出國報告(出國類別:研究)

108 年度「海洋雷達系統擴充及數值 模式赴原廠進行實地教育訓練和作 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

姓名職稱:李政達副研究員、林受勳助理研究員

派赴國家:英國、丹麥

出國期間:108年4月8日至4月17日

報告日期::108年6月26日

108 年度「海洋雷達系統擴充及數值模式赴原廠進行實 地教育訓練和作業技術操作」出國計畫-出國報告

著 者:李政達

出版機關:交通部運輸研究所

地 址:10548 臺北市敦化北路 240 號

網址:www.iot.gov.tw(中文版>圖書服務>本所出版品)

電 話:(02)23496789

出版年月:中華民國 108年6月

印刷者:元將影印社

版(刷)次冊數:初版一刷 10 冊

系統識別號:C10800731

行政院及所屬各機關出國報告提要

頁數:182 含附件:120

報告名稱:108年度「海洋雷達系統擴充及數值模式赴原廠進行實地教育訓練和

作業技術操作」出國計畫--出國報告

主辦機關:交通部運輸研究所

出國計畫主辦機關/聯絡人/電話:

交通部運輸研究所/孟慶玉小姐/02-23496755

出國人員姓名/服務機關/單位/職稱/電話:

李政達/交通部運輸研究所/港灣技術研究中心/副研究員/04-26587127

林受勳/交通部運輸研究所/港灣技術研究中心/助理研究員/04-26587123

出國類別:□1.考察□2.進修☑3.研究□4.實習□5.其他

出國期間:108年4月8日至4月17日

出國地區:英國、丹麥

報告日期:108年6月26日

分類號/目:HO/綜合類(交通類) HO/綜合類(交通類)

關鍵詞:波浪特性(Wave characteristics)、船舶繫纜線分析(Vessel mooring lines Analysis)、海嘯之建模(Modelling Tsunamis)、設備和儀器(Equipment & instrumentation)、海洋雷達(Ocean radar)、訊號處理(Signal processing)、海水酸化(Ocean acidification)

內容摘要:

參加英國 Ocean Business 研討會並於南安普敦國家海洋中心(NOC)與 Lucy Wyatt 教授進行陣列雷達後端分析處理之研究討論,討論臺中港示範區海洋陣列雷達;另與儀器原廠研發人員專題討論雷達系統與船舶自動識別系統結合擴充情形,並加以應用至離岸風電基地母港(臺中港)鄰近港區航行安全管理,再前往丹麥 DHI 原廠進行數值模式實地操作訓練與作業技術指導,加強本所研究人員模式使用的熟悉程度,提升專業研究與探討的分析能力、促進人員國際技術交流。最後安排幾項港埠設施參觀活動,以實地考察當地現況學習實務經驗與港灣工程技術。

本文電子檔已上傳至出國報告資訊網

摘要

對此次技術交流活動主要目的提出簡單介紹:

- 1. 參加 Ocean Business 研討會與專家學者針對現場海氣象觀測及海岸 漂沙機制調查技術發展方面,進行觀測研究心得討論,並相互討論交 換意見。
- 於南安普敦國家海洋中心與 Lucy Wyatt 教授進行陣列雷達後端分析 處理之研究討論,並討論臺中港示範區海洋陣列雷達(如圖 1.2 所示)
 第1季觀測結果討論,與日後風場解析的研究建議。
- 3. 前往原廠(DHI)進行數值模式實地操作訓練與作業技術指導,加強本 所研究人員模式使用的熟悉程度,提升專業研究與探討的分析能力、 促進人員國際技術交流。
- 4. 直接與儀器原廠研發人員討論雷達系統與船舶自動識別系統結合擴充情形,提供改善建議,以應用至離岸風電基地母港(臺中港)鄰近港區航行安全管理與海上事故之緊急救難。

對本次技術交流活動之效益,所發表的技術心得與成果:

- 1. 本次出國計畫參加 Ocean Business 研討會與專家學者針對現場海氣 象觀測及海岸漂沙機制調查技術發展方面,進行心得討論,並交換意 見,對於個人擴展視野及本所研究業務均有實質之幫助。
- 2. 利用海洋雷達進行港區航船的安全管理,國際間已經有許多成功的案例可供我國的借鏡,國內雖處於起步階段,但各國學者專家仍給予寶貴建議,德國海洋雷達研究人員建議臺灣訊號分析時,可以針對時間的連續性改善船舶目標判斷的誤差。
- 3. 英國 Lucy Wyatt 教授對於陣列雷達後端軟體之處理分析,以及特徵值造成判斷失誤的可能原因提供以下建議,雷達訊號包含許多不同的分量、重複反射訊號以及雜訊,建議持續觀察與蒐集,取得該地區長期的雷達訊號,以確認是否為固定雜訊,並將其由頻譜中剔除,應該能改善海洋雷達觀測的結果。

- 4. 丹麥 DHI 原廠進行數值模式實地操作訓練與作業技術指導,建議於 頻域轉時域過程,改善與實測資料比對的精度,藉此增加模式模擬時 的命中率,應能減少模式模擬時產生的誤差。
- 5. 建議臺灣未來的海岸或港灣開發要多方面整體考量,規劃上必須考慮產業、生態、景觀、永續與城市競爭力等面向,港口轉型之際,港務管理單位仍需重視管理與整體規劃之重要,以創造價值,並避免腹地閒置浪費。

最後對安排的幾項技術交流活動參觀地點作一簡介,能以當地的實務 經驗與港灣工程技術學習,得到增廣見聞的收穫;希望對此次奉派參加108 年度「海洋雷達系統擴充及數值模式赴原廠進行實地教育訓練和作業技術操作」 出國計畫整個過程,作出一總結與心得報告,並提出一些看法與建議。

108年度「海洋雷達系統擴充及數值模式赴原廠進行實地教育訓練和作業技術操作」出國計畫-出國報告

目次

_	•	目的	約							1
		-	•							_
=	. `	地	理位置	與行程	簡介	•••••	• • • • • • • • • • • • • • • • • • • •	•••••	• • • • • • • • •	5
Ξ	. `	專	題討論	與相關	研究應用	月概述	•••••	•••••	•••••	17
四	•	Oc	ean Bu	ısiness	2019	• • • • • • • • • •	••••••	• • • • • • • • •	• • • • • • • • • • • • • • • • • • • •	27
五	. `	相	關工程	技術活	動參觀	•••••	•••••	•••••	•••••	53
六	. ,	交流	流活動	心得與	建議	•••••	•••••	•••••	•••••	59
附	錄	A	英國南	安普敦	d Ocean	Busines	s 2019	• • • • • • • • •	•••••	63
附	錄	В	技術交	を流資*	斗(一)~(四	a)	•••••	•••••	•••••	73
附	錄	C	出國幸	银告簡素	報	• • • • • • • • • •	• • • • • • • • •	•••••	••••	165

108年度「海洋雷達系統擴充及數值模式赴原廠進行實地教育訓練和作業技術操作」出國計畫-出國報告

李政達*

一、目的

本所評估離岸風場建置後,將提升基地母港(臺中港)航班進出頻率及或鄰近港區海域航運艘次,有必要為維持交通部主管商港海域船舶航行安全預做準備,故於107年12月25日完成臺中港線性陣列雷達系統之安裝,並開始以陣列雷達調查基地母港進出口之海氣象,除此之外,本雷達系統擴充結合船舶自動識別系統,與國立中央大學及國家實驗研究院台灣海洋科學研究中心共同合作研發本土化陣列雷達動態船舶追蹤技術及航安急難救助等技術;另為探究基地母港港區所產生的漂沙問題,本所以丹麥DHI公司所研發之 Mike21 數值模式研究港區波浪、海流與漂沙之影響程度。

本次出國計畫適逢每2年一次於英國南安普敦國家海洋中心(NOC)舉辦的 Ocean Business 研討會召開,會場外貌,如圖 1.1 所示,研討會內容涵蓋海洋水下探測、海洋遙測、海洋工程、海洋科學及海洋技術等範疇,本次會議超過 360 家國際參展商,現場展示海洋領域最新產品與技術,以及海洋技術之現場演示,參加人員涵蓋海洋科學家、工程師或專業技術與其他決策人員,可以直接觸及海洋科學的發展現況,實際操作與面對面討論,為一規模龐大,多樣主題之國際海洋商業技術研討會議。



The hands-on ocean technology exhibition and training forum



圖 1.1 英國 Ocean Business 室外會場

行政院指派交通部協助風能產業開發事項,本所承辦相關研究及技術發展,研究目的與範圍係以交通部轄管的商港臺中港(離岸風電基地母港)為目標港區,進行港區海氣象、海洋環境調查、碼頭營運管理作業安全及船舶航行安全等各項研究,希望藉由本次出國計畫廣泛討論與中心研究業務密切相關之研究,使本所在學術與技術方面能獲得提升,更期待將來在從事海洋工程等領域時,能發揮所學而有所貢獻,本出國研究目的簡述如下:

- i. 參加 Ocean Business 研討會與專家學者針對現場海氣象觀測及海岸漂 沙機制調查技術發展方面,進行觀測研究心得討論,並相互討論交換 意見。
- ii.於南安普敦國家海洋中心與 Lucy Wyatt 教授進行陣列雷達後端分析處理之研究討論,並討論臺中港示範區海洋陣列雷達(如圖 1.2 所示)第 1 季觀測結果討論,與日後風場解析的研究建議。
- iii.前往原廠(DHI)進行數值模式實地操作訓練與作業技術指導,加強本所研究人員模式使用的熟悉程度,提升專業研究與探討的分析能力、促進人員國際技術交流。
- iv.直接與儀器原廠研發人員討論雷達系統與船舶自動識別系統結合擴充 情形,提供改善建議,以應用至離岸風電基地母港(臺中港)鄰近港區航 行安全管理與海上事故之緊急救難。





圖 1.2 臺灣海洋陣列雷達臺中港示範區

108年度「海洋雷達系統擴充及數值模式赴原廠進行實地教育訓練和作業技術操作」出國計畫-出國報告,行程表如附表 1、圖 1.3 所示:

表 1 108 年度派員出國進修研究實習計畫及城市地點

	日期	地點	主要行程概述		
出行說明	4/8 (一)	臺灣→英國	搭機啟程抵達,前往南安普敦國家海洋中心(NOC)		
	4/9 (二)		英國 Seaview Sensing 即時軟體研習:雷達資料後端處理及相關技術研習。		
	4/10 (三)	英國/南安 普敦	德國 WERA 陣列觀測雷達系統研習:進行相關分析技術交流及操作研習。		
	4/11 (四)		海洋工程與科學之技術研習:海上調查問題與研發技術研習。		
	4/12 (五)	荷蘭/阿姆	拜訪阿姆斯特丹史基浦機場 Nortek Oceanografische Instrumenten en Diensten B.V.儀器公司。		
	4/13 (六)	斯特丹	港灣工程設施訪察		
	4/14(日)		港灣工程設施訪察		
	4/15 (一)	丹麥/哥本哈根	丹麥 DHI 公司 MIKE 21 數值模式與水工模型試驗 系統研習:數值模式建置與模擬計算方法操作教育 訓練,水工模型試驗規劃、佈置、試驗與分析方法 觀摩研習。		
	4/16 (二)		回程, 哥本哈根-轉機點(預定法國巴黎)		
	4/17 (三)	法國→臺灣	返程搭機		

^{*}本出國計畫由李政達副研究員公費公假及林受勳助理研究員公假出行前往



圖 1.3 出國計畫候機情形

二、地理位置與行程簡介

2.1 英國國家海洋中心(National Oceanography Centre 簡稱 NOC)

該中心位於英國南安普敦郡距離火車站 2.6km 的位置,該研究大樓座落於南安普敦港旁,如圖 2.1 所示,南安普敦港是英國最繁忙的郵輪港和第二大集裝箱港,過去是鐵達尼號航線必經之地,目前國家海洋中心係英國海洋研究與技術發展的政府組織,該中心合作夥伴包括南安普頓大學與利物浦大學,加上其他海洋與地球科學學術單位,共有 520 名以上研究人員、工程師、技術人員、船舶運營人員,研究人員每年安排皇家研究船、深潛潛艇、水下無人載具負責蒐集全球海氣象數據、海底沉積物樣本,作為英國洪水預警和全球氣候異常變化之研究。



圖 2.1 南安普敦郡國家海洋中心(NOC)

英國是少數幾個國家,具有能在全球各海域進行科學研究之能力,其研究成果在許多國際海洋科學計劃中起了重要的引領作用,並與全球的海洋聯繫非常密切;海洋占地球面積71%,擁有極其豐富的礦產資源和生物資源,許多重要資源儲量比陸地儲量更豐甚,掌握豐富的海洋資源是使英國成為日不落國的重要原因之一。

英國對於海洋基礎研究設施投入十分重視,2013 年英國國家海洋中心宣佈進行海洋機器人的研究和開發,開始研製水下機器人,特別在自動水下航行器研究方面,將既有研發之自主式水下潛器(簡稱 AUV)和水下滑

翔器進行改良,未來將結合衛星觀測系統,構建全方位的自動觀測網絡; 2014年英國國家海洋學中心與英國皇家海軍簽署了一份協議,將在海洋自動化系統領域特別是海底航行器領域開展合作,並與英國自主水面航行器公司(Autonomous Surface Vehicles Ltd)和英國海洋一站式技術服務公司(Marine One Stop Technologies Ltd)合作開發的長航時無人駕駛水面航行器(Long Endurance Marine Unmanned Surface Vehicles,LEMUSV),相關技術的突破將會對海洋研究及相關產業帶來巨大機遇,對國防、空間、油氣、環保的發展具有促進作用。





圖 2.2 南安普敦郡國家海洋中心外觀

作為全球重要的海洋國家之一,國家海洋研究中心長期以來十分重視 海洋研究,根據國家科技現狀和國民經濟需求確定海洋研究重點,制訂國 家級中長期海洋科技發展規劃,未來將著重海洋酸化、海洋可再生能源開 發和海岸帶災害等研究。

2.2 Ocean Business

為瞭解全球海洋調查技術與最新的測量領域,此次參加每兩年一次的Ocean Business 2019展場(如圖2.3所示),展示內容包羅萬象,我們是以參觀者身分參加展覽,同一時間在國家海洋中心另一會場舉辦離岸調查研討會,議題廣泛包含:無人水面艦艇地平線測深之水深測量,波浪災害量測的方法,利用微型閃光成像的LiDAR作為測深應用的實驗概念,海上風電場與藍色經濟的觀點,以及透過遙感技術獲得水深測量的衛星水文學,海洋科學對臺灣而言正屬於剛起步的國家,各項技術仍尚有精進的空間,此次會議正是一個難得契機與機會,實際探訪、聽講、諮詢後覺得受益良多。





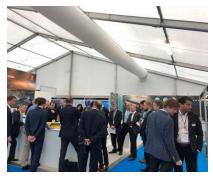


圖 2.3 英國 Ocean Business 2019 展場展示情形

本所去(107)年完成臺中港陣列式海洋雷達的架設,因此特別關注德國WERA公司在海洋雷達遙測技術的現況遂前往進行瞭解,另外為提升雷達後續的加值應用特別參觀 Rutter 公司 WaMosII的雷達分析技術,關注其近年的分析技術是否已有重大突破等,並順帶參觀臺灣唯一在 Ocean business 設展的玉豐公司,如圖 2.4~2.7 所示,討論臺灣近年來海洋研究發展的困境。



圖 2.4 臺灣玉豐海洋科儀公司 Ocean Business 2019 展示情形





圖 2.5 參展廠商的公司牆

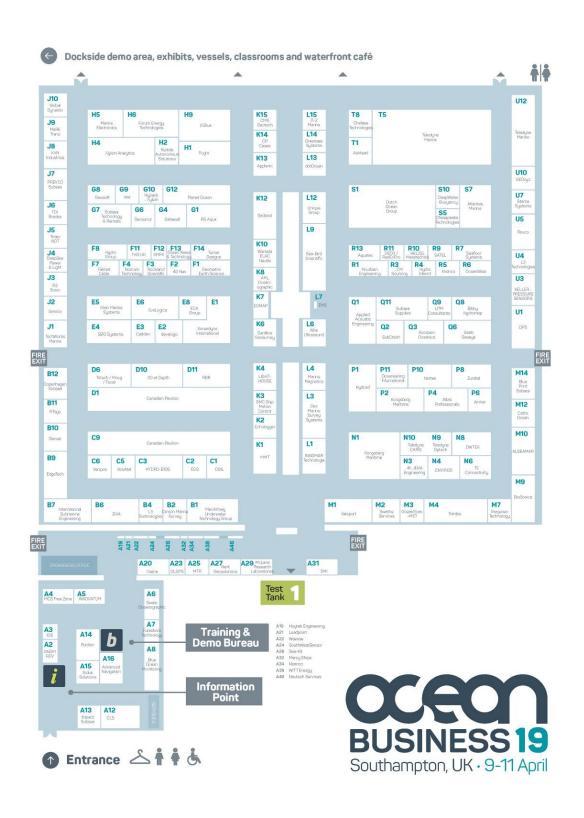


圖 2.6 參展廠商的公司位置分配圖(一)

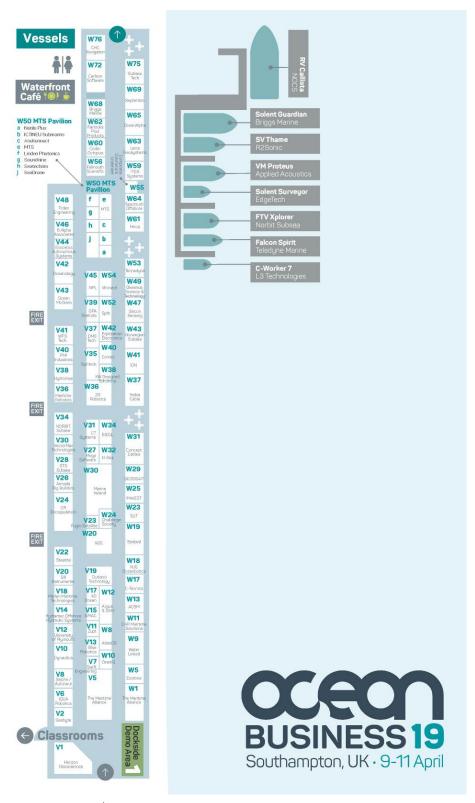


圖 2.7 參展廠商的公司位置分配圖(二)

2.3 荷蘭阿姆斯特丹港

阿姆斯特丹是荷蘭的首都,如圖 2.8 所示,座落於馬肯湖的西南端,鄰近阿姆斯特丹港,阿姆斯特丹港為荷蘭的第二大港,該港貨運的輸送量可達 7,580 萬噸,僅次於鹿特丹港,12 世紀初期僅是個漁港,經過 14 與 15 世紀的擴展與運河發展,整個城市由 100 多條河道分割,600 多座橋梁串連成一體,成為一座貿易水都,直到 17 世紀由荷蘭東印度公司開創海上貿易的歷史後,逐漸發展成為荷蘭的的政治、經濟、文化中心。





圖 2.8 荷蘭與阿姆斯特丹港

第一次踏上荷蘭這塊土地,就抵達荷蘭的阿姆斯特丹,從那刻起我即刻感受到這個城市脈動非常的迅速,自行車、火車與輕軌列車十分活絡,可見來此轉車、轉機、商務與觀光的人數非常多,整個中央車站人聲鼎沸,往來行人絡繹不絕。值得一提的是荷蘭的水運路線非常複雜,大致上分為兩類,第1類為交通運輸船主要搭乘的人士為通勤或生活交通,第2類為觀光運輸船主要搭乘的人士為來荷蘭攬勝的遊客,觀光航行路線也與一般交通路線不同,搭乘交通船時人員可以直接購買 GVB 交通卡,並搭乘 GVB 指定聯營的運輸船,擁有便捷的水運令人印象深刻,如圖 2.9 所示。





圖 2.9 阿姆斯特丹港水運情形

除此之外,荷蘭自行單車車速與臺灣相比偏快,而且單車騎士普遍不帶安全帽,令人感到印象深刻,可以算是單車的友善國家,荷蘭單車史如何演進成為今日的規模,要先追朔第二次世界大戰戰後的交通重建,公路運輸的規劃建設不佳衍生汽車與單車爭道導致交通事故頻發生,死亡率高居不下,1970年代開始單車族相繼街頭抗爭,經過多年的抗爭與努力,自行車專用車道(圖 2.10 所示)逐漸完善,政府在道路設計上設有減速丘、紅色專用車道,提醒用路人此路段是交通頻繁區處,需提高警覺留意自行車騎士安全,如此高水準的表現,才能維持單車騎士的安全,您可以清楚在荷蘭街頭觀察到許多 Uber eat 的自行車在用餐時段非常忙碌的進行外送服務。



圖 2.10 阿姆斯特丹港自行車道使用情形



圖 2.11 荷蘭的天空自行車道 (風傳媒 CUP 提供)

2.4 哥本哈根

丹麥王國行政區域之劃分共有 14 郡、2 個特別市(哥本哈根市及菲特列斯堡市(Frederiksberg))及其下轄之 275 小市。哥本哈根為丹麥王國的首都,哥本哈根也是丹麥最大的港市,如圖 2.12 所示,現為丹麥王國的首都,哥本哈根市位於丹麥西蘭島東部,隔著厄勒海峽對望瑞典馬爾默港,是北歐最重要的都市之一。

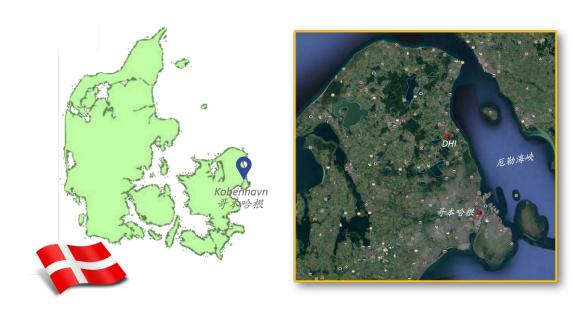


圖 2.12 丹麥與哥本哈根

根據丹麥的歷史記載,哥本哈根在 11 世紀初期還是個小的漁村,隨

著貿易與造船技術的提升,逐漸成為丹麥政治、經濟、文化的中心,隨著工程技術發展,以及地理位置的絕對優勢,哥本哈根港水深港闊,設備優良,每年出入港口的船隻約達3萬5,000艘以上,為丹麥主要貿易區域,哥本哈根透過火車輪渡與日德蘭半島及納維亞半島各國相連接,算的上是西歐和北歐間鐵路、航空的樞紐,如圖2.13所示。

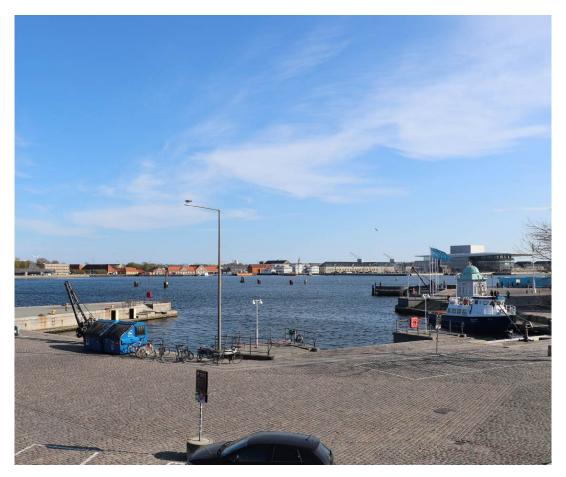


圖 2.13 哥本哈根皇家碼頭與軍港

本次出國行程共計停留英國倫敦、南安普敦、荷蘭阿姆斯特丹、丹麥哥本哈根等地,透過空檔前往參觀阿姆斯特丹港與,其中非常有幸參加英國國家海洋中心舉辦的 Ocean Business 2019,才有機會與各海洋科學領域人員接觸與討論,會中整體活動安排相當緊湊,研討過程十分熱烈與知性,現場有專門類海洋儀器的演示與專業人員的講解說明,許多新穎的想法與概念非常創新,從中汲取到不少新知識與海洋科技研發成果,最重要係透過本次出國計畫,瞭解到未來海洋學研究的趨勢,可作為日後研究方向的參考借鏡。本行程安排主要行程概要如附表 2 所示。

表 2 出國計畫主要行程概要

	化2 山西可重工安门在侧安	,	
日期/星期	工作內容	時間/地點	
4/8 (一)	由倫敦起程前往英國南安普敦國家海洋中	全天/臺灣-英國倫敦	
4/0 (*)	心(NOC)進行參訪。		
	Ocean business 2019(Day1)與英國雪菲爾大		
4/9 (二)	學教授 Lucy Wyatt 學習即時軟體 Seaview	全天/南安普敦	
117 (—)	Sensing 的研習討論,學習雷達資料後端處	工八份又自私	
	理及相關技術。		
	Ocean business 2019(Day2)與德國 WERA 陣		
4/10 (三)	列觀測雷達系統分析技術交流及系統原理	全天/南安普敦	
	的說明。		
4/11 (四)	Ocean business 2019(Day3)與海洋工程師與	全天/南安普敦/英國	
	科學研究人員討論海上調查關鍵技術問題	-轉機點(南安普敦)-	
	與研發技術,由南安普敦轉機至荷蘭。	荷蘭	
	拜訪鄰近阿姆斯特丹史基浦機場之 Nortek		
4/12 (五)	Oceanografische Instrumenten en Diensten	全天/荷蘭	
	B.V.儀器公司。		
4/13 (六)	港灣工程設施訪察	全天/港口	
4/14(日)	港灣工程設施訪察	全天/港口	
	丹麥DHI公司 MIKE 21 數值模式與水工模	全天/荷蘭(轉機點阿	
4/15 ()	型試驗系統研習:數值模式建置與模擬計	姆斯特丹)-丹麥/哥	
4/15 (一)	算方法操作教育訓練,水工模型試驗規	本哈根(霍斯霍爾	
	劃、佈置、試驗與分析方法觀摩研習	姆)	
4/16/		全天/丹麥-轉機點	
4/16 (二)	回程由丹麥哥本哈根轉機回法國	(哥本哈根)-法國	
1/17 (-)	再由法國巴黎戴高樂機場返回臺灣桃園中	全天/轉機點(巴黎)-	
4/17 (三)	正國際機場	臺灣	

三、專題討論與相關研究應用概述

3.1 英國 Seaview Sensing Ltd.之雷達分析技術與後端處理專題討論

日前本所港研中心臺中港所架設的海洋線性陣列雷達觀測系統已於去(107)年12月25日正式啟用,該系統屬於美國系統,由於本研究團隊欲探究雷達的訊號品質,因此於本次出國計畫(4月8~17日)前,特別向英國雪菲爾大學的 Lucy Wyatt 教授相約於 Ocean business 會場進行專題討論,故先將第 1 季臺中港雷達觀測資料與實測資料提供予 Lucy 教授進行分析,經 Lucy 教授的檢定後覺得臺灣的雷達系統很不可思議,她覺得雷達的訊號品質非常良好,訊雜比(Signal-to-noise ratio 或稱 SNR)非常的高,顯示周邊的干擾信息量較低,處理過程非常愉快,與 Lucy Wyatt 教授專題討論的情形,如圖 3.1 所示,這讓我回想到當初美國 Pierre 教授來臺架設雷達時,對於周邊環境的重視,他曾說過雷達系統十分敏感,因此選址前必需特別小心,避免干擾進到系統裡面來。





圖 3.1 與英國雪菲爾大學的 Lucy Wyatt 教授進行專題討論情形

有關 Seaview Sensing 軟體發展要追朔到 2,004 年 Sheffield-Seaview 模式,該研究團隊可以利用雷達訊號進行表面流、表面波與風速的解析,並且獲得很好的研究成果,現在 Seaview Sensing 軟體已經於各個國家開始應用,包括:英國、美國、法國、德國、澳大利亞、土耳其、臺灣等,可與碼頭設計、結構物維護、海象觀測、港口與堤防安全等議題結合。

計算的基本公式主要係以Barrick's equation [1971][1972][1977]雷達頻

譜分析的理論,Lucy 教授表示當一個雷達訊號如果向遠方發射,當遭遇 阻擋時訊號便會直接反射回來,訊號的本質並不會有相應上的改變,但是 當海面上的波浪因受表面流的影響,雷達反射訊號會因為表面流影響,訊 號將相應上有個頻率的偏移,稱為都卜勒頻偏。

$$\sigma = \sigma_1 + \sigma_2 + \cdots$$

$$\sigma_1(\omega, \phi) = 2^6 \pi k_0^4 \sum_{m=\pm 1} S(-m\mathbf{k}_0) \delta(\omega - m\omega_b)$$

$$\sigma_2(\omega, \phi) = 2^6 \pi k_0^4 \sum_{m, m'=+1} \int_{\mathbf{R}^2} |\Gamma|^2 S(m\mathbf{k}) S(m'\mathbf{k}') \delta(\omega - m\sqrt{gk} - m'\sqrt{gk'}) \, \mathrm{d}\mathbf{p}.$$

因此可在都卜勒頻譜中得到第 1 階海洋表面回波(G1)峰值,又在布拉格散射定律闡述都卜勒頻偏將發生在二分之一雷達波波長的位置,計算可得表面流的流速,另外透過第 2 階海洋表面回波(G2)進行非線性的雙重積分、實測資料與經驗公式可以反推表面波的 Hs 與風速,如圖 3.2 所示,依照觀測與解析的經驗,Lucy 教授建議雷達系統應有兩站,解算時比較不會犧牲空間資訊,如果僅有徑向資料,就必需犧牲空間資訊來疊代,故解算出來的範圍將會因此變小。

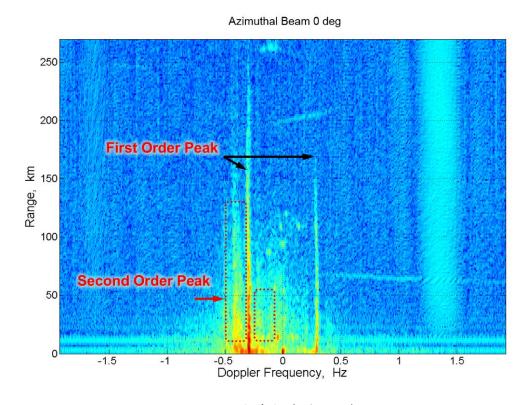


圖 3.2 雷達都卜勒頻譜

Lucy 教授針對海氣象觀測時表示,雷達系統配置並非全是優化配置,建議可以增加天線的數量,如此空間解析度將予之增加,便有足夠的空間資訊來進行數值上的解算。面對高度動態或干擾環境,將雜訊從信號中分離,實務上相當困難的,需一開始直接避免,詳細資料請詳附件 B 之(一)。

3.2 德國 WERA 之海洋雷達系統特點準確性和局限性專題討論

本次專題討論是在英國海洋中心研究室中召開,主講人是德國 WERA 公司創始人 Thomas Helzel 先生,專題討論的主題延續 1 樓展場的內容,進一步說明海洋雷達系統特點準確性和局限性問題,邀請卡如圖 3.3 所示,專題討論情形如圖 3.4 所示。

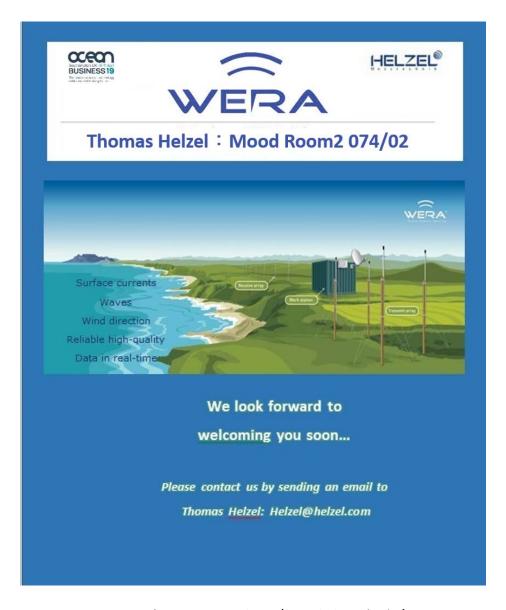


圖 3.3 德國 WERA 公司專題討論的邀請卡









圖 3.4 與德國 WERA 公司進行雷達系統特點準確性和局限性專題討論

首先要瞭解 WERA 是一種近岸的遙感系統,系統利用超視距雷達技術監測海表面之海流,波浪和風向,訊號傳遞可以垂直極化電磁波耦合到導電海洋表面並沿著地球曲率傳遞訊號,雷達訊號將在粗糙的海洋表面進行交互作用,並產生布拉格效應,使用者可利用該訊號加以分析應用。WERA 可以依據使用者需求,環境條件選擇緊凑型或陣列型天線系統,它是第一個實時檢測海嘯的系統,而且可作為搜索和救援操作的危害管理介面參考,為了給我們的 WERA 用戶提供最有效和最好的服務,我們始終與當地服務提供商合作,如印度 Elektronik 實驗室可確保持續運作並確保出現任何故障時,能及時排除縮短反應時間,Thomas 表示印度的科學團體加入 WERA 小組後,對印度研究人員科學研究高度讚賞,其使用回饋有助

於進一步改進海洋雷達技術。

在空間解析度方面 Thomas 表示此與雷達系統之天線數量有關,如用戶需要得到比較好的空間解析度,必需增加接收天線的數量,比如 8 支接收天線(Rx)解析度約達 15°、12 支接收天線(Rx)約達 9°、16 支接收天線(Rx)解析度約達 7°,顯見天線數量越多越好,缺點是需要的場佈空間將與之變大。另外在訊號處理與分析方面,Thomas 表示不論採用 Beam Forming 演算法或 SeaSonde 演算法都能得到不錯的結果,但以陣列雷達解算流場,其訊號分析速度與 SeaSonde 方式相比,陣列式的解算速度仍比較快,以 16 支接收天線的系統為例,Beam Forming 演算法處理時間約 9 分鐘,4 支方陣接收天線的系統,SeaSonde 演算法約處理 18 分鐘。

專題討論中 Thomas 特別提到英國雪菲爾大學 Lucy Wyatt 教授與她的 團隊所開發的 SeaView Sensing,因為當時 Lucy 教授也在會場,因此 Thomas 十分慎重地介紹她,足見其學術地位與價值非凡, Lucy 教授目前已經可以利用 WERA 的雷達資料,預測 48 小時以內場域的流場變化(目前該團隊研究的極限)。展望海洋雷達近年來發展,功能日新月異,已經逐漸廣泛應用於海洋調查,比較新興的船舶動態追蹤等議題,各國正處於角力狀態,惟本所港研中心本(108)年辦理「離岸風電海下工程技術研發計畫(3/4)」時,已經與國立中央大學共同辦理合作計畫,目前該追蹤技術已經掌握,屬於進行式的業務,本所港研中心將不斷精進研發,未來如有機會兩國(臺灣與德國)合作,國內的雷達技術肯定有相當大的斬獲與進步,詳細資料請詳附件 B 之(二)。

3.3 丹麥 DHI 之船舶繫纜分析與港口航運能力改善專題討論

順利抵達丹麥 DHI 後, Qian-Ming, Lu 博士為我們介紹 DHI 的環境, 如圖 3.5 所示,以及這家公司的歷史,這家公司早期生產經營造波系統, 是全世界造波機重要的製造商,本所港研中心 20 年前早因試驗研究需要, 於廢省前交通處時代,曾經透過物資局以進口高科技研究設備為由,免稅 採購造波系統,現該造波機仍設置於本所港研中心的風洞實驗室。





圖 3.5 丹麥 DHI 公司的工作環境

隨後 Lu 博士便與我們先行討論造波系統更新合作的可能,他表示目前造波機業務 5 年前左右便不再提供服務,為因應公司轉型部分,最後一個造波系統的案例是在香港大學,該案結束後公司便結束該項服務業務, 旗下團隊員工則分屬前往各部門工作,因此他非常樂意促成,但不保證公司會願意支持。

於 DHI 簡單的用過午餐後, Lu 博士便向我們介紹目前公司新拓展的業務以及新產品,船舶繫纜分析(MA 模式)與港口航運能力(NCOS)改善專題討論,討論重點分述於下兩小節:

3.3.1 丹麥 DHI 模式 MA(Mooring Analysis)

船舶有很多時候需要繫泊,以進行資源的補給,因此繫泊問題時常且密切的發生,如港口和(浮動)碼頭、港口和遊艇碼頭、近海環境、海上停泊、海上串聯繫泊等。纜繩可以防止船舶在繫泊時因為潮流產生移動變化,因此確定和評估船舶運動與繫泊設備的力量,關係到泊位設計、繫泊系統評估,也關係到纜繩的選用,如何選用一條好的纜繩,關鍵在於強度要夠強、彈性要適當、具耐腐蝕性與抗磨等功能,船繫泊情形如圖 3.6 所示。

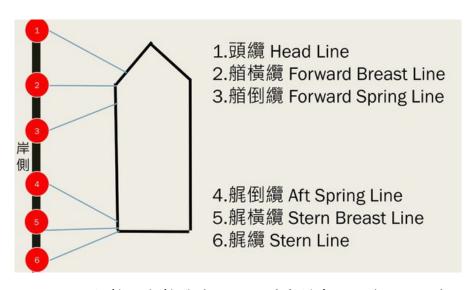


圖 3.6 船舶繫泊與繫纜線的說明(資料來源:商船飛行)

使用 MA 模式求解船舶繫纜問題時,需先使用 MIKE 21 HD FM 或 MIKE 21 BW 解析非均勻入射波場或流場,以計算第二階風、潮、流的漂移力(頻域計算),此時需準確輸入船體幾何形狀和 gyrostatic 數據,如此才能進一步在時域中探討船體所有的 6 項自由度的浮體運動,Lu 博士為我們演示了澳大利亞港的案例,該港增為澳洲運量增長最快的集裝箱港口之一,港區優化後將允許更大的船舶過境,因此特別以數值模擬研究,以確定在幾個關鍵泊位,如有過往船舶(像是 LNG 船舶)經過對船舶繫泊的影響,目前的解析度已經可以達到 0.2 x 0.2 m²,如圖 3.7 所示。

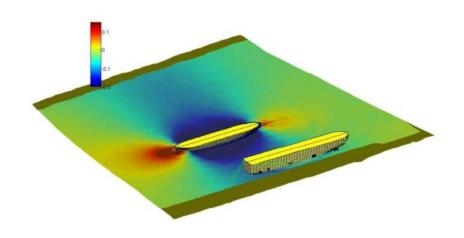


圖 3.7 船舶繫泊分析情形

Lu 博士表示現階段使用者介面(GUI)已較從前容易使用,不論是高度 複雜的船舶模型的評估(使用者自訂,如圖 3.8 所示),開放水域探討,或 與其他 MIKE 型號 (特別是與 MIKE FM HD 和 BW 配合使用)都沒有 問題,透過出色的介面與定義明確的輸入/輸出,可以準確地計算出高度複雜的非線性波場所造成船舶運動,對於未來的發展與技術支援,丹麥 DHI 非常樂意辦理技術培訓活動,詳細資料請詳附件 B 之(三)。

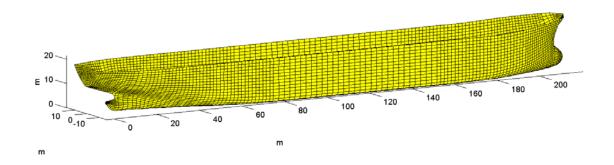


圖 3.8 使用者自訂之船舶模型

3.3.2 NCOS(Non-Linear Channel Operability Simulator)

受船舶大型化影響,丹麥 DHI 公司預測未來 2-4 年船舶規模將會擴大,因此世界上很大一部分港口都必須相應的擴大容量,然而過去的分析方式多利用經驗方程式評估,但總因缺少波浪與流體動力學的分析,結果總是不大明確,因此丹麥 DHI 公司在改進,成功協助澳洲港務管理局改善航道容量的使用率,營運管理的效率,減少不必要航道的疏濬成本,為船舶與港口級別提供透明的風險狀況,利於港區管理單位調度管理與最大化的利用。

Lu Qian-Ming 博士表示自己很榮幸能為我們介紹這套 Non-Linear Channel Operability Simulator(NCOS)軟體,因為這套管理系統是 DHI 公司特別向澳洲港務管理局專案設計的,成功解決澳大利亞港所面臨的各項問題,如碼頭可工作天的分析,碼頭閒置情形等問題的量化,有效作為政府重大決策的參考,如圖 3.9 所示,Lu 博士仔細的向我們解釋研究團隊的架構,首先將既有數值模式與實際海氣象資料進行比對,以求得港口各項模擬參數,再將影響船舶大小、船型等因素納入 NCOS 進行分析,可預測7天後航道碼頭的使用情況,並預測這樣的港灣環境條件下,評估船舶吃水深的安全機率,再據以提出優化的解決方案,詳細資料請詳附件 B 之(四)。

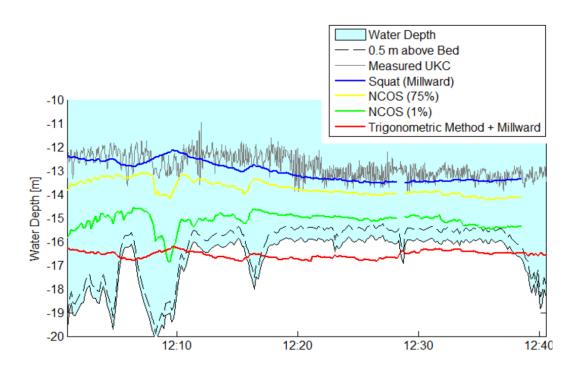


圖 3.9 丹麥 DHI 港灣 NCOS 軟體

四、Ocean Business 2019

展示會場與研討會兩個地點是不一樣的,如需進入展示會場的人員,主辦方為統計與控管進出人員,任何參加人皆可以免費入場,只需填寫基本資料,比如來自地點,姓名、性別、年紀及職業等,旁邊會有專門人員協助參觀者列印取得入場通行證,進出人員必須在入口掃描通行證方可進入,此部分亦支援有線上報名登錄,不喜歡現場排隊擁擠的,可先行上網報名,如圖 4.1 所示。



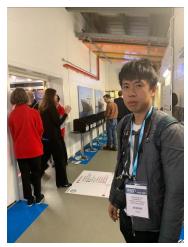




圖 4.1 Ocean Business 2019 現場報名情形

但如需參加離岸測量研討會(Offshore Survey 2019)以及晚宴的人員,此部分非免費入場,需要線上報名及刷卡付費方可參加,會場人員與行程表看板合影,如圖 4.2 所示。



圖 4.2 離岸測量研討會(Offshore Survey 2019)行程表

4.1 加拿大 Rutter 公司波浪雷達系統 WaMoS® II

WaMoS® II 軟硬體現場解說,如圖 4.2 所示,該系統硬體組件是由標準船用航行 X-band 雷達、數位系統轉換器及標準個人電腦所組成。此硬體組件可以擷取和存取海平面的數位元元雷達影像畫面,透過地形顯示器、數據機、網際網路及內部網路遙控,可將波浪資料輸出到現地使用者手邊的其他航行用儀器;該系統波浪分析軟體提供一般可接受統計的最佳海況參數和海平面海流,使用者可架構安裝地理介面連續顯示主要海況參數。





圖 4.2 加拿大 Rutter 公司波浪雷達系統 WaMoS® II 現場解說

該系統量測原則是根據 X-Band 雷達技術。在接近任何一般 X-Band 雷達的範圍(小於 5 公里),明顯的表面波(稱為海洋散亂)變成可見的條紋,其海洋散亂是從海平面的微波散射所傳送的電磁波的迴波訊號所產生。系統工作極限至少需要每秒 3 公尺風速方可偵測波浪模式。依據雷達重複掃射時間,資料搜集約需 80 秒隨後之資料處理約需 40 秒,如此每 2 分鐘即可產生方向波譜。WaMoS® II 的設計可在惡劣環境情況進行量測並證明在低能見度下亦可操作,它可設在無人的平臺上、移動船隻和海岸場址進行自動化操作,而該系統可偵測海浪波長,由 40~600 m 涵蓋之間,週期為 5~40sec 範圍之內,其他多功能系統,如圖 4.3 所示。



圖 4.3 加拿大 WaMoS® II 多功能系統

整個 High Resolution Current Analysis (HRC) 系統分析處理(波高、波向、波長、週期、流速、流向)過程及原理,如下:

- 1. 雷達影像部份:為了波浪分析從全部雷達影像中切取界定數量的矩形 部份,然後轉換成笛卡兒(Cartesian)座標。一個標準笛卡兒影像涵蓋 2平方公里區域。
- 2. 分離傅立葉(Fourier)轉換:由離散傅立葉的轉換,連續之雷達影像部分轉換成 3D 影像頻譜。
- 3. 表面流的計算:表面海流可由縮減 3D 影像頻譜(3D-image spectrum) 中的頻頻能量(Spectral energy)的位置與線性表面重力波定義之散亂關系的理論位置之距離獲得。準確地決定表面流是從雷達影像計算方向性波頻譜基本步驟。
- 4. 3D 影像頻譜濾波:頻譜:結合海洋波浪的能量,利用如帶通濾波器 之散亂關系,可從背景雜訊中分離出來。
- 5. 2D 波頻:為導出 2D 波譜,在頻率域中將 3D 影像波譜積分;利用調節轉換函數(Modulation TransferFunction, MTF)獲得 2D 波數頻譜 (2D-wave number spectrum)。
- 7.1D 頻譜計算:方向積分可產生 1D 頻譜,隨而導出所有海況參數。
- 8. 示性波高的預估:示性波高(Significant wave height)與雷達影像中的訊 雜比(Signal to noise ratio)有關;內部運算功能可檢核其有效性與處理 參數的微調;若多風天氣的參考資料可使用,將可得到最佳的結果, 分析情形如圖 4.4 所示。

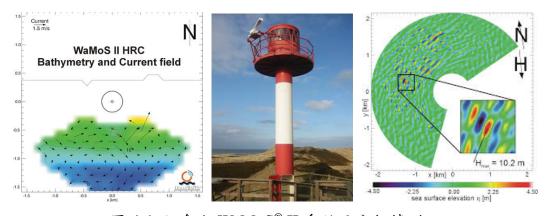


圖 4.4 加拿大 WaMoS® II 系統及分析情形



sigma S6 WaMoS® II High Resolution Current Analysis (HRC)



sigma S6 WaMoS* II High Resolution Current Analysis (HRC) is an option available for the sigma S6 WaMoS* II wave and surface current monitoring system. HRC delivers ocean surface current information with high spatial resolution to aid in drift prediction of oil slicks, the management of offshore activities, harbour entry and route planning, safer navigation and coastal protection. HRC also displays bathymetry information in shallow water (up to approximately 30m water depth) to assist in the monitoring of sedimentation and erosion processes.

Coastal waters are characterized by complex wave fields that are influenced by inhomogeneous bathymetries, and changing tidal and wind induced currents. WaMoS® II HRC allows carrying out surface current and bathymetry measurements over large areas to anticipate the need for and better target high-resolution surveys.

HRC maps are useful in supporting operational decisions for the offshore industry, port operations as well as coastal authorities. HRC measurements provide detailed information about water depth and currents within the range of the radar image, which in general covers an area of several square kilometers.

These WaMoS^{*} II maps provide insight into small-scale dynamic processes helping to better understand complex current fields that affect wave behavior and ultimately any smaller scale processes, such as

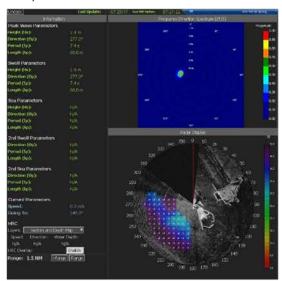


Figure 1: sigma S6 WaMoS* II statistical wave parameters and HRC map

eddies either offshore or in the coastal zone.
Bathymetry maps, updated on a short temporal interval are valuable to better understand morphodynamic changes, such as natural erosion and deposition over time or due to events such as storms.

At present, the HRC-option can be applied on fixed offshore platforms and at coastal sites. The HRC parameters provided are: high spatial resolution (50m-200m) Surface Current Speed, Surface Current Direction, Water Depth, in form of a map. The size of the map depends on the radar coverage (footprint).

Figure 1 displays statistical wave parameters on the left, a 2-D frequency direction spectrum on the top and a HRC map overlaid over a radar image at the bottom. Both the $sigma~S6~WaMoS^*~II$ and the HRC requires a minimum wind speed of 3 m/s and a minimum wave height of about 0.5 m - 0.75 m. In Figure 1 the waves

are only high enough on the west side of the island for measuring and displaying HRC information. The color-coding refers to the local water depth, ranging from 9 to 28 meters, and the arrows are showing the surface current field. Alternatively, to the bathymetry the user can choose to display the current color-coded, which shows a variation in currents from 0.2 m/s to 1.2 m/s.

sales@rutter.ca

MKT-02594, Issue 01

RCR: 8741

www.rutter.ca



sigma S6 WaMoS® II High Resolution Current Analysis (HRC)



The combined water depth and current field displayed in Figure 2 below shows a complex current field. Short term features such as eddies can be picked up easily with *sigma* S6 WaMoS* II High Resolution Current Analysis.

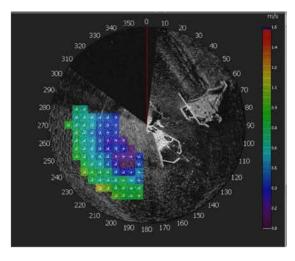


Figure 2: sigma S6 WaMoS® II system showing a complex current field

The user can choose the spatial resolution and data update rate according to the application at any time. As Bathymetry changes are usually very slow, 30 minutes of data analysis per day will be enough to capture those. If the interest is in seeing short term changes in the surface current, for example, to support navigation, then it is important to choose a resolution that corresponds to a faster calculation and update rate. With this configuration, one can still see the detail in the data that is needed, but the update rates of the data are fast enough to still receive the results in real time.

sigma S6 WaMoS® II HRC

www.rutter.ca

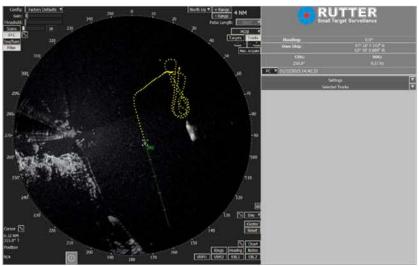
- · Real time High resolution surface current speed and direction to support
 - coastal, port and offshore operations
 - design of offshore structures
 - design of onshore structures
 - navigation into small ports
 - and assist of coastal protection management
- High spatial resolution to aid in drift prediction of oil slicks
- Small scale eddies can interfere with drilling equipment
- Real time High resolution Bathymetry data to survey coastal areas
- Assists in the monitoring of sedimentation and erosion processes



sigma S6 Small Target Surveillance

Rutter's sigma S6 Small Target Surveillance (STS) System provides enhanced radar imagery, target detection and tracking in the marine environment. A versatile tool, detecting and tracking a wide range of target profiles from persons in water and small maneuvering craft to large vessels, the system is a

practical solution for specialty radar applications such as search and rescue, improved vessel traffic monitoring, asset protection and surveillance applications including antipiracy and coastal water protection. The *sigma* S6 Small Target Surveillance System has proven itself on offshore platforms, support vessels, patrol vessels, seismic operations and in a range of coastal surveillance and monitoring applications.



sigma S6 Small Target Surveillance – Small Target Tracking

In the seismic survey industry,

the *sigma* S6 Small Target Surveillance System enhances operational productivity by improving the detection and tracking of small and nearly hidden targets, such as wooden buoys, fishing gear and floating debris that can foul seismic streamers and acoustic sensors in tow.

For pleasure craft ranging from day boats to Expedition Mega Yachts the sigma S6 Small Target Surveillance System improves the detection of floating objects that cause costly damage to hulls, rudders and props.

The sigma S6 Small Target Surveillance System can be installed with a dedicated Rutter 100S6 radar, but also passively interfaces with, and significantly enhances commercially available marine radars. The system is fully motion compensated and operates equally well from both fixed locations and vessels under way. It includes Rutter's integrated target tracker, SeaTrack, specifically tuned for optimal tracking of different target types simultaneously, while supporting up to 500 simultaneous targets. Ideal for detecting and tracking small targets, SeaTrack allows for optimal detection and tracking compared to common Automatic Radar Plotting Aid (ARPA) radar trackers, taking advantage of the sigma S6's superior imaging and signal processing.

The *sigma* S6 Small Target Surveillance System features full integration with select FLIR IR cameras. Features include the ability to support multiple cameras, intelligent selection of a best camera for specific targets, and automatic slewing to targets approaching the radar location or entering protected areas. These features support quick decision making in addressing potential threats and possible interruptions to operations. For other systems, the *sigma* S6 Small Target Surveillance System supports

sales@rutter.ca MKT-02591, Issue 01

RCR: 8741



sigma S6 Small Target Surveillance

NMEA Tracked Target Message (TTM) output to provide standardized targeting information to those cameras.

The sigma S6 Small Target Surveillance System offers a variety of outputs to both record and stream radar imaging and targets to external systems. A built-in Screen Recorder allows recording of the radar display which is useful for documenting an incident, scientific research or ice breaking operations.



sigma S6 Small Target Surveillance – FLIR camera integration

Recordings are supported as a series of JPEG or PNG images, or as an AVI videos. In addition, the *sigma* S6 Small Target Surveillance system comes standard with a web enabled interface, allowing external systems to interface with the *sigma* system to view radar imaging (GeoTIFF, PNG, JPEG) and targets (GML, KML, DXF, ESRI).

sigma S6 Small Target Surveillance

- Marine certified (IEC 60945)
 - Rack Mountable/Desktop Radar Data Processor
 - 19" marine certified Rack Mountable/Desktop monitor (alternate sizes available)
 - Keyboard/Trackball Unit (Desktop style or Console Mount)
- Windows 7 operating system
- SeaTrack tracker, optimized for detection and tracking of different target types
- Fully motion compensated scan-to-scan integration of up to 128 radar sweeps, allowing the sigma S6 Small Target Surveillance System to identify and detect both fast maneuvering and small slowing moving targets
- Advanced sea, rain, interference & clutter suppression
- AIS Class-A and Class-B target overlay
- Built-in interfaces for FLIR camera systems and TTM output to other camera systems for enhanced target verification and identification
- Automatic Screen Recording in selectable time intervals for evidence documentation
- Remote client capability
- Computer-Based Training package

sales@rutter.ca MKT-02591, Issue 01

RCR: 8741



sigma S6 Oil Spill Detection

Rutter's sigma S6 Oil Spill Detection system combines proven capability in early detection of oil on water with tools that generate essential information for containment and cleanup, aiding to minimize environmental damage and cleanup costs due to oil spill events. The sigma S6 Oil Spill Detection system has been extensively tested and

proven to be effective in independent trials conducted by the Norwegian Clean Seas Association for Operating Companies (NOFO) and is used worldwide. sigma S6 Oil Spill Detection systems are installed on fixed platforms, FPSO's, offshore workboats, patrol vessels and specialty clean-up vessels in many regions of the world, including Brazil, the North Sea, Gulf of Mexico, Eastern Canada, China and Russia.

The sigma S6 Oil Spill Detection System has detected oil slicks as small as 5L, and can detect spills out to 4 nautical miles from the radar site across a broad range of sea states, weather conditions, at day



sigma S6 Oil Spill Detection System - Oil Detected

or night. The sigma S6 Oil Spill Detection system automatically alarms when possible oil slicks are detected on the ocean's surface. With the confirmation of an oil spill, the system outlines the extent of the oil spill showing its deformation and drift over time, and provides calculated estimates for the oil spill's volume.

The sigma S6 Oil Spill Detection System can be passively interfaced with existing commercially available marine radars, and is also available with the Rutter Radar 100S6 with either horizontally or vertically polarized radar antennas. Vertically polarized radar antennas enhance ocean surface detail, providing superior oil spill detection results. The system is fully motion compensated and operates equally well from both fixed platforms and vessels under way.

The sigma S6 Oil Spill Detection System features full integration with select FLIR IR cameras. Features include the ability to support multiple cameras, intelligent selection of a best camera for specific targets, and automatically direct the camera to oil spill targets as they are detected. These features support quick decision making in addressing potential spills, minimizing impact to the environment and operations. For other camera systems, the sigma S6 Oil Spill Detection System supports the NMEA Tracked Target Message (TTM) output to provide standardized targeting information.

The automatic detection, outlining and tracking of multiple, simultaneous oil spills is supported. Oil spills may also be manually outlined, different colors may be assigned to each oil spill area, and the outlines of manually outlined and automatically detected oil spills with target properties may be recorded and exported to disk or over email via ESRI formatted data files in support of oil spill response operations. The *sigma* S6 Oil Spill Detection System offers a variety of outputs to both record and stream oil spill imaging, targets, outlines and drift vectors to external systems. A built-in Screen Recorder allows recording of the radar display which is useful for documenting an incident, scientific research or clean-up operations. Recordings are supported as a series of JPEG or PNG images, or as an AVI videos. In addition, the system comes standard with a web enabled interface, allowing external systems to interface with the *sigma* Oil Spill Detection system to view radar imaging (GeoTIFF, PNG, JPEG) and targets (GML, KML, DXF, ESRI).

sales@rutter.ca MKT-02590, Issue 01

RCR: 8741



sigma S6 Oil Spill Detection

sigma S6 Oil Spill Detection System

- Marine certified (IEC 60945)
 - Rack Mountable/Desktop Radar Data Processor
 - 19" marine certified Rack Mountable/Desktop monitor (alternate sizes available)
 - Keyboard/Trackball Unit (Desktop style or Console Mount)
- Windows 7 operating system
- · Automatic oil spill detection, outlining and tracking
- Fully motion compensated scan-to-scan integration of up to 128 radar sweeps, allowing the sigma S6
 Oil Spill Detection System to identify small quantities of oil on the ocean's surface
- Advanced sea, rain, interference & clutter suppression
- · AIS Class-A and Class-B target overlay
- Built-in interfaces for FLIR camera systems and TTM output to other camera systems for enhanced target verification and identification
- Automatic Screen Recording in selectable time intervals for evidence documentation
- Remote client capability
- Computer-Based Training package

4.2 美國 EdgeTech 公司

水下無人載具又稱水下機器人(underwater robotics),誕生於本世紀 40 年代末期,至今已有 60 年以上的發展歷史,當今世界各國如美國、加拿大、英國、義大利、法國、挪威、俄羅斯、日本及瑞典等國,都已相繼開發出各類型的無人水下載具,隨著調查需求與目的性不同,各自在不同研究範圍中展現一定的性能技術與優勢。不論從自然資源調查、礦產的開採、海底地形調查、水下聲學研究、傳統目標物搜尋與水下打撈作業、不論這些海岸工程、海洋科學以及軍事用途總能發現它們同的蹤影,其中愛迪泰克(EdgeTech)公司是間 1965 年所創建的公司,算的上是海洋儀器製造與開發的先驅,不論是海底管線、水下結構物、海底電纜、鑽油平臺、港灣碼頭等水下設施檢測作業,都能發現它們的身影。

該公司擁有一整套內部測試設施,包括測試池,聲學測試室,壓力測試室,以及測試和海上試驗之兩用研究船。這些設施使公司能夠對每個系統進行全面測試和校準,以確保提供最可靠和最高質量的產品和系統,受到不少海權發達國家的重視與支持,由於本次出國計畫前已經開始關注該公司 EdgeTech 3400 Sub Porfiler 底質剖面儀,便趁此機會前往展場進一步瞭解,如圖 4.5 所示。





圖 4.5 美國 EdgeTech 公司介紹與討論底層剖面儀的情形

在介紹本儀器之前先介紹傳統地層剖面儀的原理,該儀器係利用聲波 在水中和底質沉積物內傳播和反射的特性不同,來推探測底層的狀況,不 幸的是傳統的底層剖面儀在反射極限處會發生邊緣散射,導致聲學訊號將 朝向四面八方(即 360 度)反射,使儀器的接收器無法順利接收,產生量測 不確定性,以至於後來的儀器開發朝向雙頻接收發的回聲測深技術基礎上發展。美國 EdgeTech 3400 採用雙 2-16 kHz 傳感器,可銜接拖魚(Tow fish) 側掃聲納,以完整量測並反映海底真實現況的反射係數測量,便可以確定海床沉積物的類型。



3400

SUB-BOTTOM PROFILING SYSTEM

III FEATURES

- · Enhanced Sub-bottom PVDF receivers
- · Sub-bottom mode or pipeliner mode
- · Dual 2-16 kHz transducers
- · Pole-mount or tow options
- Digital receiver on towfish with Ethernet telemetry and power
- · Reduced diameter tow cable
- Real-time pitch, roll, heave and depth sensors
- · Surface echo attenuation
- Pulse library tailored for different survey applications
- · Data display in multi-frequency bands

APPLICATIONS

- Geological surveys
- · Environmental site investigations
- Sediment classification
- Buried pipeline & cable surveys
- Archeological surveys
- Mining/dredging surveys
- Map, measure & classify sediment layers within the sea floor





Building on the long running success of the EdgeTech sub-bottom profiler product line, the EdgeTech 3400 provides users many enhancements to current sub-bottom profiler systems. The 3400 is a wideband Frequency Modulated (FM) sub-bottom profiler utilizing EdgeTech's proprietary Full Spectrum CHIRP technology. The system generates high resolution images of the sub-bottom stratigraphy in oceans, lakes, and rivers and provides excellent penetration in various bottom types. The EdgeTech 3400 comes in a dual 2-16 kHz transducer configuration. The towfish is configured with new PVDF receiver arrays segmented for standard sub-bottom profiling operations or a unique "pipeliner" mode for optimal location and imaging of buried pipelines. The system offers Real-Time Reflection Coefficient Measurements. This unique ability of the EdgeTech Sub-Bottom Profiler system allows users the ability to collect complex 'analytic' data using linear system architecture to measure sediment reflection and analyze sediment type determination. Additionally, the system has discrete transmit and receive channels allowing for continuous data collection resulting in a high ping rate particularly important for construction and pipeline surveys.

The topside configuration can support higher power configurations using an external amplifier. The newly designed towfish can either be towed behind a vessel or pole mounted over the side of the vessel. The EdgeTech 3400 Sub-bottom Profiling System comes as a complete package and includes a towfish, cable and a topside processor (configurable as a portable or rackmount topside) running EdgeTech's DISCOVER sub-bottom acquisition & processing software. The 3400 can also be interfaced to 3rd party software.

For more information please visit EdgeTech.com

info@EdgeTech.com | USA 1.508.291.0057



3400 SUB-BOTTOM PROFILING SYSTEM

KEY SPECIFICATIONS

TOWFISH		SB-216S
Frequency Range		2 - 16 kHz
Vertical Resolution		6-10 cm (3 - 4 inches)
Penetration (typical)		
In coarse calcareous sand		6 m (20 feet)
In clay		80 m (262 feet)
Transmission Type		Full Spectrum® FM Signal (CHIRP)
Length/Width/ Height	i i	114 / 55 / 30 cm (45 / 21 /12 inches)
Weight in Air		65 kg (144 lbs)
Weight in Water		33 kg (73 lbs)
Depth Rating		100 m
Tow Cable Length		50 m (75 max)
TOPSIDE INTERFACE		
Hardware		Rugged, portable splash proof enclosure (or Rackmounted)
Operating System		Windows* 10
Display		Splash proof semi-rugged laptop
File Format		Native JSF, SEG-Y & XTF
Input/Output		Ethernet
Power Input		120/220 VAC Auto sensing
POLE MOUNT		
Length/Width/Height		114 / 55 / 39 (45 / 21 /12 inches)
Weight in Air		65 kg (144 lbs) – towed configuration
		70 kg (155 lbs) - pole mounted configuration
Weight in Water		33 kg (73 lbs) – towed configuration
		35 kg (78 lbs) – pole mounted configuration
Deck Cable Length		10 m (75 max)
TOW CABLE		
Tensile Strength		545 kg (1202 lbs)
Min. Bending Radius		15 cm (6 inches)



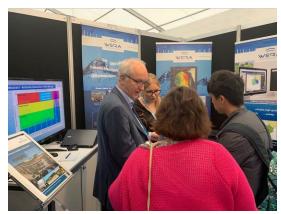


For more information please visit EdgeTech.com

info@EdgeTech.com | USA 1.508.291.0057

4.3 德國 WERA 展場介紹與演示說明

本次德國WERA公司展場的展示主題是離岸 0 至 300 公里範圍的量測與分析應用,該公司 Thomas Helzel 除了眾所皆知之高解析度海流量測應用,介紹更多有關雷達的應用如搜索、救援、汙染物(油汙)漂移預測等。該雷達系統可以利用 5-50 MHz 頻率量測不同海域目標,特別是海嘯預警主題格外令人感到興趣,展場中 Thomas 說明加拿大溫哥華島 2016 年 10 月 14 日案例,如圖 4.6,據悉當時雷達系統量測該雷達反射訊號有機會發海嘯,尤其是淩晨 5:30 分預測海嘯發生機率明顯增加,由 50%提高至 75%,顯示海嘯波浪正逐步朝向溫哥華島,1 個小時之後,於當地時間 6:30 抵達海灘,成功預測。另外一案是荷蘭奧德多普(Ouddorp)量測之案例,由於該系統沒有參與「雷達檢測模式計畫」故無法即時為荷蘭發布海嘯警告,但事後透過軟體分析,荷蘭 WERA 於 2017 年 5 月 29 日確實也量測到海嘯訊號,且與實測狀況相符,只是因為「雷達檢測模式計畫」是德國 WERA公司需要收費的服務,因此如有這樣的需求必須與該公司洽談合作計畫,對於海嘯發生機率較低的臺灣而言,並無此迫切需求,但仍可作為國內技術未來研究的目標。



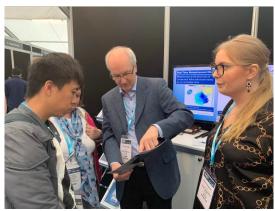
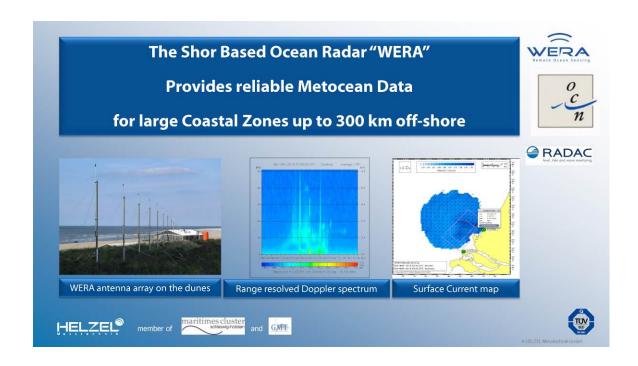
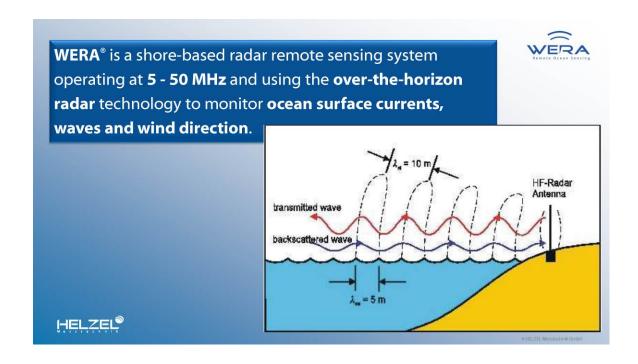


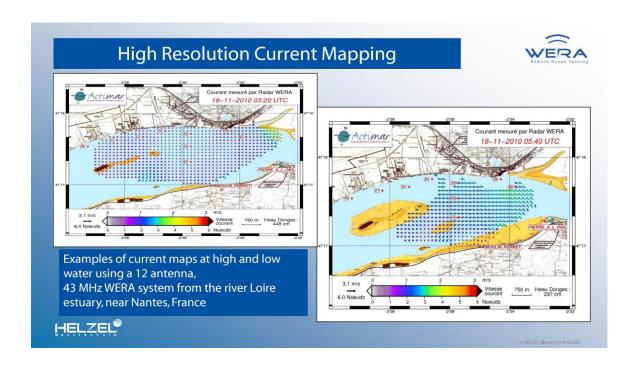
圖 4.6 展場中 Thomas 介紹加拿大溫哥華海嘯案例情形

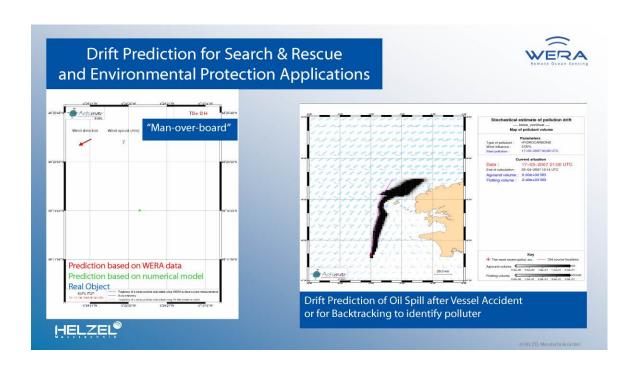
今年 Thomas 表示 WERA 與往常不同地方,係將使用者顯示介面系統升級至第三版,讓整體的使用環境更佳的人性化,更利於新加入 WERA 團隊的使用者操作,使其有著良好愉快的使用體驗,目前臺灣臺北港使用的版本為第一版使用者介面系統,依據荷蘭的經驗如果需要使用第三版的系統應該還要需支付德國 WERA 公司一大筆預算,因此除非臺灣系統需要升級,否則並不建議採購。

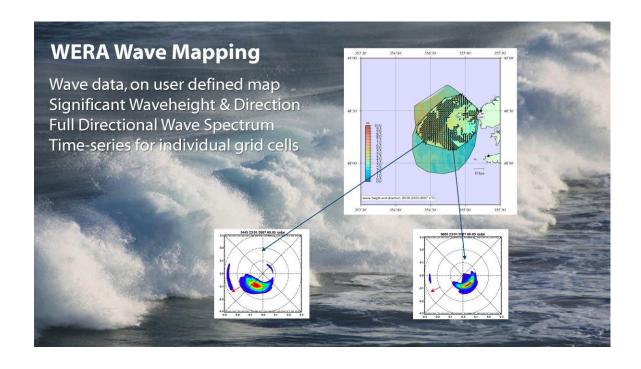










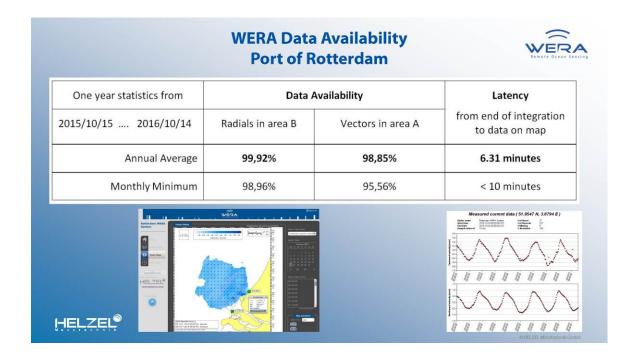


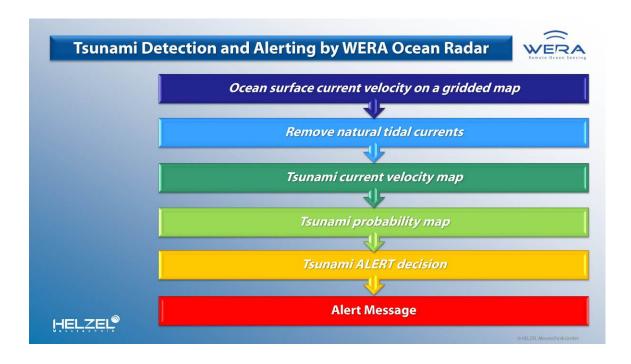


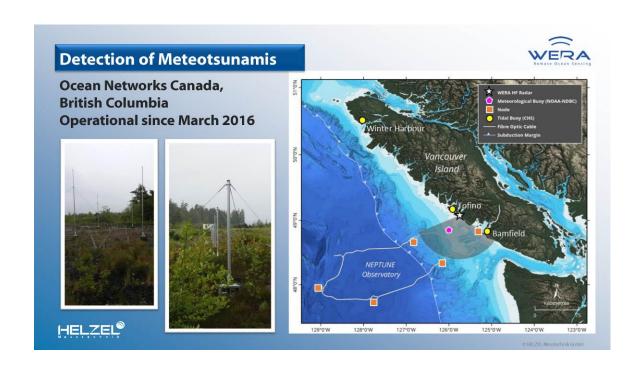


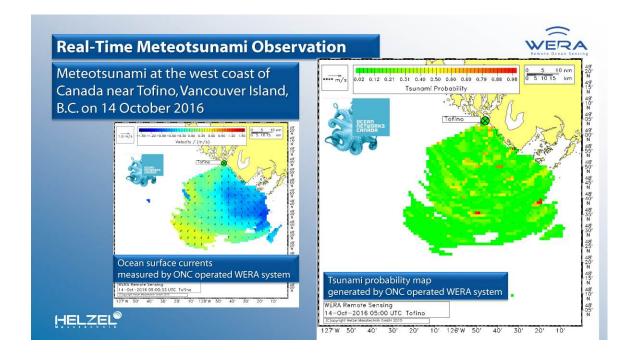


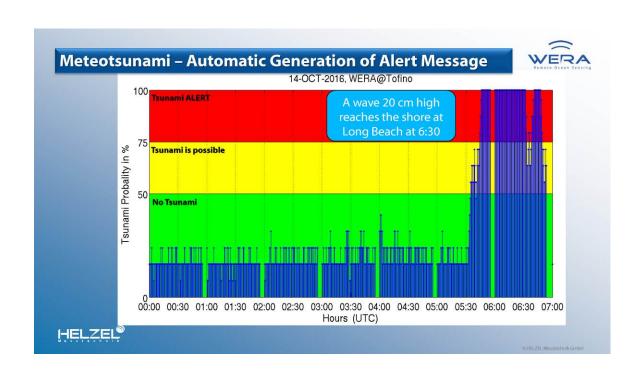


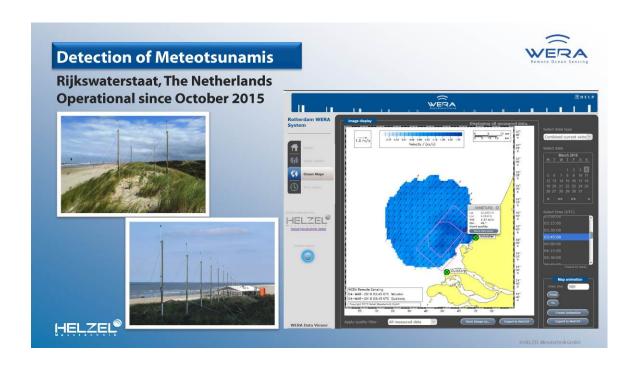


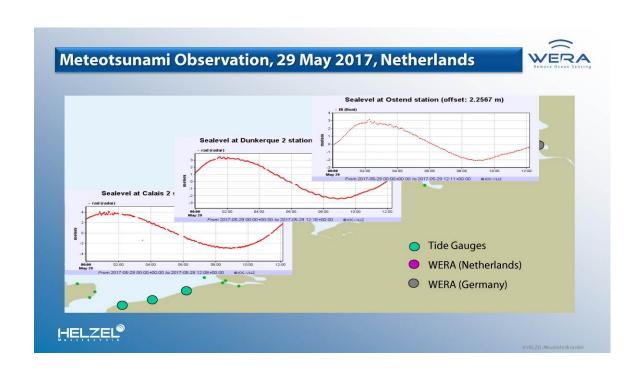


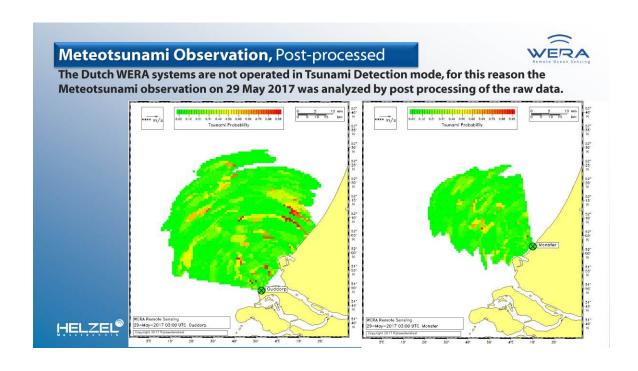












4.4 臺灣(Taiwan)玉豐海洋科儀公司(DWTEK)展場

話說能在英國見到臺灣廠商的那種感覺十分親切,臺灣玉豐海洋科儀公司(下稱:玉豐公司)過去曾經執行本所港研中心海底電纜財務採購服務,因此對港研中心來說並不陌生,身為臺灣唯一參展的廠商,此次來到南安普敦當然要順道過去打氣,如圖 4.7。提到玉豐公司就要不得不說到創辦人張碩文他兒子張乃仁,張董本是間螺絲的製造商在臺生產專業螺絲 40年,2008年正逢金融海嘯,因此讓張董產生企業轉型的念頭,由於張乃仁經理平時就對水下學研究十分著迷,特別是水下攝影機(ROV)的開發研究,時常想像國人自製研發的儀器有朝一日能成為海洋界的勞斯萊斯,張經理終於在那個海洋產業並未蓬勃發展時,說服老爸張董轉型製造高階科技產品。





圖 4.7 玉豐海洋科儀公司(Taiwan)與張乃仁經理展場碰面

張經理轉述玉豐致力於水下機電,旗下水下攝影機已經成功潛至深海 8,000 公尺水深,未來將持續精進,努力整合臺灣資源,打造亞太地區水 下機電的金字招牌,今天來參展就是來執行全球市場佈局的,但他坦言大 環境仍未見轉好,無奈神情全往臉上擺,臺灣加油!



4.5 美國 Teledyne Marine 公司展場

美國 Teledyne Marine 公司為本次展場中會場最大的公司,該公司屬於 Teledyne Technologies 集團下的分公司, Teledyne Technologies 集團跨足太空航太、軍事國防電子、環境海洋、能源、化學、生物等領域,該公司所研製的 Teledyne RDI ADCP 本所港研中心 20 幾年前吳基、林受勳等研究人員曾經使用過,如圖 4.8 所示,該儀器可以在吵雜背景環境與高濃濁度中進行量測且不受干擾,常用於石油公司海上平臺環境,單點測量準確度很高,缺點是該儀器的價格較高。由於外國國家人民普遍支持海洋研究,很少發生漁民捕撈造成儀器遺失,反觀我國國情緣故常發生漁民捕撈,造成儀器遺失問題頻傳,因此本所港研中心近幾年來改採用挪威 Nortek 公司的 AWAC,實在因為挪威公司的產品較為便宜。



圖 4.8 美國 Teledyne Marine 公司與其旗下產品

4.6 實際操作展演

有關水下無人載具現已逐漸取代潛水人員,而成為水下作業的主流, 儀器可隨探勘目的與需要額外加裝機械手臂等配件,外型像個小型的潛水 艇或流線型的水雷,由於儀器大多為低耗能,而且設有太陽能板不需要電 纜連接母船,已經適合長期性、例行性或危險性的工作,現階段自主式的 儀器,已經具有感測、判斷以及行動的功能,各家廠商趁此機會無不使出 渾身解數向參觀者展示儀器的性能,如圖 4.9 所示。





圖 4.9 南安普敦港實際操作展演

4.7 展場中的花絮:葡萄酒與大提琴

直擊 Ocean business 展場,你會發現很多驚奇的事物,記得當天與 Lucy 教授於南安普敦會場碰面後,進行後端雷達訊號分析討論會議,結束之後不知時間已晚,發現奇怪人手上一杯葡萄酒在進行寒暄社交,事後才知道葡萄酒會是 Ocean business 的傳統,彼此之間透過這樣的聚會,彼此可以洽談商業活動,包括儀器代理合約、合作計畫研究等,但最令我興奮的事情,居然連大提琴都搬到會場來,在美酒與音樂的催化下,不知已經談成多少生意,如圖 4.10 所示。





圖 4.10 展場中的葡萄酒與大提琴

五、相關工程技術活動參觀

5.1 赫爾辛格港(Helsingør Nordhavn)

Helsingør Nordhavn 又稱 Helsingør North Harbour(北港)鄰近克倫堡,赫爾辛格是個市政遊艇港約有 1000 個泊位,是由赫爾新格漁港改建而成,丹麥政府 1932 年至 1934 年保留一部分漁港一部份改建成遊艇港,並於1970 年擴建成今日規模,在觀光需求的帶動下,北歐丹麥 Helsingør 與瑞典 Helsingborg 交通運輸航線相當密切,民眾可由丹麥購買船票連人帶車上船前往瑞典觀光。

實際到訪此處您會實際感受到厄勒海峽的強風,浪高目視 1m 以上,海流目測 2m/s,遊客難於行走,海鷗更是難以保持平衡,幾乎無法飛行,直接停留在原地。令人注意是赫爾辛格港的港口外的防波設施,非常特別直接引起了我們的興趣,如圖 5.1 三相防波設施圖,第一種保護措施是混凝土結構的防波堤,次類結構物屬於一般剛性的保護措施直接抵抗波浪的衝擊力,為常見的港埠結構,缺點是入射波浪幾乎全反射,結構物承受波壓甚大,當波高水位增大時,結構所受重複波的力量太強容易損壞,第二種是拋塊石保護措施,其消波原理是利用拋石間的孔隙形成緩衝墊,以及允許海水一部分透射進入孔隙中改變波浪的入射角度,一部分反射,將海水的衝擊力轉換為摩擦力,以及以滲透形式吸收重複波力量,同時可保有親水性的環境,第三種是反水牆保護措施,這種保護措施比較少見,這種設



圖 5.1 赫爾辛格港三相防波設施圖(混凝土結構式/拋塊石/翻水牆)

計立牆外側有一內凹曲面,如圖 5.2 翻水牆,如此一來當波浪來襲時,即 可減少越波翻牆的機會,本所港研中心曾經在臺 11 線花東海岸公路建議 採用此類設計規劃,目前成效良好,能有效降低波浪翻牆越波,增加汽機 車用路人行車安全,故同地點同時具有三種設計的港口相當罕見,特別在 此介紹說明。



圖 5.2 赫爾辛格港翻水牆照

5.2 英國南安普敦港(Port of Southampton)

南安普敦港地處英國南岸中心,是本次出國行程中的必經之地,介於 泰斯特與伊欽兩河之間,外側有懷特島作為保護,港擴水深,可作業進港 時間長,該港得利於優越的自然條件,吸引無數客貨船來往,貿易經濟十 分發達,南安普敦港與周邊照片,如圖 5.3。





圖 5.3 南安普敦港與鄰近船舶主題公園

該港自世界大戰開始承擔了後勤補給線的地位,經濟歷經多次轉型,

由早期穀物與菸草加工,演變成為航運重鎮,再轉型為工業生產、石化與電器生產中心。據悉(訊息來源:英國 HR Simon 提供),南安普敦環境優美,古蹟保存良好且外有懷特島可供觀光,也是珍珠的盛產地,尤其是奧斯本宮(Osborne House)更是維多利亞女王最愛前往渡假休閒的去處,是英國著名的渡假勝地。

另一個必須提到的事,就是英國皇家郵輪鐵達尼號(RMS Titanic),鐵達尼號的首航係由 1912 年 4 月 10 日南安普敦港起航前往紐約,但未抵達目的地於 1912 年 4 月 15 日沉沒於大西洋,其航線如圖 5.4 所示,當時因為鐵達尼號未有足夠的救生設備導致無數人員喪生,促使「國際海上人命安全公約(SOLAS)」修訂公救生艇和其他救生設備的數量以及安全規程。





圖 5.4 英國皇家郵輪鐵達尼號與航線圖

5.3 瑞典 Lillgrund 離岸風場與奧瑞桑橋(Øresundsbroen)

從哥本哈根凱斯楚普機場(Copenhagen Kastrup International Airport)返回法國戴高樂機場的轉機的時候,我注意海面有兩件重要事情,第一件事情是離岸風力發電機分佈非規則分佈,由照片計算海面風機共有 48 座,(由左到右依次 1,1,2,2,3,2,3,3,4,4,4,3,3,4,3,2,1),經查詢相關文獻,符合該數量且處於厄勒海峽南側的風場為瑞典 Lillgrund 離岸風場,如圖 5.5,每座風力發電機 2.3MW,總裝置容量達 110MW。



圖 5.5 瑞典 Lillgrund 離岸 風場 (西門子 SWT-2.3-93型,葉片直徑 93m,風機總高度 115m)

第二件事情是連接丹麥與瑞典國家的奧瑞桑橋(Øresundsbroen)又稱厄勒海峽大橋或歐雷松德大橋,這個工程曾經被美國國家地理頻道系列節目介紹過,該橋目前是歐洲最長的鐵路公路隧道,從機場起飛後你很難不被他吸引,這座橋的特點是由瑞典行車前往丹麥,行經至跨海大橋,竄入地底隧道,再抵達丹麥哥本哈根,圖 5.6 奧瑞桑人工島與 Google map,其中橋樑連接隧道與人工島設計是工程團隊的設計巧思,其目的有二,確保厄勒海峽航道可讓大型客輪自由通行,在這樣的想法基礎,巧妙的利用人工島將橋樑與海底隧道連接在一起,人工島是挖掘隧道所產生的土方,將去化的土方填海造島,成功的創新突破使彼端兩的交通時間縮短,由船運的60 分鐘縮短為 10 分多鐘。





圖 5.6 厄勒海峽 Google map 與奧瑞桑人工島

奥瑞桑大橋全長 7.845 公里,隧道長 3.51 公里,加計明隧道 0.54 公里,總長 11.895 公里,北歐風格之斜張外型係由著名建築師 Georg K.S. Rotne 所設計,如圖 5.7 所示,為簡約北歐風格奧瑞桑大橋現況。該橋 2,000 年正式通車,通車初期使用運量並不如預期,加上高額的建造價格,因此不斷受到國人質疑,直到丹麥人前往瑞典置產,才使運量有顯著增加,探究其背後之可能原因,可能係瑞典馬爾默房價物價較丹麥哥本哈根低導致。



圖 5.7 奥瑞桑橋 Georg K.S. Rotne 與人工島 (照片來源 bbs.voc.com.cn)

六、交流活動心得與建議

本次出國計畫配合行程 10 天內前往英國、丹麥等地,不論參加海洋 年度儀器盛會、進行專題研究、參觀水工模型實驗室以及許多碼頭設施, 無不受益良多,深覺與外界交流的重要性,一部分可作為檢討手邊業務之 參考與借鏡,另一部分可以自我反省研究方向與盲點,並有改善工作態度 及強化自身動機,下就各項技術與交流活動提出心得與建議:

(一)、專題討論與相關研究應用心得:

本次出國計畫洽逢 Ocean business 因此許多海洋領域的廠商都來此地匯集,因此可以利用時間與教授及原廠技師進行專題討論,有關陣列雷達後端分析處理之研究討論,Lucy 教授建議參考 D.E. Barrick 與 J.J. Green 的研究文章,臺中港海洋雷達系統訊號品質很好,基於單站理由無法解算合成向量的波、流與風,建議以徑向方式作為討論,如果需解算合成向量的大小,將喪失部份空間資訊,建議增加接收天線的數量或於臺中港內增設第二站,才能有效解決問題。

德國 WERA 應用雷達波進行海嘯預警,能即早進行危險區域人員疏散,降低海嘯生命與財產傷害,該系統可作為臺灣研究團隊預警系統研發的借鏡,有關海洋雷達應用船舶追蹤部分,臺德兩國皆可實現雷達波偵測船舶動態之目的,未來如有共同合作機會,將有助於彼此間雷達技術的發展。

丹麥 DHI 船舶繫纜的問題已經獲得解決,並成功於 Mike21 的架構下開發出 MA(Mooring Analysis)模組,且以澳大利亞港為例,進行港區優化管理,並獲頒港務管理單位頒發的獎項,未來本所港研中心即將轉型為運輸研究中心,針對航運管理及碼頭用量優化等迫切需求,未來可與丹麥團隊進行合作評估,以作為交通部政策擬訂或港務公司未來營運之參考。

(二)、Ocean Business 2019 心得:

從大學到現在從事海洋研究多年已將進十年,拜科技發展之 賜,海洋調查的方式與範圍比從前進步很多,現代化的調查方法, 讓我們有機會窺探海洋的全貌,此次有機會參加 Ocean Business 2019 這才意識到這十年間的研究方向已經轉向,國外的研究團隊逐漸轉向重視「海水酸化」議題,經過交流討論才知海水酸化與氣候的關係如此密切,自然海水原偏弱鹼性,其 PH 值約在 7.9 至 8.4 之間,然而在 18 世紀工業革命之後,越來越多石化產品被過度使用,二氧化碳被釋放回到大氣,透過降雨溶解作用,二氧化碳逐漸回到海洋,導致 200 年後的海水 PH 值下降了 0.1,海水的 PH 值降低至 7.8 左右,因此有研究認為海水酸化將造成珊瑚死亡加劇,造成海洋生態鏈的斷裂,影響海洋生態鏈的完整性,終將導致許多生物的滅絕。就因海水酸化程度與大氣中二氧化碳濃度成正本比,因此海水越酸大氣中二氧化碳濃度越高,地球就越顯暖化,雨量分配將更加極端,洪澇事件比例增高,氣候就越不穩定,這就是為什麼海洋學家近幾年越重視此議題的原因,本所港研中心基於交通部職掌轄管商港範圍的海氣象調查,對此未來有機會應針對海水酸化議題加以研究,未來港埠發展才會通盤且全面。

(三)、相關工程技術活動參觀心得:

經濟貿易的繁榮與港區碼頭的發展息息相關,每個港口都有著不同的設置目標,不論是捕釣魚、經濟貿易或休閒光觀都需要堤防保護,丹麥人發揮創意王國的專長,將不同類型的堤防設置於赫爾辛格港內外周邊區域,從工程的角度來看這樣的設計方式並不利於現場施工與驗收,但從結果來看該港區發展理念兼顧多功能之需求,尤其是碼頭翻水牆的工法設計十分罕見,值得我國借鏡參考。

離岸風電計畫自 106 年起執行至今,已進入第三個年頭,卻未能眼見離岸風場,一直以來十分好奇,本次出國計畫終於由丹麥返程時順利見到瑞典的離岸風場,以瑞典 Lillgrund 風場為例,每座風機約 2.3MW,該風場 48 座離岸風機僅能提供 110MW,故臺灣 2025年計畫達成 5.5GW 的裝置容量目標,相當需建設 50 座瑞典 Lillgrund風場,為避免臺灣海峽過於壅塞,每座風機發電機組之狀置容量需朝向大型化邁進(4MW 或以上),但考量臺灣地區平均受到 3~4 個颱風侵襲,是否能經得起天候的考驗,國人仍拭目以待。

奥瑞桑橋曾經獲選為國家地理雜誌人類史中偉大工程之一,也 是國際合作成功的案例之一,該工程人工島的設計十分令人驚艷, 完美解決隧道挖掘土岩方去化的問題,不僅成為中國港珠澳大橋的 借鏡(2018年10月24日通車,現為全世界最長跨海橋隧組合公路), 也成為未來中國解決臺灣海峽交通問題的選項,雖然此議題牽涉許 多政治問題,但從工程的角度來看已經可以實現,而且此工程造價 相較全面海底隧道更加經濟。

(四)、交流心得與綜合建議:

- 1. 本次出國計畫參加 Ocean Business 研討會與專家學者針對現場海氣象 觀測及海岸漂沙機制調查技術發展方面,進行心得討論,並交換意見, 對於個人擴展視野及本所研究業務均有實質之幫助。
- 2. 利用海洋雷達進行港區航船的安全管理,國際間已經有許多成功的案例可供我國的借鏡,國內雖處於起步階段,但各國學者專家仍給予寶貴建議,德國海洋雷達研究人員建議臺灣訊號分析時,可以針對時間的連續性改善船舶目標判斷的誤差。
- 3. 英國 Lucy Wyatt 教授對於陣列雷達後端軟體之處理分析,針對特徵值造成判斷失誤的可能原因提供以下建議,雷達訊號包含許多不同的分量、重複反射訊號以及雜訊,建議持續觀察與蒐集,取得該地區長期的雷達訊號,以確認是否為固定雜訊,並將其由頻譜中剔除,應該能改善海洋雷達觀測的結果。
- 4. 丹麥 DHI 原廠進行數值模式實地操作訓練與作業技術指導,建議於頻 域轉時域過程,改善與實測資料比對的精度,藉此增加模式模擬時的命 中率,應能減少模式模擬時產生的誤差。
- 5. 建議臺灣未來的海岸或港灣開發要多方面整體考量,規劃上必須考慮產業、生態、景觀、永續與城市競爭力等面向,港口轉型之際,港務管理單位仍需重視管理與整體規劃之重要,以創造價值,並避免腹地閒置浪費。

附錄 A 英國南安普敦 Ocean Business 2019





More than just a static exhibition...

Ocean Business is unique.

Not only can visitors meet face to face with 330+ exhibitors from across the globe, they can also see the latest products and services first hand with over 180 hours of free to attend live demonstrations held on-board vessels, in dockside waters, in a test tank and in classrooms.

Visitors can also attend the Offshore Survey conference and a variety of free to attend co-located meetings held by leading organisations in the industry.

Social activities will also run alongside, providing all important networking opportunities with colleagues old and new.





The exhibition training & demonstration sessions, co-located meetings, welcome drinks and wine trail are free to attend. There is a fee to attend the Offshore Survey of consequent Open Parisage drinks.





Join more than 5,000 visitors from over 60 countries

International Exhibition

See the latest product launches from 330+ international exhibitors

Training & Demonstrations

Get hands-on with 180+ hours of training and demo sessions

Offshore Survey Conference

Hear from industry experts addressing the major issues facing the international offshore survey community

Co-located Meetings

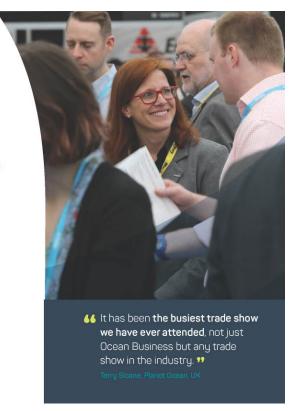
Attend co-located meetings and seminars organised by independent groups or organisations in the industry

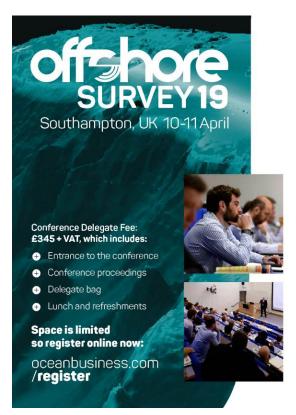
Ocean Careers

Discover opportunities and meet potential new employers at this three-day careers event held alongside

Social Activities

Network at social events held throughout the show





Offshore Survey is a technical conference focussing on the technology, operations and business issues in the global field of offshore surveying.

The 2019 conference has a great line up of papers covering autonomous and unmanned vehicles, imaging, data and future perspectives, amongst others. Two days of inspiring, intriguing and thought provoking sessions that offers an insight into innovative technologies, case studies and reality checks as well as some insight on the future potential of offshore surveys.

Sessions include:

- Autonomous Vehicles and Vessels
- Future Industry Perspective
- Satellite Derived Products
- Coast and Environmental
- Imagery and Visualisation
- Education and Competencies
- Data and Digitalisation





International Exhibition



The global show with more than 330+ exhibitors showcasing the lastest in the industry...











Training & Demonstrations

180+ hours of free to attend live demonstrations



Tuesday 09 April

Test Tanks 1 & 2

RJE Oceanbotics Oceanbotics SRV-8 ROV with 8 thrusters - agility, manoeuvrability, speed and

Data-download from submerged lander with ROV using LUMA250LP optical modem

Atlantas Marine

VideoRay's mission specialist series underwater ROV technology

Outland Technology ROV 2500 demonstration

Teledyne SeaBotix

Advantages of the vortex thrust technology for underwater inspection

Deep Trekker DTG2 ROV 4K, and sonar. DTX2 ROV 4K, 300m depth

Saab Seaeye ROV demonstration

develogicPopup telemetry solutions - compact seafloor lander combined with popup data ferries with iridium data transmission

Docksides 1 & 2

Kongsberg Maritime Live demo of the GeoPulse Sub-bottom Profiler USV

CoastEye Mini-Buoy - portable water quality monitoring buoy for estuarine and coastal environments

Chelses Technologies Group Pollution monitoring from sewage to oil in water using the CTG lux range of flurometers

Real-time access to multi-parameter water quality data through Wi-Fi and inductive modern technology

Kongsberg Maritime Flexview: multibeam sonar for observation class ROVs

CHC Navigation

Autonomous bathymetric surveying using CHC Apache 5

Maritime Robotics
Otter USV with mutibeam echosounder

Teledyne Oceanscience /SeaBotix Civil engineering demonstration

L3 ASV Global

An autonomous vessel demonstration showcasing state-of-the-art inspection techniques

DWTEKDWTEK / advanced navigation ROV and subsea navigation system demonstration

dotOcean Situational awareness on a cloud linked ASV swarm

Seafloor Systems
EchoBoat ASV G3 vehicle with integrated multibeam echosounder, QuickCast SVP cast system, and our ULARS – USV Launch and Recovery System

Vessels

Operation and data presentation of SWiFTplus multi-parameter profilers

Live demonstration of the Nortek vessel mounted current profiling system

Rockland Scientific On-vessel demonstration of the MicroCTD turbulence profiler

Geomatrix Earth Science
Demonstrating the new GeoEel LH-16
ultra high resolution digital streamer
by Geometrics

Klein Marine Systems

Don't miss the opportunity to see the newest Side Scan Sonar technology from Klein Marine. Understand why 'The difference is in the image!'

Sea-Bird Scientific
Improvement in active optical sensing

Kongsberg Maritime Multibeam solutions for bathymetric and imaging applications

Sea-Bird Scientific

Latest developments in Ocean pH technology

Kongsberg Maritime Advances in remote survey and AUVs

EdgeTech Introducing the EdgeTech 3400 sub-bottom profiler

Maximising DVL and current profiling data quality from moving platforms

nke Instrumentation

The WiSens logger range: more sensors and more capabilities in physico-chemical monitoring

Teledyne Bowtech New laser range gated camera and GIGE camera

Tritech International
Demonstration of tritech sensors and tools for ROV and AUV



Tuesday 09 April

Turner Designs
Environmental monitoring utilising
fluorescence spectroscopy: successful
vehicle integrations

Xylem
Measuring waves from surface to seabed
with the MOTUS and the new SeaguardII
DCP Wave/Current Profiler – comparison

SubCtech

Demonstration of latest pC02 flow-through and in situ measurement systems

The Integrated Sediment Profiler (ISP), a parametric system operating at frequencies between 5kHz and 20kHz and the beamwidth is ±1.5°

Teledyne RD Instruments New technology for long range current

PanGeo Subsea Application of PanGeo's technology for mitigating risk for Offshore installations and creating value for seabed survey

Teledyne GaviaAUVs from littoral to deep ocean (Gavia, Osprey, and SeaRaptor overview)

International Submarine Engineering 1-10m Altitude AUV Survey: How the Explorer can collect specialised low altitude data and images

RJE Oceanbotics Oceanbotics SRV-8 ROV with 8 thrusters - agility, manoeuvrability, speed and strength

Teledyne MarineTechnologies enabling the progression of manned submersibles

L3 OceanServer Innovative UUV software: new vectormap (VM) and underwater vehicle console

SeaBat T-Series: multiheam sonar configuration minimising processing time and a better use of resources

Teledyne Reson/BlueView/Bowtech Subsea sonars portfolio including Bowtech cameras, lights and the new Teledyne RESON T50-S

Sonardyne International

Fusion 2 – next generation; combined LBL and INS software

Bibby HydroMap High-resolution 3D marine asset inspection surveys for coastal monitoring

Teledyne Bowtech New underwater communication system

Kraken Robotics Systems An introduction to high speed interferometric SAS: how I learned to stop worrying and love the resolution

Teledyne Caris

Applying machine learning and automation to gain efficiencies in data processino

NaviSuite software enables automatic object detection, SLAM technology for real-time point clouds and mesh from a single camera, and tracking of underwater

Atlas Professionals
The Atlas Competence Programme
assures competency within a function/
field of expertise through a recognised competence programme

Delivering complex multi-disciplinary high resolution surveys

Foreshore Technology
Customising DredgeMaster to handle
unique monitoring and data entry
scenarios, DredgeMaster Web real time
data for vessel/shore fleet management

QPSEnhanced visualisation and analysis with the all-new Fledermaus 8

Anexonect
Design of X-mas Tree Cable Assemblies
- Wet Mate PBOF assemblies, using
web-based application, without the need
for any CAD software/skills

develogic Acoustic and seismic signal recording systems - for marine mammal population assessment, construction noise monitoring and tsunami early warning

Classify ocean sounds with smart arrays whether static, drifting or towed using the icListen and its new smaller platform

Teledyne Reson/Blueview
Inspecting with the new Teledyne Reson
T20 MotionScan and Teledyne Blueview

CHC Navigation Automonous bathymetric surveying using CHC Apache 5

INNOMAR Technologie Innomar SES-2000 smart SBP for USV integration

SBG Systems
SBG systems full inertial solution
(hardware/post processing software

Training & Demonstrations

180+ hours of free to attend live demonstrations



Wednesday 10 April

Test Tanks 1 & 2

Blue Robotics Blue ROV2 demonstration

Atlantas Marine VideoRay's mission specialist series underwater ROV technology

Data-download from submerged lander with ROV using LUMA250LP optical modem

RJE Oceanbotics Oceanbotics SRV-8 ROV with 8 thrusters - agility, manoeuvrability, speed and strength

Outland Technology ROV 2500 demonstration

Deep Trekker DTG2 ROV 4K, and sonar, DTX2 ROV 4K, 300m depth

Imaging systems for seafloor landers: video assist deployment, still and video imaging systems, data telemetry

Docksides 1 & 2

Kongsberg Maritime
M3 Sonar PHS: Kongsberg's smallest
multibeam for unmanned hydrographic

Zunibal ANTEIA system, a compact wave buoy which gives real time wave information

Kongsberg Maritime Live demo of the Geopulse sub-bottom profiler USV

Seafloor Systems
EchoBoat ASV G3 vehicle with integrated multibeam echosounder, QuickCast SVP cast system, and our ULARS – USV Launch and Recovery System

Chelsea Technologies Group Green shipping initiatives for monitoring water to ensure vessels are fully compliant with global regulations

Teledyne Benthos Combined vehicle / positioning / acoustic comms demonstration

dot0cean

Situational awareness on a cloud linked ASV swarm

Maritime Robotics Otter USV with multibeam echosounder

INNOMAR Technologie Innomar SES-2000 smart SBP on dot0cean Calypso USV

An autonomous vessel demonstration showcasing state-of-the-art inspection techniques

DWTEKDWTEK / advanced navigation ROV and subsea navigation system demonstration

Geomatrix Earth Science Demonstrating the new GeoEel LH-16 ultra high resolution digital streamer by Geometrics

Klein Marine Systems
Don't miss the opportunity to see the
newest Side Scan Sonar technology
from Klein Marine. Understand why The difference is in the image!

Valeport Operation and data presentation of SWiFTplus multi-parameter profilers

Nortek Live demonstration of the Nortek vessel mounted current profiling system

Merine Sonic Technology ARC explorer MKII dual simultaneous high resolution side scan sonar

Edgetech New rugged acoustic release - features and advantages of EdgeTech releases

Kongsberg Maritime GeoPulse compact: a new lightweight / low power sub-bottom profiler

Sea-Bird Scientific
Expanding capabilities of biogeochemical sensors for autonomous and remote-operated systems including floats, AUVs, and ROVs

Kongsberg Maritime Multibeam solutions for bathymetric and imaging applications

Teledyne Vehicles

Integrated sustems for mine countermeasures: air and sea operational results from ANTX

Sea-Bird Scientific Real-Time Data Moorings using Inductive Modem Communications

Through-water optical communications for ROV-driven data retrieval and instrument control

2G Robotics A brief background on the tech used in 26's underwater laser scanners before teaching attendees how to effectively plan a dynamic laser scanning mission

RIEGL Laser Measurement Systems
An update on RIEGL's shipborne, airborne and UAV-borne topobathymetric solutions

In-classroom presentation of data collected from on-vessel demonstration of MicroCTD Turbulence Profiler



Wednesday 10 April

nke Instrumentation Ocean Environmental Sensorrs latest achievements in CO₂ and absolute density measurement

A technical description of the RBR inductive conductivity cell theory, calibration and performance

SBG Systems
Presentation of SBG systems full inertial solution (hardware/post processing software)

Details on TruePix™ that provides highly compressed water column imagery (1% of traditional water column imagery)

Teledyne Benthos Teledyne Benthos / iXblue collaboration

Xsens Technologies How to keep a stable heading in magnetic distorted environments

AML Oceanographic Removing the technical and financial unpredictability of surveying through underway profiling with MVP

Subsea Technology & Rentals An overview of STR's Seaspyder Drop Camera Systems

L3 OceanServer Learn how new OceanServer UUVs help complete difficult missions

Teledyne Oceanscience
Oceanscience Z-Boats - platform
enhancements to improve your
operational success (Z-1800 and Z-1250)

Pressure-tolerant, high-energy li-po battery solutions for deep-sea platforms and vehicles

Maritime Robotics
Otter USV with multibeam echosounder

EcoSUB/Planet Ocean AUV mission planning made simple, the ecoSUB way

Exocetus Autonomous Systems
Overview of the Exocetus MOD2 Glider

capabilities and features

Teledyne SeaBotix
Better performance, smaller footprint
- new power enhancements for Teledyne
SeaBotix ROVs

Teledyne Benthos Advanced acoustic communications -case studies from around the globe

Teledyne RESON
ParaSound sub-bottom profiler case studies in search for deep water resources

INNOMAR Technologie
Using a parametric 3D SBP for offshore site explorations

Sonardyne International Unlocking a world of ocean science applications with Ranger 2

Bibby HydroMap DriX - the future of hydrographic survey

Teledyne Odom/PDS Introducing the new Teledyne Odom EchoTrac E20 single beam

Teledyne Webb Research Slocum G3 Glider - latest innovations update

Atlas Professional
The Atlas Competence Programme
assures competency within a function/
field of expertise through a recognised competence programme

TechWorks Marine

Real-time data for dredging operations.
The use of in-situ and earth observation data for permits compliance

HELZEL Messtechnik Reliable MetOcean data in real-time for coastal management - latest news on ocean radar for current and wave

Autonomy and remote operations in EIVA NaviSuite. Learn how vessel/crew size can be reduced as well as for automated processing features

QPS
From beams to bENCs with QPS products

Aultipurpose electronic fisheries Logbook (eLog) and management solution

SeeByte

Demonstration of human machine

HYPACK, A Xylem Brand

Undersea, surface and aerial mapping solutions using HYPACK

Data transmission - smart, reliable

DECO / RadExPro
Processing of HR/UHR marine seismic: focus on demultiple

A tutorial on RBR's RSKtools, the open source Matlab tool box for visualising and post-processing CTD data

Maximising DVL and current profiling data quality from moving platforms

Geomatrix Earth Science Training session on the G-882 marine magnetometer GP120 digital altimeter

Kongsberg Maritime Underwater positioning sensing systems

Training & Demonstrations

180+ hours of free to attend live demonstrations



Thursday 11 April

Test Tanks 1 & 2

Outland Technology ROV 2500 demonstration

Teledyne Teledyne Underwater Optical Communications System

Blue Robotics Blue ROV2 demonstration

Hydromea Data-download from submerged lander with ROV using LUMA250LP optical modem

Atlantas Marine VideoRay's mission specialist series underwater ROV technology

Saab Seaeye ROV demonstration

Docksides 1 & 2

Chelsea Technologies Group Primary productivity measurements using the FastOcean and Act2 for probing phytoplankton photosynthesis

Kongsberg Maritime Dual axis scanning sonar for long term monitoring solutions

Kongsberg Maritime Live demonstration of the Geopulse Sub-bottom profiler USV

DWTEKDWTEK / Advanced Navigation ROV and subsea navigation system demonstration

An autonomous vessel demonstration showcasing state-of-the-art inspection techniques

Teledyne Oceanscience Autonomous survey options for every budget (Z-1800 and Z-1250)

INNOMAR Technologie Innomar SES-2000 smart SBP on dot0cean Calypso USV

Maritime Robotics Otter USV with multibeam echosounder

Vessels

Klein Marine Sustems

Nein Marine Systems
Don't miss the opportunity to see the newest Side Scan Sonar technology from Klein Marine. Understand why "The difference is in the image!"

Valeport Operation and data presentation of SWiFTplus multi-parameter profilers

Marine Sonic Technology ARC Explorer MKII dual simultaneous

high resolution side scan sonal

See the latest developments of the QAS⁴ Magnetic Transverse Gradiometer System with integrated sidescan sonar and SAMM data acquistion software

Classrooms

Kongsberg Maritime Underwater gas sensors and systems

Sea-Bird Scientific

Traceability of radiometric measurements in ocean colour validation

Mapping cloud: visualise, analyze and share multibeam data in real-time

EdgeTechNew features in the EdgeTech 4205 side scan sonar

Sea-Bird Scientific Measuring nitrate in fresh and salt water

Geomatrix Earth Science
Training session on the G-882 Marine
Magnetometer GP120 Digital Altimeter
Board

Prevco Subsea Housing
Prevco subsea housing design, material choices and accessories

Training and instruction on survey engine geophysical interpretation software suite

How to design an ASV or AUV? Simulation to Launch

For surveyors, coastal-engineers and planners: satellite info on bathymetry, seafloor, coastline and water properties. Reduce risks and increase efficiency

Ultra High Density (UHD): 1024 Otta High Density (DHD): 1024 soundings/ping. Ultra High Resolution (UHR): beam width down to 0.3° × 0.6° and Multimode. Providing full coverage multifrequency surveys in a single operation with a single system

XylemMeasuring waves from surface to seabed with the MOTUS and the new SeaguardII DCP Wave/Current Profiler - comparison

Teledyne RD Instruments Latest advancement in Doppler Velocity Log Technology, including extending Bottom Tracking Range (XRT)

Swale Oceanographiic
Using unmanned boats in discharge, bathymetry and water quality surveys



Delegates must be on site to reserve a place. Arrive early if you wish to attend morning sessions.



Thursday 11 April

SubCtech Demonstration of latest pC02 flow-through and in situ measurement systems

Teledyne SeaBotix SeaBotix SWIM-R: ROV enhancements for offshore oil and gas applications

Teledyne Vehicles TM vehicles enabled by autonomy

Swathe Services
USS will present the new accession class USV

Teledyne Webb Research Deep apex - profiling to 6,000m

Solutions for navigating and positioning underwater vehicles in aquaculture

Falmouth Scientific

High performance sub-bottom acoustic sources and transducers

Teledyne PDS/BlueView/Reson Marine construction inspection with RESON T20 MotionScan and Teledyne BlueView M900

Teledyne RESON/BlueView/PDS

Forward bathymetry with the new Teledyne RESON F30. Principles, use and applications

RTsys Underwater acoustic recording real-time assessing data swarm mode AUVs

The Atlas Competence Programme assures competency within a function/ field of expertise through a recognised competence programme

Latest capabilities and experiences with the ScanFish sensor platform, including using it for UXO surveys, the 3D steering option and how the XL version works with the PanGeo Sub Bottom Imager

Norcom Technology

Using electronic charts and data overlays to assist project planning

Wärtsilä ELAC Nautik Wärtsilä turnkey solutions for research and survey vessels

Pro-Oceanus Systems

Latest advancements for improved dissolved gas measurements

ROV and instruments without the need for any CAD software, with outputs of BOM, engineering drawing and a digitally search-able parameters

Teledyne TSSThe importance and benefits of cable and pipe tracking 'Target Scaling'

Marlin is a marine intelligence system that combines temporal project planning with 3D spatial situational awareness, and allows for playback and reporting

Autonomous survey with QINsy and Qimera

HYPACK, A Xylem Brand HYPACK 2019 latest features

RBR
RBRs system integration tools for RBR
CTD integration on OEM platforms. The
use of the OEM development kit, RBR
interface library, and dedicated Jira OEM
technical support

GeosoftShowcasing Oasis montaj and its application to offshore site investigations

CoastEue Mini-Buou - portable water quality monitoring buoy for estuarine and coastal environments

Sonar and ASVs for mapping bathymetry, seagrass, and substrate classification



Download the app now...

With so much FREE content over three days, the new Ocean Business App is a vital tool to help you plan your schedule.



Play Store, search for 'Diversified Communications UK'

Co-located Meetings

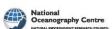
Leading organisations host FREE to attend meetings alongside

Tuesday 9, Wednesday 10 and Thursday 11 April Seminar Room



NOC Workshops and Seminars

Understanding the needs of the industry and delivering information that underpins it's objectives.



The NOC is the UK's leading institution for integrated coastal and deep ocean research. The Centre undertakes and facilitates world-class, agenda-setting scientific research to understand the global ocean by solving challenging multidisciplinary, large scale, long-term marine science problems to underpin international and UK public policy, business and wider societal outcomes.

This year, the NOC's key aims are to understand the needs of industry; and to demonstrate how the NOC's science and technology can be used to deliver information that can support and underpin industry objectives. This will be facilitated through their workshop and seminar programme, held daily throughout Ocean Business in their seminar room.

Find out more:

oceanbusiness.com

Sessions with focus on the following areas:

- The NOC's involvement with the South Coast Marine Cluster
- Ships and equipment chartering
- Marine science and technologu
- Marine data products



Wednesday 10 April Conference Room 344/32

Enterprise Europe Network B2B matchmaking event

Your chance to meet potential business and technology partners in one day!

- Are you looking for new customers, partners or financiers for your company?
- Are you looking for new potential partners to develop your business and research objectives?
- Are you seeking partners to adapt your technology for dual-use applications?
- Or maybe you just want to boost your innovativeness?

This free to attend matchmaking event will give you the opportunity to meet potential business partners during pre-arranged 20 minute meetings and create real business development opportunities with both exhibitors and visitors, active in the maritime sector. Your agenda will be sent to you one week before the event with the exact time and location of your meetings.

Participants are asked to register online in advance:

oceanbusiness.com



Co-located Meetings

Leading organisations host FREE to attend meetings alongside

FREE TO ATTEND

Science, Policy and Blue Growth in the Atlantic at the ATLAS Workshop

Wednesday 10 April Room G1

Free and open to all, the EU ATLAS Horizon 2020 project warmly invites exhibitors and delegates to participate. Representatives with interests in marine spatial planning (MSP), blue growth sectors, and policy and regulation are especially without the sectors.

ATLAS is a four-year project with partners from multinational industries, small and medium enterprises (SMEs), governments and academia. Together, these partners are assessing Atlantic deep-sea ecosystems to create the integrated and adaptive planning products needed to support

sustainable blue growth, marine conservation and resource use in the context of a changing climate.

The workshop will showcase the initial results from the 'Industry reactions to ATLAS recommendations' study and provides the opportunity for exhibitors and delegates to join the discussion and share perspectives.

Find out more:

oceanbusiness.com



FREE TO ATTEND

Key Enabling Technologies to drive innovation and competitiveness in your business

Tuesday 9 April, 10.00 - 12.00 Conference Room 344/32

As a partner in the European project KETMaritime, Marine South East will be presenting information and case studies on key technologies, such as: micro and nanoelectronics; nanotechnology; industrial biotechnology; advanced materials; photonics; and, advanced manufacturing technologies, which can assist maritime companies in bringing new processes, products and services to market.

The workshop will include discussion of case studies to enable firms to understand how some of these technologies could directly assist their business. The event would be of interest to both SMEs and larger companies who sare interesting in learning about Key Enabling Technologies that could transform their business.

Participants are asked to register online in advance:

oceanbusiness.com





Are you interested in BlueTech clusters?

Monday 8 April, 12.00 - 17.00 Lecture Theatre

BlueTech Clusters bring together the Triple Helix – academia, industry and policy makers – to create a "Blue Voice" region-by-region, country-by-country. The BlueTech Cluster Alliance (BTCA) - Ten leading BlueTech Clusters from eight countries – will meet at Ocean Business 2019 and invite anyone interested in BlueTech clusters to join us. We will discuss how BTCA member clusters and member companies collaborate and explore ways we can work with developing clusters globally.

Find out more:

oceanbusiness.com



UK Hydrographic Society AGM

Wednesday 10 April, 14.30 Room G2

All fully paid-up individual and corporate members are invited to attend. Please come along and have your say on the future of the

Find out more:

oceanbusiness.com





Discover job opportunities and gain career advice in

marine science and ocean technology whilst networking with leading industry experts and prospective employers www.oceancareers.co.uk



Social and Networking Opportunties

We understand the importance of networking with collagues old and new so we organise the following to help with those all important informal get togethers:

Welcome Drinks

Pitcher & Piano Southampton S014 3JB 8 April 2019 18.00 - 19.30

Wine Trail

The Exhibition Floor 9 April 2019 1700 - 1900

SOLD OUT!

Ocean Business Dinner

Southampton Harbour Hotel Southampton SO14 3TL 10 April 2019 19.00 - Midnight

Top up your CPD Points

Claim accredited CPD hours at the training & demonstration sessions or conference, which have all been formally recognised as professional development.

Download the Show App...



Visit the App Store or Google Play Store, search for 'Diversified Communications UK' and look for the app icon.



附錄 B 技術交流資料

(一)海洋雷達後端處理系統介紹:





Seaview Sensing Software

Lucy R. Wyatt

Seaview Sensing Ltd and School of Mathematics and Statistics University of Sheffield

email: lucywyatt@seaviewsensing.com



1

Outline

- Seaview Sensing Ltd
- What are we measuring and why?
- What methods are available?
- The Sheffield-Seaview method
- Accuracy and limitations
- The software package
- Some examples

References are indicated with [n] and listed at the end.



2

Seaview SensingLtd

- Established in 2004 to commercialise software developed at University of Sheffield
- Small team of consultants undertaking research and software development, installation, support.
- Our software provides surface current, wave (including the directional wave spectrum), and wind (wind speed less robust) accessible as file downloads and via a Data Viewer.
- Software has been installed on systems in UK, France, Germany, USA, Australia, OMAN, Turkey
- Data has been processed on our servers from radars in UK, USA and Korea.



3

What are we measuring and why?



from Pierson et al. 1955 [26]



The sea surface can be described by waves of different amplitudes, wavelengths (or frequencies) propagating in different directions - a directional spectrum $S(k,\theta)$ ($S(f,\theta) = S(k,\theta) \times \frac{dk}{df}$). From this we can determine:

- Energy spectrum $E(f) = \int S(f, \theta) d\theta$,
- Significant waveheight $Hs = 4 \times sqrt(\int E(f)df)$,
- Mean period $T_1 = \frac{\int E(f)df}{\int fE(f)df}$
- Mean direction $\theta_m = \tan^{-1} \frac{\int \int S(f,\theta) \sin(\theta) d\theta df}{\int \int S(f,\theta) \cos(\theta) d\theta df}$

and many other parameters.e.g wavepower and energy period, all using standard methods.

What are we measuring and why?

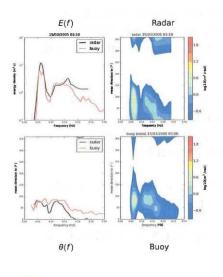
Waves are categorised as:

wind waves – generated by the local wind. **swell** – generated a long way from the observation point.





What are we measuring and why?



Example of a directional spectrum.

The larger lower frequency (higher period, longer wavelength) peak, 0.06Hz, is swell.

The higher frequency peak, 0.12Hz, could be the wind wave peak although there is evidence of higher frequency waves, > 0.2Hz, in a different direction (spectrum is multi-modal).



6

What are we measuring and why?

Wave data are important for:

- Design, maintenance and monitoring of coastal structures e.g. piers, harbours, breakwaters, wind farms, marine renewable installations;
- Operational assistance for coastal construction projects;
- Monitoring severe weather conditions, storm surge forecasting;
- Beach erosion and sediment transport;
- Baseline data for monitoring the impact of climate change;
- Oceanographic research,

...



3

What are we measuring and why?

With the radar we are measuring the magnitude of backscattered signal from the sea surface Doppler shifted by waves of half the radio wavelength - Bragg scattering.

Wave measurement is possible because non-linear wave-wave interactions generate such waves propagating at different speeds from the linear waves used for surface current measurement.

Non-linear electromagnetic-ocean wave interactions also contribute but are less important.

These two mechanisms are described by a non-linear integral equation.



8

What are we measuring and why?

Barrick's equations

The basic measurement is the power spectrum of radar backscatter, $\sigma(\omega,\phi,d)$, which is the sum of the first $\sigma_1(\omega,\phi,d)$ [5] and second $\sigma_2(\omega,\phi,d)$ [4], [6], [3] order parts of the spectrum:

$$\sigma_1(\omega,\phi,d) = 2^6\pi k_0^4 \sum_{m,m'=\pm 1} S(-2m'\mathbf{k}_0) \delta(\omega - \sqrt{2gk_0\tanh 2k_0d})$$

$$\sigma_2(\omega,\phi,d) = 2^6\pi k_0^4 \sum_{m,m'=\pm 1} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |\Gamma|^2 S(m\mathbf{k}) S(m'\mathbf{k'}) \delta(\omega - \sqrt{gk \tanh kd} - \sqrt{gk' \tanh k'd}) dpdq$$

where

 $\mathbf{k}_0 = (k_0 \cos \phi, k_0 \sin \phi)$ is the radio wavenumber at bearing ϕ ,

 $\mathbf{k} + \mathbf{k'} = -2\mathbf{k}_0$ Bragg condition,

 $|\mathbf{F}|^2$ coupling coefficient containing the physics associated with 2nd order hydrodynamic and electromagnetic processes, d is water depth, $S(\mathbf{k}) = \frac{S(k,\theta)}{k}$ and $\mathbf{k} = (p-k_0,q)$.

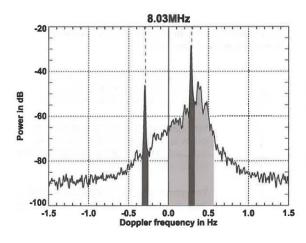
Our aim is to solve for $S(\mathbf{k})$ and/or parameters thereof.

d is water depth,
$$S(\mathbf{k}) = \frac{S(k, \theta)}{k}$$
 and $\mathbf{k} = (p - k_0, q)$.



What are we measuring and why?

The Doppler spectrum



Pisces measured Doppler spectrum.

2 first order Bragg peaks - darker shading.

Second order around higher Bragg peak lighter shading.



10

What methods are available?

• Short-wave (wind) direction and spreading – from σ_1 .

[22], [11], [35], [28]

• Highly linearised or empirical estimates of waveheight, period, direction and E(f) – from σ_2 normalised by σ_1

[2], [1], [23], [31], [12], [34], [8], [27]

• Integral inversion – from σ_2 normalised by σ_1 [20], [21], [32], [14], [24], [13], [33], [29]

These methods have been applied to single and/or dual (or more) radar data.

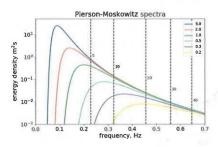


11

What methods are available?

Short-wave (wind) direction and spreading

These methods make the assumption that the first order Bragg waves are local wind waves aligned with the local wind direction.



Pierson-Moskowitz ocean wave spectra [25] for the significant waveheights (metres) indicated.

Vertical dashed lines show the 1st order Bragg-matched linear wave frequencies for the radio frequencies (MHz) indicated.

The short-wave assumption is best at high frequencies and high sea-states.



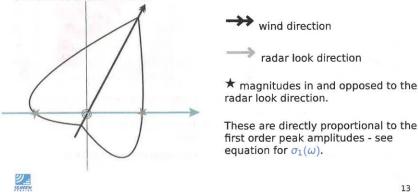
12

What methods are available?

Short-wave (wind) direction and spreading

Assume a short wave directional model e.g. $D(\theta_w,s)=\cos^s\frac{\theta-\theta_w}{2}$ or $D(\theta_w,\beta)=\mathrm{sech}^2\beta(\theta-\theta_w)$ where θ_w is shortwave or wind direction, s or β describe the spreading about θ_w and $S(f_{sw},\theta)=E(f_{sw})D(\theta_w,spread)$.

Sometimes the spread is set to a fixed value e.g. s=4 is quite common, sometimes both are found.



What methods are available?

Linearised and empirical methods

Barrick [2] showed how and under what conditions his equations could be linearised to obtain a weighted linear relationship between σ_2 and E(f) thus confirming the suggestion of Hasslemann [9].

This has motivated other similar methods mostly involving modifications to the weighting using empirical methods (buoy data) [12], [8], [27].

At the time it was claimed that the result was independent of wave direction but this was subsequently questioned [30].

Others have derived empirical expressions for Hs, T1 by comparing integrals (possibly weighted) of σ_2 with buoy data [23],[31], [34].

In general these methods:

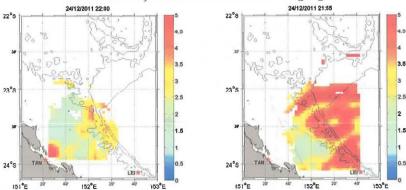
- cannot account for changes in water depth
- are sensitive to changes in wave direction, are often calibrated using buoy data for the local wave conditions and dominant directions and are thus not generally transferrable to other locations.



14

What methods are available?

Sensitivity to direction and averaging



Very different waveheights from the two radar systems looking at the sea from different directions. Need to combine information from at least 2 radars (or possibly different directions or frequencies) to get accurate measurements. More averaging also needed.

NB the above data are obtained with the standard WERA algorithm.



15

What methods are available?

Inversion

This involves simplifying [19] and discretising the equations, in some cases linearised by assuming a wind-wave model for $S(k', \theta')$, and solving using a numerical method which could involve:

- regularisation ([20], [21], [18]),
- singular value decomposition ([14]),
- constrained iteration ([32], [33], [7]),
- Bayesian methods ([24]),
- optimisation ([13]).

The solution in some cases gives the first five Fourier coefficients of the directional distribution (equivalent to a buoy measurement, [29]) and in others gives the spectrum on a wavenumber or frequency-direction grid from which all the Fourier coefficients can be obtained.

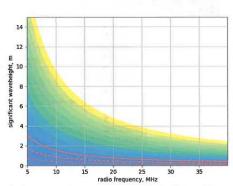


16

What methods are available

Frequency limitations

The important parameter that determines the maximum waveheight for validity of inversion and empirical methods is the radio wavenumber x waveheight shown here.



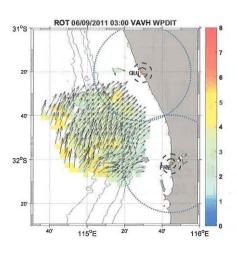
Linearisation becomes increasingly inaccurate as you move into the white region of the plot. Red lines mark lower limits for directional spectra (solid), waveheight (dashed) and wind direction (dotted).



17

What methods are available?

Difference between phased array and compact systems

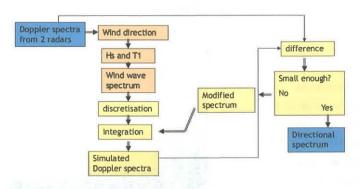


1-hour average map of waveheight and peak direction measured with 8.512MHz WERA in West Australia. Maximum measured range is about 90km.

- SeaSonde inversions assume spatial homogeneity over a measurement annulus and use the antenna pattern.
- In 2014 paper [17] (4.5MHz in Scotland) waveheight and period were measured by averaging over 10 range bins (41km - blue dotted line - little variability reported over that range) and over 3 hours.
- Measured direction found to vary so only measurements close to the radar sites used - black dashed annulus.

13

The Sheffield-Seaview method



Wind direction - using maximum likelihood method

Hs and T1 using empirical formulae

Integration - evaluation of RHS of 2nd order equation.

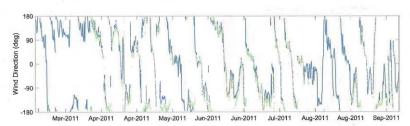
Modification - uses difference and the value of the coupling coefficient.



19

Accuracy and Limitations

Wind (short-wave) direction and spreading



The series of wind directions measured with the WERA radar in South Australia compared with winds from a nearby Bureau of Meteorology automated weather station.

figure provided by Charles James, SARDI, SA, Australia [15]



20

Accuracy and Limitations Wind (short-wave) direction and spreading Comparisons of radar and scatterometer wind directions from locations around Australia [29]. The colour coding is percentage of observations in each 10° bin. Maximum on the scale is set at 0.9 x the maximum percentage in any bin. Bins with < 2% of the maximum are not shown Statistic Number of data pairs Direction difference ° 18061 6.80 0.39 7058 8426 8.08 0.68 4.37 0.88 95% confidence interval concentration Complex correlation 0.90 circular correlation 21 **Accuracy and Limitations** Wind (short-wave) direction and spreading SAG 07/04/2011 23:00 WWDS WDIR QC Radar wind directions (small black arrows) and spreading (colour-coded) with occasional overlays

*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助

137°E

of scatterometer winds (red arrows scaled by wind

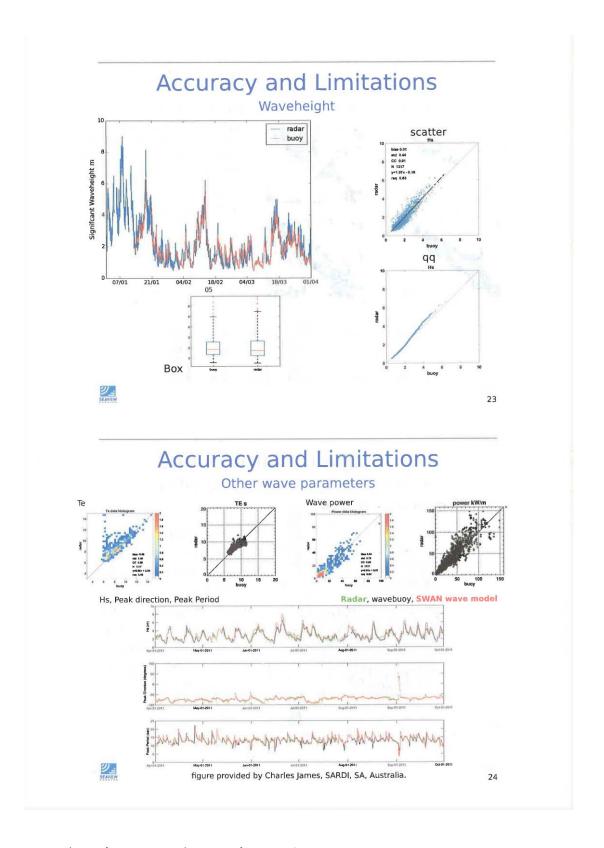
22

speed).

36°S

SEAVIEW

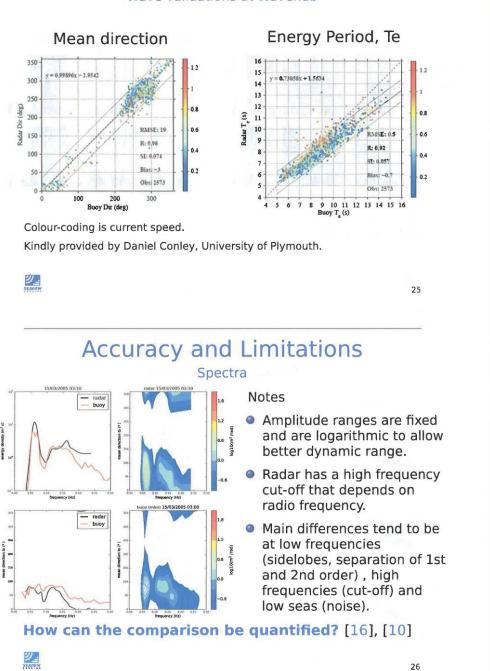
135°E

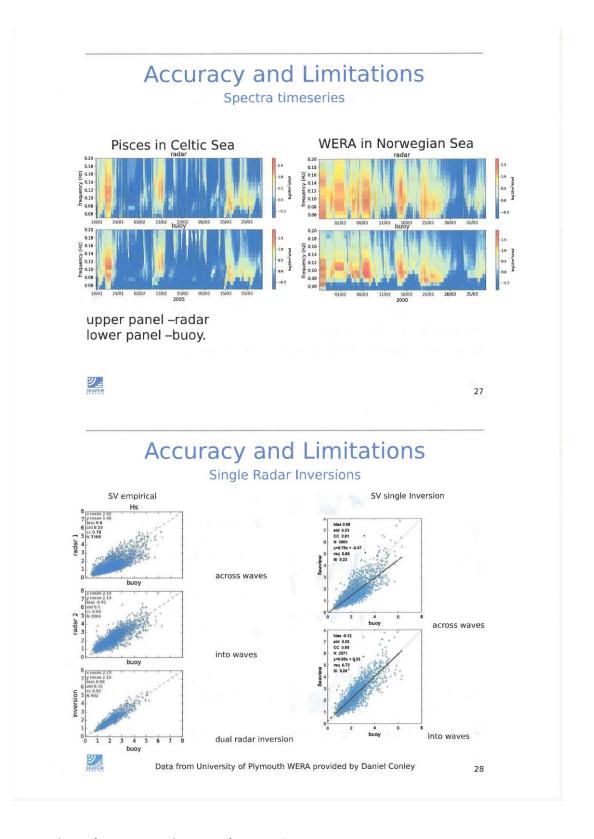


*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助

Accuracy and Limitations

Wave validations at Wavehub





*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助

Accuracy and Limitations

Limitations, constraints and requirements

- Radar configurations not always optimised for waves.
- Separation of wave from current signal in noisy or highly dynamic environments is tricky.
- High waveheights cannot be measured with high radio frequencies (needed for high spatial resolution and interference avoidance), aiming to extend waveheight range using Creamer et al/Janssen formulation, preliminary results encouraging, yet to be fully implemented.
- Low waveheights cannot be measured with low radio frequencies (needed for long range and high sea measurement). Solution is to use a radar capable of operating over a range of radio frequencies with automated waveheight monitoring.
- Range and coverage not fixed depends on radio frequency, interference environment, shipping, waveheight.
- Phased-array radars need to maintain low sidelobe levels for good quality wave measurement. Need at least 16 antennas in the receive array to achieve this
- Averaging Doppler spectra over 20 minutes or more is needed now implemented on some systems



29

The Seaview Software package

comprises:

- Creation of static data (and graphics) files containing deployment information '.sdt';
- Inversion configuration file editable by the user '.conf';
- Utility to read Doppler spectra files in various formats (WERA: '.spec');
- Core inversion in C: 'sea parameters Doppler-spectra';
- Output to an hdf file '.sea';
- Post processing utilities mostly in Perl and GMT for plotting, text file creation, grib available, netcdf to come, database upload;
- Web-based data viewer;
- man pages and site-specific documentation.

Can be run offline (any Linux system) or within a server (Debian or Ubunutu).



30

The Software package

The Sea program

Command line:

```
## This is sea (version 5.45-pre?)

Copyright (c) 2004-2013 Seaview Sensing Ltd.
Copyright (c) 2001-2004 University of Sheffield exclusively licensed to Seaview Sensing Ltd.
All rights reserved
Using static data file

./SB2.sdt
Using configuration file
./dual.conf
Using Depler spectrum files
./spec/20123382305_per.SB2.spec

//spec/20123382305_per.SB2.spec

//spec/20123382305_per.SB2.spec

Directional wave spectrum output file is
201212032305.sea
Inverting all cells.

9 in total
9 initial quality values
9 with radials
9 segmented
9 model beams
9 model cells
9 in the feasible HF spectrum
9 of invertible quality
9 have neighbours
9 to invert

9 to invert

9 to invert

10 2001-2003 Seaview Sensing Ltd.

Wrote global data

LKR discretisaation is aquare grid 1:3

Inverting with Chahine-Twomey-Wyatt (CTW)
iterations 100
relaxation 1.00
Row-access is heuristic fold
Linear Creamer multiplier 1.00
3.24 0.912 0.911 [1] 3.22 0.913 0.912 [2] 3.17 0.916 0.915 [3] 3
0.896 [4] 3.41 0.930 3.092 [5] 3.30 0.909 0.908 [6] 3.19 0.914 0
3.15 0.916 0.916 [8] 3.16 0.916 0.916 [9]
9 cells inverted
[1] [2] [3] [4] [5] [6] [7] [8] [9)
9 cells post-processed
Inversion completed (0 sec, 0.05 sec/cell)
```

W.

31

The Software package

Post-processing Utilities

Command line: seahs -b all -o hstest 201212032305.sea

Output file:

-5.42246 50.350720 0.0655 0.2255 1.538 1.737 7.121 6.922 93.17 34.686 -6.42246 50.350720 0.0655 0.2255 1.538 7.737 7.121 6.922 93.17 34.686 -6.4250 3.348 7.629 7.696 6.730 94.88 7.730 94

The whole '.sea' file can be explored using **h5dump**.

Corresponding man page:

MICE)

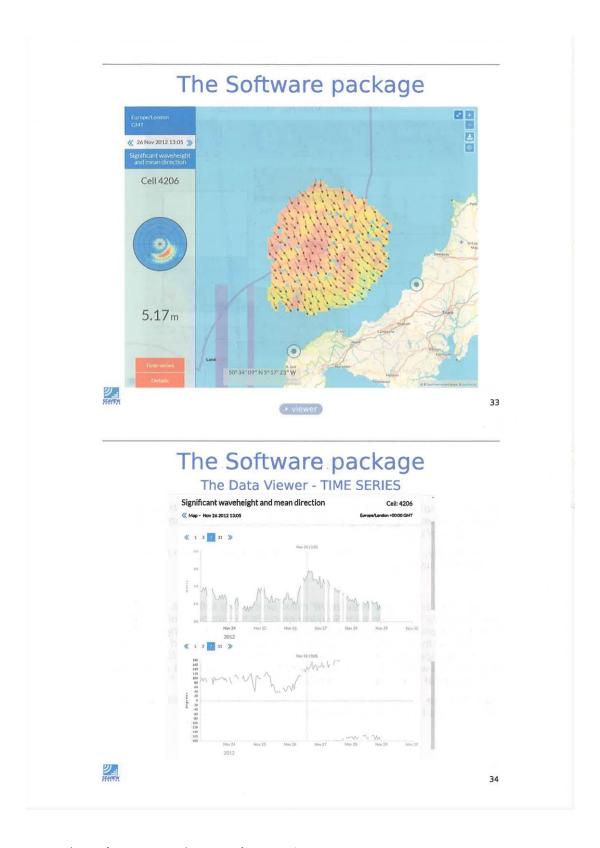
Mice and - rese inverted significant wavelenight file format.

CEXCRITION

The data is became describe the mainti-base inverted significant wavelening to the season of the seaso

ツ<u>.</u> SEAVIEW

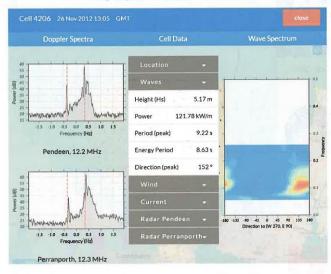
32



*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助

The Software package

The Data Viewer - DETAILS





35

Endorsements

"Empirical and theoretical wave algorithms provide reliable estimates of Hs. Seaview delivers high quality direction estimates and good frequency distribution of energy"

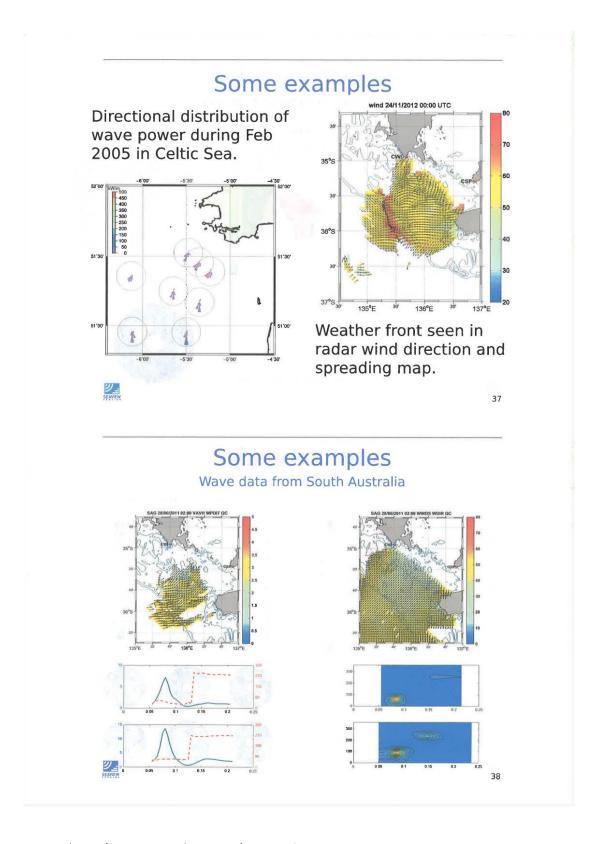
Daniel Conley, University of Plymouth, UK, from a presentation at UK Challenger Conference, 2016.

" I am happy to endorse Seaview HF radar processing software. I would especially like to complement Seaview on customer support during our preparation phase, through onsite installation, and in supporting our desired use of the software. We found your team to be informative and responsive as we developed our onsite hardware planning in preparation for installation. I would argue that the scientific expertise resident in Seaview's human capital should be considered a significant selling point."

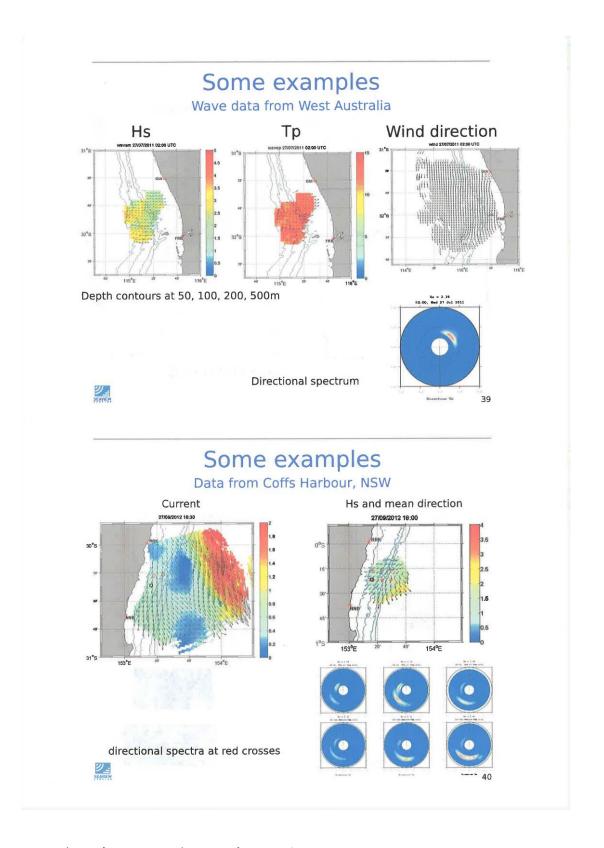
Dana Savidge, University of Georgia, Skidaway Institute of Oceanography, USA, extracts from a letter of support



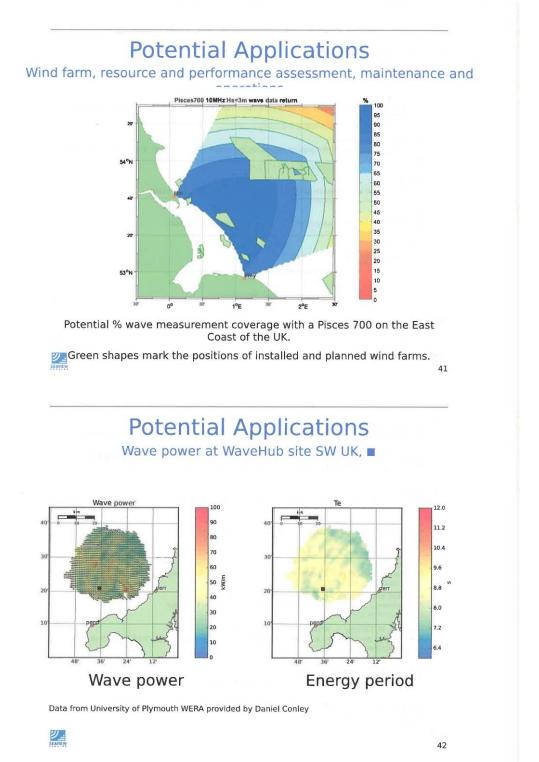
36



*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助



*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助



References D. Barrick. Extraction of wave parameters from measured HF radar sea-echo Doppler spectra. The ocean waveheight nondirectional spectrum from inversion of the HF sea-echo Doppler Remote Sensing of Environment, 6:201-227, 1977. On the nonlinear theory for gravity waves on the ocean's surface. Part II: Interpretation and Journal of Physical Oceanography, 7:11-21, 1977. Dependence of second-order sidebands in HF sea echo upon sea state. In IEEE G-AP Int. Symp. Digest, pages 194–197, 1971. First order theory and analysis of MF/HF/VHF scatter from the sea. Remote sensing of sea state by radar. In V. E. Derr, editor, Remote Sensing of the Troposphere, chapter 12. Washington, DC GPO, Row-action inversion of the Barrick-Weber equations. Journal of Atmospheric and Oceanic Technology, 23:501–510, 2006. K.-W. Gurgel, H.-H. Essen, and T. Schlick. An empirical method to derive ocean waves from second-order bragg scattering: prospects and IEEE Journal of Oceanic Engineering, 31:804-811, 2006. Determination of ocean wave spectra from measured HF radar sea-echo Doppler spectra. [10] D. Hauser, K. Kahma, H. E. Krogstad, S. Lehner, J. A. J. Monbaliu, and L. R. Wyatt, editors. Measuring and analyzing the directional spectra of ocean waves, volume EUR 21367. Directional spreading of short wavelength fetch-limited wind waves. Journal of Physical Oceanography, 17:281-285, 198 A comparison of algorithms for extracting significant wave height from Hf radar ocean Journal of Atmospheric and Oceanic Technology, 15:1157-1163, 1998. Nonlinear inversion of the integral equation to estimate ocean wave spectra from hf radar. Measurement of ocean wave spectra using narrow beam HF radar. IEEE Journal of Oceanic Engineering, 18:296-305, 1993 [15] C. James, M. Collopy, L. Wyatt, and A. Middleditch. Suitability of the southern australia integrated marine observing systemâĂŹs (sa-imos) hf-radar for operational forecasting. Journal of Operational Oceanography, pages 1–13, Jan 2019. [16] H. E. Krogstad, J. Wol, S. Thompson, and L. Wyatt. Methods for the intercomparison of wave measurements.

*資料來源:由英國雪菲爾大學 Prof. Lucy Whatt 提供或協助

Braham project high frequency radar ocean measurements: currents, winds, waves and their

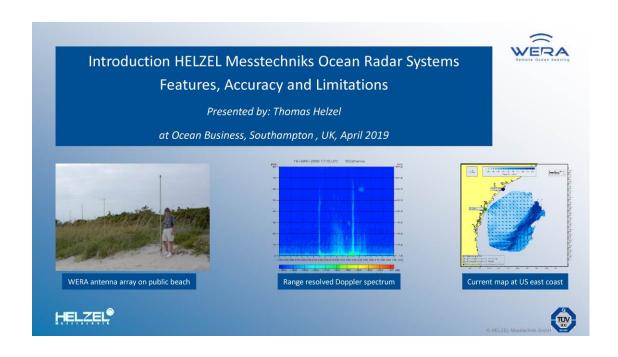
[17] B. Lipa, D. Barrick, A. Alonso-Martirena, M. Fernandez, M. I. Ferrer, and B. Nyden.

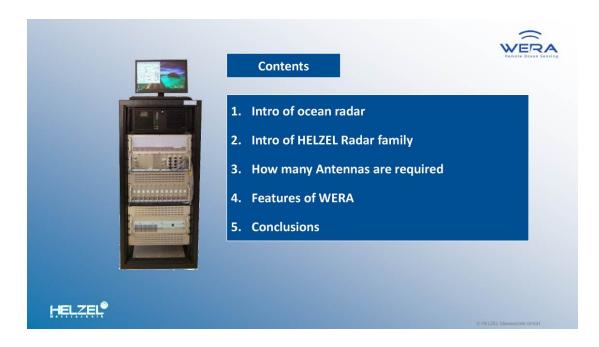
interactions.

Remote Sensing, 6:12094 - 12117, 2014.

```
Methods for the extraction of long-period ocean wave parameters from narrow beam hf radar
[19] B. Lipa and D. E. Barrick
       Extraction of sea state from hf radar sea echo: Mathematical theory and modelling.
       Derivation of directional ocean-wave spectra by inversion of second order radar echoes.
       Inversion of second-order radar echoes from the sea.
       Mapping of North Atlantic Winds by HF radar sea backscatter interpretation.
[23] J. W. Maresca and T.M.Georges.
       Measuring rms waveheight and the scalar ocean wave spectrum with HF skywave radar.
       Journal of Geophysical Research-C, 85:2759-2771, 1980
      A bayesian approach for estimating directional spectra with hf radar. Coastal Engineering Journal, 41:137–149, 1999.
[25] W. J. Pierson. and L. A. Moskowitz.
       Proposed spectral form for fully developed wind seas based on the similarity theory of S. A.
       Kitaigorodskii.
       Journal of Geophysical Research, 69:5181-5190, 1964.
      W. J. Pierson., G. Neuman, and R. W. James.
Practical methods for observing and forecasting ocean waves by means of wave spectra and
       statistics, 1955.
[27] R. J. Ramos, H. Graber, and B. Haus
      Observation of wave energy evolution in coastal areas using HF radar. 
Journal of Atmospheric and Oceanic Technology, 26:1891–190, 2009.
      A comparison of scatterometer and hf radar wind direction measurements. 
Journal of Operational Oceanography, 11:54–63, Feb 2018.
       Measuring the ocean wave directional spectrum 'first five' with hf radar.
      L. R. Wyatt.
       On Barrick's inversion procedure.
       University of Birmingham, Dept of Electronic and Electrical Engineering, Deptl Memo 487,
       https://www.researchgate.net/publication/279878594 On Barrick's Inversion Procedure, 1981.
      Significant waveheight measurement withHF radar. International Journal of Remote Sensing, 9:1087–1095, 1988.
       A relaxation method for integral inversion applied to HF radar measurement of the ocean wave
      directional spectrum.
International Journal of Remote Sensing, 11:1481–1494, 1990.
       Limits to the inversion of HF radar backscatter for ocean wave measurement.
       An evaluation of wave parameters measured using a single HF radar system.
[35]
      Shortwave direction and spreading measured with HF radar. 
Journal of Atmospheric and Oceanic Technology, 29:286–299. 2012
                                                                                                                   46
```

(二)海洋及陣列雷達系統應用介紹:



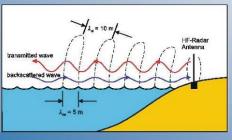


*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助

1. Introduction



WERA is a shore based remote sensing system using the over the horizon radar technology to monitor ocean surface currents, waves and wind direction. A vertical polarised electromagnetic wave is coupled to the conductive ocean surface and will follow the curvature of the earth.



The rough ocean surface interacts with the radio wave and due to the Bragg Effect back-scattered signals can be detected from ranges of >300 km.

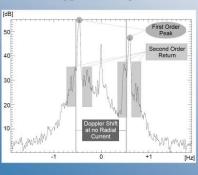


HELZEL Messtechnik GmbH

1. Introduction



The back-scattered radar signal will be **Doppler shifted** with a specific **frequency offset** given by the **velocity** of the **gravity wave** that is responsible for the **Bragg** scattering.

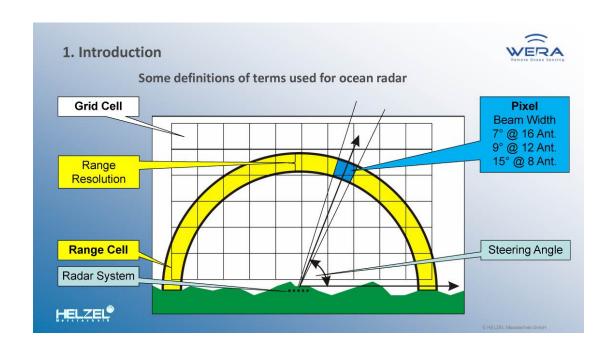


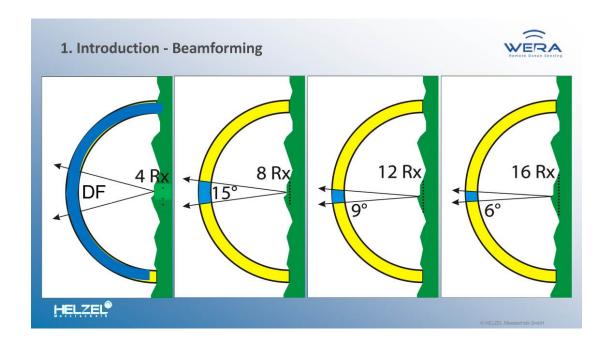
These Doppler shifted signals will be symmetrical around the centre frequency as long as the ocean surface does not move. An ocean current will shift these Bragg lines up or down in frequency.

HELZEL

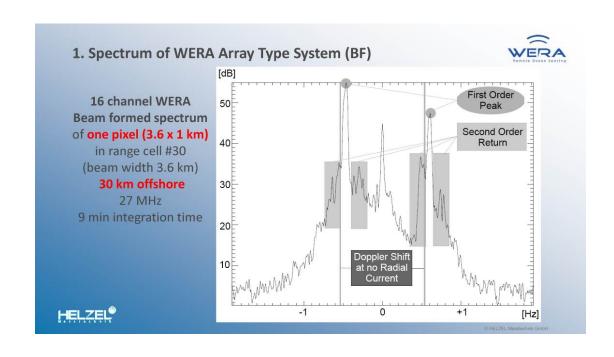
D HELZEL Messtechnik GmbH

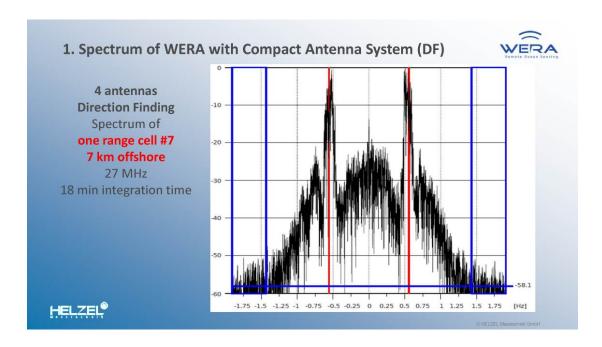
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



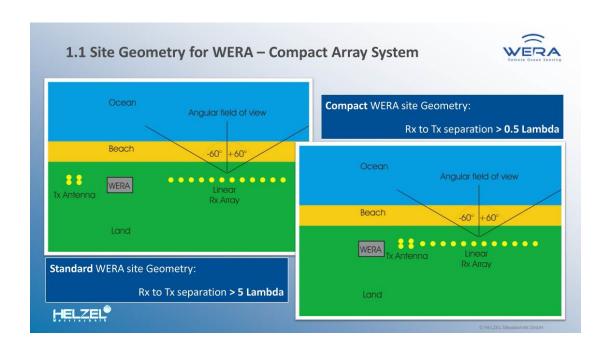


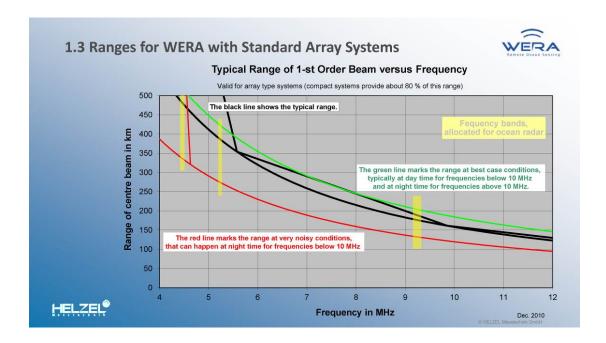
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



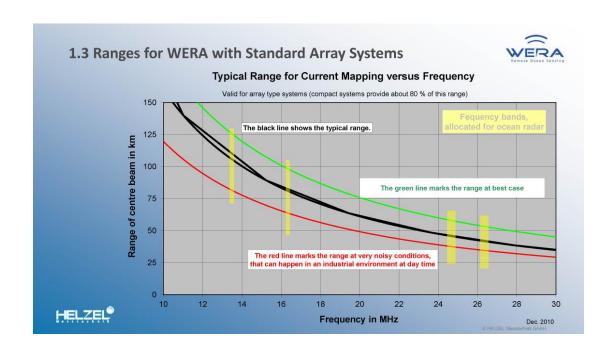


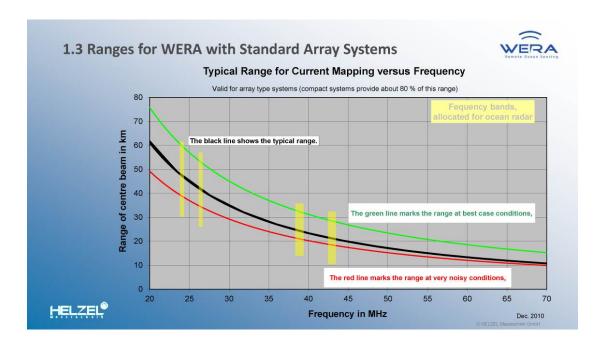
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



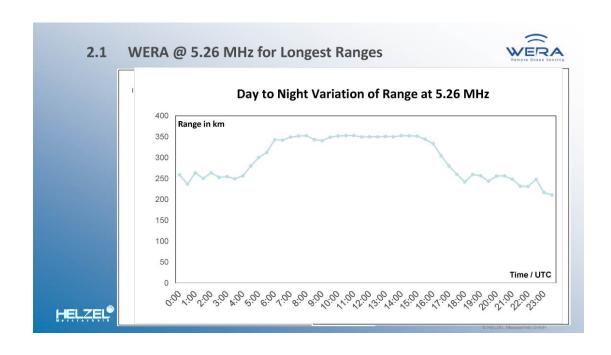


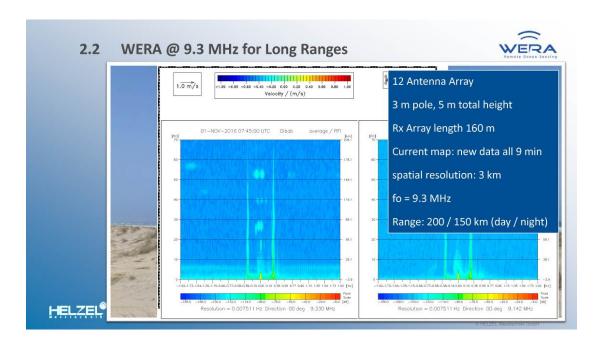
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





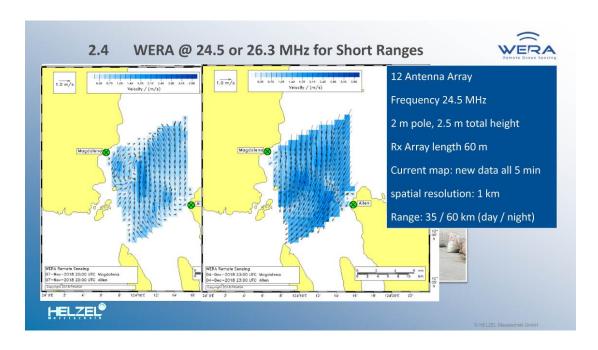
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



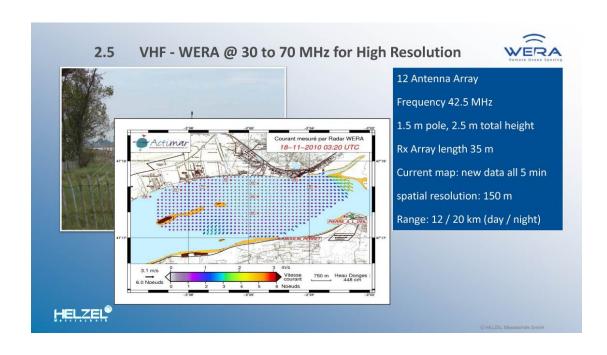


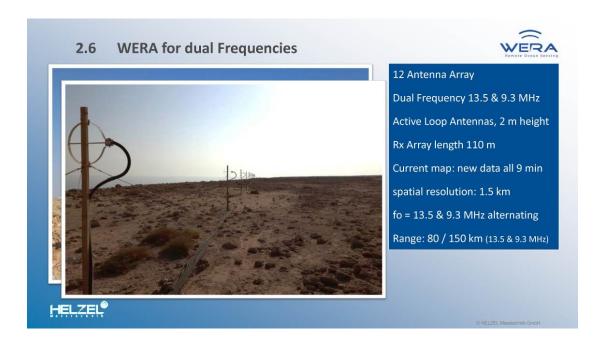
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





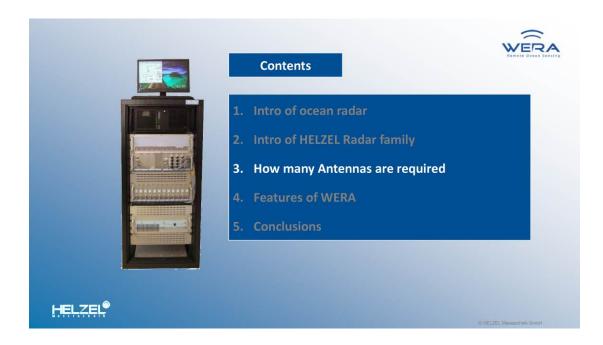
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



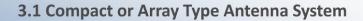


*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





Before making a decision what to use, it is important to know all about the Features and Limitations of Compact or Array Type Radar Configurations.

One of WERA's unique features is that it is flexible to be set-up in Compact or Array Type configurations.

This allows us to discuss the pros and cons of these configurations full and frank with potential radar users and enables us to find the best radar configuration for your specific application!



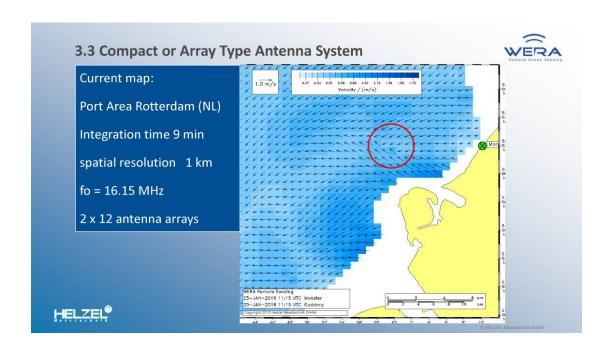
ID HELZEL Messtechnik GmhH

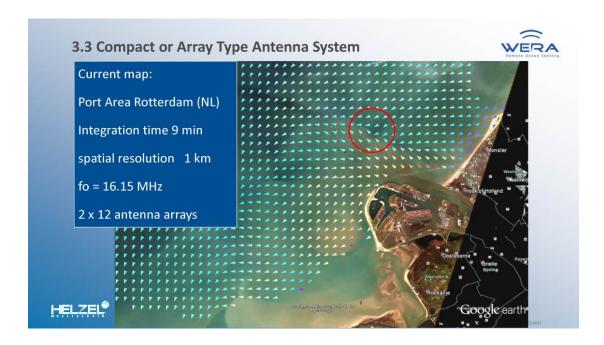
3.2 Compact or Array Type Antenna System



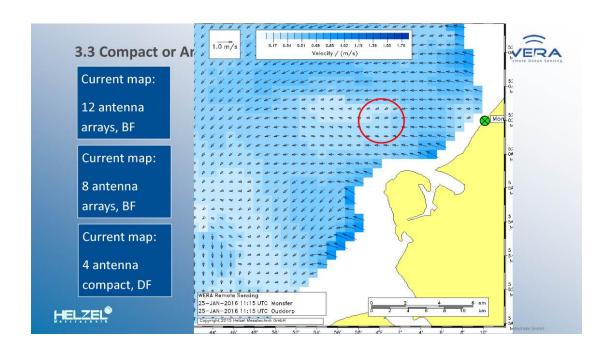
Parameter	Compact Antenna (Direction Finding)	Array Type Antenna (Beam Forming)
Receive Antenna Array:	Square of 4 Poles	8 to 16 Poles
Provided Data:	Currents and Wind Direction	High resolution Currents, Waves & Wind Direction
Field of View:	up to 270°	120° (more if curved)
Angular Accuracy:	< 10° typical Antenna calibration recommended!	< 1° Antenna calibration not required!
Temporal Resolution:	> 20 minutes	> 30 seconds
Noise Reduction:	standard	unique WERA noise

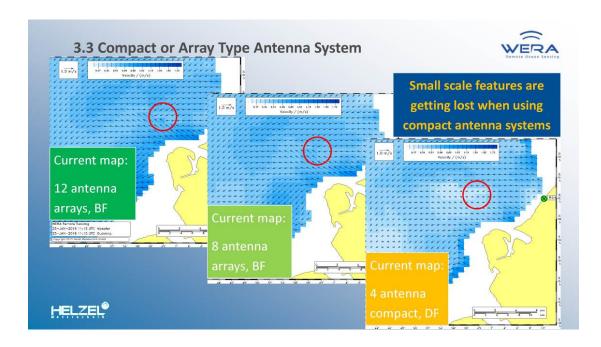
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





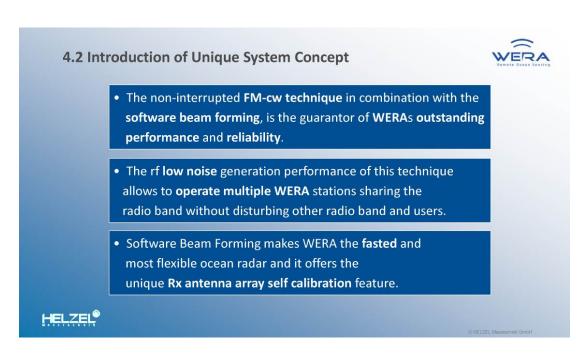
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



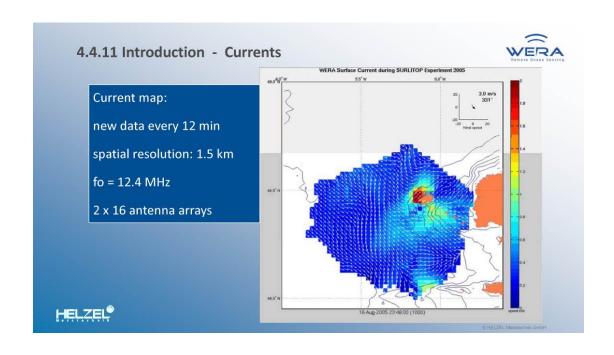


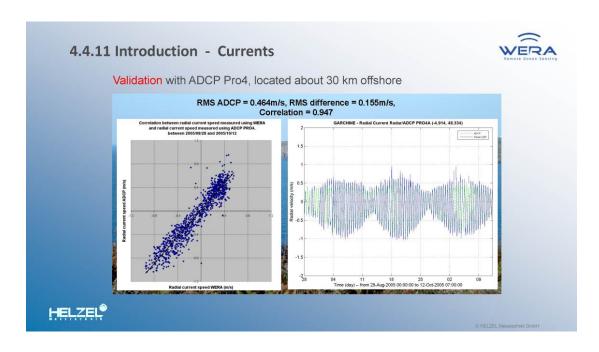
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助

4.4 Nange C	of WERA Products (Technique)	Remote Oce
1	. For Direction Finding or Beam Forming Mode	
2	. For Short or Long Ranges	
3	. In Standard, Compact or Splitted Site Geometry	
4	. Optimised Integration Time for individual applications	
5	. Intelligent Frequency Management to avoid interferences	
6	. Supports M ultiple I nput – M ultiple O utput Mode, MIMO	
7	. Provides very effective radio interference suppression, RFI	
8	. In Single- or Multi-Frequency Mode	
9	. Self organized Frequency Band Sharing	
1	Open Data Interfaces for scientific applications	

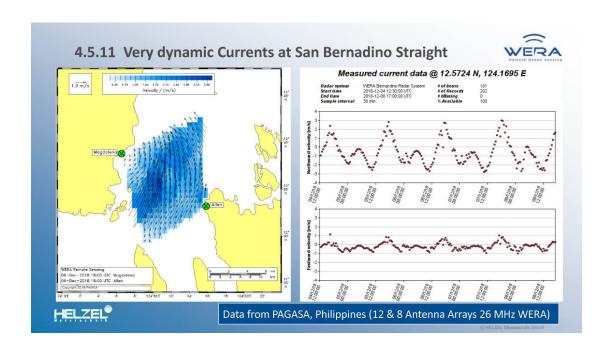


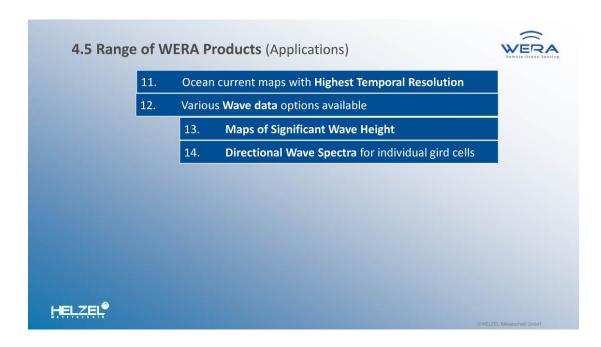
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



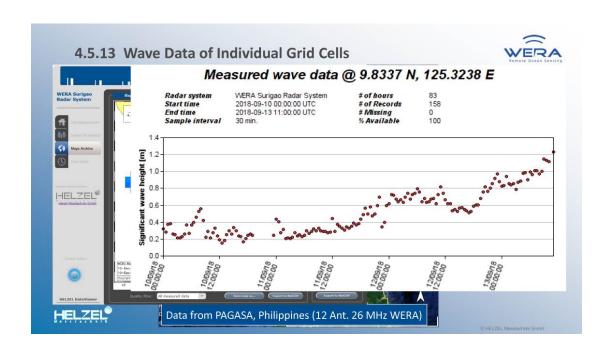


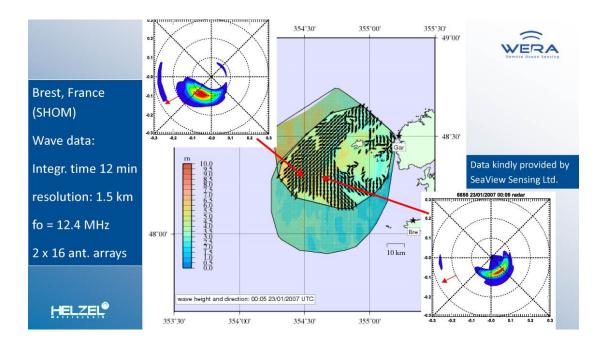
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



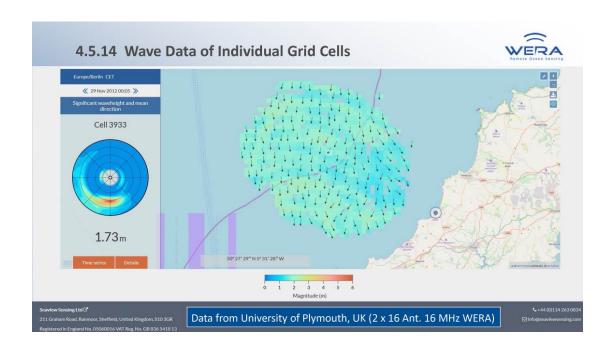


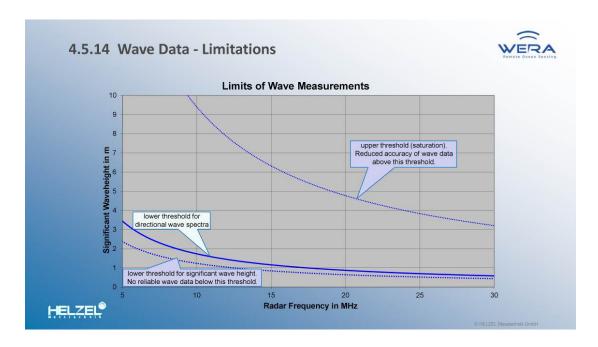
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





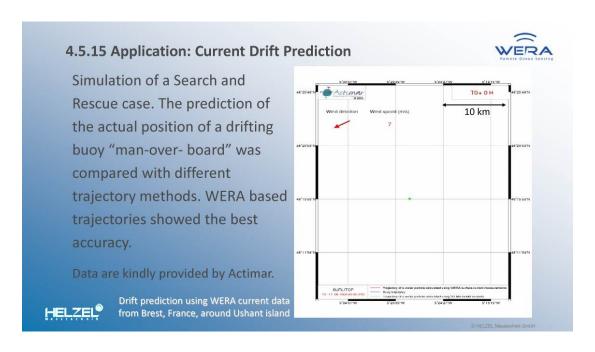
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



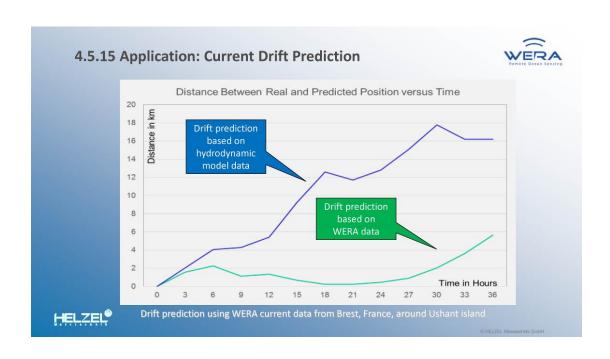


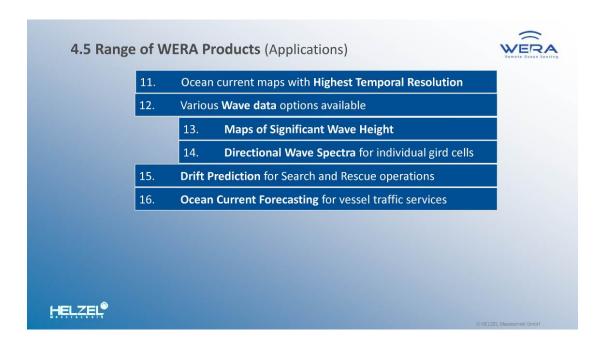
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



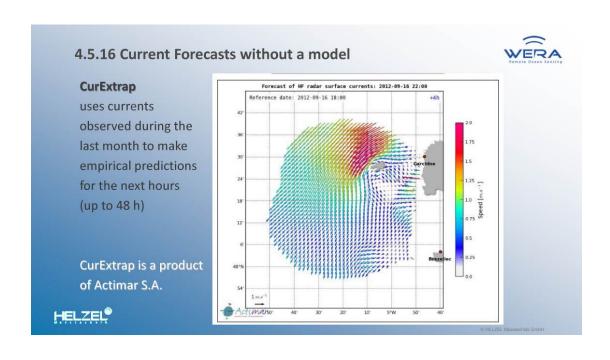


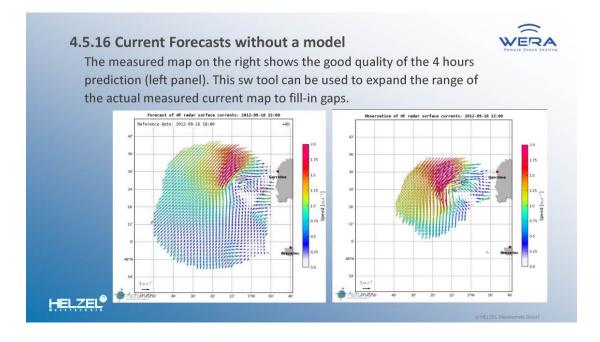
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



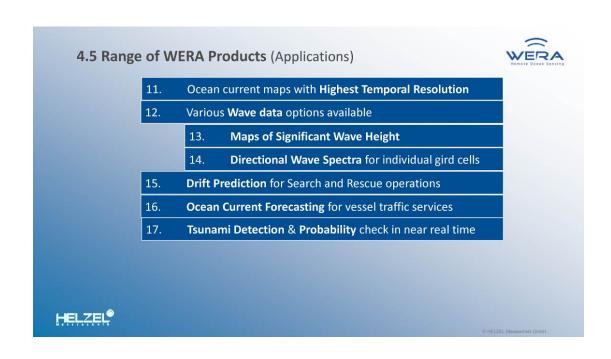


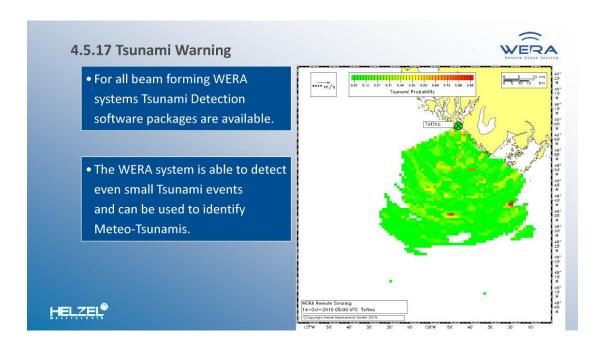
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



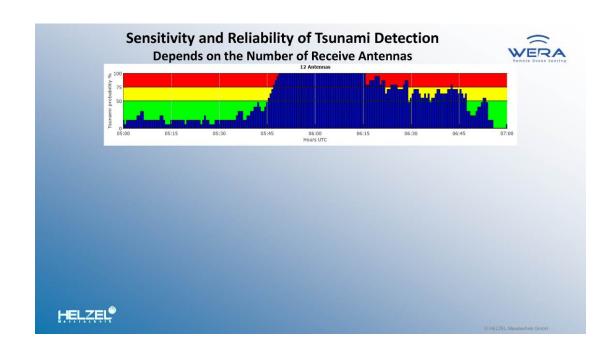


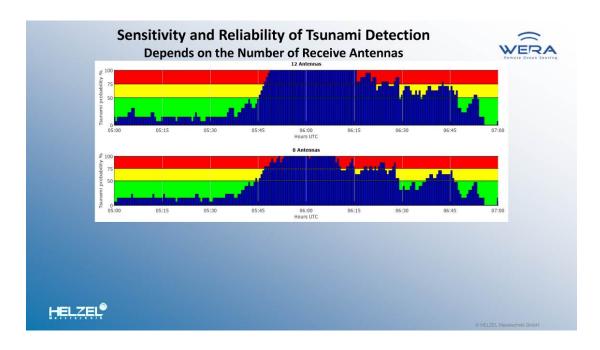
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



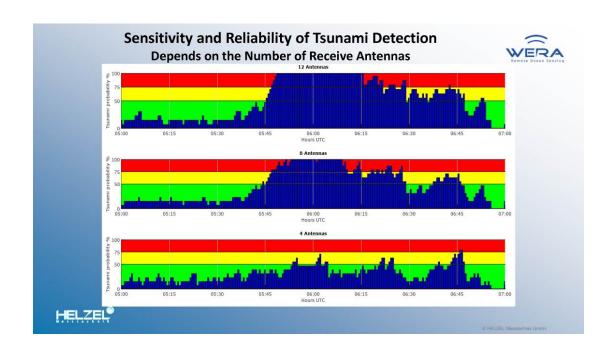


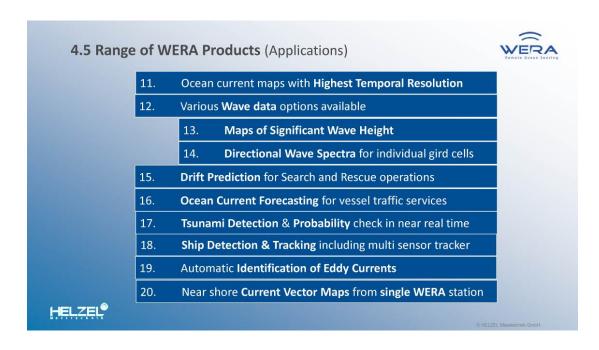
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





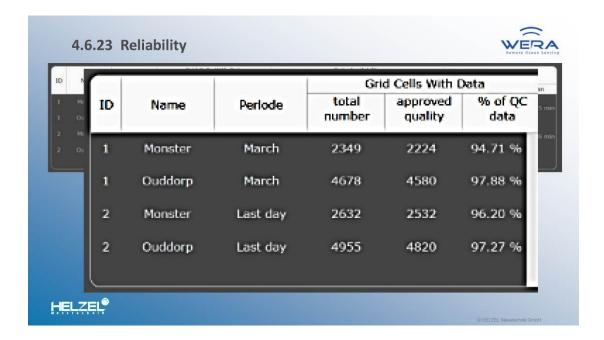
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



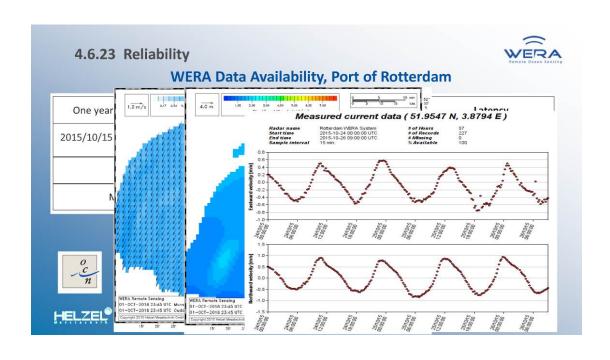


*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



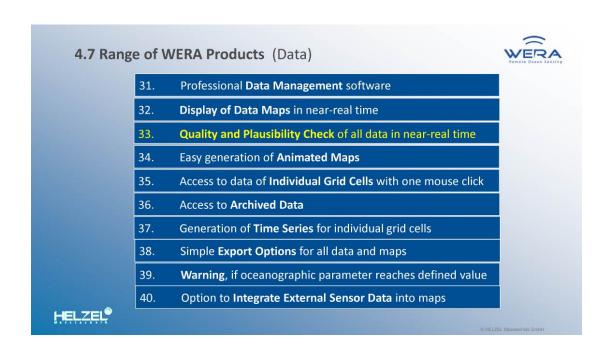


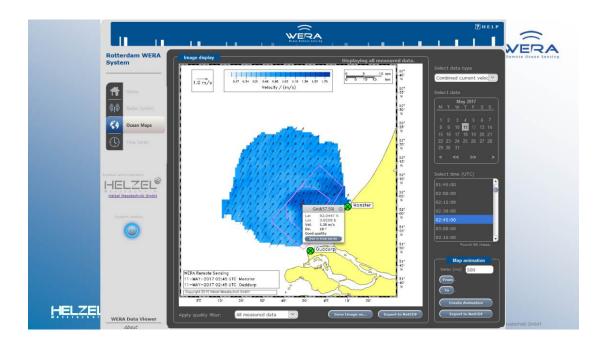
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



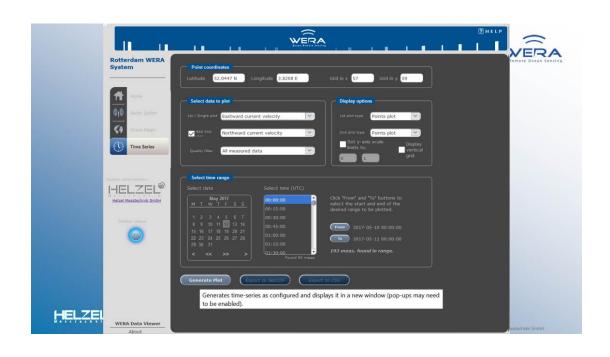


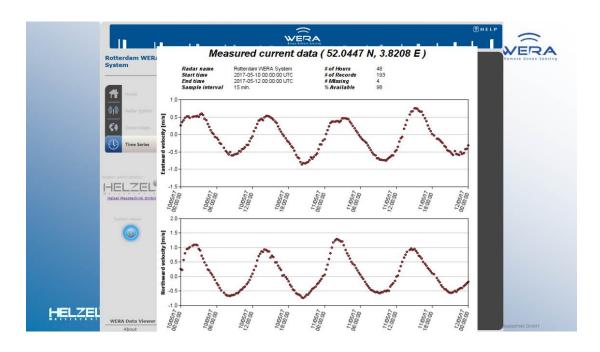
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助



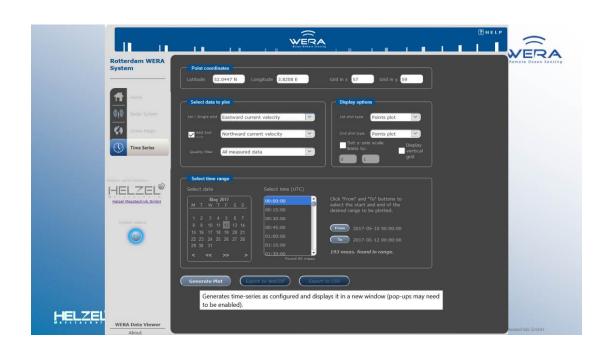


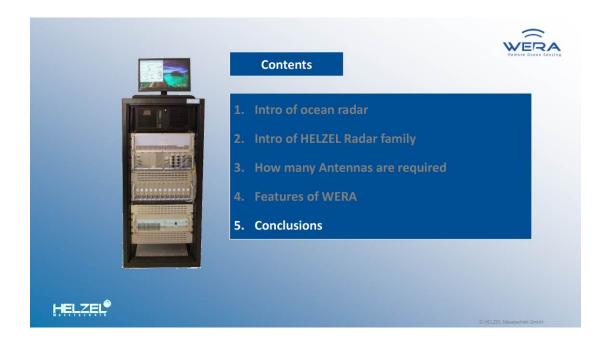
*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助





*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助

5.1 Conclusions - Summary



- WERA is the most flexible ocean radar, suited for compact or array type antenna systems
- > Various small antenna options and flexible site geometry available
- WERA provides the longest range performance
- > The FMcw technique makes WERA the fasted ocean radar
- WERA is the first system that ever detected a Tsunami in real-time
- > **Dual frequency** options are available for multiple use applications
- > Web based user interface and easy access to data archive
- Data interface for MetOcean applications (GRIB)



ID HELZEL Messtechnik GmhH

5.2 Conclusions - Summary



- WERA can provide wave data on the grid (SWB-option)
- > Hazard management interface for Search and Rescue operations
- Short term current prediction for vessel traffic services
- > Automatic Eddy current detection, important for fishing industry
- > HELZEL established **certified QM** system
- Highest data availability validated by users (SHOM, RWS)
- > Self calibration of antenna system (once per hour)
- > Real-time quality check of all data (for each grid cell)



© HELZEL Messtechnik GmbH

*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助

5.3 Conclusions



- Helzel Messtechnik provides all services to configure the WERA systems and software according to your requirements. This already starts with the conceptual phase to find the best suited configuration for your specific application.
- > An intensive user training is essential and always included.
- To provide the most effective and best service for our WERA users, we always cooperate with local service provider, in India this is Elektronik Lab. This ensures sustainability and guarantees short reaction time in case of any malfunction.
- The success of your project is our priority.



© HELZEL Messtechnik GmbH

5.3 Conclusions

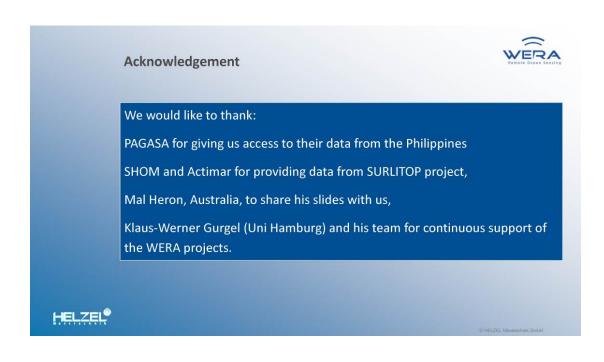


- The WERA user group invites scientific groups from India to join the WERA group. The scientific exchange with researchers and users from India would be much appreciated and for sure would help to further improve the ocean radar technology.
- The WERA partner Elektronik Lab can initiate an Ocean Radar manufacturing in India. This can make this technology more attractive, in particular for the South-East Asian market.
- HELZEL Messtechnik offers WERA seminars at the company in Germany, at least once a year. Potential WERA users from India are more than welcome.



© HELZEL Messtechnik GmbH

*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助

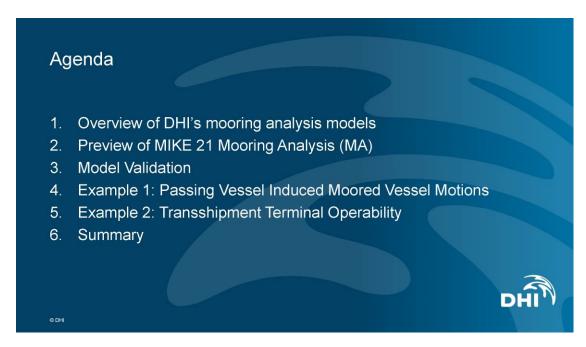




*資料來源:由德國 WERA 儀器製造商 Thomas Helzel 提供或協助

(三)丹麥 DHI-MA 模組之船舶繁纜分析:





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明



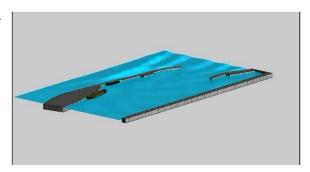
Overview of DHI
Mooring Analysis Software



© DH

Overview of mooring analysis model

- · Timeline of the model so far
 - 2011: WAMSIM
 - 2016: DVRS
 - 2017: MIKE 21 Mooring Analysis (MA)
 - Faster
 - More user-friendly
- now becomes official MIKE software product



© DH



Overview of mooring analysis model

- Dynamic moored vessel response model
- · Calculates motions of a moored object (e.g. ship) subject to
 - Wind
 - Waves
 - Currents
- · Results:
 - Motions in 6 degrees of freedom
 - External forces and moments
 - Forces in fenders and mooring lines

Passing Vessel Disardon

DHI

The plant of the second vessel Motions

Moored Vessel Motions

84

20

00.20

00.34

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

00.30

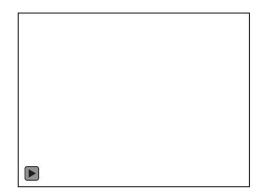
00.30

00.30

© DH

Overview of mooring analysis model

- · Applied in
 - Ports & Terminals
 - Harbours & Marinas
 - Offshore environments
 - · Offshore moorings
 - Offshore tandem moorings
 - Floating wind turbines/breakwaters
 - · Ships at anchor

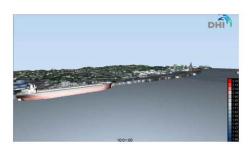


© DHI



Overview of mooring analysis model

- · To determine and evaluate
 - ship motions
 - forces in mooring equipment
- · Comparison with guidelines to
 - Calculate downtimes/operability
 - Port layout optimization
 - Berth design
 - mooring layout/system evaluation



DHI

© DH

02.

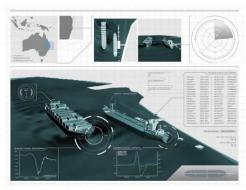
Preview of MIKE 21 Mooring Analysis (MA)



© DHI

Features

- Solves the equations of motions for all 6 degrees of freedom in time domain
- Accurate representation of vessel hull geometry and gyrostatic data
- Wave diffraction forces calculated from non-linear, non-uniform incident wave fields or flow fields (e.g. produced by MIKE 21 HD FM or MIKE 21 BW)

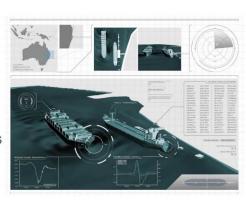


© DHI



Features

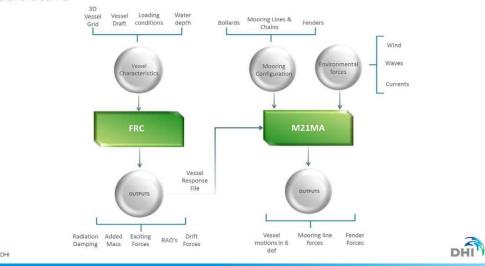
- Implicitly resolves both bound and free long period waves in shallow water
- Non-linear restoring forces due to mooring lines, fenders and posts
- Frictional damping in surge and roll modes due to scraping along fenders
- Viscous surge and sway damping
- Wind, current forces and 2nd order wave drift forces



© DHI



Structure



Background Frequency Response calculator (FRC)

- Frequency domain
- · Boundary element method code
- Solves
 - 1st order wave-induced frequency response functions of offshore structures (added mass, radiation damping, exciting forces)
 - 2nd order drift force frequency response functions



© DHI

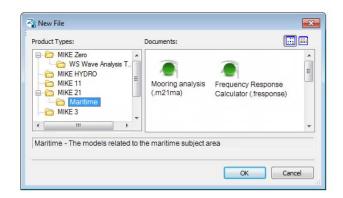
Background MIKE 21 MA

- Input
 - 2D and/or timeseries data (water levels, surface elevation, fluxes)
 - Frequency response from FRC (converted to time domain)
- Calculates
 - exciting forces (from Haskind relation)
 - 2nd order drift forces
 - Wind and current forces (from drag)
 - Mooring forces in lines and fenders (from force vs. deflection curves)
- curves)
 Movement for floating bodies (from equation of motion for body dynamics)

Placement in MIKE 21 suite

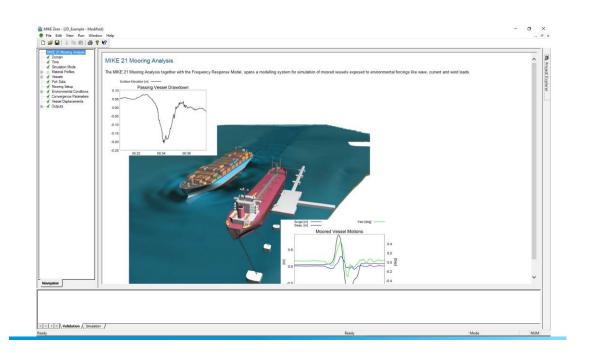
 seperate group under MIKE 21:

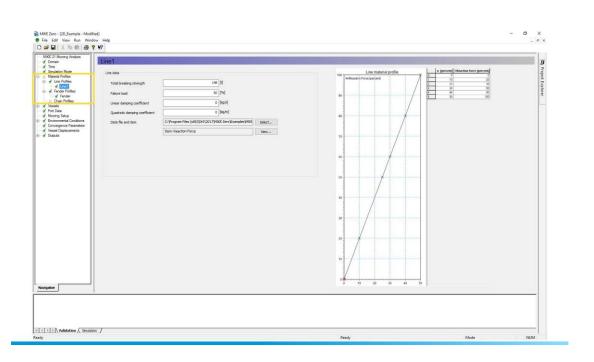
Maritime



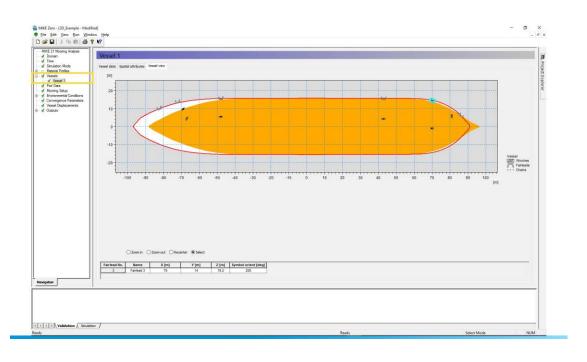
© DHI

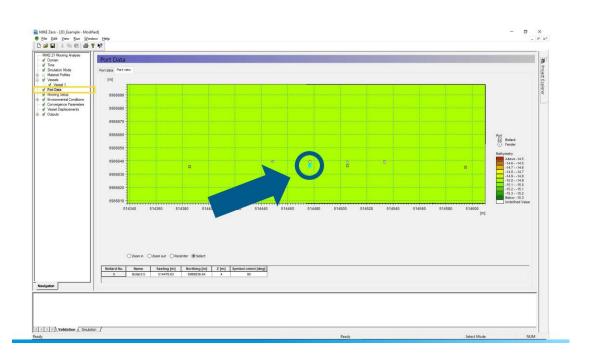




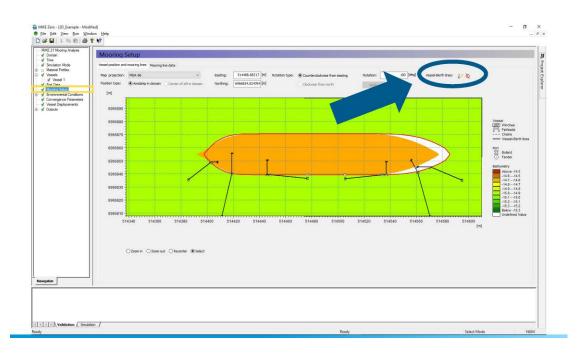


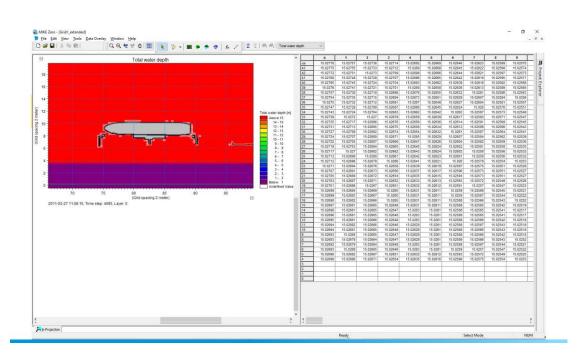
*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明



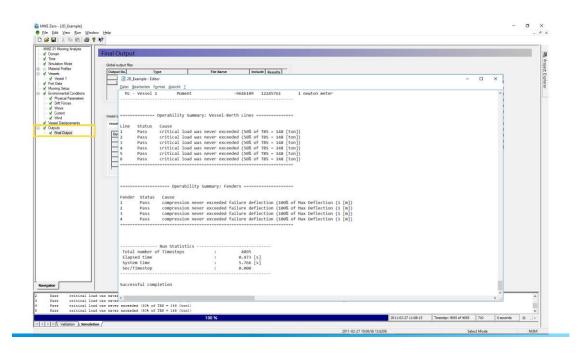


*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明



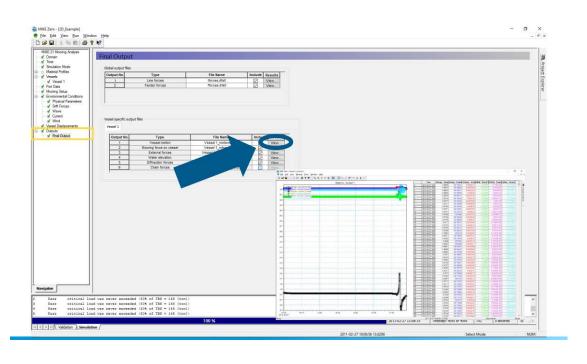


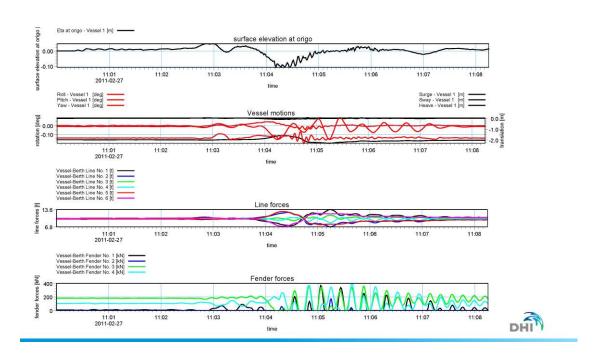
*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

What makes MIKE 21 MA unique

- Seamless connection with output data form MIKE 21 BW and MIKE 21 HD
 - the easiest possible way of introducing 2D waves and currents in your model
- · Great user interface
 - Introducing and editing elements in a very easy way

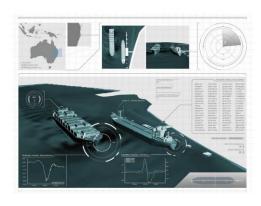




© DHI

What makes MIKE 21 MA unique

- · Calculation speed
 - Once you have run the FRC, simulations are very fast
- · Working on easy access to
 - vessel hulls,
 - drag curves and
 - other essential input



© DHI

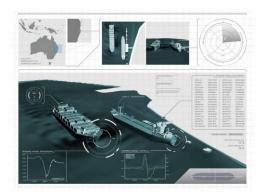


What makes MIKE 21 MA unique

- MIKE 21 MA is part of MIKE
 - High levels of quality
 - Future development
 - Training activities

© DHI

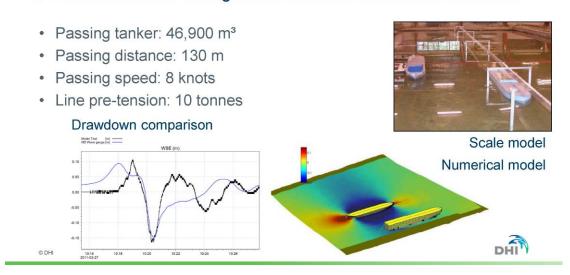
- Access to professional support



✓ Wind, current forces and 2nd order wave drift forces

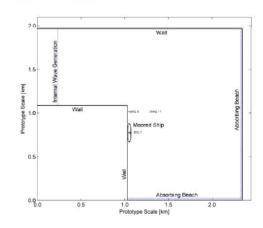
03.
Validation

Port of Brisbane: Passing vessel induced moored vessel motion



LNG tanker moored in sheltered harbour

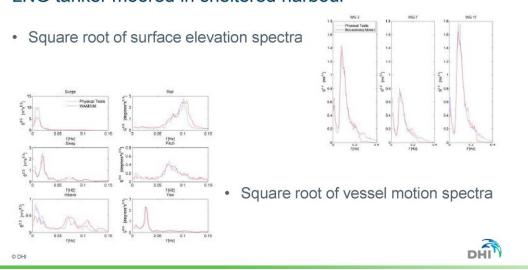
- LNG tanker
- 6 linear-elastic mooring lines
- · 2 linear-elastic fenders
- · L-shaped harbour
- $H_S = 4.91 \text{ m}$
- $T_p = 11.0 s$

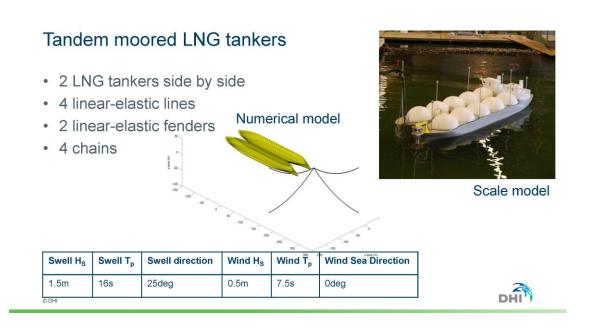


© DHI



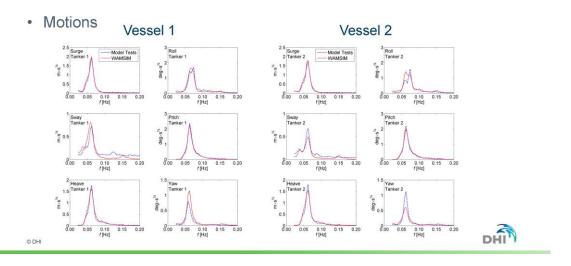
LNG tanker moored in sheltered harbour





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

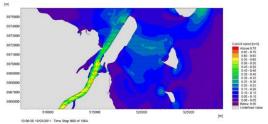
Tandem moored LNG tankers





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

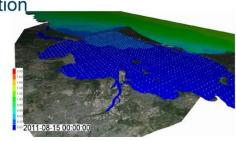
- · One of Australia's fastest growing container ports
- · Channel optimization to allow larger vessels to transit
- · Numerical modelling study to identify effects of moored vessel motions induced by passing ships at several key berths





Port of Brisbane channel optimization

- · Integrated impact assessment
 - Numerical modelling to solve one particular task
 - Limits potential for coupled impact assessment and makes it difficult to compare independent studies
 - Integrated platform provides foundation for multipurpose investigations

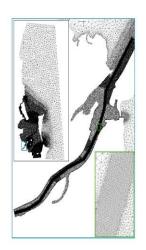


- Navigational studies
- Channel sedimentation studies
- Dredge spill investigations
- Marine ecology and water quality assessment
- Collision risk with marine mega fauna
- Oil spill risk assessment
- Underwater sound pollution



© DHI

- Wave and hydrodynamic modelling
 - DHI's spectral forecast model for Australian waters (OzSea)
 - Locally generated wind and swell waves
 - MIKE 21 HD FM to model tidally driven circulation in Moreton Bay
 - Water level validation at 5 stations



DHI

© DHI

Port of Brisbane channel optimization

- · Passing vessel modelling
 - Drawdown
 - drop of surface elevation along the length of the hull of the moving vessel
 - Simulation in MIKE 21 HD FM
 - Pressure field
 - moving stencil was interpolated onto the model domain grid
 - · Generated from 3D vessel hull

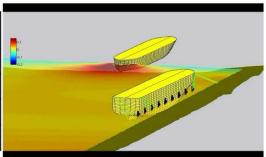
DHI

© DHI



· Passing vessel modelling

tanker	LOA (m)	Beam (m)	Draft (m)	Displacement (m³)
MR 10.4	183	33	10.4	48,180
LR 10.4	226	32.5	10.4	60,507
MR 11.2	183	33	11.2	52,200
LR 11.2	226	32.5	11.2	65,622

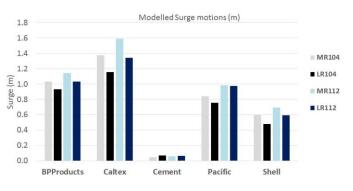


© DHI



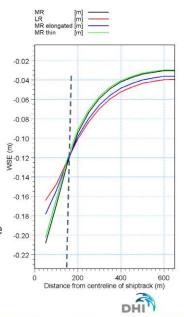
Port of Brisbane channel optimization

- Results: surge motion of moored vessel
 - Largest motions at Caltex berth
 - Although maximum drawdowns from the passing of the LR tankers at the berths are higher, the moored vessel motions are lower at most berths



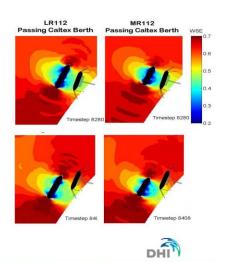
DHI

- · Results: Passing distance threshold
 - The vessel generating the max. drawdown varies with distance from vessel to edge of model boundary
 - For two vessels with identical draft and almost identical width, although the max.
 extent of the drawdown field is greater for the longer vessel, the wider drawdown wave dissipates slower with distance.
 - The longer vessel will only cause larger drawdown than the short vessel after a certain distance.



Port of Brisbane channel optimization

- Although the max. extent of the drawdown field is larger for the LR tanker, the water level induced pressure gradients at the moored vessel are lower under the passing LR scenario
- Lower in line and transverse gradients from the passing of the LR tanker results in lower turning moments of the vessel



© DHI



Project example 2

Transshipment Terminal Operability Objective



© DH

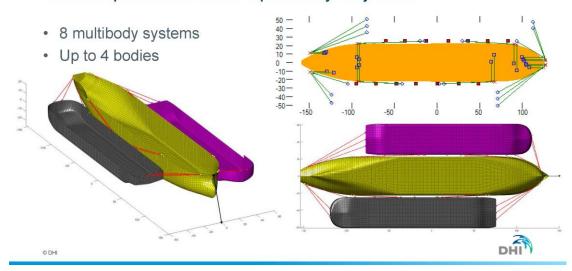
Transshipment Terminal Operability Objective

- Development of an offshore transshipment facility for the transfer of iron ore from shallow draft vessel to ocean going vessel
- Determine operability of a number of tandem moored vessel systems
- Process
 - Run FRC for each of the multybody systems
 - Determine environmental forcings
 - Create MIKE 21 MA setup
 - Use setup as template to generate batches of MIKE 21 MA setups
 - Determine no. of scenarios which exceed operability threshold for each mooring system

© DHI



Transshipment Terminal Operability Objective



Transshipment Terminal Operability Objective

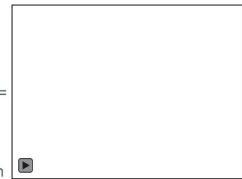
- · Environmental conditions
 - 90,000+ wave, wind and current conditions
 - · Constant wind speed and direction time series
 - Constant current speed and direction time series
 - H_S, T_p and direction were provided for both swell and wind wave components
 - Pierson-Moskowitz spectrum with MIKE's random wave generator -> time series of surface elevations

© DHI



Transshipment Terminal Operability Objective

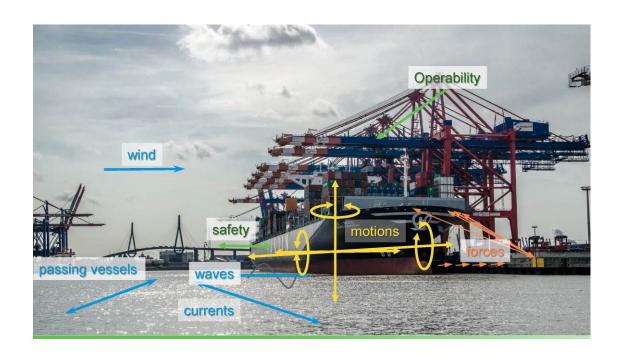
- Results
 - Example run times
 - FRC: 3 body case, 7824 submerged panels = 27 h
 - MIKE 21 MA: 90,000 simulations = 2 days
 - Final result were operability tables detailing the operability for each mooring system for each year/month
 - To choose which mooring system to develop

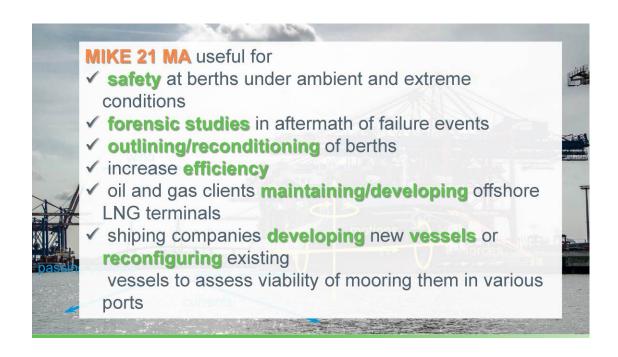




© DH







*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

Summary

- highly sophisticated model to assess
 - moored vessel response in open water and ports
- Seamless connection with other MIKE models (especially in conjunction with MIKE FM HD and BW) can accurately represent vessel motions as a result of highly complex, non-linear wave fields
- · Great GUI, easy to use with well defined inputs/outputs
- Outputs are all time series and post-processing is easily done with MIKE 21 Toolbox Pre- and Postprocessing Tools
- Very fast

© DH



Summary

- · Part of MIKE
 - High levels of quality
 - Future development
 - Training activities
 - Access to professional support



© DHI





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

(四)優化澳大利亞港航道容量的綜合方法:





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

Channel Capacity Optimization - Quick Overview

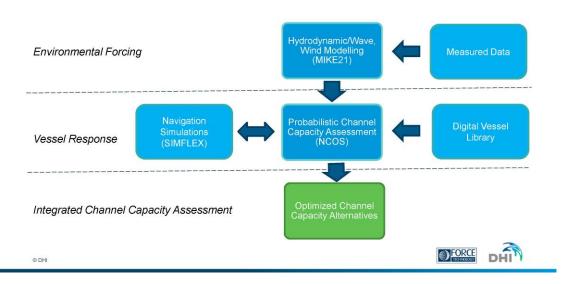
- Incorporates assessment of manoeuvrability and UKC, sometimes also sedimentation
- Most UKC methods relies on older 2D slender body methods or empirical equations.
- Manoeuvrability is often assessed through fullbridge simulators but usually using only a few simulations
- Combined effects of channel hydrodynamics and waves are often simplified
- The optimization potential and adopted level of conservatism and risk is not always made clear to Channel Operators



© DHI



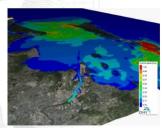
Nonlinear Channel Optimisation Simulator



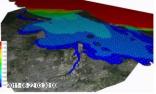
Environmental Forcing

Flexible Mesh 2D/3D Hydrodynamic Model covering the entire port

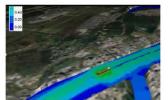
- Separate swell penetration and local wind wave generation
- Detailed flow patterns at berth scale
- Compatible with high-end full bridge simulators
- Multi-year hindcasts in days/weeks
- · 7-day forecasts in hours



2D/3D Currents



Surface Gravity Waves



Displacement (ship) Waves

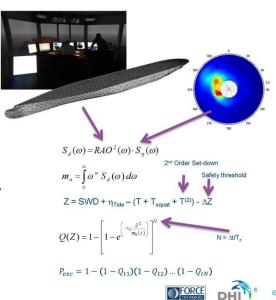




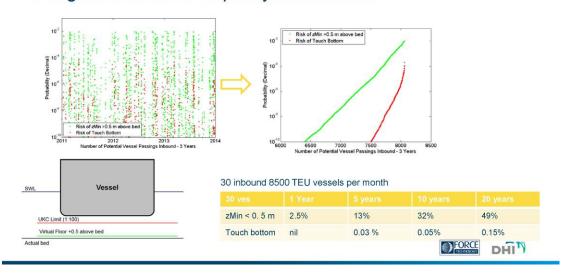
Vessel Response

Non-Linear Channel Operability Simulator (NCOS)

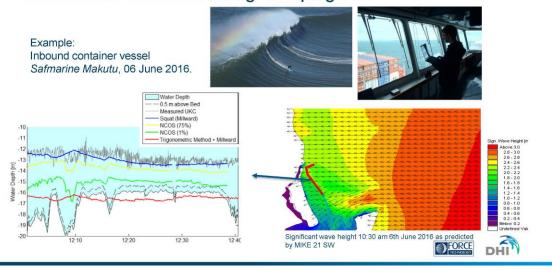
- 3D boundary element method (2nd Order) that implicitly accounts for the forward speed and water depth.
- Vessel UKC response comparable to high-end Full-Bridge Simulators
- Deterministic treatment of long term varying tide, current, wind and wave fields.
- Probabilistic treatment of wave response allowance
- · Integrated Risk Evaluation at Port Level



Integrated Channel Capacity Assessment



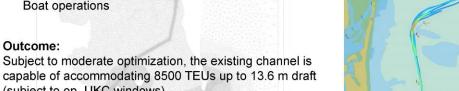
A full-scale UKC Monitoring Campaign



*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

Case Study 1: Port of Brisbane

- 90 km long Navigational Channel
- Declared depth down to 14 m to 15 m LAT
- Need to accommodate 8500 TEU Containers
- Operability based on 36 months of detailed hindcast
- More than 2.2 million unique NCOS vessel transits
- Full-bridge SIMFLEX used to optimize corners, swing basin and quantify effect of improved Tug-**Boat operations**



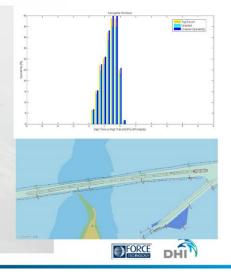
(subject to op. UKC windows) FORCE

Case Study 2: Port of Geelong

- 27 km Channel length with declared depth down to 12.3 m
- Safe Access required for 12 m draft Suezmax
- The section "The Cut" provides significant capacity challenge
- 30 days of environmental hydrodynamic hindcast
- 2,700 NCOS simulations undertaking
- SIMFLEX used to identify constraints due to bank effects and high wind induced drift

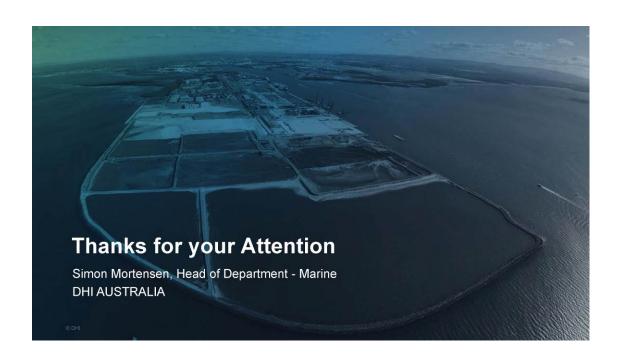
Outcome:

Subject to moderate revising speed profiles and safety threshold it was deemed safe to accommodate 12 m draft vessels in existing channel



Starting Time [hr] Before High Tide





*資料來源:由丹麥 DHI 公司 Qian-Ming Lu 提供或協助說明

108年度『海洋雷達系統擴充及數值模式赴原廠進行實地教育訓練和作業技術操作』出國計畫

簡報人:李政達

Institute of Transportation,MOTC 交通部運輸研究所

出國心得報告

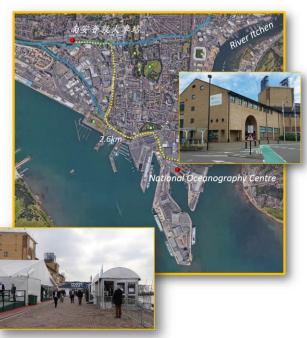
中華民國 108年6月



-出國行程(1)-→

南安普敦郡-國家海洋中心(NOC)





專題討論



Seaview Sensing Ltd 之雷達分析技術與後端處理專題討論



- Lucy Wyatt教授肯定臺灣海洋雷達系統(臺中港站),SNR高,訊好品質良好。
- ■後端計算的基本公式主要係依據Barrick's equation 雷達頻譜分析的理論。
- ■雷達系統配置現況並非全優配置,建議增加天線數量,以改善空間解析度。



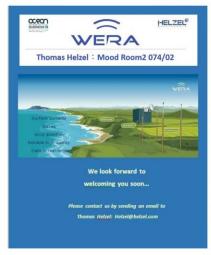


專題討論—★



WERA之海洋雷達系統特點準確性和局限性專題討論

- ■WERA可以依據使用者需求,環境條件選擇緊湊型或陣列型天線系統。
- ■WERA近岸遙感系統,可利用超視距雷達技術監測海表面之海流,波浪和風向。











- ■全球海洋調查技術與最新的測量領域之Ocean Business 每兩年舉辦一次。
- ■離岸調查研討會需付費參加。
- ■海洋儀器展示,採現場報名或網路報名登入,報名者免費入場。





Ocean Business 加拿大Rutter公司波浪雷達系統WaMoS® ||

- WaMoS® II 系統架構是根據X-Band的雷達技術。
- WaMoS® II 系統量測極限至少需大於每秒3公尺的風速。
- ■可架設在無人的平臺上、移動船隻或海岸場址進行自動化操作。





Ocean-Business (金)

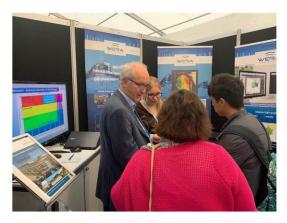
- ■美國水下無人載具開發之專家公司。 ■該公司擁有完整內部測試設施(測試池·聲學測試室)·可供儀器開發測試。
- ■原廠技師介紹EdgeTech 3400 Sub Porfiler底質剖面儀與現場討論。

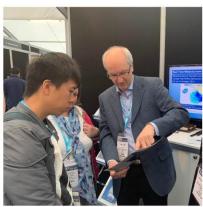




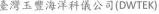
- Ocean-Business - (金) 德國WERA展場

- ■雷達系統可以利用5-50 MHz頻率量測不同海域目標。
- ■演示海洋雷達的相關應用,如搜索、救援、汙染物(油汙)漂移預測等。
- ■海嘯預警系統成功偵測海嘯波之雷達訊號,並發佈疏散警報。





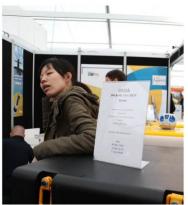
- Ocean-Business - 金灣五豐海洋科儀公司(DWTEK)





- ■今年臺灣唯一在英國Ocean business設展的公司。
- ■全球佈局,未來持續精進。
- ■努力整合臺灣資源,打造亞太地區水下機電的金字招牌。

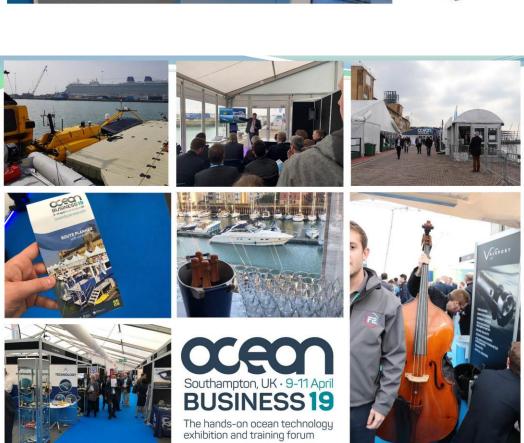




Ocean-Business (美國Teledyne Marine公司展場

■本次展場中會場最大的公司。





出國行程(2)-



─參觀活動—会

荷蘭阿姆斯特丹港交通運輸(水陸兩用經驗)

- ■荷蘭單車車速快且普遍不戴安全帽
- ■自行單自行車之友善城市。
- ■運河與水運交通船。









專題討論─★

DHI之船舶繫纜分析與港口航運能力改善專題討論

- MIKE 21 MA模式,能探討船體6項自由度之浮體運動。
- MIKE 21 MA模式之數值模擬研究,可以特定分析關鍵泊位的運動。
- NCOS可分析碼頭的工作天,量化碼頭閒置情形,做為政府重大決策的參考。



參觀活動 →

丹麥赫爾辛格港翻水牆

- ■赫爾辛格是個市政遊艇港。
- ■港內外三相防波設施。
- ■港邊環保裝置藝術。







參觀活動─★

瑞典Lillgrund離岸風場

■瑞典Lillgrund離岸風場,共48座風機,每座發電機2.3MW,總容量達110MW。



參觀活動 →

奥瑞桑橋(Øresundsbroen)

- ■奧瑞桑橋(Øresundsbroen)又稱厄勒海峽大橋或歐雷松德大橋。
- ■交通時間縮短:由船運的60分鐘縮短為10分多鐘。
- ■厄勒海峽Google map與奧瑞桑人工島。





參觀活動—★

奥瑞桑橋(Øresundsbroen)

■奥瑞桑橋全長7.8公里,海底隧道長3.5公里,明隧道0.5公里,總長11.9公里。



心得結論—★

- 1. 本次出國計畫參加Ocean Business研討會與專家學者針對現場海氣象觀測及 海岸漂沙機制調查技術發展方面,進行心得討論,並交換意見,對於個人 擴展視野及本所研究業務均有實質之幫助。
- 2. 利用海洋雷達進行港區航船的安全管理,國際間已經有許多成功的案例可供我國的借鏡,國內雖處於起步階段,但各國學者專家仍給予寶貴建議, 德國海洋雷達研究人員建議臺灣訊號分析時,可以針對時間的連續性改善 船舶目標判斷的誤差。
- 3. 英國Lucy Wyatt教授對於陣列雷達後端軟體之處理分析,針對特徵值造成 判斷失誤的可能原因提供以下建議,雷達訊號包含許多不同的分量、重複 反射訊號以及雜訊,建議持續觀察與蒐集該地區,取得長期的雷達訊號, 以確認是否為固定雜訊,並將其由頻譜中剔除,應該能改善海洋雷達觀測 的結果。
- 4. 丹麥DHI原廠進行數值模式實地操作訓練與作業技術指導,建議於頻域轉時域過程,改善與實測資料比對的精度,藉此增加模式模擬時的命中率, 應能減少模式模擬時產生的誤差。



心得結論—★

5. 建議臺灣未來的海岸或港灣開發要多方面整體考量,規劃上必須考慮產業、 生態、景觀、永續與城市競爭力等面向,港口轉型之際,港務管理單位仍 需重視管理與整體規劃之重要,以創造價值,並避免腹地閒置浪費。

