cm/s
 PUV wave mode: Yes
 Max sampling rate: 1 Hz
 Length: 55 cm
 Diameter: 7.5 cm
 Weight: 2.4 kg
 Depth ranges: 300, 2.000, 6.000 m
 # analog inputs: 2

Molded heads enables custom design to be made on request

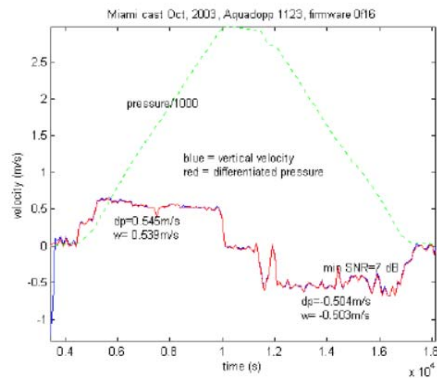


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6000m pressure rating Aquadopp



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NORTEK

How are different users using the Aquadopp?

- The 300m version is mounted on fixed structures like piles, keys and platforms
- Mounted on surface buoys for measurement of surface currents
- Mounted on bottom frames for near bed current measurements
- The 3 & 6,000m versions are mounted on deep-water mooring lines
- Also mounted on deep-sea landers for near bed current measurements
- On risers offshore, often combined with motion units

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Current Profilers

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The Aquadopp profiler

Maximum ranges: 12, 25, 60, 90m
Velocity range: ± 10 m/s
Accuracy: 1% ± 0.5 cm/s
PUV wave mode: Yes
Max sampling rate: 1 Hz
Length: 55 cm
Diameter: 7.5 cm
Weight: 2.4/2.6 kg
Depth ranges: 300, 2,000,
6,000 m
analog inputs: 2



nortekgroup.com



What makes the Aquadopp Profiler special?

- Physical size; it is so easy to work with due to its weight and size
- Right angle head; you can place the sensor right at the bottom, and start to measure just centimeters away from the boundary
- High Resolution (HR) mode; change the firmware to HR, and start to measure 1 cm vertical resolution boundary profiles
- No mode setting; whether the velocity is 1 cm/s or 10 m/s the Aquadopp Profiler will measure correctly
- 2 analog inputs; measure salinity and sediment concentration synchronously with currents
- PUV wave mode

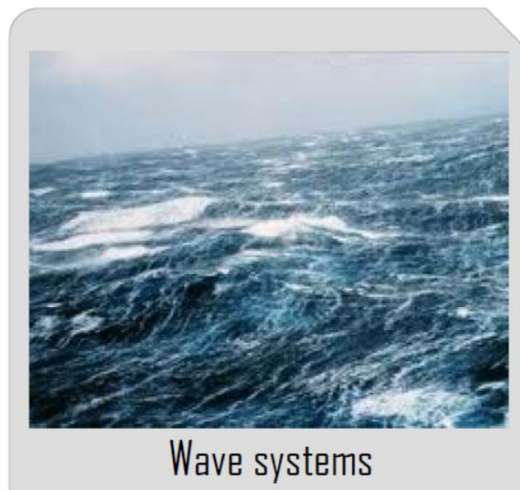
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How are different users using the Aquadopp Profiler?

- On surface buoys, often with the Z-cell version
- In low profile bottom frames, with the ASP head
- Inline (it is easy to mount due to its form factor)
- In tripods, operating in HR mode (boundary profiles)

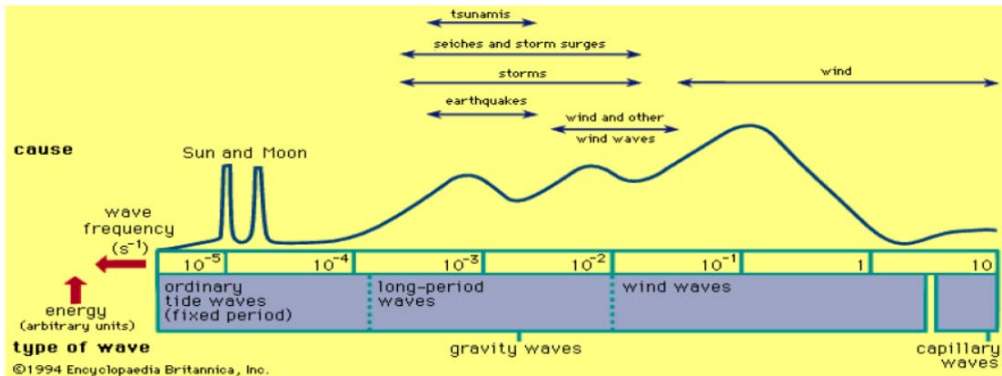
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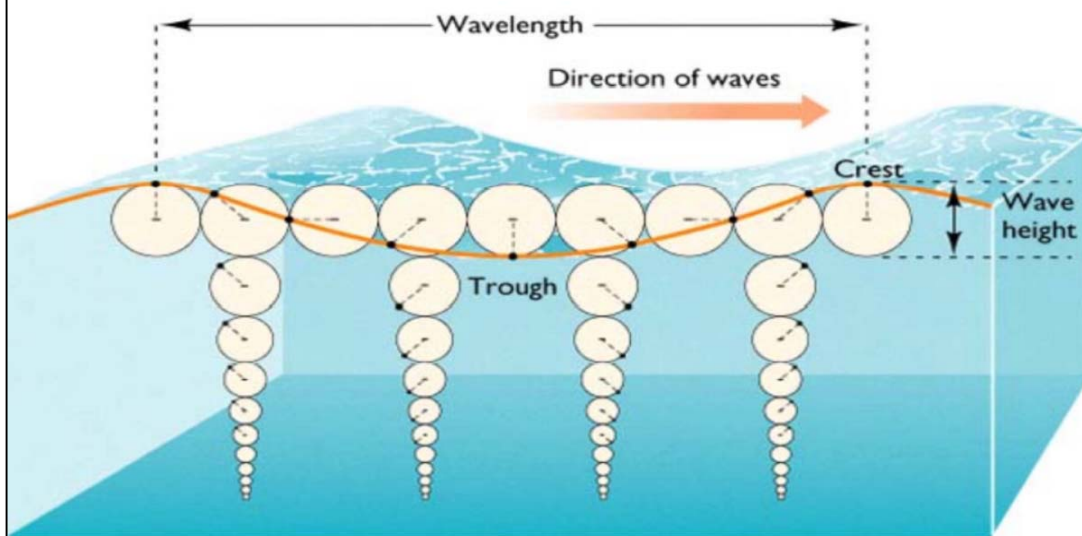
Wave Energy Distribution



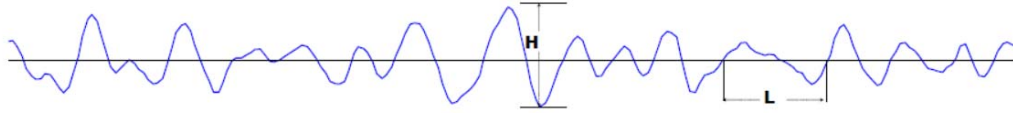
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Attenuation of wave properties



Wave Estimates

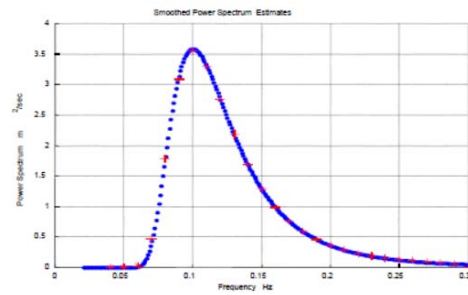


- H_s Significant Wave Height is the “mean of the 1/3 largest waves in a record”. Requires time series to estimates this directly

- Inferred Estimate - Spectral alternative

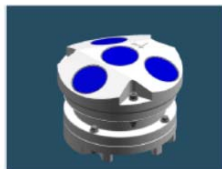
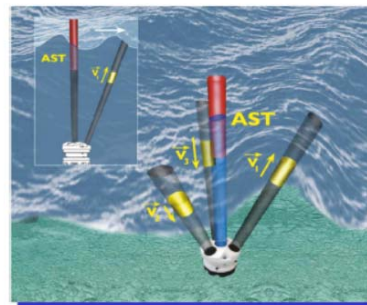
$$H_s = 4\sqrt{m_0}$$

$$m_k = \int f^k S(f) df$$



AWAC: Waves and Current Profiles in one instrument

- 1/0.6/0.4 MHz Transmit Frequency
- Measure current profile 25/50/90m range
- Wave measurements 35/60/100m range
- Bottom Mounted – Out of Harms way

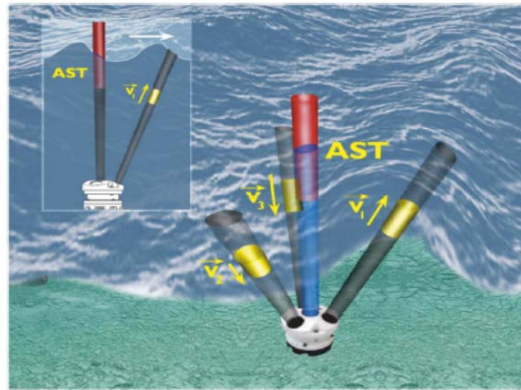


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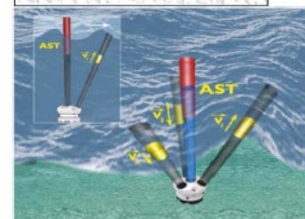
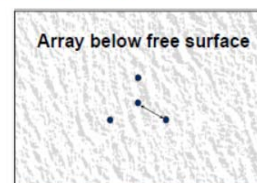
AWAC in operation

- Measures further up in water column for better signal
- Specifically Designed for Long Term Wave Measurements
- Adaptive Cell Depth
- Maximum Likelihood Method (MLM) for wave measurements



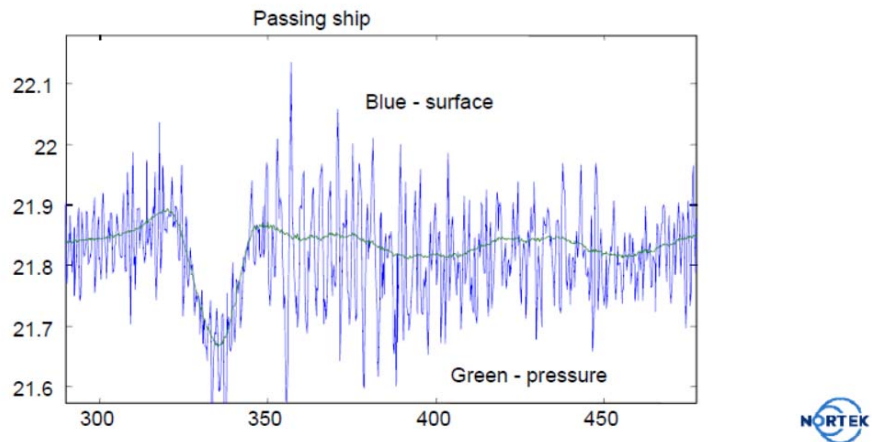
Maximum Likelihood Method ... In short

- First introduced by Capon (1969).
- Uses a Spatial Array.
- Transfer function is directionally dependent
- Sweeps through Frequency and Direction to find most probable solution for direction and Frequency Spectrum. Conceptually similar to a least Squares.



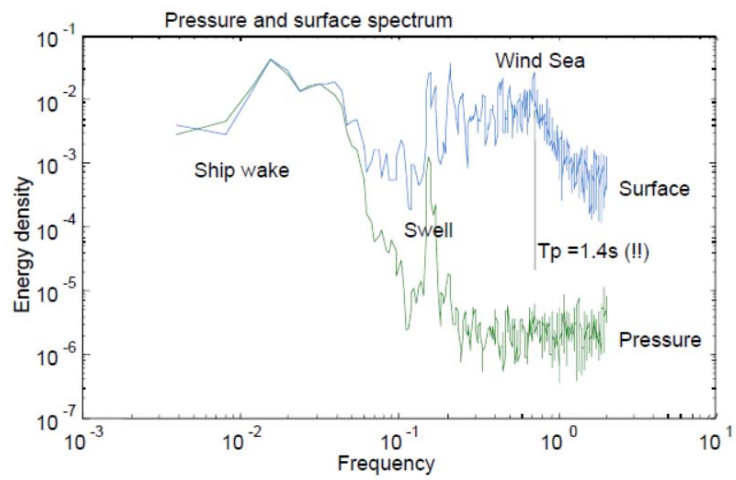
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With AST overlaid



Comparison of spectra

Pressure and surface spectra






Turbulence and more

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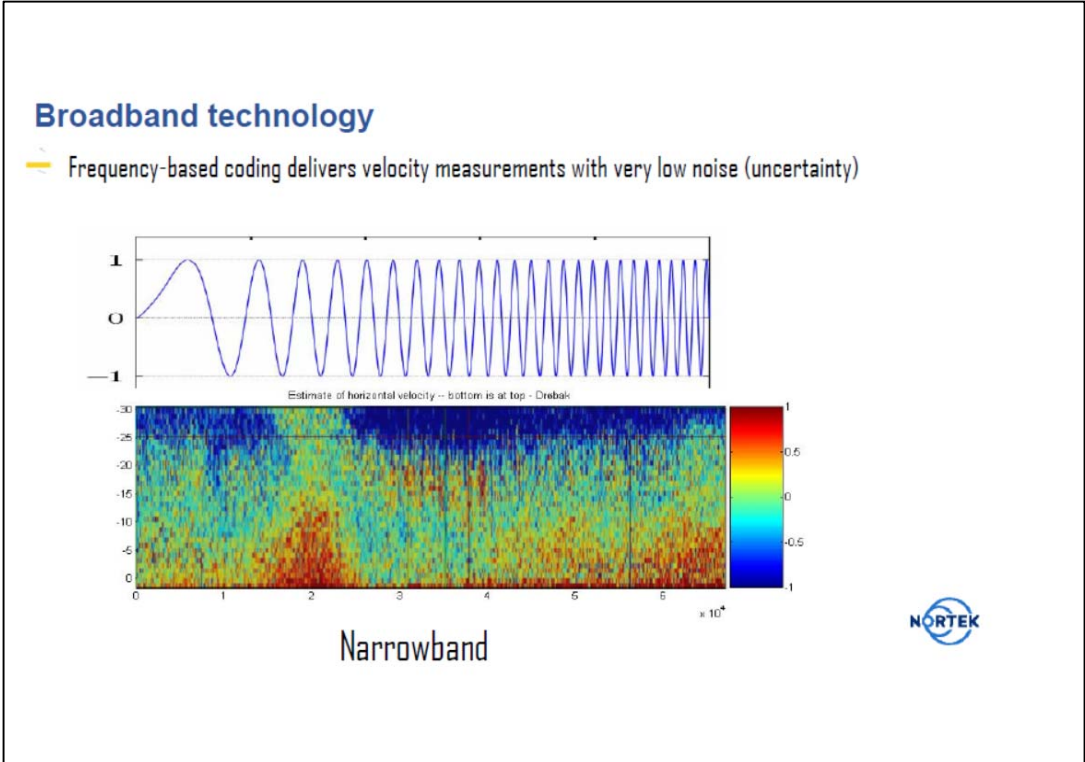
The Signature series current profiler

— A HIGH PERFORMANCE SCIENTIFIC POWERHOUSE



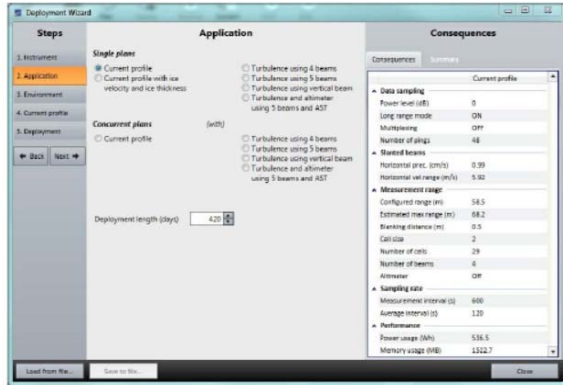
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Patented Concurrent Measurements

- Multiple measurements in the same second
- Patented technology
- For example, can measure small cells at fast rate in bursts for turbulence and at the same time measure large cells at regular intervals for mean currents.

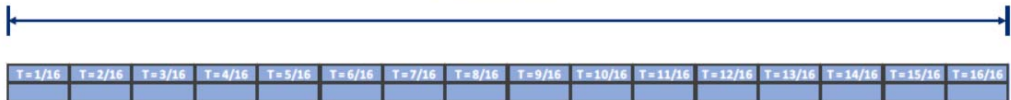


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Concurrent Measurements

One Second



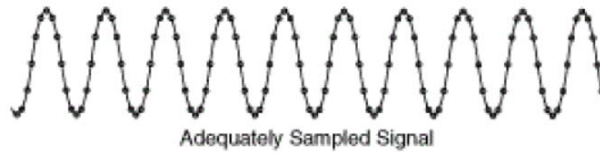
No other instrument can do this!

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Fast Sampling rate

- Up to 16 Hz sampling for superior turbulence characterization, both in stand alone and online mode
- 4 times faster than any other ADCP

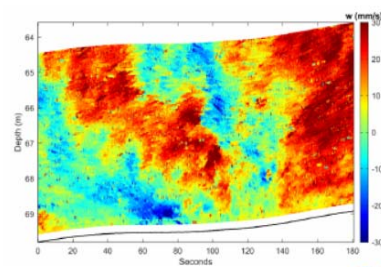
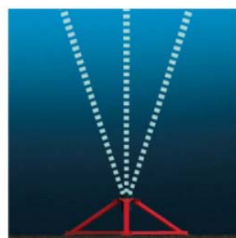
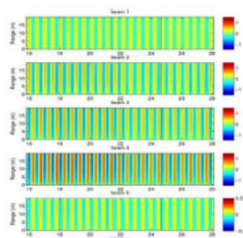


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Multiple Beam Operation

- Perfect for turbulence measurements where velocity and distance are sampled along 5 beams
- Allows direct estimate of all five second-order turbulent variables
- HR mode on vertical beam gives unprecedented and detailed data on flow structures

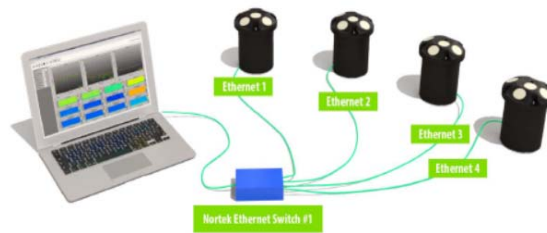


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Ethernet Communication

- Allows for fast data download speeds (1 GB in 6 minutes)
- Easy access from any location in the world
- Simple integration into existing or new networks



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Single Ping Data

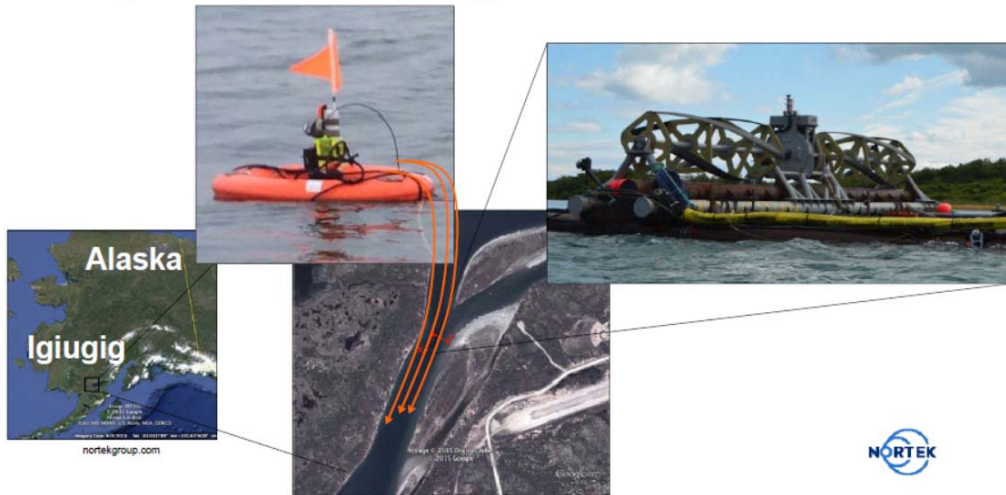
- Takes the guess work out of data processing
- Improves data quality by removing contamination from fish or other influences
- Allows researcher to decide which time scale to study later



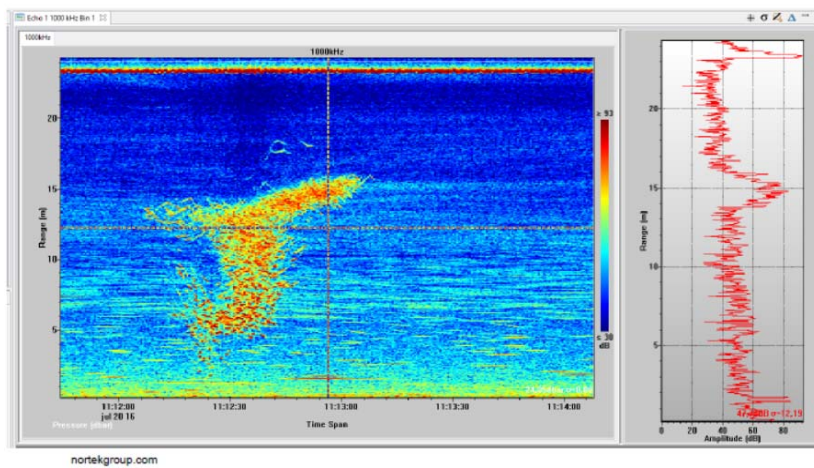
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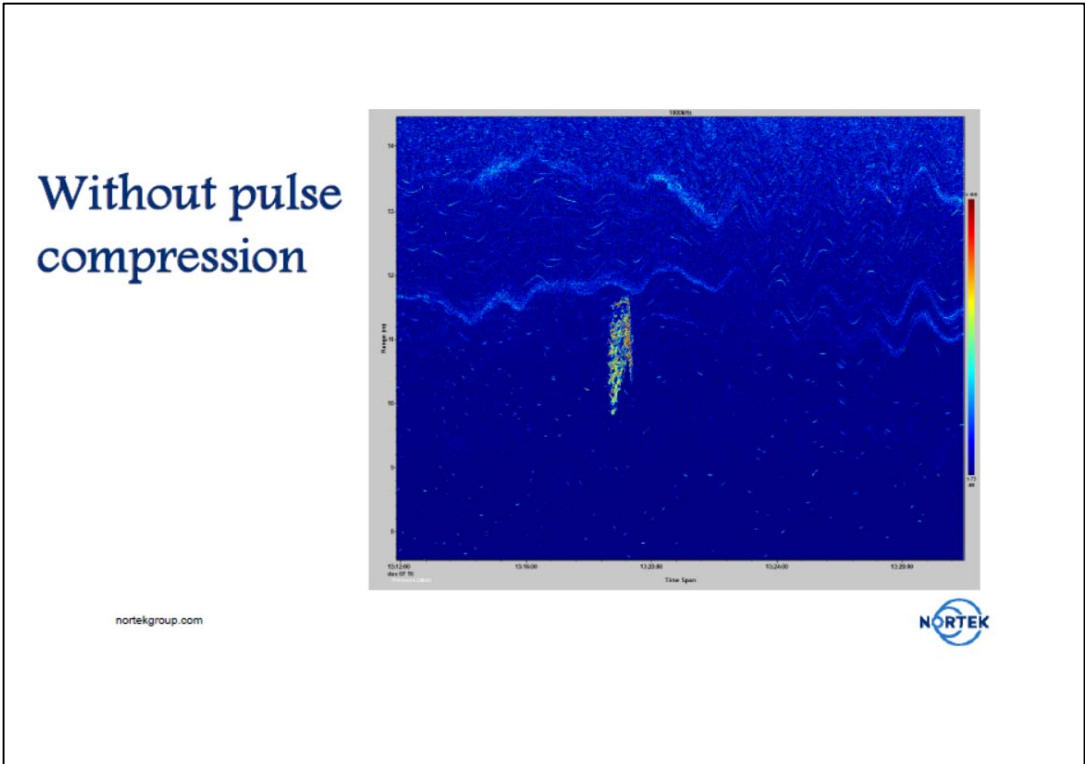
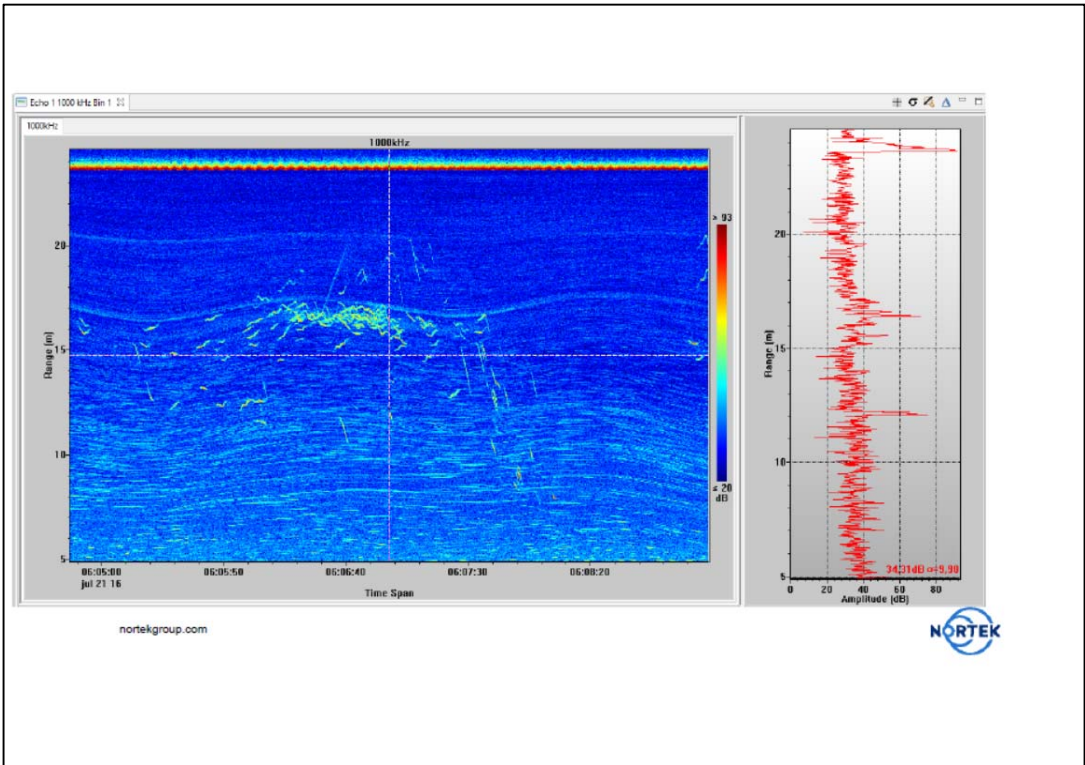


AHRS (= Attitude Heading Reference Sensor)

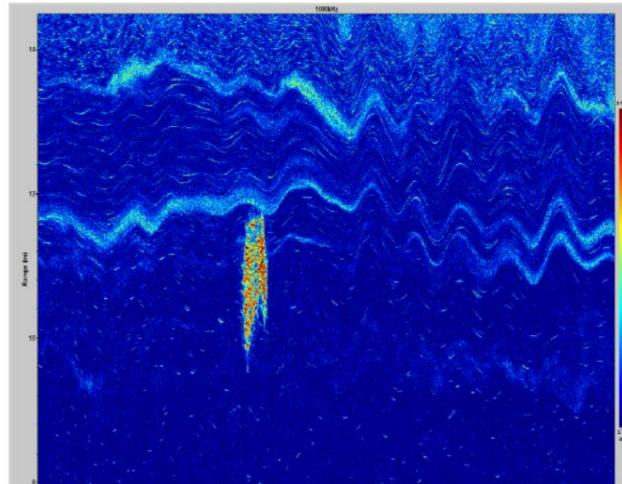


Signature1000 – echo sounder mode





With pulse
compression



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How are different users using the Signature 500/1000?

- For measurements of oscillatory flow (8 Hz, 5 beams)
- For truly simultaneous wave and current profile measurements
- For studies of near surface or near-bed vertical flow profiles (HR mode and Signature 1000)
- For combined measurements of currents and ice thickness (draft) and ice drift
- On surface buoys with the AHRS and map to vertical functionality
- Scientists use them to study flows in wave fields
- The tidal turbine industry needs information about oscillatory flow

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Signature 55

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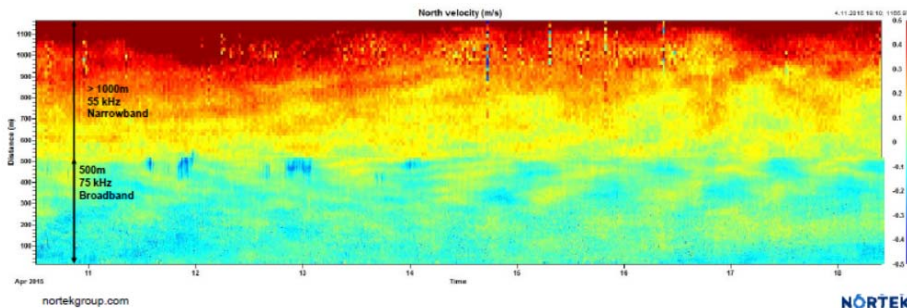
Signature 250



Signature55 Advantages

Dual-frequency Broadband Processing

- Frequency-based coding delivers high resolution velocity measurements with very low noise (uncertainty) in the ~600m range
- User selected/alternating long-range mode provides profiles of up to and over 1000m

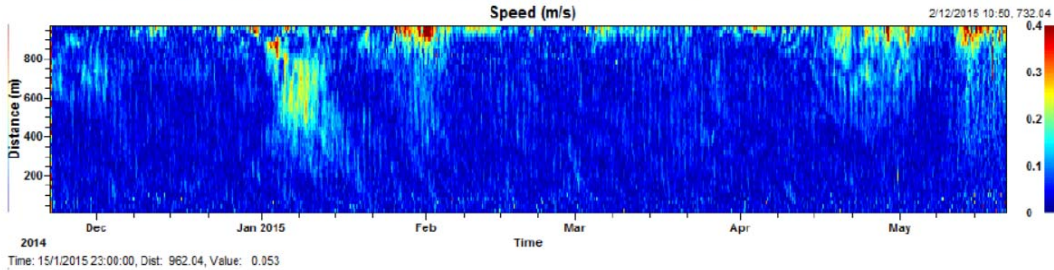


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Signature55 Advantages

- Low Power Consumption
 - On average 50% reduction in power consumption compared to similarly configured competitor ADCP.
 - Longer deployment time, smaller batteries, less time in the field.



Time: 15/1/2015 23:00:00, Dist: 962.04, Value: 0.053

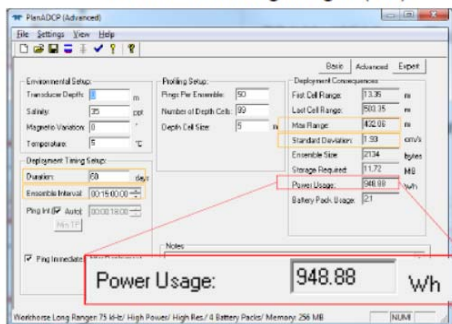
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Above instrument operated for this entire time on just TWO ALKALINE BATTERIES (for a total of only 1080 Wh). Not possible with the competition.

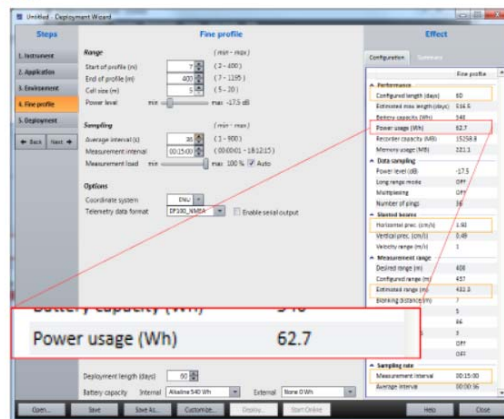


75 kHz WH LongRanger vs Signature55 Power Comparison (Broadband/)

75 kHz WH LongRanger (BB)



Signature55 (BB)



* LR requires High Power to reach > ~220 m

Exact Same Configuration, but Signature55 uses 93% less power

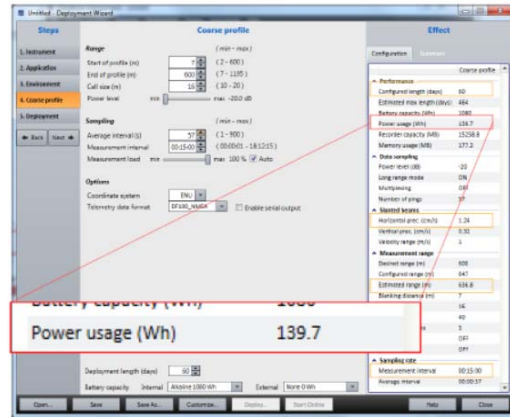
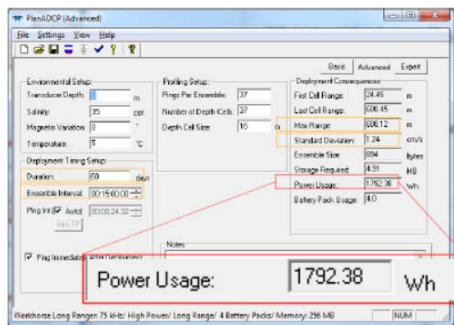
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75 kHz WH LongRanger vs Signature55 Power Comparison (Narrowband)

Signature55 (BB)

75 kHz WH LongRanger (BB)



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Exact Same Configuration, but Signature55 uses 93% less power



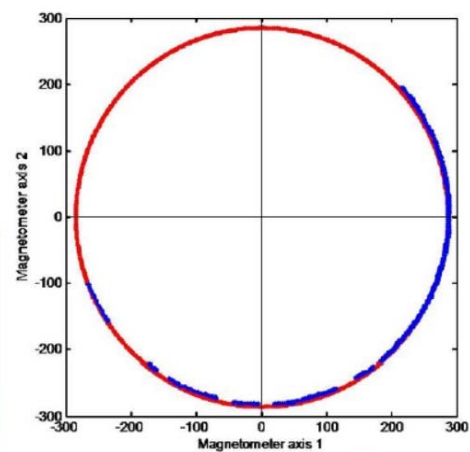
Signature55 Advantages

Records All Raw Data

- Improves data quality by removing contamination from fish or other influences
- Allows for compass calibration in post-processing.



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How are different users using the Signature 55?

- On surface buoys
- Mounted in bottom frames
- Inline in dedicated inline frames
- In subsurface buoys
- When really long profiles are needed
- On offshore installations

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Signature 250

Untitled - Deployment Wizard

Steps	Instrument
1. Instrument	Type <input type="radio"/> Signature55 <input checked="" type="radio"/> Signature250 <input type="radio"/> Signature500 <input type="radio"/> Signature1000
2. Application	Licensed features <input checked="" type="checkbox"/> Average current profile - 4 beams <input checked="" type="checkbox"/> Wave measurements <input checked="" type="checkbox"/> Ice measurements
3. Environment	
4. Average	
5. Deployment	Recorder Capacity: 16 GB Sensors <input type="checkbox"/> AHRS

← Back Next →

200m range

Wave height & direction
from 150m depth

Ice thickness and ice
drift with currents

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How are different users using the Signature 250?

- On surface buoys
- Mounted in bottom frames
- Inline in dedicated inline frames
- For deepwater wave measurements
- To measure combinations of ice and currents

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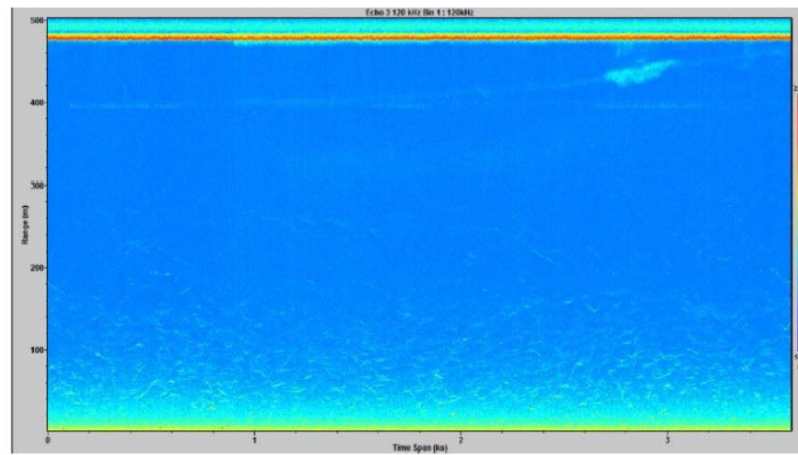
Signature 100

- 3 - 400m current profiling range
- Optional 70-120 kHz center transducer
- Echo sounder mode with same range as current profiler
- Bridges the gap between the Signature 55 and the Signature 250

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70-120 kHz vertical beam echo sounding mode, detecting krill



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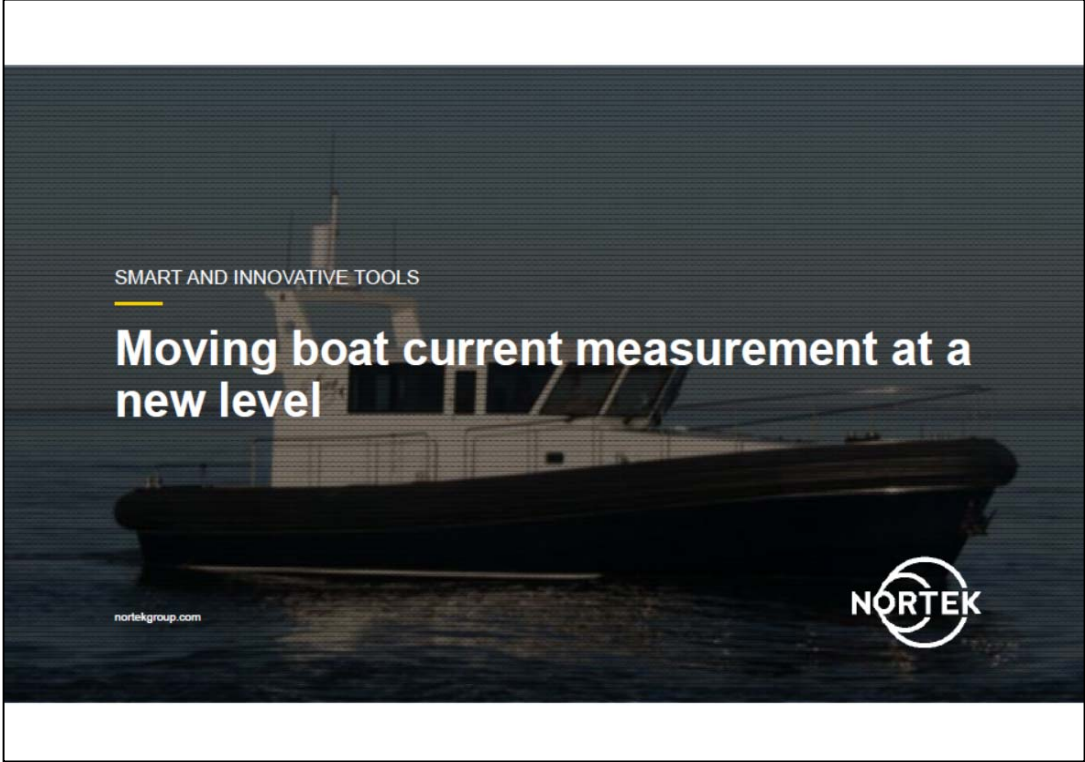


How are different users using the Signature 100?

- On surface buoys
- Mounted in bottom frames
- Inline in dedicated inline frames
- For combinations of biological and physical oceanography measurements
- As an affordable alternative to the TRDI Quartermaster 150 kHz

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Signature 500 or 1000

- AD2CP functionality
- Fast
- Best of both worlds:
 - Proper Broadband
 - Great Bottom Track
- 5th beam



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Connection box and computer

- Get good data
- UPS back-up battery
- Ethernet connections
- Secure connections
- Properly configured
- Robust
- Accurate timing from the GNSS



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Acquisition software

Get good data

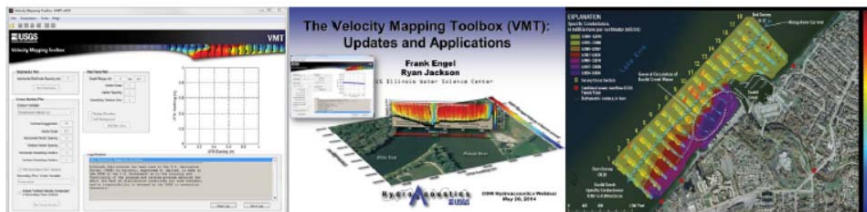
- Start without hassle
- Reliable
- See that your data is coming in.



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Processing software

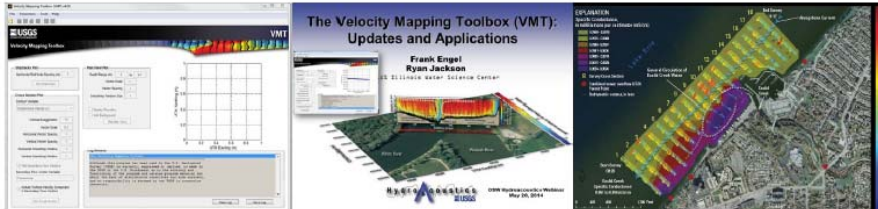


- USGS Velocity Mapping Toolbox
- Open Source Matlab
- MS Windows Executable
- License Free
- Export data from Acquisition SW

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Processing software

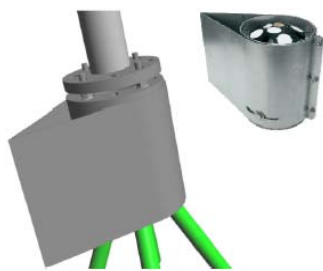


- USGS Velocity Mapping Toolbox
- Open Source Matlab
- MS Windows Executable
- License Free
- Export data from Acquisition SW

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Additional parts



- Fairing ADCP mounting frame

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- GNSS with heading and attitude Information
- GNSS timing reference using NTP/PTP over Ethernet



HOW TO SECURE 100% DATA CAPTURE

Planning a deployment

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Checklist for trouble-free deployments

- Know your deployment site and plan after this
- Firmware and software updated
- Functionality test performed
- Configuration uploaded to instrument
 - Overnight test deployment
- New battery pack is connected
 - Desiccant bag and O-rings
- Battery and memory space requirements met
- Pressure offset
- Compass calibration verified
- Insert dummy plugs
- Transducers have unobstructed sight into water column



Know your deployment site

Consider the environment the instrument is to be deployed in

- Expected currents and waves
- Depth
- Duration of deployment
- Available resources
- Maintenance access
- Online cable
- Mounting Guideline -> Web site -> Support -> Instrument Manuals



Support site

- Most up to date firmware and software
- Manuals



Software Download

Instrument Manuals

System Integration

Parts and tips

Warranty

Return of goods

Software

Please note that there are two columns for firmwares, one for the standard hardware and one for the one phased into production from April 2020.

If your current firmware version number starts with 0.xx or 1.xx upgrade from the Firmware Standard col. Firmware versions starting with 2.xx or above, upgrade from the Firmware Middle column. Should you upgrade this is not a problem. Your instrument will just stay in firmware upgrade mode so you can repeat the upgrade.

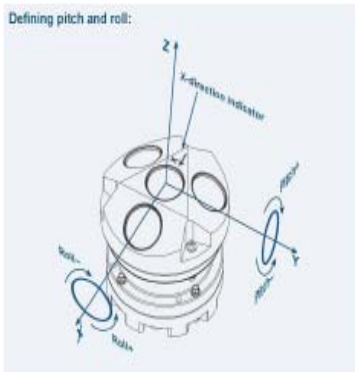
Nortek Windows programs run on all versions since XP (SP3), including Windows 8, except where noted.

Instrument	Software	Firmware Standard	Firmware Middle	Comments
Adv4000p	V1.40.14 12.05.2019	V1.21 28.11.2009	V0.20 11.08.2019	Firmware V1.21 has speed and direction beta in case based support for velocity and direction mode calibration errors resolution and re-prog and upgrade. Support for legacy hardware options with the inclusive modern option running V0.20 in beta.
Adv4000p Deepwater	V1.40.14 12.05.2019	V1.21 28.11.2009	V0.20 11.08.2019	For 24, 24 and 24 systems, 1.20 is compatible with V0.20. Support for legacy hardware and re-prog and upgrade. Support for legacy hardware options with the inclusive modern option running V0.20 in beta.
Adv4000p Profil	V1.17.2019	V0.10.2019	V0.10.2019	Firmware V0.17 and later supports a 600 kHz beta



Functionality test

- Based on final test checklist
- Tested >10,000 instruments
- Used to test all sensors and communication

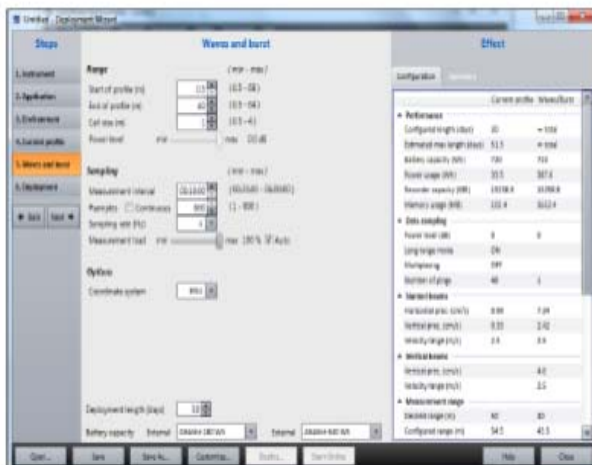


APPENDIX A

Final test checklist



Deployment configuration



- Think about data requirements
- Adapt to the conditions
- Observe the consequences of your choices in the summary
- Test overnight



Changing the battery pack

- Remove the titanium screws and washers holding the end cap to the pressure case and remove the end cap
- Disconnect the 2 pin and pull the battery out of the pressure case
- Replace the battery and reattach the 2 pin connector
- Reattach the end bell and the screws



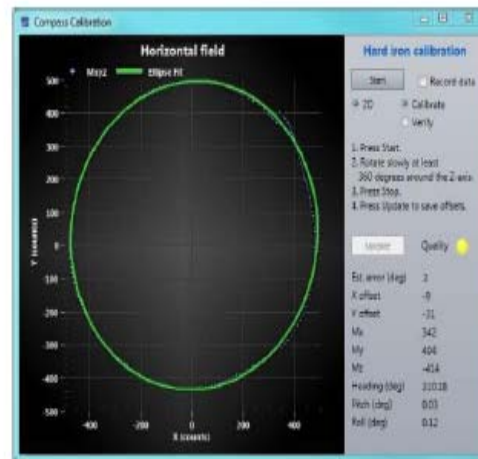
Compass calibration

- To adjust for magnetic materials that may be present in your deployment frame
- Assemble everything that is going to be deployed
 - Remember to degauss the batteries
- Make sure it is possible to rotate the entire system 360° horizontally
- Choose Instrument -> Compass Calibration
- Any material that may be disrupting the magnetic field in the vicinity during calibration may skew the directionality of the data



Compass calibration

- When doing this in real life your circle will not be as even as this one
- Do not be alarmed, but rotate slowly to get as good readings as possible
- The extreme values at both the axis are the most important parts of the circle

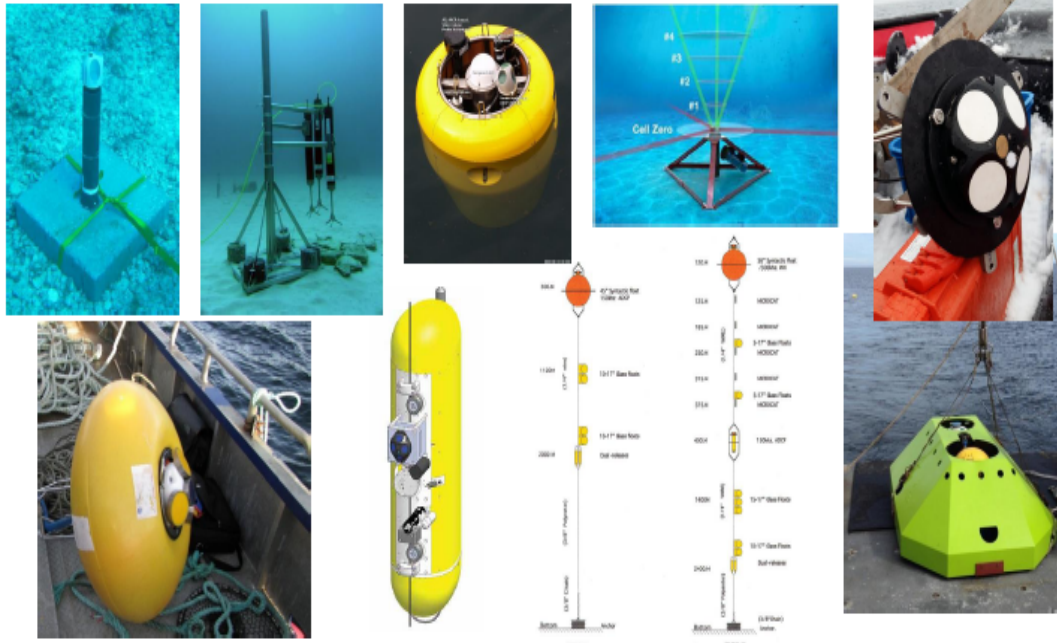


Setting the pressure offset

- Choose Instrument -> Set Pressure offset and follow the instructions
- Be aware
 - Negative values are reported as 0 dBar. Choose a positive number e.g. 0.2 meters if the instrument is in air
 - This is a really important sensor for the **AWAC AST** since the AST window is chosen from the pressure readings



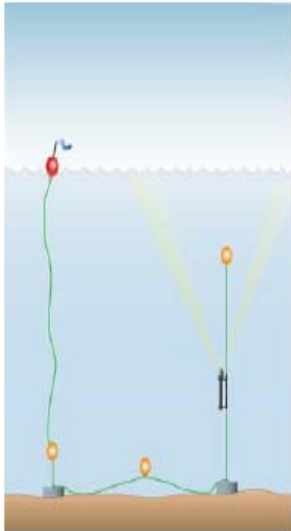
Mounting options



Considerations for deployment

- Free sight into water column
- Stable, low tilt instrument
 - Drag-down
 - Bottom topography
- Surface buoys
 - Prone to damage, i.e. boats, wind, waves, vandalism, etc
- Anchor and material choice

Mooring line

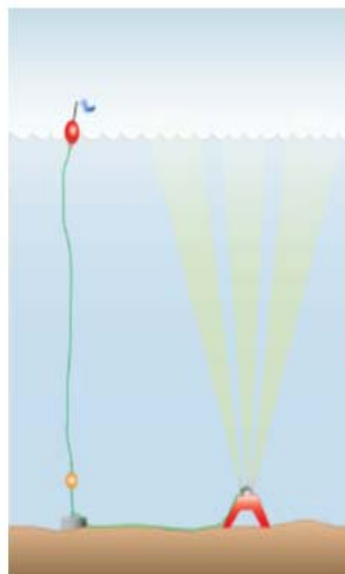


- Simplest setup
- Aquafin/clamp
- Multiple instruments
- Full profiles
- Buoy interference
- Drag-down

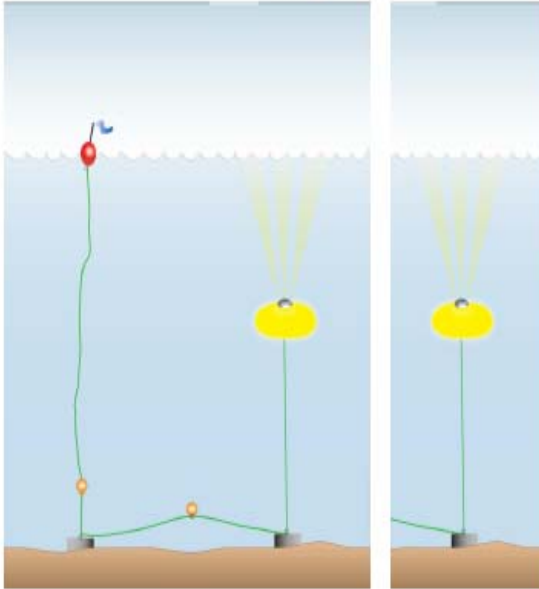


Bottom mounted

- Frame
- Gimbal
- Length of bottom rope
- Acoustic release



Subsurface buoy

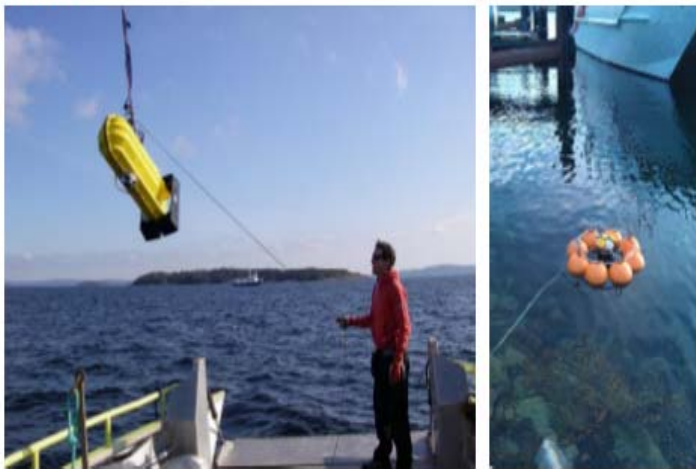


- Not limited by depth
- Natural frequency response
- SUV patented wave processing
- "Free gimbal"
- Drag-down



What materials should we use for our rig?

Line?



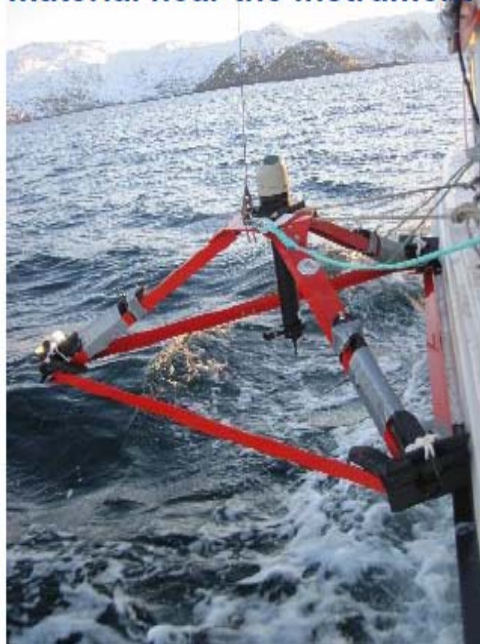
Anchor choice?



Buoyancy?



Choice of material near the instrument



Choice of material near the instrument

- A316 steel
- Galvanized
- Rust proof



五、荷蘭阿姆斯特丹 Nortek B.V.公司

5.1 訓練單位介紹

本次參訪之訓練單位係為 Nortek 位於荷蘭阿姆斯特丹之分公司，該公司主要負責淘刷監測儀(scour monitor)、SeaDarq 雷達，其中 SeaDarq 雷達是由 SeaDarQ 公司所開發，SeaDarQ B.V.公司於 2011 年由挪威 Nortek AS 的荷蘭分公司 Nortek BV 收購，Nortek B.V.公司的位置正好位於荷蘭史基浦機場附近，交通上十分便利，因此我們前往 Nortek B.V.公司時，皆採較為經濟的步行方式，以節省旅費，由所住的飯店至 Nortek B.V.公司路程約 20 分鐘。該分公司目前的負責人為 Sicco Kamminga 先生，也是主要負責本次教育訓練課程的講師。Nortek B.V.公司之成立歷史，可以追溯到 1997 年由 Sicco Kamminga 創立了 Ingenieursbureau SDKamminga B.V.，簡稱 ISDK，而於 2002 年 Qmetrix B.V.公司成立，2004 年並與 ISDK 合併為 Qmetrix B.V.，2009 年 7 月 10 日，Qmetrix B.V.更名為 Nortek B.V.。



圖5.1 位於荷蘭阿姆斯特丹Nortek B.V.公司外觀照片



(圖片來源：google map)

圖5.2 位於荷蘭阿姆斯特丹Nortek公司地理位置

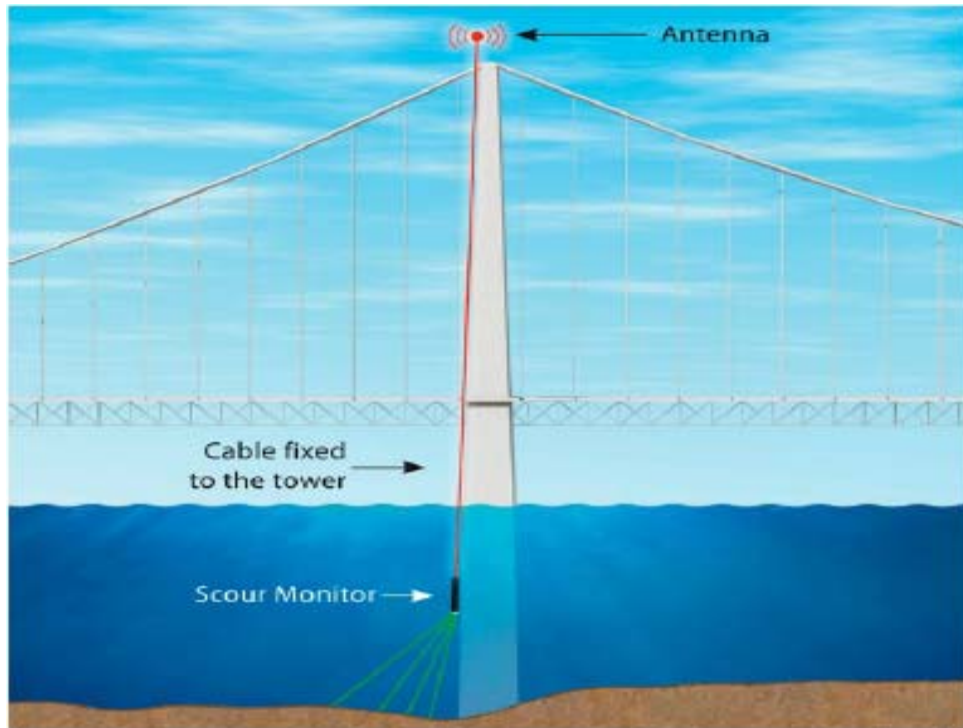


圖5.3 步行前往Nortek B.V.公司

5.2 課程內容說明

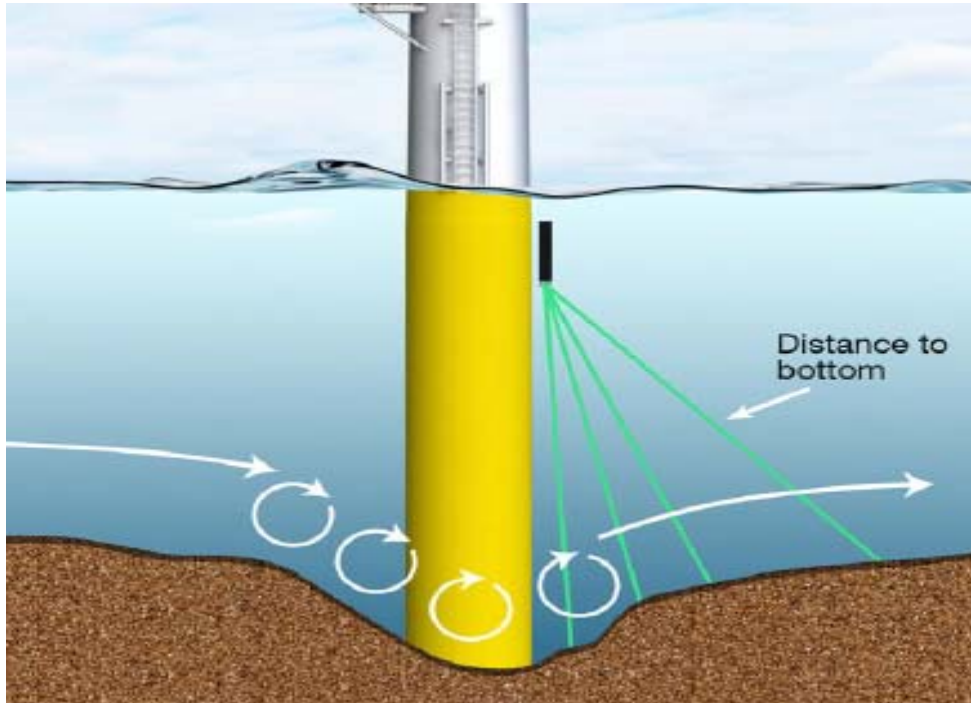
本次教育訓練活動由 Sicco Kamminga 先生為我們介紹淘刷監測儀 (scour monitor)、SeaDarQ 雷達、Signature VM 等海洋調查儀器，除了有關本所既有相關設備之操作說明及設定外，並介紹其他相關海洋儀器等設備。首先，說明淘刷監測儀，淘刷監測儀的應用可於離岸風機、水壩、橋梁及基樁等結構物中，監測於水下週邊基礎淘刷之情形，淘刷情形的發生主要是由颱風、強烈的海流等等都有可能造成。然而，對於淘刷發生時，由於其變化是很短暫的現象，因此為了調查此種淘刷變化狀況，Nortek As 公司便開發出淘刷監測儀這種觀測儀器，淘刷監測儀具有 4 個不同角度之音鼓 (transducer)，並利用窄波音束 (narrow acoustic beam)，由音鼓發射聲波至測量底床位置，再將其反射之訊號接收後，而獲得量測資料，淘刷監測的記錄方式，可採即時監測 (real time)，亦可採用自記式 (autonomous) 的方式，這樣的方式可根據研究人員自身需求，選擇適合的觀測記錄方式，其安裝示意圖可參考圖 5.4 至圖 5.5，並由負責該項業務的工程師為我們說明，如圖 5.6。

淘刷監測儀的相關儀器規格為，音鼓其頻率為 1MHz，一共有 4 個音鼓安裝於儀器上，其 4 個音鼓之角度為 10° 、 20° 、 30° 及 45° ，解析度為 1-1.5cm 或 2-3cm，音鼓至量測區域為 1-20m，重量為 1.7kg，長度為 590mm，直徑為 75mm，通訊介面為 RS422，調製速率 (baud rate) 300-115200，內建溫度感測器量測範圍為 -4°C ~ 30°C ，精確度為 0.1°C ，解析度為 0.01°C ，儲存記憶體為 9Mb，並可視情況擴充增加，傾斜計其最大量測範圍為 30° ，精確度 0.2° ，解析度 0.1° 。



(圖片來源：scour monitor原廠使用手冊)

圖5.4 淘刷監測儀安裝於橋梁示意圖



(圖片來源：scour monitor原廠使用手冊)

圖5.5 淘刷監測儀安裝於單樁(monopiles)示意圖



圖5.6 淘刷監測儀系統操作說明

Sicco Kamminga 先生再為我們介紹船載式剖面流速儀（Vessel-mounted current profiler），一般底定式剖面流速海流儀的觀測及安裝方式，需由研究人員先將儀器設定觀測地點所需的相關環境參數，並進行羅盤方位校正，若採即時觀測，研究人員亦需安裝海底電纜及數據通訊系統，其工作十分繁瑣並艱辛，而研究人員若無法正確設定相關參數資料，常會造成觀察之資料品質不佳，而船載式剖面流速儀，提升了操作的便利性，並降低了操作的複雜度，因此可以確保其資料的品質更為優良，船載式剖面流速儀亦整合為一整套的系統，其系統包含高性能升波剖面流速測量系統即 Signature VM500 或 Signature VM1000，19 吋機櫃式電腦，GNSS 羅盤系統，可依據所需獲得的資料特性選擇相關設備，其相關規格如表 5.1。

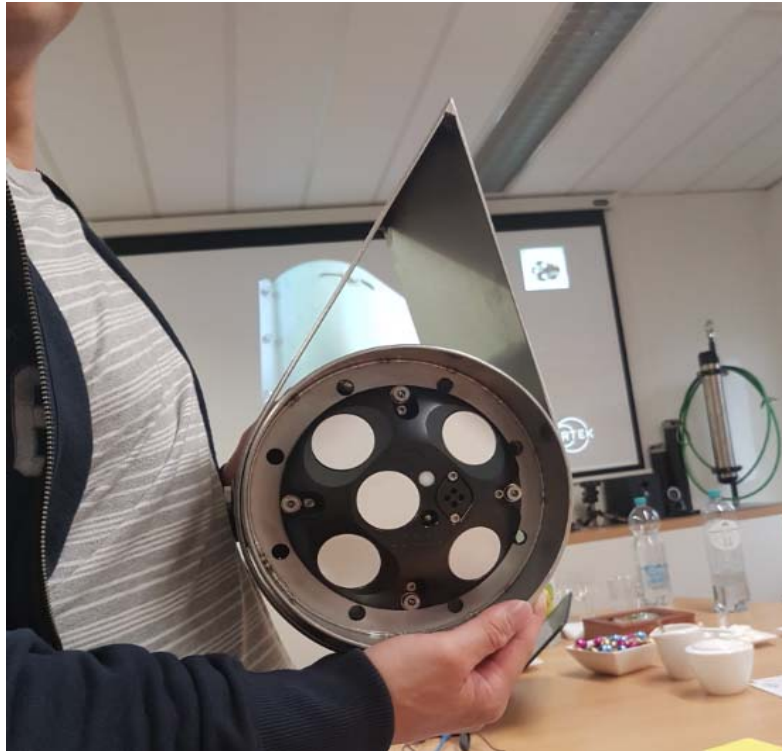


圖5.7 船載式剖面流速儀(Signature VM)

表5.1 船載式剖面流速儀(Signature VM)規格說明

項目	規格	
儀器型號	VM1000	VM500
剖面量測範圍(Profiling range)	30m	70m
層數(Cell size)	0.2-2m	0.5-4m
盲區(Min. blanking area)	0.1m	0.5m
精確度(Maximum sampling rate)	測量值的0.3%±0.3cm/s	測量值的0.3%±0.3cm/s
流速解析度(Velocity resolution)	0.1 cm/s	0.1 cm/s
最大取樣頻率(Max sampling rate)	14Hz	6Hz

音鼓數量(No. of beams)	4個傾斜25度	4個傾斜25度
底部速度量測(Bottom velocity measurements)		
Single ping std@3m/s	0.5 cm/s	0.5 cm/s
長期精確度(Long-term accuracy)	$\pm 0.1\% \pm 0.1 \text{ cm/s}$	$\pm 0.1\% \pm 0.1 \text{ cm/s}$
最小高度(Minimum altitude)	0.2m	0.3m
最大高度(Maximum altitude)	50m	200m
速度範圍(Memory)	$\pm 12 \text{ m/s}$	$\pm 12 \text{ m/s}$
速度解析度(Velocity resolution)	0.01 mm/s	0.01 mm/s
最大取樣頻率(Maximum sampling rate)	4Hz	2Hz
深度量測(Depth measurements)		
音鼓數量(No. of beams)	1個垂直音鼓	
最大取樣頻率(Max sampling rate)	2Hz	2Hz
最大範圍(Max. range)	30m	70m
垂直解析度/垂直精確度 (Vertical resolution/accuracy)	0.001m/量測值的1%	
回聲強度(Echo intensity)		
取樣頻率(Sampling)	與流速相同	

解析度(Resolution)	0.5db
動態範圍(Dynamic range)	70db
音鼓數量(No. of beams)	4個傾斜25度
波束寬度(Beam width)	2.9°
其他資訊	
溫度感測器量測範圍	-4°C to 40°C
資料儲存記憶體	16GB
直流輸入電壓	12-48V DC
通訊方式	RS232/RS422 或乙太網路
操作溫度	-4°C to 40°C
儲存溫度	-20°C to 60°C

Sicco Kamminga 先生繼續為我們介紹 SeaDarQ 雷達，該雷達使用之頻段為 X 波段，範圍為 8-12GHz 的無線電波段為 X 波段，該雷達可選擇裝置於陸地上或船舶上，其功能主要可用來監測漏油事故，一但海上漏油事故發生，除了需耗費大量的人力及物力等等資源，亦對海洋生態造成嚴重的威脅，而為了應對此種狀況，使用 SeaDarQ 雷達，可以迅速發現油汙的動向，立刻採取相關對策，來處理油汙事故或是惡意排放油汙，且雷達監控人員不需在現場監控是否有油汙事故的發生，其雷達能自動監測，針對油汙事故的發生，發出提醒警報來進行通知，並可以即時的方式來顯示相關資訊如圖 5.8 及圖 5.9，亦可於 SeaDarQ 的軟體上顯示油汙其流向並標示；另外，SeaDarQ 雷達亦可進行觀測波浪、波向，並可搭配船舶自動識別系統 (Automatic Identification System, 即 AIS) 進行船舶監控 (Ship Tracking)，SeaDarQ 雷達在水文地理模式(hydrography mode)中，亦可以量測底部水深及海流。



圖5.8 Siccio Kamminga 先生說明SeaDarQ 雷達

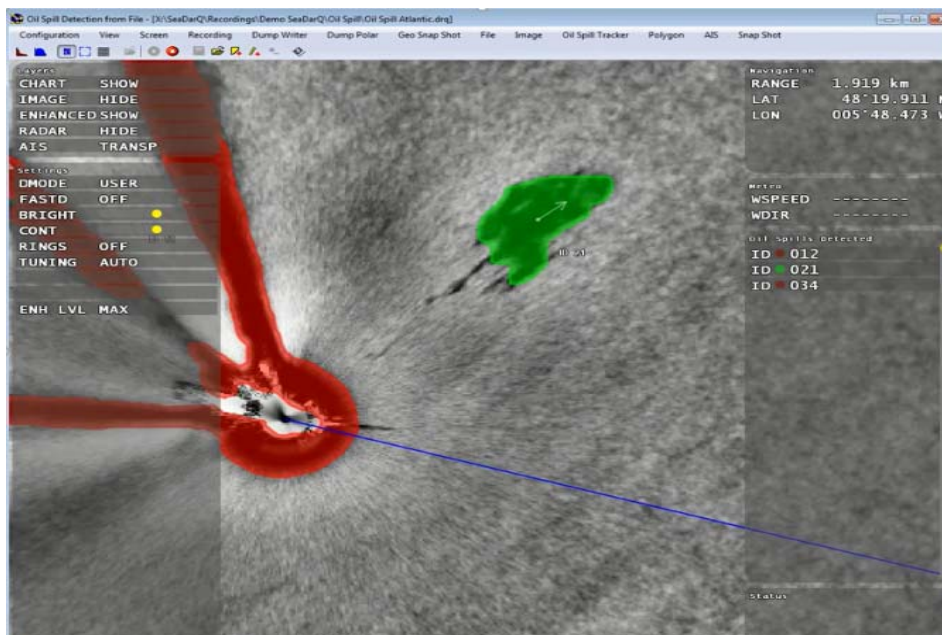


圖5.9 SeaDarQ 雷達軟體操作畫面

Siccio Kamminga 先生帶我們到該公司倉庫現場操作 SeaDarQ 雷達，並由 Jos van Heesen 工程師，於現場用電腦連接雷達設備，並為我們示範如何操作雷達，如圖 5.10~圖 5.11。另外，SeaDarQ 雷達擁有 2 種不同的軟硬體版本，分別為

Work Boat 與 Pro 版，其主要差異為 Work boat 的版本僅可裝置於船舶上，其所測量之流向僅有單一向量，而 Pro 版可裝置於港口、海上工作平台，具有紅外線攝影機介面裝置等等，SeaDarQ 雷達的軟體 Work Boat 與 Pro 版，亦可與雷達 Sperry BridgeMaster E series、Raytheon MK II、Furuno FAR-2xx7 series、Terma Scanter 2000series、GEM SU047、JRC selected Generic types 等雷達整合並解析其訊號，故若已有該項軟體設備，則只需配合軟體，即可使用相關功能，其規格可參照表 5.2，有關本次荷蘭阿姆斯特丹 Nortek B.V. 公司教育訓練相關照片如圖 5.12 所示。



圖5.10 Jos van Heesen 工程師操作SeaDarQ雷達

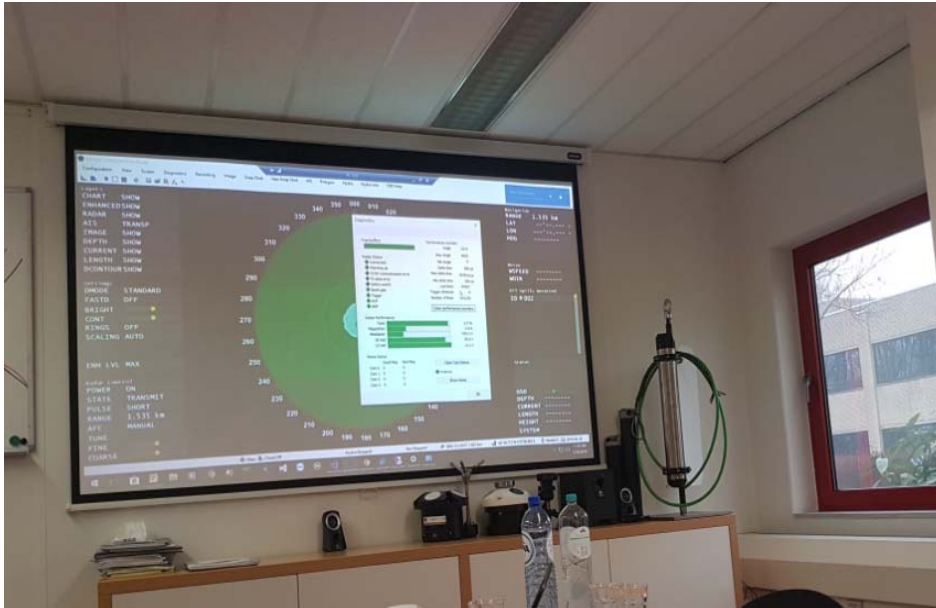
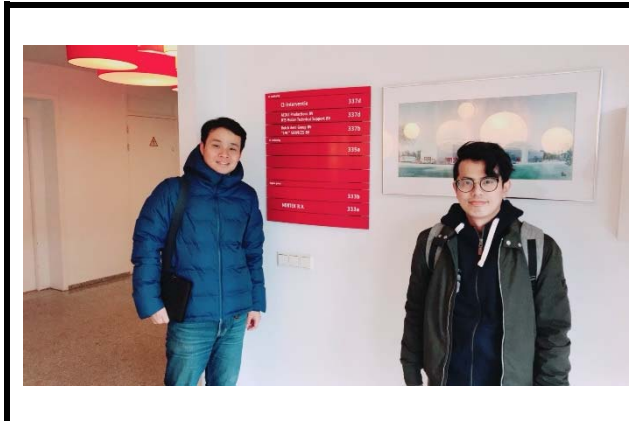


圖5.11 Sicco Kamminga 先生說明SeaDarQ雷達

表5.2 SeaDarQ雷達簡要規格說明

Function / Parameter		Interface	
Image Presentation:	Logarithmic display of amplitude, Zooming, panning, scrolling overlay of geocode information Software STC – Sensitive Time Control – adjustable gain control	Video Input:	0-1 Volt Analog, 75 Ohm*
Image sampling grid:	Cartesian	Trigger Input:	TTL*
Detection range:	0.1-3.5 km (greater range for higher antenna)	Azimuth Input:	TTL/RS422 pulses, up to 4096 pulses/revolution*
Resolution:	Better than 3.75 m (short pulse mode)	North Reset Input:	TTL/RS422 pulses, up to 4096 pulses/revolution*
Operational wind speed:	> 2 m/s	Data communications:	RS232/RS422*
Vessel Movement	Real time		*Signal levels can be customized.
Compensation:		Recommended navigation radar system specifications	
Static Object Enhancement:	Up to detection resolution in real-time	Frequency:	X-Band
Operator Controls		Antenna length:	8 feet or longer
Keyboard and Mouse:	Function buttons/ docking windows/ pop-up menus	Minimum antenna height:	15 meters
Current Mode		Polarisation:	Vertical
Current Speed:	Range: ± 2 m/s; Accuracy: ± 0.1 m/s; Resolution: 0.1 m/s	Field of view: Range:	>2500 m
Current Direction:	Accuracy: 5°-10° Measurements apply to upper 3 m water layer	Azimuth:	360°
Water depth:	Depth range: up to 30 m; Accuracy: ± 0.5 m	Pulse width:	50 ns/250 ns/1 μ s
		Peak Power:	25 kW and more
		PRF:	1800 Hz/1300 Hz/ 650 Hz
		Rotation speed:	48 RPM
		Receiver:	No clutter suppression
		GPS/DGPS:	NMEA RS232/RS422 OUTPUT
		Heading:	NMEA RS232/RS422 OUTPUT

(資料來源：<http://www.seadarq.com/lib/brochures/seadarq-v3-brochure/view>)



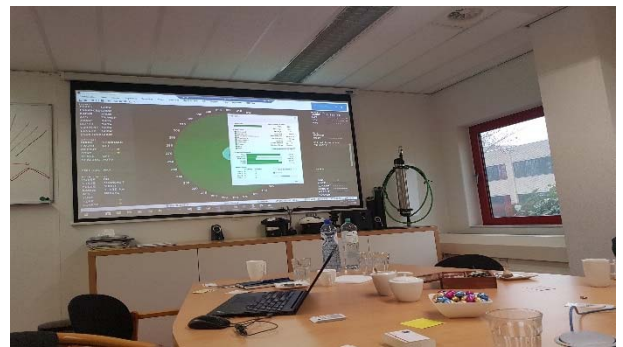
(a)



(b)



(c)



(d)



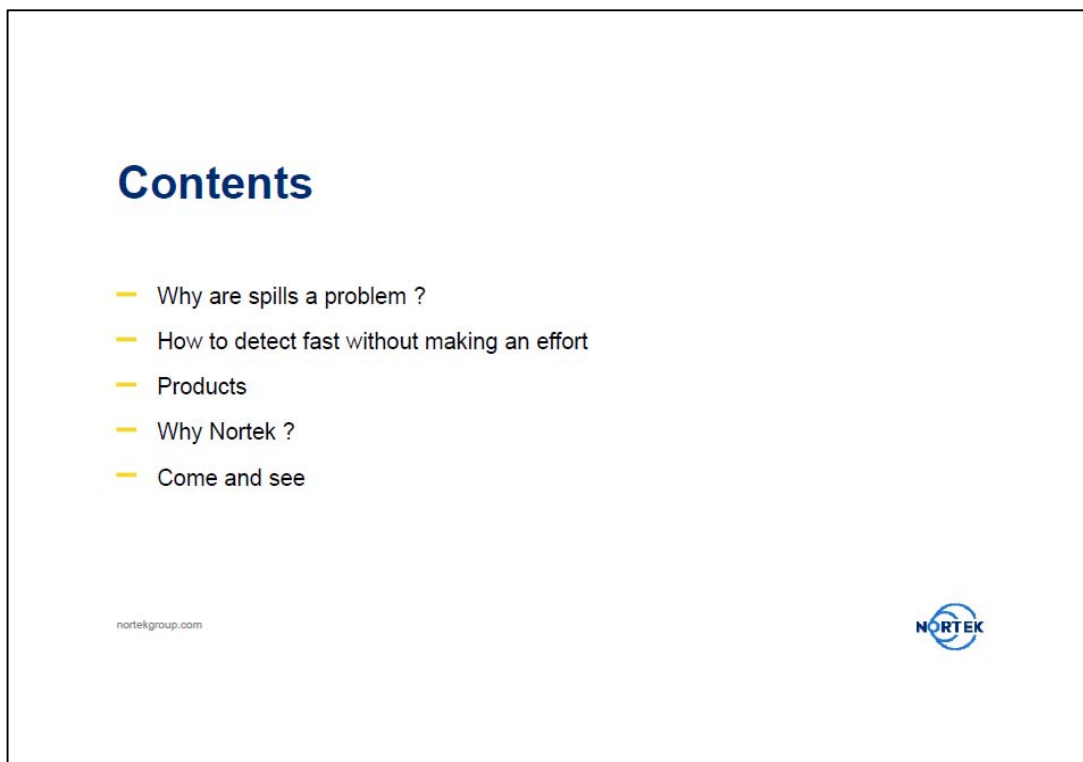
(e)



(f)

圖5.12 教育訓練期間相關照片

5.3 課程相關資料



Problem

- Oil spills happen fast
- Vessels spill oil purposely



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Risks

- Oil on the coast
- Risks to flora and fauna
- Oil in ports pollutes equipment
- Expensive cleanup is needed.



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Environmental Damage



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- You do not know which vessel spilled the oil ?
- You do not know about the accident very quickly.
- Contingency starts too late.
- Where is the oil going ?



How should it be ?

- Find oil quickly
- See who caused it
- Cover a wide area
- Start cleaning up right away.

- Keep your area clean.



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Why



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- Patrolling 24/7 is expensive.
 - Boats
 - Airplanes
- Satellites are not always there
- Navigation and VTS radars are designed to show vessels.



Oil Spill Detection by Radar

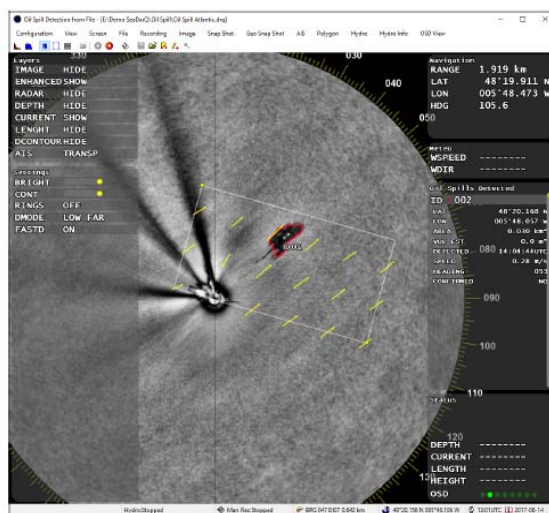
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Oil Spill Detection Radar

- Automatically Detect Oil in a range of several NM around a site.
- See where the oil is going to:
- See currents and waves.
- Connect to a radar
- Acquisition and Processing Computer
- Software
- Land based or vessel mounted

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- Software to operate the system





Waves – good backscatter

Clutter disturbances – Oil on water – no waves

TNO

Range 2 – 4 NM

Prestige 2002 – RWS ARCA

SeaDarQ B.V.

Nortek B.V. - 2011

NORTEK

System Setup

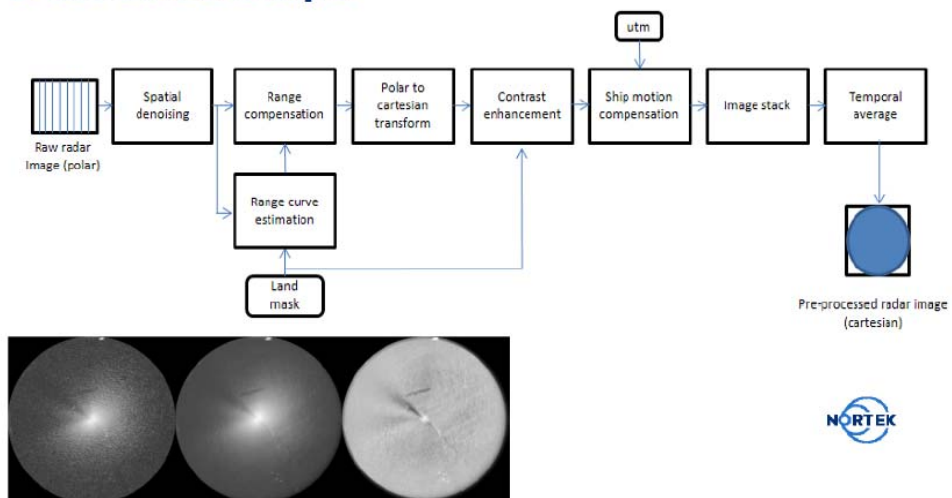


System setup for good performance:

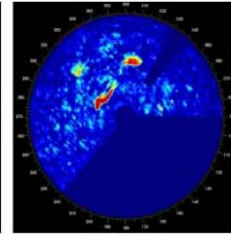
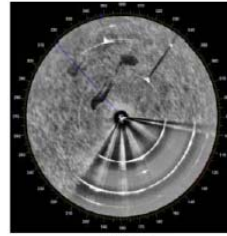
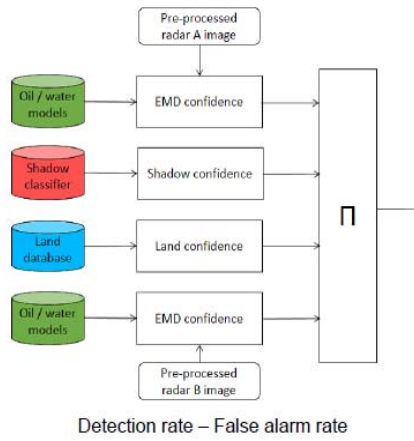
- Radar which meets the requirements for OSD
 - Dynamic range
 - VV polarized antenna
- Data acquisition is important
 - Timing of all channels
 - Details – sea clutter
- Processing
 - model based instead of threshold detector



Detection steps

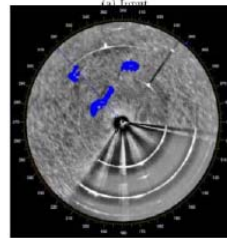


Tracking and Alarming



Evaluation on 21 spills

Paper available



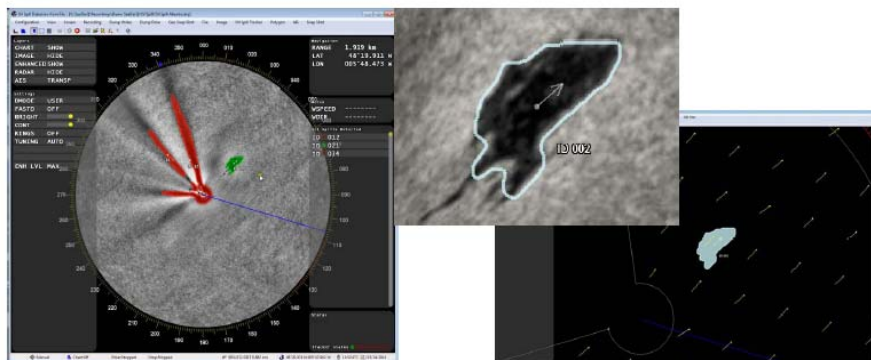
Some Examples



EMSA vessel in France



EMSA vessel in France



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How to get the best detection range ?

- At low wind conditions Vertically Polarized Antennas give better range than Horizontally polarized antennas.
- A good radar
- Data Acquisition should be good to obtain the best detection
- Signal processing - to obtain the best images, good and thorough clean up of the data is needed.
- Best contrast in images that adapts with weather conditions
- Automatic Spill Detection does the hard work 24/7.
- Detection range depends on wind conditions and mounting height
- You need wind to be able to detect oil spills

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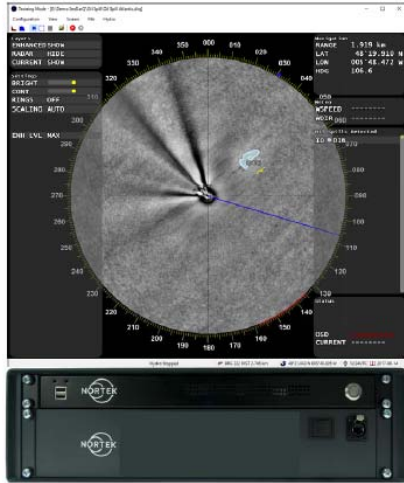


Products

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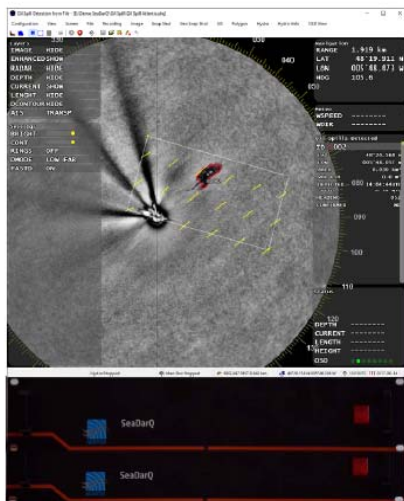
SeaDarQ Workboat



- Small
- Easy to install and use
- Automatic Oil Spill Detection
- Single current vector
- Used on smaller vessels



SeaDarQ Pro



- All features
- Automatic Oil Spill Detection
- Tracking and Alarming
- Hydrography area coverage
- Online interface
- IR camera interface
- Optional radar, meteo, IR, GPS
- Ports, Platforms, OSRVs



Why Nortek ?

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Nortek Instruments in use for operational applications.

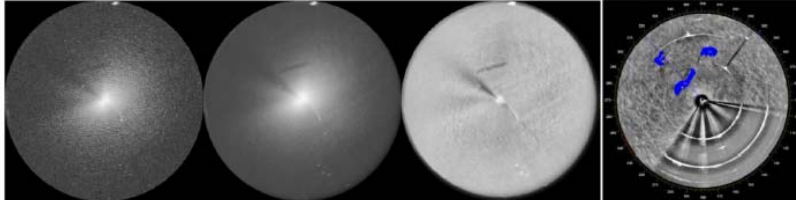


Waves and Currents

Currents from Buoys



Why Nortek SeaDarQ ?



- Data Acquisition
- Data Processing
- User Support

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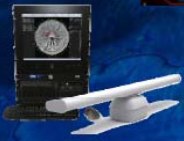
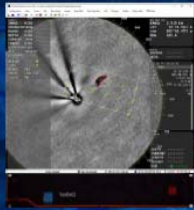
Nortek SeaDarQ installations

- Ports in China through the MSA and Transas VTS
- Vessels in Brasil (Astro Maritima, CBO, Brassbunker)
- EMSA
- ARCA, Dutch Government
- Rotterdam
- Chevron Brasil

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Let's detect the spill quickly !



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六、心得與建議事項

本次儀器原廠實地教育訓練及作業技術操作日期由 107 年 3 月 22 日起至 3 月 30 日止，共計 9 天，訓練課程相當扎實豐富，對自身本職學能提升助益良多，本次訓練課程內容經事先與儀器原廠人員溝通，希望為在有限時間裡達到最大訓練成效，使參訓人員均能獲取所需相關知識，歸國後將訓練期間所學知識技能傳授於同仁，提升本所海洋領域人員研究能量，以下茲將本次儀器原廠實地教育訓練及作業技術操作心得與相關建議說明如後：

6.1 心得

1. 本次英國 Aquatec 公司訓練課程，使本所參訓人員充分瞭解該公司所生產相關儀器之功能及操作使用方法，Aquatec 公司所開發之相關儀器，包含 AQUAclamp、AQUAmodem、AQUAscat、HYDROlog、AQUAswitch、AQUAdisp，每一種儀器皆可應用在解決特定問題上面，Aquatec 公司研發能力及拼鬥精神，可作為我國在離岸風電發展及技術開發等面向參考。
2. 本所設置於各港現場波流觀測系統係採底碇式安裝，透過海底電纜，並配合工作船隻將水下波流儀佈放於指定位置，而海底電纜易受違法底拖漁船破壞，影響觀測資料即時傳輸功能，英國倫敦 Aquatec 公司近年已研發出水下光學式數據機 (optical modem) 及聲波式數據機 (acoustic modem)，此項技術如可與 Nortek 公司所生產之表面波高波向與剖面海流儀結合，未來除可簡化現場佈放流程，對於離岸風電場海象資料即時傳輸無疑為一大利多，惟仍須考量水下無線傳輸距離及傳輸容量是否符合本所現場觀測系統。
3. 挪威奧斯陸 Nortek 總公司所開發表面波高波向與剖面海流儀 Acoustic Wave and Current profiler (AWAC)，已廣泛應用於各國波浪及海流觀測，且儀器本身俱備即時傳輸功能，對於四面環海的臺灣，無疑是一大利器，而

公司近年所研發之新一代水下波流量測儀 Signature，雖俱備可同時觀測波浪及海流之優勢，但卻無即時傳輸功能，兩部儀器各有不同觀測特性，端看使用者如何取捨選用。

4. 此次 Nortek 總公司教育訓練，本所參訓人員皆承辦過海象觀測系統佈放作業，現場觀測系統建置及後續維護保養著實不易，透過經驗分享交流，請 Nortek 總公司研發工程師，嘗試開發水下無線傳輸系統，或可與英國倫敦 Aquatec 公司合作，結合已俱備即時傳輸功能之 AWAC，待技術成熟後移轉至 Signature，將可增加本所現場海象觀測系統穩定性，提升本所海象觀測能量。
5. 有關荷蘭阿姆斯特丹 Nortek B.V. 公司訓練課程，使參訓人員得以學習淘刷監測儀之功能及操作使用方法，並瞭解到 Nortek B.V. 有關 SeaDarQ 雷達之應用及其相關功能，目前臺灣設置有數座環臺高頻雷達測流系統 CODAR (Coastal Ocean Dynamics Application Radar)，並於臺北港區內設有 Wera HF 高頻雷達，高頻雷達具有長距離測流的能力，而 SeaDarQ 所能測量之範圍較小，但其具有偵測油汙擴散之功能，此項技術如可引進，透過油汙即時監控系統，對於我國油汙監測將可達到即時監控立即應變之功效。
6. 此次儀器原廠實地教育訓練先後分別至英國倫敦 Aquatec 公司、挪威奧斯陸 Nortek 總公司及荷蘭阿姆斯特丹 Nortek B.V. 公司等地，對於課程內容安排及行程規劃需經過無數次檢討及溝通，方得成行；本次訓練除使受訓人員增加其國際觀，受訓期間所獲得相關知識與技術，將可提升我國在海洋研究領域上研發能量。
7. 本次教育訓練相關課程及授課內容，讓此次參訓人員受益頗豐，對於本國人才培訓可藉此增加國外專業職能學習機會，推廣臺灣海洋港灣領域成就能見

度，落實國際間科技人員、研究技術實質上交流，對於促進國際學術交流及國外經驗吸取有相當大助益。

6.2 建議

1. 出國教育訓練實屬不易，建議提前與授課講師溝通聯繫，將授課內容妥適規劃，使訓練課程發揮最大效益。
2. 本次儀器原廠教育訓練皆採英文授課，建議應充實自身外語能力，避免因語言上之隔閡，影響訓練成效。
3. 對於需長時間訓練或講授之課程，建議可採做中學（learning by doing）方式授課，使學員對授課內容之吸收，達到最佳成效。