出國報告（出國類別：考察）

訪問英國海洋專責研究機構

服務機關：國家海洋研究院

姓名職稱：邱永芳代理院長、林世昌副研究員

、沈寶蘭秘書、陳祥穎技正

派赴國家/地區：英國

出國期間：108年6月15日至6月24日

報告日期：108 年 9 月 16 日

摘要

國家海洋研究院於 108 年 4 月 24 日正式成立，組設五個一級業務單位(綜合規劃及人力培訓中心、海洋政策及文化、海洋科學及資訊、海洋生態及保育、海洋產業及工程等 4 個研究中心)及三個輔助單位，協助海洋委員會辦理海洋政策規劃、海洋資源調查、海洋科學研究、海洋產業及人力培育發展業務，以整合國家海洋研究量能、提昇國家海洋科研實力、發揮海洋研究群聚效益，提升海洋產業競爭優勢，促進國家經濟永續發展，定位為國家海洋智庫。

國家海洋研究院目前規劃與推動中的工作計有: 全國海洋資料庫、全國海洋觀測網、洋流能關鍵技術與研發、海岸國土變遷監測、海洋生態調查及國家級船模試驗中心籌建計畫等六大工作。為汲取先進國家海洋相關產業、學術、及研究機構之經驗，以利前項工作之推動，經英國在臺協會(British Office)等單位的協助下，完成至該國具指標性的海洋相關部門與機構進行參訪的規劃，簽訂合作交流協議、建立協調聯繫機制，讓國際了解台灣對於海洋研究的重視。此次英國考察的行程摘述如下：

1. 參訪勞氏檢驗（LR, Lloyd's Register）英國倫敦全球總部，雙方簽訂技術與合作協議。
2. 參訪 Lloyd's Register Global Technology Centre，與涉海相關部門主管及高階研究員進行研究與技術交流。
3. 參訪 University of Southampton 船模試驗中心與新建完成拖曳水槽(Towing Tank)及高速台車系統，就廠房興建、水模機組設計規劃及施工、認證、船模試驗檢測技術、與營運策略等範疇交流。
4. 參訪英國國家海洋中心(National Oceanography Centre)、Discovery 研究船及相關研發產學合作機構，就該中心目前所推

動多領域海洋基礎科研調查、國家海洋資料庫、海洋研究船維運、產業合作及未來雙方國際合作策略進行實質討論。

5. 參訪Gill Instruments與HR Wallingford海洋科學儀器公司與其試驗中心，了解調查海調科儀、水工試驗、操船模擬設備之性能諸元及關鍵核心技術，參觀組裝與測試工廠，與原廠研發人員進行技術交流，了解其系統整合及試驗設計方式。

本次參訪對國家洋研究院未來在執行海洋資源調查、海洋科學研究、海洋產業創新研發、建置國家海洋研究船隊、水工模型與船模驗相關實驗室、高階研究人力與技術人員交流、未來國際海洋科研調查合作等重要工作事項至甚重要，參訪團隊從中汲取許多寶貴經驗，參訪報告可供本院相關研究中心之進行後續研究、產學合作、實驗室與船隊維運等之重要資訊參考。重要效益摘述如下:

1. 與勞氏檢驗（LR）簽訂技術與合作協議:

該公司為國際頂尖獨立稽核服務的驗證機構，於海洋工程及船舶之設計、建造、驗證有完整的經驗及規範外，旗下的研究人員與驗船師人數為業界最高;在海洋產業及創新部份，其創新監測設備及整合式應用管理軟體，於產業界有相當高之評價;在專業人員培訓部份，其課程與師資均高於國際相關規範，也為公部門提供服務;雙方簽訂技術與合作協議後，勞氏將為國海院提供所需的研究資訊及技術支援，有益於國海院未來在新建研究船、關鍵實驗室、船模試驗中心、人員培訓之規劃、認證與執行。

2. 參訪University of Southampton船模試驗中心:

該校船模試驗中心的設備規格可供快速船舶之測試，該中心之(1)造波機組與波浪消波處理、反射波反制設計、(2)台車系統軌道的平衡、固定、抑震工法，(3)監測器配置及定位、(4)安全管理(訪客管理、技術人員工作安全管理、(5) 船模試驗檢測技術與認證、與(6)營運策略等，可供國家海洋研究院未來在建置船模中心的參考。

3. 參訪 National Oceanography Centre、Discovery 研究船及相關研發產學合作技術創新機構:

National Oceanography Centre 隸屬政府部門，擁有 647 位科學家、工程師、職員與技術人員，在基礎科學研究調查、海洋資料庫與研究船維運、產業創新合作與跨域系統整合、人才培育及國際海洋研究合作等面向有非常好的實蹟，其運維策略可供未來國家海洋研究院在整合海洋科研、產學合作、人才培育、研究船維運及國際海洋研究上重要借鏡。在本次參訪中 National Oceanography Centre 更主動邀請本院參與 Argo 海洋觀測計畫，並推薦日本國立研究開發法人海洋研究開發機構(JAMSTEC)為本院的區域合作夥伴，亦提供日方對口聯絡人相關資訊，對未來臺英、臺日、及臺日英的國際合作有了良好的開端。

4. 參訪 Gill Instruments 與 HR Wallingford 海洋科學儀器公司:

Gill Instruments 專長為超聲波風速計和氣象站產品、HR Wallingford 以造波機、海事工程、無人船、各種軟體與操船模擬機聞名，兩者公司以生產高品質、高耐用度之設備揚名國際。本次參訪包含參觀組裝與測試工廠，與原廠研發人員進行

技術交流，有益於本院(1)了解海氣象常用之風速調查儀器的規格、限制、系統整合介面與特殊功能、(2)確認未來國家海洋研究院建置海洋觀測儀器的設備需注意事項、(3)了解造波機、離岸風電機、操船模擬機的規格、限制、系統整合介面與特殊功能、及(4)確認未來國家海洋研究院建置水工試驗及操船模擬機等設備需注意事項。

海洋為資源寶庫、氣候變遷關鍵、生活處所及貨貿交通之所在，深遠影響國家經濟與人民生活福祉，海洋也是台灣最重要的出路，本次的參訪行程能順利成功，要特別感謝海洋委員會各級長官在預算上的支持、英國在臺協會(British Office) 的協調、及英國勞氏檢驗（LR）、University of Southampton、National Oceanography Centre、Gill Instruments 與 HR Wallingford 等單位的大力協助，讓國家海洋研究院能以更高的視野佈局未來，整合全國海洋研究量能接軌國際研究，不斷提昇國家海洋科研實力，朝向國際級的國家海洋研究機關努力邁進。

目次

一、　目的

國家海洋研究院於 108 年 4 月 24 日正式成立，組設五個一級業務單位(綜合規劃及人力培訓中心、海洋政策及文化、海洋科學及資訊、海洋生態及保育、海洋產業及工程等 4 個研究中心)及三個輔助單位(圖 1.1)，協助海洋委員會辦理海洋政策規劃、海洋資源調查、海洋科學研究、海洋產業及人力培育發展業務(圖 1.2)，以整合國家海洋研究量能、提昇國家海洋科研實力、發揮海洋研究群聚效益，提升海洋產業競爭優勢，促進國家經濟永續發展，定位為國家海洋智庫。

圖 1.1 國家海洋研究院之組織編制

圖 1.2 各研究中心簡介

國家海洋研究院目前規劃與推動中的工作計有:全國海洋資料庫、全國海洋觀測網、洋流能關鍵技術與研發、海岸國土變遷監測、海洋生態調查及國家級船模試驗中心籌建計畫等六大工作。為汲取先進國家海洋相關產業、學術、及研究機構之經驗，以利前項工作之推動，經英國在臺協會(British Office)等單位的協助下，完成至該國具指標性的海洋相關部門與機構進行參訪的規劃，簽訂合作交流協議、建立協調聯繫機制，讓國際了解台灣對於海洋研究的重視。

參訪行程表如表 1.1 所示。

表 1.1 出國行程概要

日期		行程概要	地區
6月15日	(六)	抵達倫敦希斯洛機場	倫敦
6月16日	(日)	整理參訪資料並聯繫相關單位	倫敦
6月17日	(一)	參訪 Lloyd's Register英國倫敦全球總部	倫敦
6月18日	(二)	參訪 Lloyd's Register Global Technology Centre與 University of Southampton船模試驗中心	南安普頓
6月19日	(三)	參訪 National Oceanography Centre	南安普頓
6月20日	(四)	參訪 Gill Instruments	利明頓 (住宿牛津)
6月21日	(五)	參訪 HR Wallingford	瓦林福德 (住宿牛津)
6月22日	(六)	與 HR Wallingford轉介之Cussons水槽規劃公司聯繫，並返回希斯洛機場候機	倫敦 希斯洛機場
6月23日	(日)	倫敦希斯洛機場起飛	倫敦 希斯洛機場
6月24日	(一)	抵達高雄	臺灣

二、 行程說明

1 參訪 Lloyd's Register 英國倫敦全球總部

國際知名船舶稽核認證機構--勞氏檢驗（Lloyd's Register, 簡稱 LR）成立於 1760 年，總部位於英國倫敦，其主要業務包含提供客戶符合國際標準的驗證（Certification） 、確證（Validation）、查證（Verification）和訓練（Training）服務，該公司是世界上第一個設立船級社的民間機構，針對船舶建造及其相關設備訂有十分嚴謹技術規範，透過獨立稽核人員(驗船師等)透過船檢在船舶建造和調試期間進行監控，並在設備和船舶運營期內進行持續檢查以確保船舶和設施持續符合規範要求，該公司也是國際船籍社之創始會員，公司旗下有超過 150 位專任驗船師與 100 位技術專家在世界各地服務，是目前國際第 2 大船級社，該公司所出版的技術規範一直是國際與業界指標。

LR 為國際海軍安全協會（International Naval Safety Association, INSA）創始成員，職負海軍艦艇和潛艇的認證規範研擬，於 2000 年完成相關規範制定，也是世界上第一個針對特殊規格的軍用船制定符合國際規範且軍艦特殊作戰需求的船級單位。該公司目前的稽核業務除了船舶及設備外，還擴及至風電、鑽油平台、電信、能源管理系統、企業責任、職業安全、教育訓練等諸多面向。

LR 倫敦總部建於 2000 年，由著名的 Rogers Stirk Harbour + Partners 建築師事務所承造，因應英國氣候及開放的企業組織文化，在辦公隔間及外牆運用大量強化玻璃，在兼顧結構應力、消防安全及門禁管理的前提下，達善用自然光、開放空間與全視野的需求(圖 2.1)，是倫敦的著名地標建築。在臺灣高雄軟體科技園區向海側的著名地標-慶富集團營運總部大樓(圖 2.2)亦由該事務所設計，外觀與結構設計與 LR 倫敦總部高度類似。

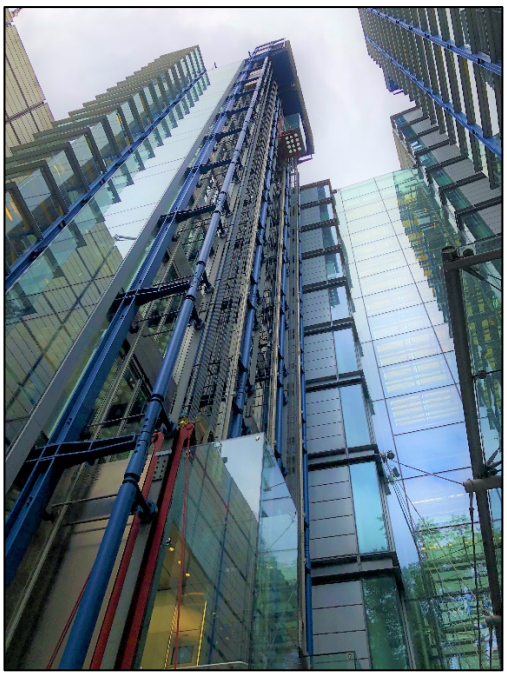


圖 2.1 LR 英國倫敦總部大樓

圖 2.2 慶富集團營運總部大樓

參訪 LR 總部的首站是 LR 歷史資料的展示室，在總部之北亞區再生能源事業部經理 Kevin Todd(圖 2.3 右 2)及 LR 臺灣分公司許首雄總經理(圖 2.3 右 1)的解說中，見證 LR 的成長(圖 2.3 至 2.6)。

圖 2.3 LR 英國倫敦總部大樓門牌

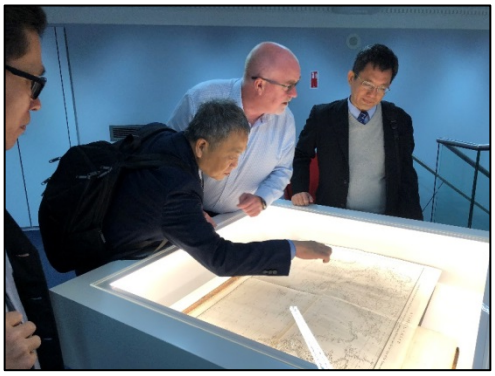


圖 2.4 LR 歷史資料的展示室

圖 2.5　LR 歷史資料的展示室

圖 2.6 第一艘入籍 LR CLASS 的船舶

簡短的參訪後，本次訪問團在 LR 總部的會議室中與 LR 北亞區再生能源事業部經理 Kevin Todd 進行交流，由本院林世昌副研究員負責簡報本院的組織架構、各研究中心職掌、目前推動中及未來規劃中之重要工作(圖 2.7)，隨後由邱院長針對 Kevin Todd 的提問回覆。

早在今年 5 月中旬，本院與 LR 已就交流議題進行確認，因此 LR 總部高層特別指派曾協助日本 47 個地區確認離岸風電風場最佳場域及為臺灣離岸風電廠商進行風場認證的再生能源事業部經理 Kevin Todd 向本院參訪團隊簡報 IRIS 監測平台(圖 2.8)，目前該平台已廣泛運用在海洋觀測與預報、海洋數據傳輸與雲端資料庫、離岸風場及船舶營運及風險管理等服務。

臺灣離岸風電負責電力傳輸的水下纜線是維繫電網穩定的關鍵要素之一，如何進行 24HR 監測與自動化警報，在可能發生斷纜情境前適時進行應力調整、電纜保護與檢查，至為重要，然也是目前最常被政府及環保團體忽略的項目。因此簡報中，Kevin Todd 特別為展示 IRIS 監測平台於水下纜線系統之應用，所有資料展示在 server 網頁上進行完整的監控。

在簡報與技術交流中，Kevin Todd 也從國際海洋能開發的現況及未來環境預測、臺灣在海洋能開發的挑戰與機會等議題提出他的觀察所見，提

供許多的寶貴意見，有助於本院海洋產業及工程研究中心未來在這面向上的研發規劃。

圖 2.7 與 Kevin Todd 會談

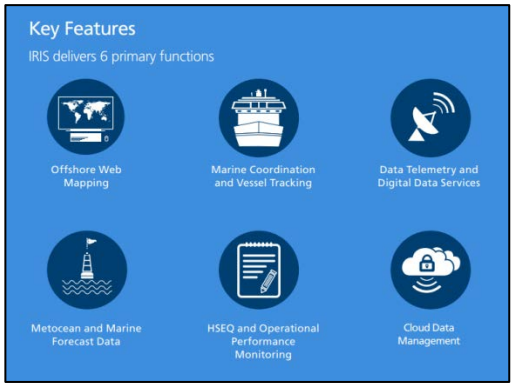


圖 2.8 IRIS 監測平台
資料來源: Kevin Todd, LR, 2019

第二階段則是由海洋技術部門總監 Tim Kent (Technical Director, Marine & Offshore)與本院研究團隊進行交流並代表公司與本院簽訂合作協議。

勞氏集團(LR)共有 16 個子公司(圖 2.9)，本案經 LR 高層決議指示，為強化該公司與本院未來在科學研究及技術合作交流的廣度與深度，先就合作議題指派各相關部門預擬簡報，安排專人導引本參訪團隊至 Lloyd's Register Global Technology Centre 參訪，並由法務部門於 6 月初與本院負責涉外聯絡的林世昌副研究員確認 MOU 英文版細節，最後指派出其負責亞洲事務的子公司 Lloyd’s Register Asia 的技術部門最高主管 Tim Kent 代表 LR 與本司簽訂 MOU(圖 2.10)，在參訪日由相關部門的主管為本院參訪團隊簡報。

為突顯雙方的實質合作及 LR 對本案的重視，於完成 MOU 簽署後，LR 台灣分公司立即規劃在本院參訪團隊返臺後第 4 日，假海洋委員會第一會議室舉辦「智能化系統於造船產業用研討會」，當日 LR 亞洲公司、各系統專案負責團隊、國內大型造船產業均派高層與會。

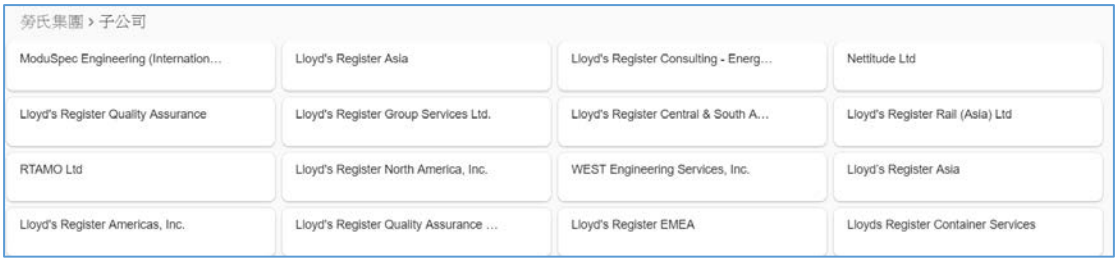


圖 2.9　LR 子公司

資料來源:勞氏集團子公司，GOOGLE

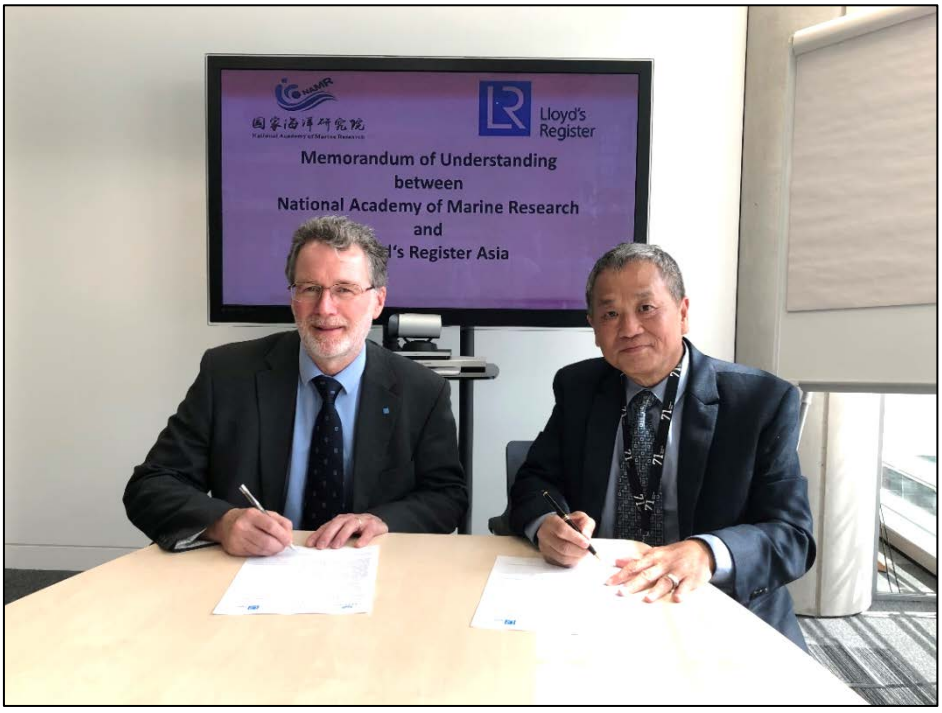


圖 2.10 國家海洋研究院與 LR 簽訂 MOU

2 參訪 Lloyd's Register Global Technology Centre 與 University of Southampton 船模試驗中心

2.1 參訪 Lloyd's Register Global Technology Centre

位於南安普頓大學(University of Southampton)校區之海事卓越中心(Maritime Centre of Excellence)的 Lloyd's Register Global Technology Centre 佔地 4.3 公頃，為 LR 之主要科技研究單位，規劃可供 400 位 LR 研究人力進駐，是 LR 在發展海洋科技領域的重要基地。

Lloyd's Register Global Technology Centre 也與 University of Southampton 的團隊進行合作研究，研究成果耀眼國際，該中心目前在海洋工程科學領域具國際級領導地位。

本次參訪由該中心的主管 Paul James (Programme Manager) 接待並主持會議(圖 2.11)，與會人員包括 Gary Pogson (Innovation Owner Marine & Offshore)、Joseph Morelos (Technology Innovation Manager)、Vaibhav Parsoya (Innovation Owner Marine & Offshore)、Amelia Stead (Business Model Innovation Architect, Marine & Offshore) 均為海洋部門的高層主管。

圖 2.11 本院參訪團與 LR Global Technology Centre 研究人員

簡報議題與大綱摘述如下:

（1） 智能船艦應用區塊鏈技術

介紹資料結構(Digital Structure)之區塊鍊技術在軍艦的最新之智能化應用。LR 在智能船艦應用區塊鏈技術訂定完整且先進規範，該技術分為 AL0~AL5，LR 在 AL2、AL3 等級技術領先全球，目前積極研發 AL4 及 AL5(無人船)等級以上的高階技術中。

（2） 離岸風電分機系統安全監控

運用「數位孿生」(Digital Twins) 監控技術，來分析、預測風機的結構或材料的損害，避開人因錯誤判斷風險。另為驗證 Digital Twins 的正確性(圖 2.12)，LR 利用「Assurance of Digital Twins for Health Management」以儀器設備相互溝通(end to end)的技術(圖 2.13)，進行連續性現場驗證，確認監控系

統的正確性與限制，LR 對該項技術訂有完整的檢驗機制及標準作業程序。

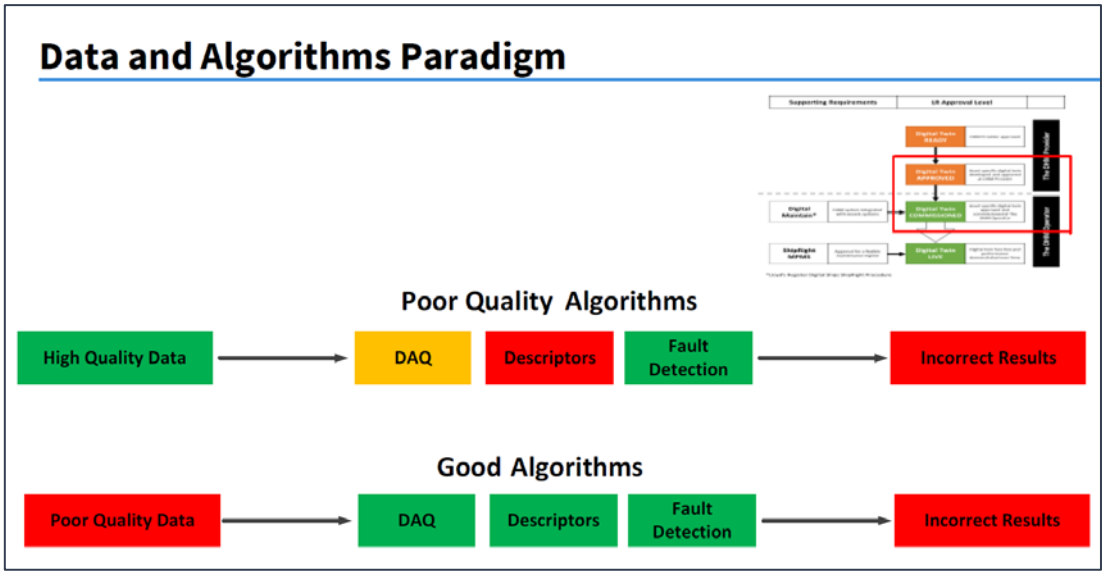


圖 2.12 資料與演算法的盲點
(資料來源:LR 簡報資料)

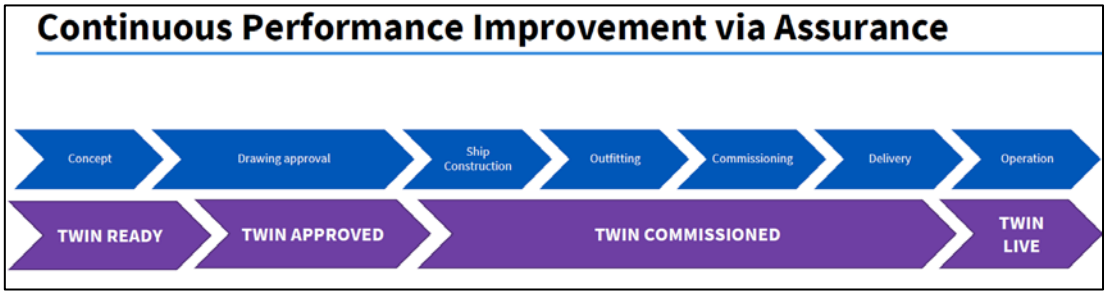


圖 2.13 Assurance of Digital Twins for Health Management 驗證技術
(資料來源:LR 簡報資料)

（3） 特殊規格船舶(如海軍軍艦)的認證

先進國家對於軍艦認證(如圖 2.14)要求遠高於商船認證規範。LR 是全世界第一個針對特殊規格的軍用船(包含航空母艦、驅逐艦、巡航艦、快速艦、潛艦、無人艦等)制定符合國際規範且軍艦特殊作戰需求的船級單位，從船舶設計圖、材料認證、設備認證、巡查記錄、直接測量檢查、測試和試驗表格、整船檢查、變更和修改等均有嚴謹完整規定(圖 2.15)，也協助多國政府單位進行軍艦承造

船廠之安全和環境評估。

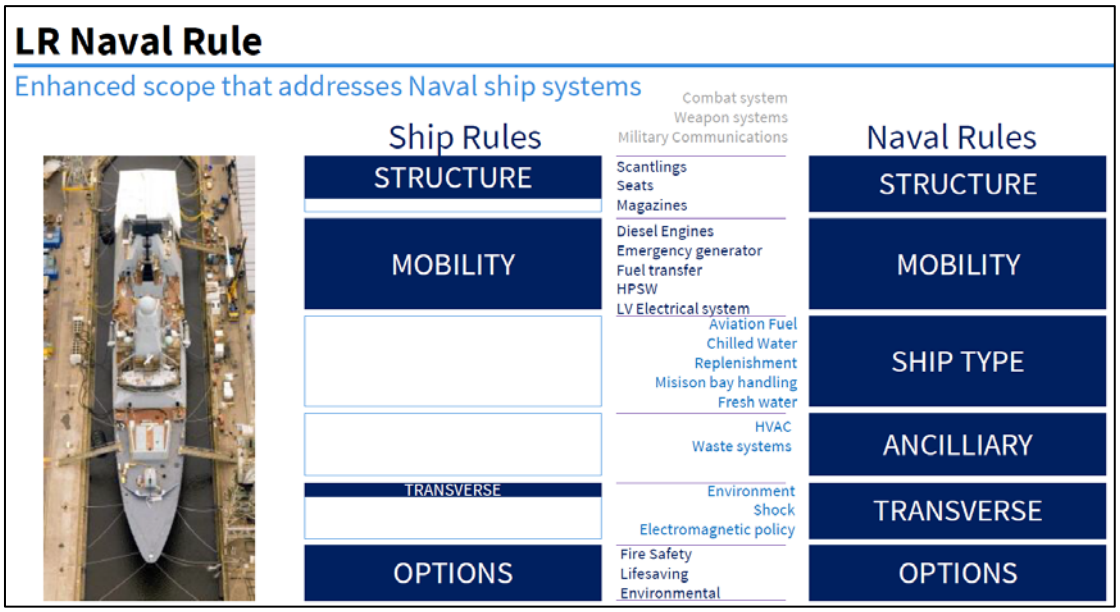


圖 2.14 LR 海軍船艦認證規範

(資料來源:LR 簡報資料)

圖 2.15 LR 快速小艇認證規範
(資料來源:LR 簡報資料)

2.2 參訪 University of Southampton 船模試驗中心

南安普敦大學(University of Southampton)船模試驗中心(圖 2.16)位南安普頓大學校區之海事卓越中心(Maritime Centre of Excellence)。

由南安普敦大學及 LR 共同合作興建中的國際級船模試驗中心(主體建築工程約新臺幣 6.4 億元、造波機等相關儀器設備約新臺幣 1.6 億)，建置全歐洲大學中最大的拖航水槽(Towing Tank，L/H/D 為 138m/6m/3.5m)，待完成的高速台車驅動控制系統測試後即可提供學校辦理教育訓練、支援流體動力學(fundamental fluid dynamics)、再生能源(renewable energies)及創新船舶設計等領域的基礎和應用研究，並協助遊艇、快艇、商船等船舶產業進行船模試驗。

圖 2.16 南安普敦大學船模試驗中心

本次參訪行程由船模試驗中心的籌建經理 Martin(圖 2.17)親自引領，在 Martin 簡報該試驗中心主體建物與試驗設備的設計、建造工法細節、船模試驗認證及未來營運規畫後，再由營運經理 Bertrand 帶領本院參訪團隊參訪實驗室(圖 2.18)、拖航水槽(圖 2.19 及圖 2.20)、造波機(圖 2.21)、拖曳台的避震設計(圖 2.22)、高速台車(圖 2.23)及各式船模用螺槳(圖 2.24)。

該拖航水槽配備高速台車系統，台車最高速度為 12m/sec(由 0 加速至 12m/sec 僅需 40m，有 60m 可供維持 5 秒量測段)，拖曳台的避震設計讓台車能平直加速並避免震動，可模擬不規則波的新式造波機，水槽末端的消波設計可有效的防止反射波。該試驗中心可提供高速艇(航速 50 節)的船模試驗。

圖 2.17 籌建經理 Martin 介紹船模試驗水槽

圖 2.18 營運經理 Bertrand 介紹實驗室

圖 2.19 測試中之船模試驗水槽

圖 2.20 Bertrand 介紹船模試驗水槽

圖 2.21 水槽用造波機

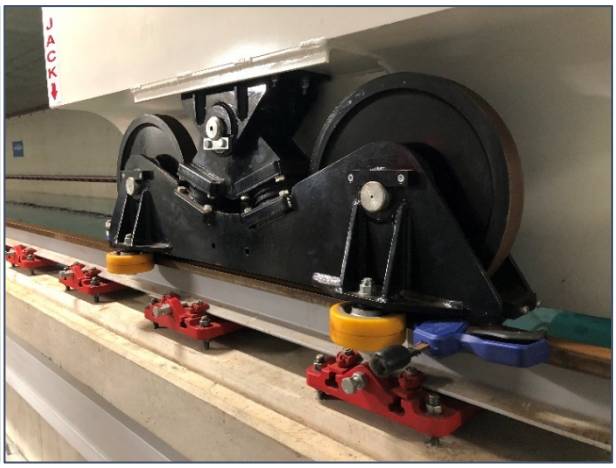


圖 2.22 拖曳台車避震系統

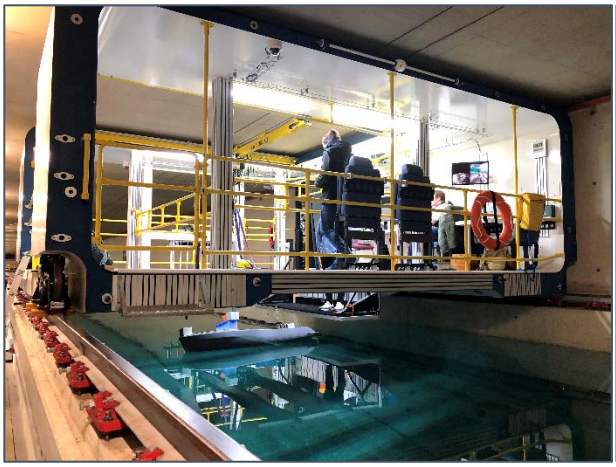


圖 2.23 高速台車作業平台

圖 2.24 各式船模用螺旋槳

3 參訪 National Oceanography Centre

英國國家海洋中心(NOC, National Oceanography Centre)(圖 3.1 及圖 3.2) 成立於 2010 年 4 月 1 日，為英國最大的海洋科學與技術研究機構，隸屬英國自然環境研究委員會(Natural Environment Research Council)(圖 3.3)，在 Southampton 與 Liverpool 各有 1 處研究基地，每年的營運經費約 6000 萬英磅(約 24 億新臺幣)，政府提供 50%經費，餘由外單位之研究計畫支援，中心研究人力共 647 名。

圖 3.1 英國國家海洋學中心
(資料來源:Alan Evans 簡報)

圖 3.2 國家海洋學中心接待大廳

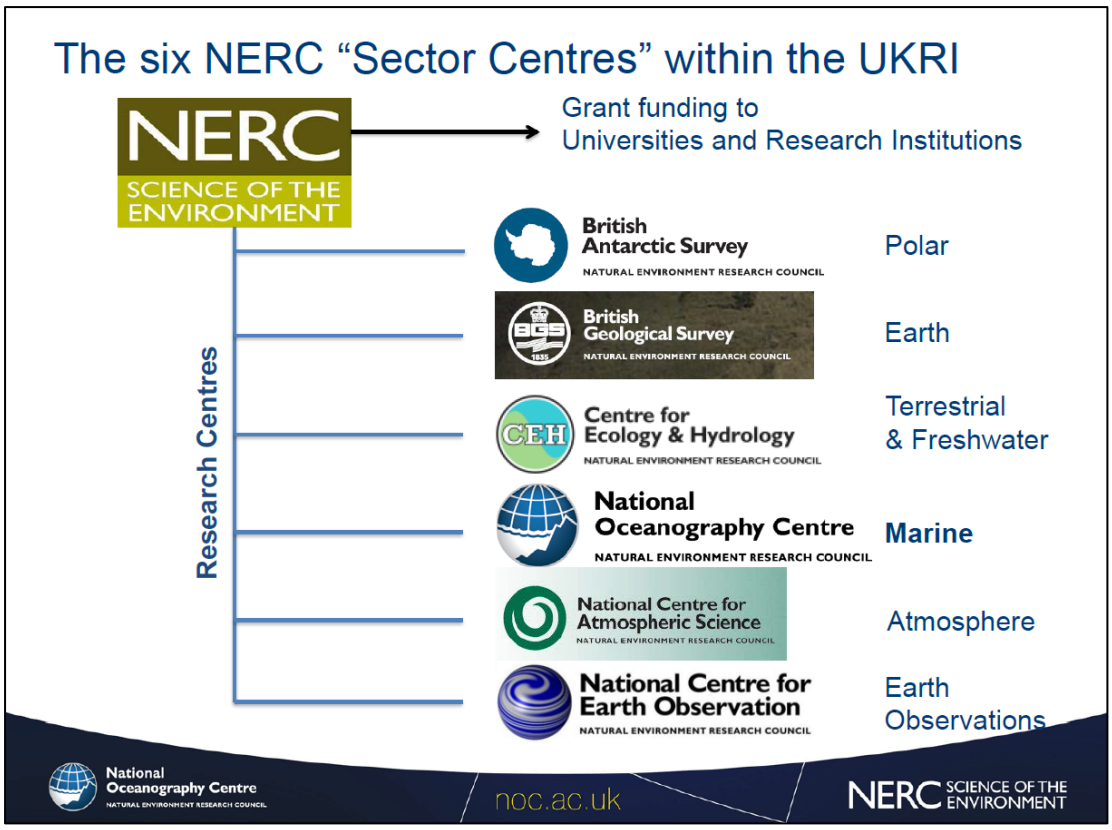


圖 3.3 自然環境研究委員會與所屬機構組織
(資料來源: National Oceanography Centre)

National Oceanography Centre 下轄 RRS James Cook(圖 3.4)、RRS Discovery(圖 3.5)等 2 艘先進大型研究船，為 world-class research ship 等級，可在 6 級海象下安全作業並執行全球海洋研究。

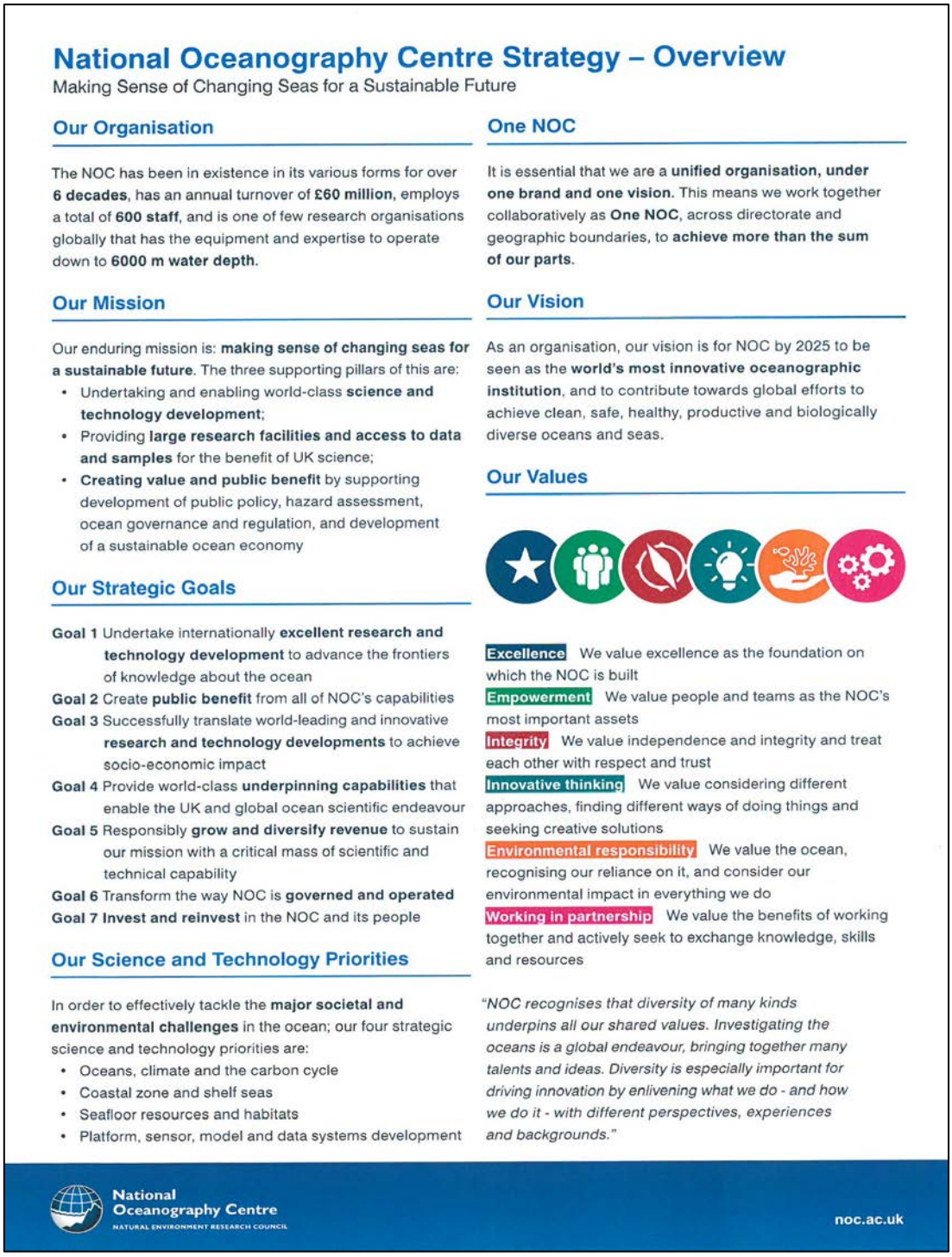
圖 3.4 RRS James Cook

圖 3.5RRS Discovery

(資料來源: National Oceanography Centre)

該中心的主要工作為透過嚴謹的海洋科學調查、產出國家政策、海洋

環境保護及產業發展所需的數據、資料與資料，提供國家訂定海洋政策規劃參考。國家海洋學中心的宗旨為「了解海洋，實現可持續發展的未來(Making sense of changing seas for a sustainable future)」(圖3.6)。



National Oceanography Centre Strategy – Overview

Making Sense of Changing Seas for a Sustainable Future

Our Organisation

The NOC has been in existence in its various forms for over **6 decades**, has an annual turnover of **£60 million**, employs a total of **600 staff**, and is one of few research organisations globally that has the equipment and expertise to operate down to **6000 m water depth**.

Our Mission

Our enduring mission is: **making sense of changing seas for a sustainable future**. The three supporting pillars of this are:

- Undertaking and enabling world-class **science and technology development**;
- Providing **large research facilities and access to data and samples** for the benefit of UK science;
- **Creating value and public benefit** by supporting development of public policy, hazard assessment, ocean governance and regulation, and development of a sustainable ocean economy

Our Strategic Goals

Goal 1 Undertake internationally **excellent research and technology development** to advance the frontiers of knowledge about the ocean
Goal 2 Create **public benefit** from all of NOC's capabilities
Goal 3 Successfully translate world-leading and innovative **research and technology developments** to achieve socio-economic impact
Goal 4 Provide world-class **underpinning capabilities** that enable the UK and global ocean scientific endeavour
Goal 5 Responsibly **grow and diversify revenue** to sustain our mission with a critical mass of scientific and technical capability
Goal 6 Transform the way NOC is **governed and operated**
Goal 7 **Invest and reinvest** in the NOC and its people

Our Science and Technology Priorities

In order to effectively tackle the **major societal and environmental challenges** in the ocean; our four strategic science and technology priorities are:

- Oceans, climate and the carbon cycle
- Coastal zone and shelf seas
- Seafloor resources and habitats
- Platform, sensor, model and data systems development

One NOC

It is essential that we are a **unified organisation, under one brand and one vision**. This means we work together collaboratively as **One NOC**, across directorate and geographic boundaries, to **achieve more than the sum of our parts**.

Our Vision

As an organisation, our vision is for NOC by 2025 to be seen as the **world's most innovative oceanographic institution**, and to contribute towards global efforts to achieve clean, safe, healthy, productive and biologically diverse oceans and seas.

Our Values

Excellence We value excellence as the foundation on which the NOC is built
Empowerment We value people and teams as the NOC's most important assets
Integrity We value independence and integrity and treat each other with respect and trust
Innovative thinking We value considering different approaches, finding different ways of doing things and seeking creative solutions
Environmental responsibility We value the ocean, recognising our reliance on it, and consider our environmental impact in everything we do
Working in partnership We value the benefits of working together and actively seek to exchange knowledge, skills and resources

"NOC recognises that diversity of many kinds underpins all our shared values. Investigating the oceans is a global endeavour, bringing together many talents and ideas. Diversity is especially important for driving innovation by enlivening what we do - and how we do it - with different perspectives, experiences and backgrounds."

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

noc.ac.uk

圖 3.6 國家海洋中心發展中心 DM

(資料來源: National Oceanography Centre)

本院於出訪前 3 週已將擬討論議題(國家海洋學中心維運、海洋水文觀測、海洋資料庫管理等)EMAIL 委請英國在臺辦事處函轉 National Oceanography Centre。該中心十分重視本院研究團隊的到訪，特由國際戰略夥伴辦公室(International & Strategic Partnerships Office)主任 Alan Evans 組織相關部門主管為本院團隊簡報(圖 3.7)。NOC 出席主管計有:

- Alan Evans，International & Strategic Partnerships Office 主任，圖 3.7 左 1。
- Jackie Pearson，International & Strategic Partnerships Office 經理，圖 3.7 右 1。
- Dr. Brian King，Marine Physics and Ocean Climate Group，主管，圖 3.7 右 2。
- Dr. Helen Snaith，British Oceanography Data Centre，主管，圖 3.7 右 3。

圖 3.7 本院與 NOC 主管合影

National Oceanography Centre Hosts
Alan Evans, Head of the International and Strategic Partnerships Office
Dr Brian King, Marine Physics and Ocean Climate Group
Dr Helen Snaith, British Oceanographic Data Centre
Aidan Thorn, Head of the Marine Robotics and Innovation Centre
Jackie Pearson, Marine Manager, International and Strategic Partnerships Office

Agenda

10:00	Arrive at reception to be met by Jackie Pearson. Transfer to Library Red Room to be joined by Alan Evans.
10:10	Introduction to the National Oceanography Centre – Alan Evans
10:30	Overview of NERC's ships and NMEP – Jackie Pearson
10:40	The work of the National Academy of Marine Research *To be joined by Brian King and Helen Snaith*
11:10	Marine hydrological observation – Brian King
11:30	How NOC manages marine data – Helen Snaith
11:50	Questions
12:00	To the Marine Robotics Innovation Centre for an overview - Aidan Thorn
13:00	To cafeteria for lunch
14:00	Transfer to RRS *Discovery* for brief overview and visit to the Bridge
14:30	Return to Library Red Room
14:40	Closing comments with Alan Evan and Jackie Pearson
15:00	Depart NOCS

圖 3.8 參訪 NOC 議程表

3.1 National Oceanography Centre 簡介

參訪的第一個行程是由 Alan Evans 主任簡介國家海洋中心（National Oceanography Centre）（圖 3.9），該中心年度預算 6000 萬英鎊，轄下的科學家、工程師、技術人員與行政職員共計 647 名員工，分別進駐在南安普頓院區（Southampton，525 人）及利物浦院區（Liverpool，122 人)等 2 個院區及海洋研究船。

圖 3.9　Alan Evans 為本院團隊簡報

National Oceanography Centre 南安普頓院區的一級研究單位有：

- 海洋地球科學組(Marine Geoscience Group)
- 海洋物理與海洋氣候研究組(Marine Physics and Ocean Climate Research Group)
- 海洋系統數值模型組 (Marine Systems Modelling)
- 海洋生物地球化學與生態系統組(Ocean Biogeochemistry and

Ecosystems)

- 海洋技術與工程組(Ocean Technology and Engineering Group)

上述各部門的研究分工明確，從基礎性及長期性的海洋基礎觀測、全球性與區域性的數值模型建置、海洋資料管理、海洋測繪和探勘、觀測儀器開發、海洋機器人系統創新研發、到科學報告製作與企業合作等皆有專人負責。

為培育海洋科學領域人才，National Oceanography Centre 與 University of Southampton 等大學及國內企業策略結盟，National Oceanography Centre 無償提供博士生到中心實驗室及研究船進行相關的合作研究，目前有 205 名 University of Southampton 的博士生在該中心南安普頓院區實習研究。

3.2 海洋水文觀測

衛星遙測(可見光/不可見光)、機戴側掃雷達、船載式/底碇式都卜勒流剖儀 ADCP(Acoustic Doppler Current Profiler)、海流儀 AWAC (Acoustic Wave and Currents)、多頻道科學聲納(Scientific Echo Sounder)、附壓力計之倒置式迴聲儀 PIES (Pressure equipped Inverted Echo Sounder)、拖曳式溫鹽深儀(CTD)載具 SeaSoar、走航式 CTD (Underway CTD，UCTD)、ARGO 剖面觀測浮標(ARGO Profiling Float)、自走式水下載具(Autonomous Underwater Vehicle，AUV) Seaglider、船舶雷達(Marine Radar)、高頻雷達(HF Radar) CODAR、海底電纜等均可用於海洋觀測，依觀測項目、觀測範圍、精度要求、資料傳輸方式及時效性等需求決定觀測的方式。

為取得較高精確度、長期性且持續性的波高、潮位、水深、海洋分層流速、海溫、濁度、鹽度、葉綠素、CO2、營養鹽等相關資料，考量成本、

資料取樣頻率、觀測範圍、效度等因素，National Oceanography Centre 海洋物理與海洋氣候研究團隊(Marine Physics and Ocean Climate Research Group)會利用資料浮標/觀測樁/錨錠式浮標(定點的資料)、船測及施放漂流式浮標等方式來取得資料。

海洋物理與海洋氣候研究組(Marine Physics and Ocean Climate Research Group)計畫主持人 Dr. Brian King 為本院參訪團隊簡報該中心利用 Atlantic 26N array、Go-Ship、Argo 所進行的海洋觀測現況。

3.2.1 Atlantic 26N array

Atlantic 26N array(圖 3.10)係利用佈置在大西洋北緯 26 度上的陣列式錨碇浮標來量測海洋分層的流速/流向、溫鹽、濁度、pCO2、溶氧、pH 值等資料，具有高時間分辨率（可至小時）與長量測邊界(in boundaries)的優勢，儘管因測站密度低(空間分辨率欠佳、只有定點觀測數據資料)，但仍可利用模擬軟體來進行大尺度的流場模擬。部份測站可利用衛星回傳即時(real-time)海洋觀測資料，其他則透過研究船定期(每 1 或 2 年)回收。

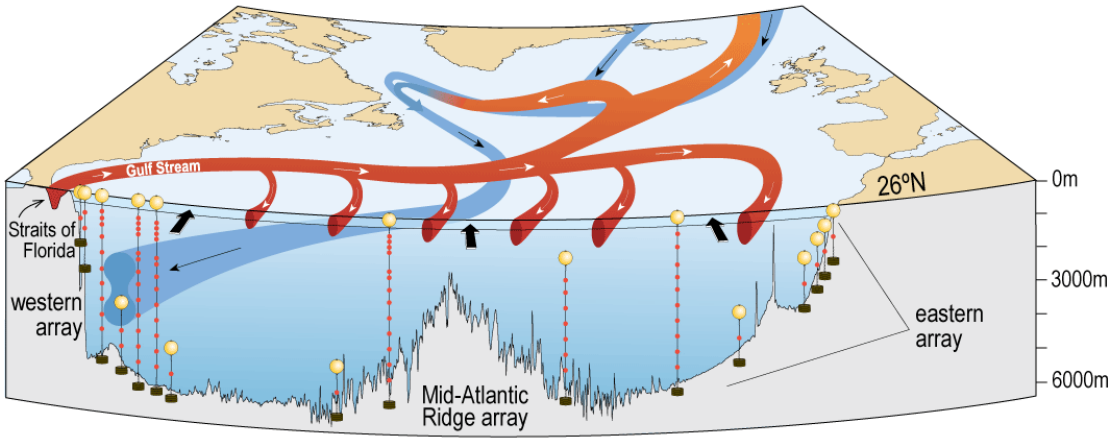


圖 3.10 Atlantic 26N array 錨碇系統觀測

(資料來源: Dr. Brian King 簡報)

3.2.2 Argo

海洋儲存與運輸大量的熱能，左右氣候變遷的發展，若能取得海洋各分層高精度的溫度、鹽度資料，就能對氣候變遷作出更精確的預測，據以研提海岸保護、調適科技、及海岸管理等策略，兩全自然環境保障與人民生命財產保護。在全球海洋科學家的倡議與多國支持下，共同發展出Argo(全球海洋浮標觀測系統，圖 3.11)，統計至 2019 年 8 月，共有 24 國 3852 個 Argo 海洋剖面觀測浮標於三大洋中正常服役，每年平均約有 800 顆 Argo 浮標加入全球觀測計畫。

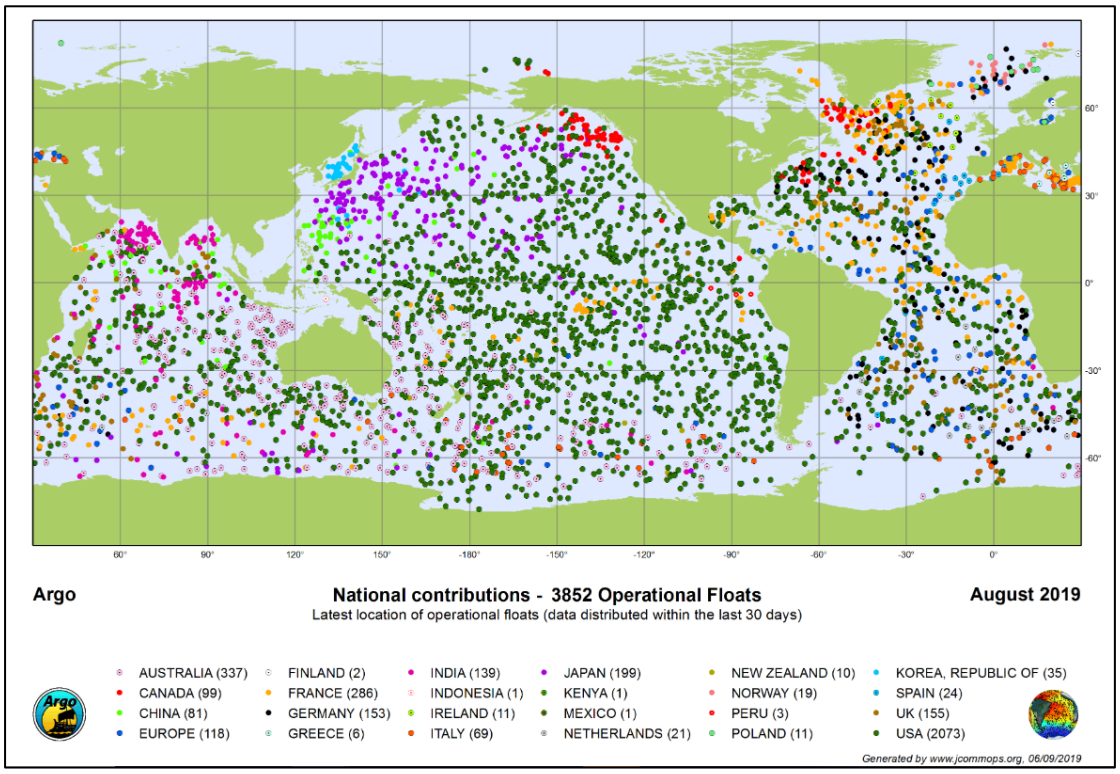


圖 3.11 全球 Argo 海洋剖面觀測浮標分佈

(資料來源:Argo 官網)

利用電池供電的 Argo 海洋剖面觀測浮標(圖 3.12)會以 10 天為週期在水深 2000m 的範圍內自動觀測各水層的溫度與鹽度，由 2000m 水深上浮至自海表面需耗時 6 小時，當浮出海表面時，自動將相關觀測資訊上傳衛星後，浮標會再自動下沉至設定深度，重復「觀測、上浮、資訊傳輸、下

沉、資料觀測」的過程(圖 3.13)，一般而言 Argo 海洋剖面觀測浮標在生命期內可進行 150 次的觀測循環。

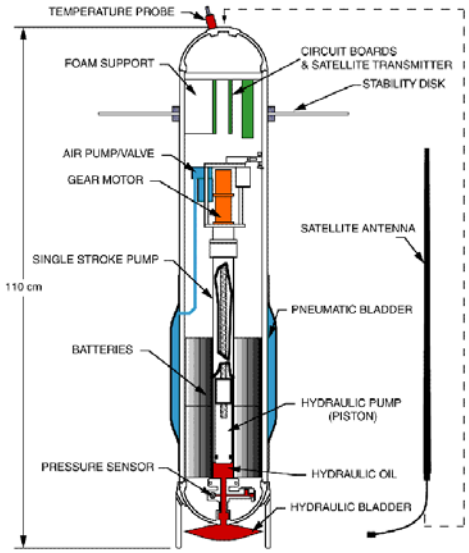


圖 3.12　Argo 海洋剖面觀測浮標
(資料來源:Argo 官網)

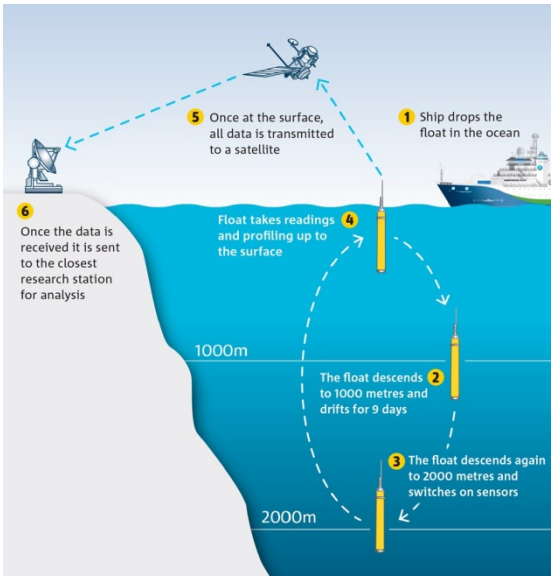


圖 3.13 Argo 浮標運作示意圖
(資料來源:CRIRO 官網)

任何國家與研究單位均可參與 Argo 計畫，並透過船艦來佈放 Argo 浮標(圖 3.14)，每個參與計畫單位共享所有觀測資訊。2014 年 Argo 浮標發展出新機型「Bio Argo floats」，除了可量測溫度、鹽度之外，也能執行海水中溶氣(dissolved oxygen)、pH、硝酸鹽(nitrate)、葉綠素(chlorophyll)、海水中溶解機物與顆粒等量測，並被運用在多國的合作研究中，諸如澳洲 CSIRO(Commonwealth Scientific and Industrial Research Organisation)與印度海洋科學中心(National Institute of Oceanography)合作的印度洋調查計畫(CSIR-NIO project)。

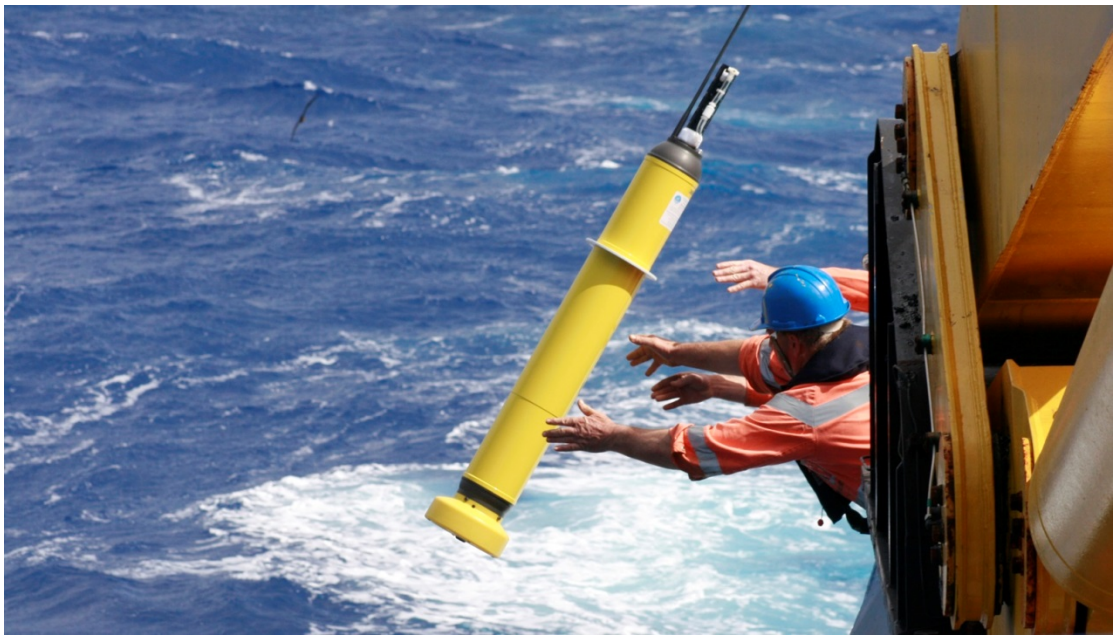


圖 3.14 Argo 浮標佈放
(資料來源:CRIRO 官網)

3.2.3 Go-Ship

儘管漂流式觀測浮標之自動化量測、濾波、供電、資料儲存與傳送等技術穩定成熟，且擁有抗腐、抗壓、耐浪、維運成本低、運作時間長等優點，但仍然無法克服其空間分辨率不佳、觀測項目有限的缺點。為取得高空間和垂直分辨率的完整的海洋生地化資料(特別是水深超過 2000m 的深海)，只能透過研究船來完成。

為獲得全球氣候變遷海洋相關數據， 2007 年 International Ocean Carbon Coordination Project (IOCCP)及世界氣候研究計畫(WCRP, The World Climate Research Programme)Climate and Ocean Variability, Predictability and Change (CLIVAR) Project 的科學家們共同倡議全球海洋船舶水文調查計畫 Go-Ship(Global Ocean Ship-based Hydrographic Investigations Program) (圖 3.15) 來發展全球尺度的海洋水文系統模型，該計畫由聯合國教科文組織(UNESCO) 政府間海洋學委員會(IOC,

Intergovernmental Oceanographic Commission)、世界氣象組織(WMO, World Meteorological Organization)及國際科學協會(International Science Council)提供經費支持，多國政府提供資源協作研究。

Go-Ship 匯集了對物理海洋學(physical oceanography)、碳循環(the carbon cycle)、海洋生物地球化學(marine biogeochemistry)和生態系統(ecosystem)等領域的科學家共同合作，探索和記錄大尺度(全球尺度)的海洋水資源的分佈、變化及成因，提出解決海水酸化、暖化、洋流改變等問題策略。

圖 3.15 Global Ocean Ship-based Hydrographic Investigations Program (資料來源: GO-SHIP 官網)

在 Go-Ship 規劃的全球海洋水文調查的航線，研究船以每 30 浬為間距執行全水深的水文量測(圖 3.16)，船期的安排是以每 5 年為周期進行全球海洋調查為目標，研究調查與船期安排等資料皆公佈在官方網頁中，目前參與的國家有加拿大、英國、西班牙、南非、挪威、瑞典、澳洲、日本、美國、 德國、愛爾蘭等國的海洋相關研究單位，船期已預規劃到 2027 年(圖 3.17)，讓科學家能以前所未有的準確度監測，模擬和預測全球

海氣象。

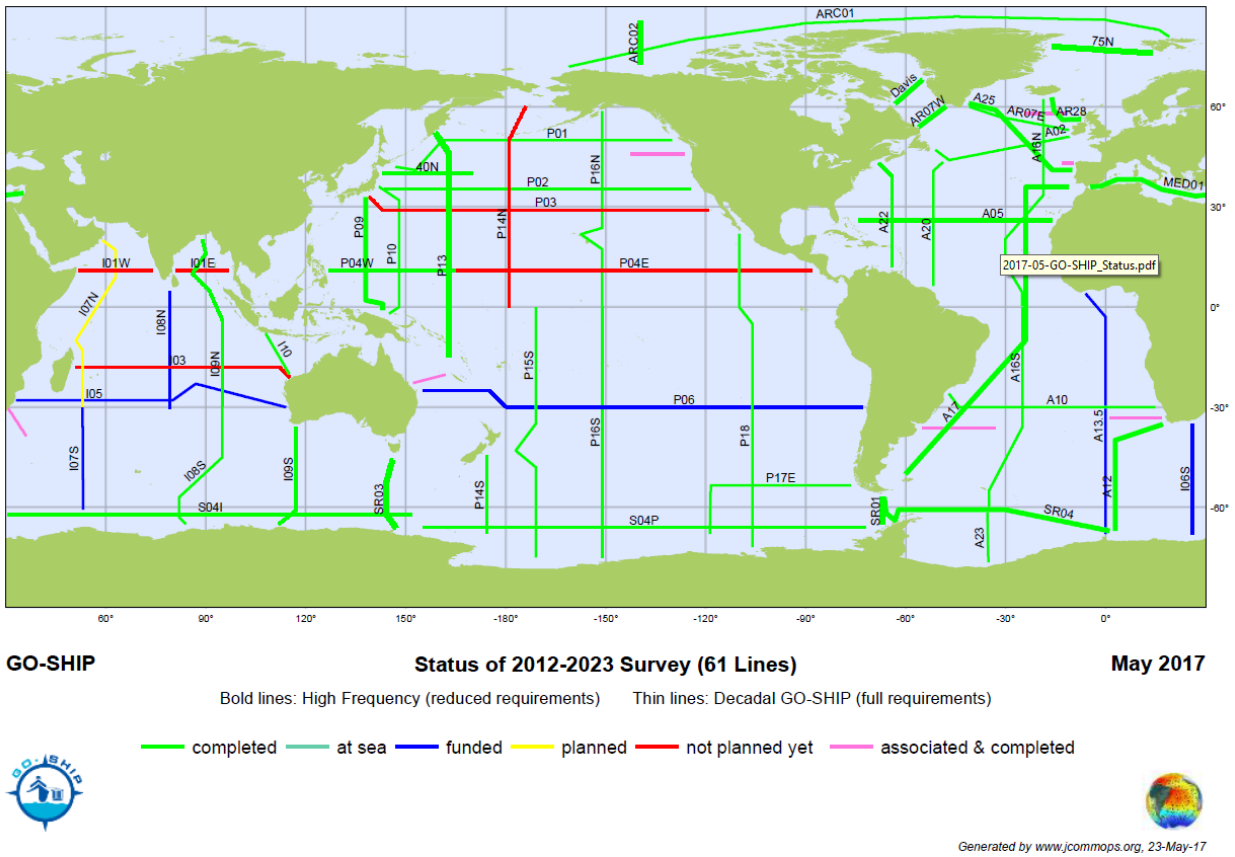


圖 3.16 Go-Ship 全球海洋船舶水文調查航線計畫
(資料來源:摘自 Dr. Brian King 簡報)

GO-SHIP Cruises and Cruise Plans (updated September 2019)

Year	Line	Segment	Nation	Sponsor	Committee Representative	Status
Annual	AR07	West	CANADA		Kumiko Azetsu-Scott	next 2020
Annual	SR01		UK		Elaine McDonagh	next 2020
Annual	ARC02		CANADA		Kumiko Azetsu-Scott	next 2019
Annual	A23		UK		Elaine McDonagh	2019 cancelled; next 2020
Annual	GSA-Radprof		SPAIN		Fiz Perez	next 2019
Annual	GSA-Samba		SOUTH AFRICA		Isabelle Ansorge	next 2019
Annual	GSA-Line P		CANADA		Kumiko Azetsu-Scott	next 2020
Biennial	A25		FRANCE-SPAIN		Fiz Perez	next 2021
Biennial	75	North	NORWAY		Emil Jeansson	next cruise not planned yet
Biennial	GSA-Arctic		SWEDEN		Leif Anderson	Next / where?
Biennial	GSA-EAC		AUSTRALIA	CSIRO	Bernadette Sloyan	next 2019
Biennial	Davis		CANADA		Kumiko Azetsu-Scott	next 2020
2014	AR07	West	UK		Elaine McDonagh	completed
2014	AR07	East	UK		Elaine McDonagh	completed
2014	P01		JAPAN	JAMSTEC	Katsuro Katsumata	completed
2014	P10		JAPAN	JMA	Masao Ishii	completed
2014	P16S	South	USA	NSF	Lynne Talley	completed
2015	A12		GERMANY		Toste Tanhua	completed
2015	A05		UK		Elaine McDonagh	completed
2015	AR07	East	NORWAY		Emil Jeansson	completed
2015	I10		JAPAN	JAMSTEC	Katsuro Katsumata	completed
2015	P16	North	USA	NSF	Lynne Talley	completed
2015	ARC01	West	USA	NSF	Lynne Talley	completed
2015	ARC01	East	GERMANY		Toste Tanhua	completed
2015	P04	West	JAPAN	JMA	Masao Ishii	completed
2016	I08	South	USA	NSF	Lynne Talley	completed
2016	I09	North	USA	NSF	Lynne Talley	completed
2016	P18		USA	NOAA	Gregory Johnson	completed
2016	P15	South	AUSTRALIA	CSIRO	Bernadette Sloyan	completed
2016	P09		JAPAN	JMA	Masao Ishii	completed
2016	A12		GERMANY		Toste Tanhua	completed (limited casts)
2017	SR04		GERMANY		Toste Tanhua	completed (limited casts)
2017	A10.5		GERMANY		Toste Tanhua	completed
2017	P06		USA	NSF	Lynne Talley	completed
2017	A02		IRELAND		Caroline Cusack	completed
2017	P17	East	Japan	JAMSTEC	Katsuro Katsumata	completed
2018	P13		JAPAN	JMA	Masao Ishii	completed
2018	SR03		AUSTRALIA	CSIRO	Bernadette Sloyan	completed
2018	S4P		USA	NSF	Lynne Talley	completed
2018	A9.5		UK		Elaine McDonagh	completed
2018	I7	North	USA	NOAA	Gregory Johnson	completed
2018	MED01		GERMANY		Toste Tanhua	completed
2019	I08	North	JAPAN	JAMSTEC	Katsuro Katsumata	funded
2019	I06	South	USA		Lynne Talley	completed
2019	40N		JAPAN	JMA	Masao Ishii	completed
2019	A17		SPAIN		Fiz Perez	completed
2020	I05		USA	NSF	Lynne Talley	funded
2020	I07	South	JAPAN	JAMSTEC	Katsuro Katsumata	funded
2020	P3	West	JAPAN	JMA	Masao Ishii	funded
2020	A10.5		SPAIN	CSIC	Fiz Perez	funded
2020	A5		UK		Penny Holliday	funded
2020	A13.5		USA	NOAA	Gregory Johnson	funded
2021	P4	West	JAPAN	JMA	Masao Ishii	funded
2021	P1		JAPAN	JAMSTEC	Katsuro Katsumata	funded
2021	A7	West	UK		Penny Holliday	funded
2021	A7	East	UK		Penny Holliday	funded
2021	AR28		UK		Penny Holliday	funded
2021	A16		USA	NOAA	Gregory Johnson	planned

圖 3.17 Go-Ship Cruises and Cruises Plans
(資料來源: GO-SHIP 官網)

英國國家海洋中心執行 Atlantic 26N array、Go-Ship、Argo 所得的觀測數據，經濾波、優化等品管處理(校驗)後，會由資料中心上傳到雲端空間或分發到全球電信系統（GTS）上，供國家氣象機構使用，並開放權限

給相關用戶下載觀測數據加值應用。平均而言，Argo 觀測資料的處理時間最短，可在數小時完成，GO-SHIP 數據資料約 3-5 週、Atlantic 26N array 錨碇資料由於錨定測量儀器數據需先經過精密校正，耗時費力，期間約 6 個月。

簡報中，Dr. Brian King 特別強調，如果本院願意參與 Argo 全球海洋浮標觀測系統，補足太平洋地區西區的觀測，英國國家海洋中心會非常樂意就 Argo 浮標的採購和部署提供建議，並協助本院訓練專業人才，也會推薦日本國立研究開發法人海洋研究開發機構(JAMSTEC)為區域合作夥伴，

3.3 British Oceanography Data Centre

海洋研究領域涉及氣象、地質、物理、化學和生物學等多元學科的研究，更與全球氣候變遷、海洋發展規劃、環境生態維護、海洋資源開發利用、海岸防護工程，密不可分。若能有跨領域的專家群、合宜的觀測設備、縝密的實驗分析、足夠且正確的調查研究資料、足量的資料儲藏空間、可驗證的資料分析軟體、配合相應的伺服器、數值模擬，就可發展出適用於產官學研界的大數據應用平台「海洋資料庫」，供相關部門進行海洋環境預測、劇烈天候防災、生態環境保護、環境影響評估、甚至國土安全防衛等的相關應用。

本次討論由海洋資料中心(British Oceanography Data Centre, BODC)主管 Dr. Helen Snaith(圖 3.18)主講並向本院參訪團隊說明 BODC 的發展沿革與任務、分工、維運管理，並針對本院未來建置國家海洋資料庫應特注意事項進行交流。

圖 3.18 Dr. Helen Snaith 簡報 BODC

British Oceanography Data Centre 的緣起可追溯自 1969 年，當時的主要任務與定位為扮演國家海洋資料中心(Act as the UK's National Oceanographic Data Centre)及成為國際海洋委員會資料交換平台(Participate in the international exchange of data as part of the Intergovernmental Oceanographic Commission (IOC) network of national data centres)。

2010 年 4 月 1 日，BODC 改隸國家海洋中心(National Oceanography Centre (NOC))，任務有:

- 管理國家海洋資料庫(The National Oceanographic Database)
- 管理英國潮汐監測網(UK Tide Gauge Network)，包含全英國 43 個海岸潮汐觀測站
- 管理國家環境研究委員會的海洋相關資料(The designated marine data centre for the Natural Environment Research Council, NERC)

- 管理海洋環境數據和信息網絡（MEDIN）的數據檔案中心(An accredited Data Archive Centre (DAC) within the Marine Environmental Data and Information Network (MEDIN)
- 為國內眾多的海洋相關計畫案管理資料

British Oceanography Data Centre 在利物浦(Liverpool)及南安普敦(Southampton)各有分部，職員總數超過 500 人，多數均為熟悉海洋科學及資料處理的科學家或資訊工程師。大部份的職員在利物浦分部工作，南安普敦分部的職員約 40 人。

British Oceanography Data Centre 嫻熟海洋環境調查資料管理及跨國海洋資料交流合作等事務，該中心在資訊系統管理、職員訓練與管理、資安防護、跨域資料庫系統整合、雲端服務與備援系統、海洋觀測資料標準格式/傳輸/校驗/上傳、模擬軟體開發、涉敏資料的處理與安全控管等面向非常值得我國在建置國家海洋資料庫的借鏡。

3.4 Marine Robotics Innovation Centre

國家海洋中心投入 350 萬英鎊創設海洋機器人技術創新中心(Marine Robotics Innovation Centre)(圖 3.19)，提供科學研究與商業發展的媒合平台。

國家海洋中心的海洋自主式機器人研究團隊(Marine Autonomous and Robotic Systems research group)在高端自主水下載具（Autonomous Underwater Vehicle, AUV）的設計與海洋科學應用，擁有 20 年以上的經驗，特別在自主式水下控制系統(Marine Autonomous Systems)更是業界翹楚。透過創新中心來匯聚國內海洋測量儀器、AUV、MMA 等領域的各組件和子系統開發商(圖 3.20)，國家海洋中心提供業者專家諮詢與專業實驗室，促成科研與小型產創的合作，已成功開發多款低成本高質量可客製

化或商規量產的海洋探測設備。

圖 3.19 海洋機器人技術創新中心

圖 3.20 技術創新中心合作夥伴

隨著營運部經理 Aidan Thorn (Innovation Centre Business Manager) 的引導(圖 3.20)，本院參訪團隊與負責研發的淺水域潛艇型 AUV(能執行溫度、鹽度、濁度等探測任務，並自動回傳觀測資料)(圖 3.21)、中層水域潛艇型 AUV(圖 3.21 及圖 3.22)、水下無人滑翔機(能執行中長距海洋水文觀測任務)(圖 3.23)、及能在深海域(6500m)進行自主探測任務的水下多功能機器人(ROV)(圖 3.24)海洋創新公司技術人員進行交流，了解其產品的設計、功能、造價、續航力、耐壓技術、供電與配重、中性浮力維持機制、與通訊傳輸。

在國家海洋中心科學家的協助下，廠商不斷改良水下自主載具的性能與耐用度，目前產品在國內外的口碑與銷售情形很不錯。是政府與民間公司科研與產業創新合作的成功典範，契合海洋機器人技術創新中心(Marine Robotics Innovation Centre)的標語「WHERE SCIENCE MEETS BUSINESS」，科學與商業互相合作、各蒙其利且相輔相成。

圖 3.20 Aidan Thorn 簡介海洋機器人技術創新中心的任務與合作夥伴

圖 3.21 小型潛艇型 AUV

圖 3.22 中層水域潛艇型 AUV

圖 3.23 中層水域潛艇型 AUV 組裝區

圖 3.24 水下無人滑翔機

圖 3.25 深海作業用無人 ROV

3.5 Research Vessel RRS Discovery

National Oceanography Centre 下轄 RRS James Cook(泊靠利物浦港)、RRS Discovery(泊靠南安普頓港)等 2 艘 world-class research ship 等級的先進大型研究船，可在 6 級海象下安全作業並執行全球海洋研究。

2 艘研究船的船期、船位、本航次研究調查項目均定期在網路更新，供相關人員查閱，2 艘研究船每年工作天數達 550 天，工作排程十分緊湊。

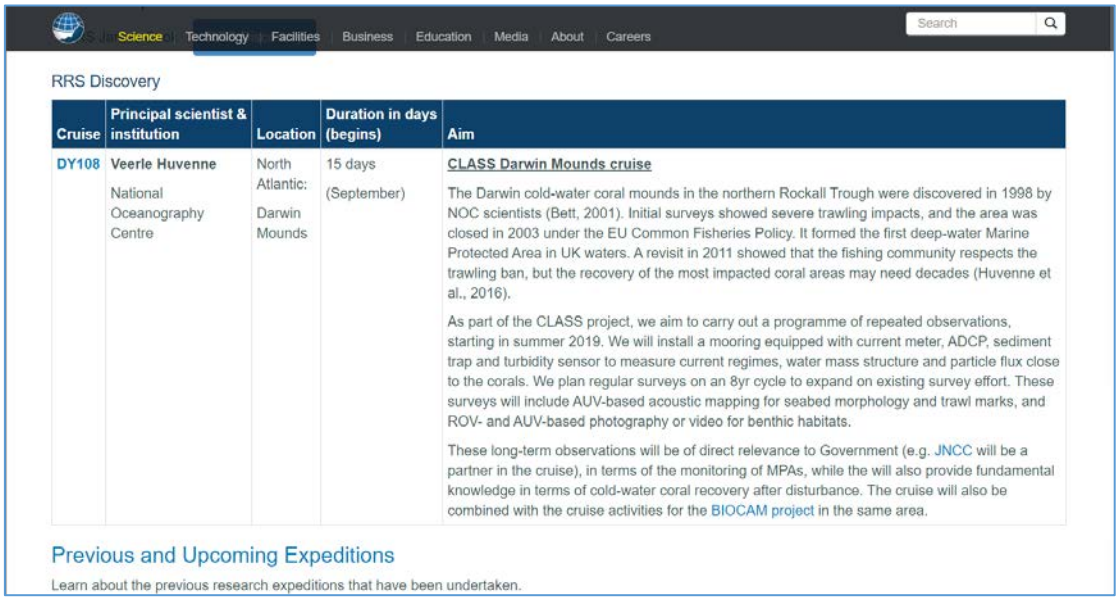


圖 3.26 RRS Discovery 船期與船位
(資料來源: National Oceanography Centre 官網)

此次參訪正值 RRS Discovery 泊港補給(圖 3.27)，國家海洋中心特安排船長 Antonio Gattit 與研究船營運中心的主管帶領本院參訪團隊在完成安檢手續後(圖 3.28)，登船參觀。

圖 3.27 RRS Discovery 號

圖 3.28 登船前的安檢程序

RSS Discovery 研究船於 2013 年 7 月 8 日交付國家海洋中心，船上的設備均是為了進行海洋觀測而選配的最新、最高科技產品，

親自為本院參訪團隊簡報的 RRS Discovery 船長 Antonio Gattit，曾任商船船長、與曾任海巡署巡防艦大副(副艦長)及巡防艇艇長的本院林世昌副研究員相見歡(圖 3.29)。

隨後船長 Antonio Gattit 為本院參訪團隊簡介駕駛台內的雷達、電子海圖、全球衛星定位系統(GPS)、電羅經、航行記錄器、風力風速計、測深儀、電子海圖(ECDIS)、航行燈控制面板等航海儀器、特高頻無線電(VHF)、中頻無線電(MF)、SSB 與衛星電話等通訊設備、船舶主機、舵機與動態定位(DP)操縱桿與指示面板(圖 3.30 與圖 3.31)。為確保海上研究及技術人員的海上工作安全，駕駛台設計為近 360 度的視角，駕駛台當值人員可直接目視後甲板人員的作業情形(圖 3.32)。

RSS Discovery 研究船配置的研究用設備有:

- Single and multi-beam echosounder surveys

- Integrated data logging
- Seismic surveys
- Clean seawater sampling
- Remotely operated vehicle operations
- CTD surveys
- Deep-water coring, trawling, dredging and instrument towing

船上有研究控制中心(圖 3.33)、器材前處理室(圖 3.34)及總面積達 389 平方公尺的多間實驗室供研究人員使用，甲板的空間可平放 18 個 20 呎的貨櫃，重型吊臂足能吊掛 20 噸重物，可輕易吊起大型浮標(圖 3.35)。

圖 3.29 兩位船長相見歡

圖 3.30 駕駛台電子航儀設備與操縱系統

圖 3.31 駕駛台舷側船舶操縱系統

圖 3.32 後甲板的吊車等重機具

圖 3.33 研究控制中心

圖 3.34 器材前處理室

圖 3.35 一站式監測浮標

圖 3.36 本院同仁與船長(右 3)於船上餐廳合影

3.6 小結

英國國家海洋中心與國家海洋研究院定位相似，其規模與發展經驗可供國家海洋研究院參考。從基礎海洋科學研究，到海洋機器人研發，以及研究船的調查、科學研究監測儀器的佈放、與產業間的合作、研究人才的培訓，到最後端的數據資訊管理與提供，整個研究產業鏈皆不需假手他人，其號稱是英國最先進的海洋研究機構實至名歸。而此次參訪最重要的目的即是讓雙方互相了解，並建立聯繫管道，過程中雙方互動良好且互贈禮物，皆期待未來能有進一步合作機會。(圖 3.37 及圖 3.38)

圖 3.37 午餐討論會

圖 3.38 本院致贈紀念品

4 參訪 Gill Instruments

Gill Instruments 成立於西元 1988 年，國際知名的氣商量測儀設備製造商，位於英國南部之利明頓(Lymington)，主要產品為高精度超音波風速計和氣象站產品(圖 4.1)，其設備為國際先進實驗室與研究船的首選。

海上風力風向會影響表層海水團流動、溶氧、海溫、波高等，進行海洋水文調查若缺漏表層海洋氣象監測，對海洋水文的模擬與預測將失真。為了解該領域監測儀器設備的規格、限制、系統整合介面與特殊功能、並確認未來國家海洋研究院建置海洋觀測儀器的設備需注意事項，本院研究團隊在多個學術單位的建議及英國在臺辦事處的協助下，擇定至知名設備大廠 Gill Instruments 總部參訪。

是日由該公司業務發展部(Business Development)經理 Jamie McKay 偕同向技術部門專家 Richard McKay (Applications Specialist)，為本院參訪團隊簡報。(圖 4.2)

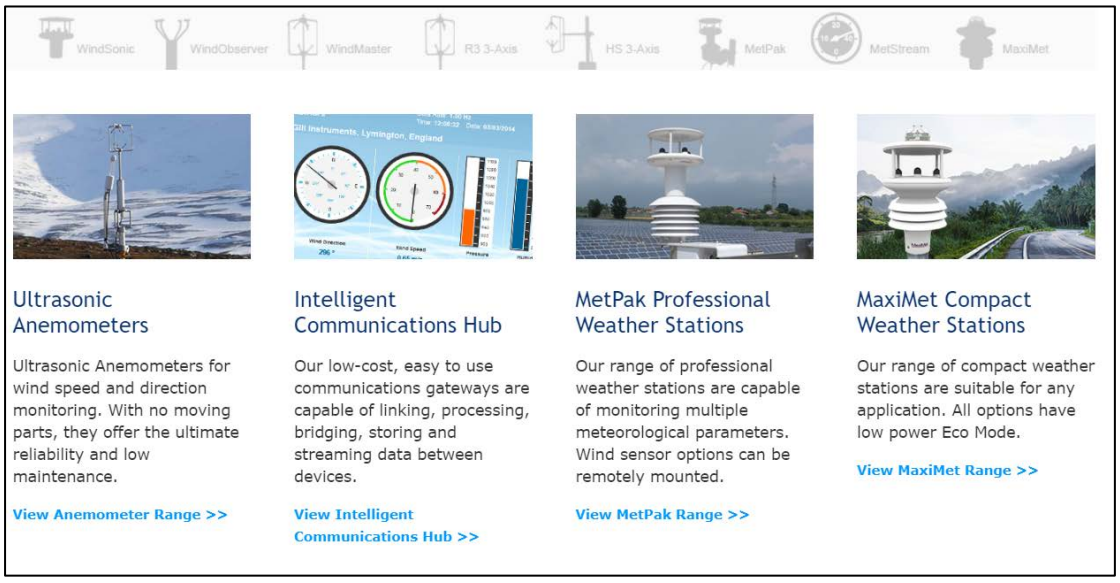


圖 4.1 Gill Instruments 產品
(資料來源: Gill Instruments 官網)

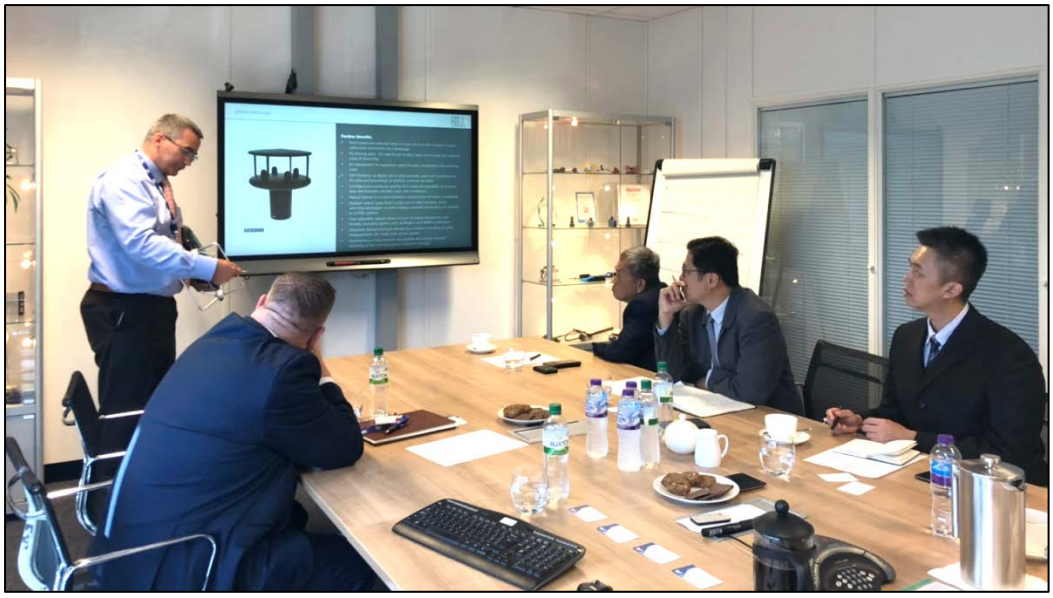


圖 4.2　Richard McKay 展示 Gill Instruments 產品

4.1　The Gill Group

Gill 集團（The Gill Group），國際知名儀器設備商，下轄 Gill Research&Development、Gill Instruments、Gill Sensors&Controls、Labcal 4 間子公司，為爭取英國頂尖大學工程類科學生畢業後到公司研發部門任職，與校方合作，由 Gill 集團提供優沃獎勵來吸引表現優異的學生，並建立未來人才資源庫。

- Gill Research&Development

  致力於產品創新的工程公司，專注於開發專有測量技術。

- Gill Instruments

  致力於為氣象和商業天氣測量市場提供超聲波風速計和氣象站產品。

- Gill Sensors&Controls

  傳感、位置傳感器和發動機控制產品的製造商，專注於過程控制、公用事業、賽車運動與國防市場等。

- Labcal

  擁有超過 20 年專業校準技術服務，提供各種參數的 UKAS 認證校準。

4.2 Ultrasonic Anemometers

傳統的風速計面臨空氣動力學阻力和軸承之磨損，而 Gill 研發的超音波風速計(Ultrasonic Anemometers)沒有活動部件，不會因磨損因素影響數據，亦無需昂貴的校準和維修費用；該儀器能由系統自我檢測，檢測結果以數位代碼顯示，讓使用者了解傳感器的現況，避免錯誤觀測數據產生的可能性。用戶在完成觀測資料輸出頻率和格式設定後(Modbus 和 NMEA 等選項)，可利用數據記錄器或網路來輸出觀測資料。

儘管 Gill Ultrasonic Anemometers 外觀和許多他牌的 2 軸、3 軸超音波風速計相似，Gill Ultrasonic Anemometers 應用四軸超音波智能處理技術，避免錯誤處理脈衝訊號的可能性(圖 4.3)，來克服環境干擾（如極低風速、極高風速、低溫、高溫）提供高精度的風向風速測量，能準確記錄風的速度與方向變化，兼具低耗電量與高耐用度的優勢。

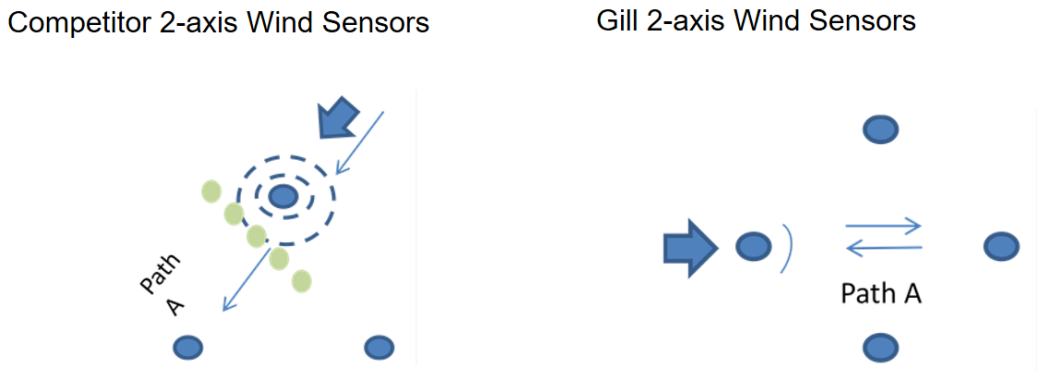


圖 4.3 Gill 與他牌風速計之傳感器設置示意
(資料來源: Richard McKay, Gill Instruments 簡報資料)

4.3 快速風洞實驗室

Gill Instruments 的快速風洞實驗室，其模擬風速可達 110m/s 可提供儀器之測試與研發使用(圖 4.4、圖 4.5、圖 4.6 及圖 4.7)。該測試設備可成三個部分：

- Settling Chamber

  不均勻的湍流會導致不可預測的力，因此利用蜂窩流動矯直機（honeycomb flow straightener）和金屬絲網平滑篩（wire mesh smoothing screens）來產生平滑的氣流。

- Contraction Cone

  利用漸小的截面積將大量低速空氣轉換成小體積的高速空氣。

- Diffuser Section

  將循環空氣減速，恢復從進入收縮錐體時之壓力，降低驅動所需的功率。

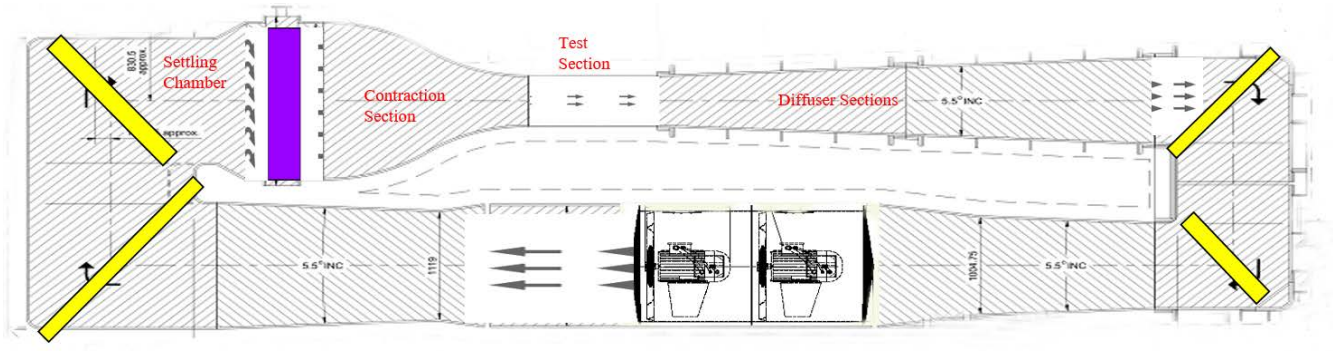


圖 4.4 循環型快速風洞實驗室

(資料來源: Richard McKay, Gill Instruments 簡報資料)

圖 4.5 快速風洞測試段外觀

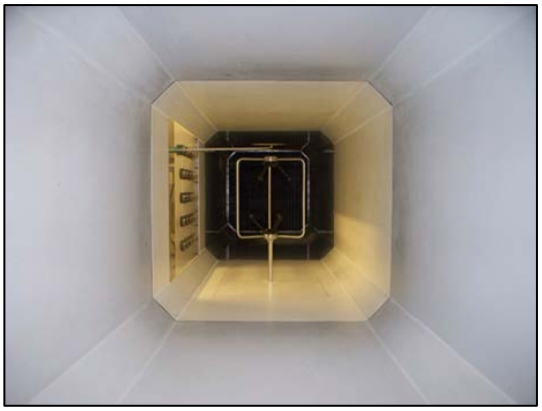


圖 4.6 快速風洞實驗室測試段

(資料來源: Richard McKay, Gill Instruments 簡報資料)

圖 4.7 本院同仁與快速風洞實驗室技師(右 1)合影

Gill Instruments 的高品質與高耐用度超音波風速計平均壽命可達 8 年以上，廣泛的運用在各種嚴苛的環境上(圖 4.8、圖 4.9 及圖 4.10)。此次參訪，Gill Instruments 亦邀請我方參觀儀器生產線，如圖 4.10 所示，足見其對產品品質的信心。

圖 4.8 漂流浮標上之 Gill 風速計

圖 4.8 海洋觀測塔之 Gill 風速計

(資料來源: Richard McKay, Gill Instruments 簡報資料)

圖 4.10 於無人船之 Gill 超音波風速計

(資料來源: Richard McKay, Gill Instruments 簡報資料)

圖 4.10 Gill Instruments 工廠

5 參訪 HR Wallingford

為了解造波機、離岸風電機、操船模擬機的規格、限制、系統整合介面與特殊功能、及確認未來國家海洋研究院建置水工試驗及操船模擬機等設備需注意事項，本研究團隊參訪以造波機、海事工程、無人船、各種軟體與操船模擬機等設備揚名國際的 HR Wallingford。

總部位英國牛津之 HR Wallingford(圖 5.1)，轄下員工包含科學家、軟硬體研發工程師、系統分析師等約 220 名，年營業額約 2400 萬英鎊，其中 60%來自海外業務收入，於休斯頓、吉隆坡、孟買、阿布達比、上海與

柏斯等地設有辦公室，擁有 60 多個國家的客戶。

此次參訪由該公司的設備業務經理 Simon Tiedeman (Business Manager, Equipment) 主持簡報(圖 5.2)，與會人員如議程表(圖 5.3)。

圖 5.1 HR Wallingford 總部

(資料來源: Simon Tiedeman, HR Wallingford 簡報資料)

圖 5.2 業務經理 Simon Tiedeman(右 2)

HR Wallingford

Agenda

Delegation Visit from National Academy of Marine Research (NAMR), Taiwan

Venue: HR Wallingford (Kestrel House) Ash Mtg Rm

Date: 21st June 2019 Time: From 10:00am

Attendees

CHIU, YUNG-FANG - Acting President - NAMR

LIN, SHIH-CHANG - Associate Researcher - NAMR

Simon Tiedeman – Equipment - HRW

Dr Keith Powell – Chief Operating Officer - HRW

Michael Case – Renewables - HRW

SHEN, PAO-LAN - Executive officer - NAMR

CHEN, HSIANG-YING – Officer - NAMR

Andrew Brown – BD Director - HRW

Dr Jim Clarke – Ships – HR Wallingford

1. Arrival at HR Wallingford (Kestrel House) expected 10:00am

1.1. Welcome & Introduction to Dr Keith Powell (COO) / Andrew Brown (BD Director)

1.2. Refreshments available

2. Renewable Energy – 10:30am

2.1. Session with Michael Case (Renewables Energy Business Development Manager)

3. Wave Generation & Instrumentation – 11:15

3.1. Session with Simon Tiedeman (ET&I Business Development Manager)

4. Froude Modelling Hall Tour – 12:00

4.1. Tour of Froude Modelling Hall

5. Lunch – 12:30pm

5.1. Manor House walk through with laid table.

6. Ship Simulator – 14:00

6.1. Tour of the ship simulator

6.2. Session with Dr James Clarke (Ships Group)

7. ARC Boat Demo - 15:30

7.1. Move to the HPE Boathouse on the River Thames.

7.2. Session with Peter Watchorn to demo the capability of the ARC Boat for surveying purposes.

8. Summary – 16:00

8.1. Return to Ash Mtg room for summary of the day

8.2. Agree actions and time line.

圖 5.3 參訪行程表

5.1 Wave Generation System

HR Wallingford 造波機(圖 5.4)聞名世界，其電力驅動式造波機（非油壓式）與吸波系統廣泛應用在船模試驗與水工模型試驗。

HR 對水工模型的試驗流程依序為(1)造波機定位、(2)控制儀器設置、(3)波浪校準、(4)模型構建測試、(5)水工模型試驗、並逐漸增加波浪強度、(6)在每次測試之間進行數據分析，直到結構失效(圖 5.5 及圖 5.6)。

圖 5.4 HR 造波機
(資料來源: Simon Tiedeman, HR Wallingford 簡報資料)

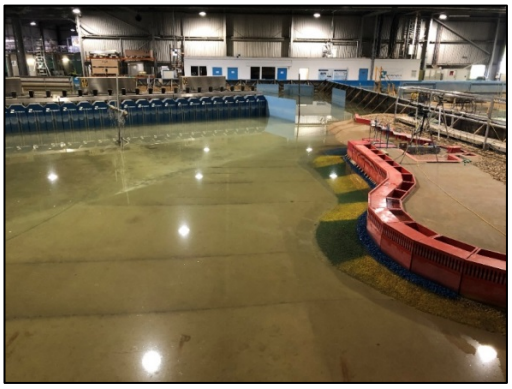


圖 5.5 HR 水工模型試驗場

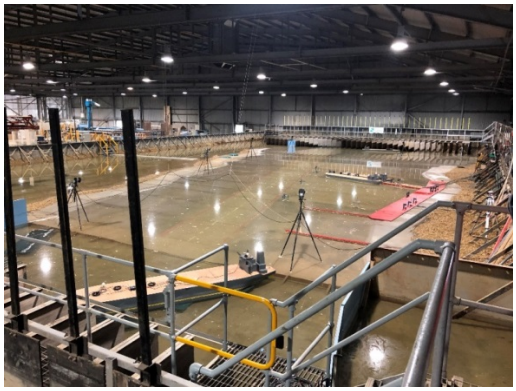


圖 5.6 HR 水工模型試驗

Simon 與工程技師向本院參訪團隊現場簡報造波機（Wave Generation System, WGS）與吸波系統（Wave Absorption System, WAS），包括系統架構、機械設計、土木設計、水槽檢查、機械安裝、電氣安裝到最後的營運管理進。(圖 5.7、圖 5.8 及圖 5.9)

圖 5.7 造波機造浪設備

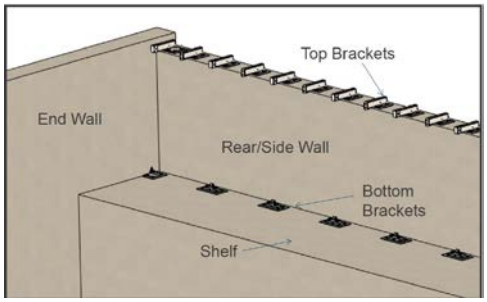


圖 5.8 造波機安裝說明

(資料來源: Simon Tiedeman, HR Wallingford 簡報資料)

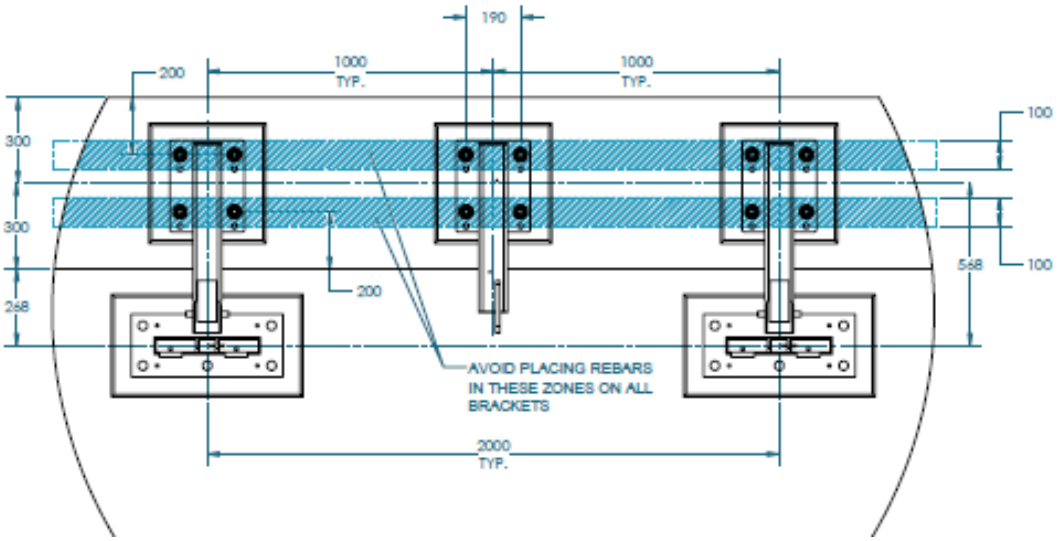


圖 5.9 支撐安裝示意圖

(資料來源: Simon Tiedeman, HR Wallingford 簡報資料)

5.2 HR UK Ship Simulation Centre

Dr. James Clarke 向本參訪團隊簡報 HR UK Ship Simulation Centre(圖 5.10)及示範操船模擬機操作。該公司之操船模擬機可依空間大小來配置必要的操縱設備與投影方式，整個動態模擬由 2 部伺服器分

工完成，內建多種船型與港灣模型，另可依據船舶性能諸元客製化專屬船型(如英國國內常見的拖船)(圖 5.11)與港灣/碼頭圖資。在設定好模擬區之海象、海流等參數後(圖 5.12 及圖 5.13)，本院前海巡署巡防艦大副林世昌副研究員進行模擬實測(圖 5.14 及圖 5.15)，其動態擬真度有不錯的表現。

圖 5.10 UK Ship Simulation Centre

圖 5.11 Dr.James Clarke 示範拖船操縱模擬

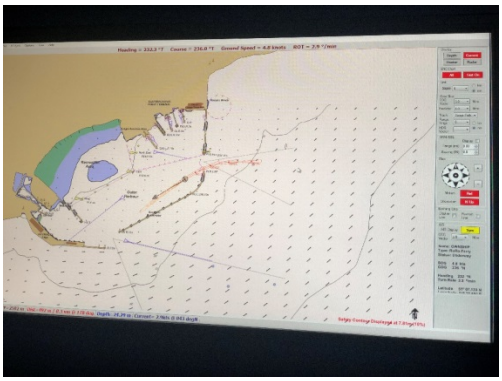


圖 5.12 港口近海域海象參數設定

圖 5.13 泰唔士河水深與流速參數設定

圖 5.14 本院林世昌副研究員親自測試

圖 5.15 大型船艦模擬機實地測試

三、 心得及建議

本次參訪對國家洋研究院未來在執行海洋資源調查、海洋科學研究、海洋產業創新研發、建置國家海洋研究船隊、水工模型與船模驗相關實驗室、高階研究人力與技術人員交流、未來國際海洋科研調查合作等重要工作事項至甚重要，參訪團隊從中汲取許多寶貴經驗，參訪報告可供本院相關研究中心之進行後續研究、產學合作、實驗室與船隊維運等之重要資訊參考。重要效益摘述如下:

1. 與勞氏檢驗（LR）簽訂技術與合作協議:

該公司為國際頂尖獨立稽核服務的驗證機構，於海洋工程及船舶之設計、建造、驗證有完整的經驗及規範外，旗下的研究人員與驗船師人數為業界最高;在海洋產業及創新部份，其創新監測設備及整合式應用管理軟體，於產業界有相當高之評價;在專業人員培訓部份，其課程與師資均高於國際相關規範，也為公部門提供服務;雙方簽訂技術與合作協議後，勞氏將為國海院提供所需的研究資訊及技術支援，有益於國海院未來在新建研究船、關鍵實驗室、船模試驗中心、人員培訓之規劃、認證與執行。

2. 參訪 University of Southampton 船模試驗中心:

該校船模試驗中心的設備規格可供快速船舶之測試，該中心之(1)造波機組與波浪消波處理、反射波反制設計、(2)台車系統軌道的平衡、固定、抑震工法，(3)監測器配置及定位、(4)安全管理(訪客管理、技術人員工作安全管理、(5) 船模試驗檢測技術與認證、與(6)營運策略等，可供國家海洋研究院未來在建置船模中心的參考。

3. 參訪 National Oceanography Centre、Discovery 研究船及相關研發產學合作技術創新機構:

National Oceanography Centre 隸屬政府部門，擁有 647 位科學家、工程師、職員與技術人員，在基礎科學研究調查、海洋資料庫與研究船維運、產業創新合作與跨域系統整合、人才培育及國際海洋研究合作等面向有非常好的實蹟，其運維策略可供未來國家海洋研究院在整合海洋科研、產學合作、人才培育、研究船維運及國際海洋研究上重要借鏡。在本次參訪中 National Oceanography Centre 更主動邀請本院參與 Argo 海洋觀測計畫，並推薦日本國立研究開發法人海洋研究開發機構(JAMSTEC)為本院的區域合作夥伴，亦提供日方對口聯絡人相關資訊，對未來臺英、臺日、及臺日英的國際合作有了良好的開端。

4. 參訪 Gill Instruments 與 HR Wallingford 海洋科學儀器公司:

Gill Instruments 專長為超聲波風速計和氣象站產品、HR Wallingford 以造波機、海事工程、無人船、各種軟體與操船模擬機聞名，兩者公司以生產高品質、高耐用度之設備揚名國際。本次參訪包含參觀組裝與測試工廠，與原廠研發人員進行技術交流，有益於本院(1)了解海氣象常用之風速調查儀器的規格、限制、系統整合介面與特殊功能、(2)確認未來國家海洋研究院建置海洋觀測儀器的設備需注意事項、(3)了解造波機、離岸風電機、操船模擬機的規格、限制、系統整合介面與特殊功能、及(4)確認未來國家海洋研究院建置水工試驗及操船模擬機等設備需注意事項。

蔡英文總統在 2018 年 4 月 28 日在海洋委員會揭牌典禮時強調海洋的重要性，提示海洋委員會要朝「健全海洋法制，做好生態保育工作」、「配合政策，推動海洋產業」及「強化海洋研究能量，培育海洋人才」三個努力

方向，未來，海洋資源調查、基礎研究以及最重要的人才培育工作，交付給國家海洋研究院來全力執行。

行政院陳其邁副院長在國家海洋研究院的成立大會上指示，成立國家海洋研究院，除了整合海洋研究量能外，更希望能參與國際組織及國際會議，擴大台灣海洋政策與國際的連結，帶領台灣邁向安全無懼、繁榮的海洋國家。

本次赴英國海洋專責機構參訪為本院在推動國際海洋科學研究、海洋產業合作及技術人員交流開啟良好先端，為強化此行的效益，可朝下列建議方向努力：

1. 爭取經費建置全國海洋水文觀測網、國家海洋資料庫，規劃國際海洋資料庫的交流合作，供相關產官學研界應用。
2. 整合海洋科研量能，建置國家海洋研究船隊，規劃協作全球海洋船舶水文調查計畫 Go-Ship(Global Ocean Ship-based Hydrographic Investigations Program)，擴大國際海洋研究參與。
3. 撰擬科技計畫，爭取經費，購置 Argo 浮標，協助全球海洋觀測研究，補足太平洋西部與西北海域觀測資料，擴大國際海洋研究參與。
4. 研究人員是海洋科研的核心，研究船是海水觀測的重要平台，關鍵實驗室對研究能量的提昇至甚重要。海洋學門涉及多領域研究，需有更多的專業研究人力投入，在編制員額有限之下，優先執行六大重點工作。並積極爭取擴編編制員額與經費來整合國家量能、建置國家海洋研究院關鍵實驗室。
5. 延續與勞氏雙方簽訂技術與合作協議的價值，編列經費就核心議題進行擴展，強化國際海洋研究人員互訪、技術交流及合辦研究。

海洋為資源寶庫、氣候變遷關鍵、生活處所及貨貿交通之所在，深遠影響國家經濟與人民生活福祉，海洋也是台灣最重要的出路，本次的參訪行程能順利成功，要特別感謝海洋委員會各級長官在預算上的支持、英國在臺協會(British Office) 的協調、及英國勞氏檢驗（LR）、University of Southampton、National Oceanography Centre、Gill Instruments 與 HR Wallingford 等單位的大力協助，讓國家海洋研究院能以更高的視野佈局未來，整合全國海洋研究量能接軌國際研究，不斷提昇國家海洋科研實力，朝向國際級的國家海洋研究機關努力邁進。

附錄 技術交流資料

IRIS for Submarine Cable Contractors & Projects

Kevin Todd
Head of Renewables
June 2019

Lloyd's Register

Working together
for a safer world

IRIS – Web Mapping & Data Services

Project Management, Mapping & Monitoring

IRIS - Key Features

Offshore Web Mapping

Marine Coordination and Vessel Tracking

Data Telemetry and Digital Data Services

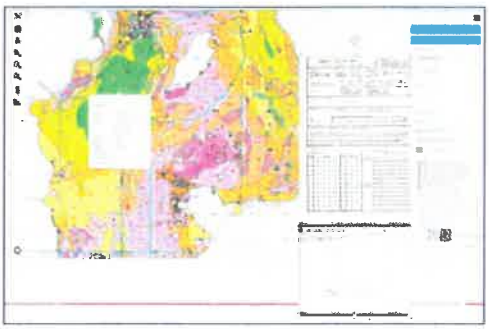
Metocean and Marine Forecast Data

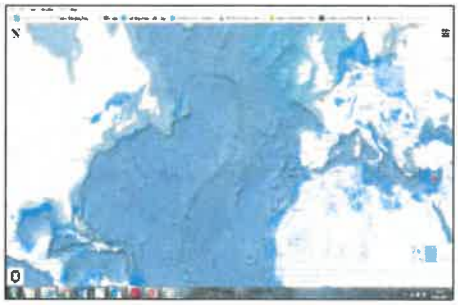
HSEQ and Operational Performance Monitoring

Cloud Data Management

IRIS App Key Feature 1 - Web Mapping
Standard Data Sets

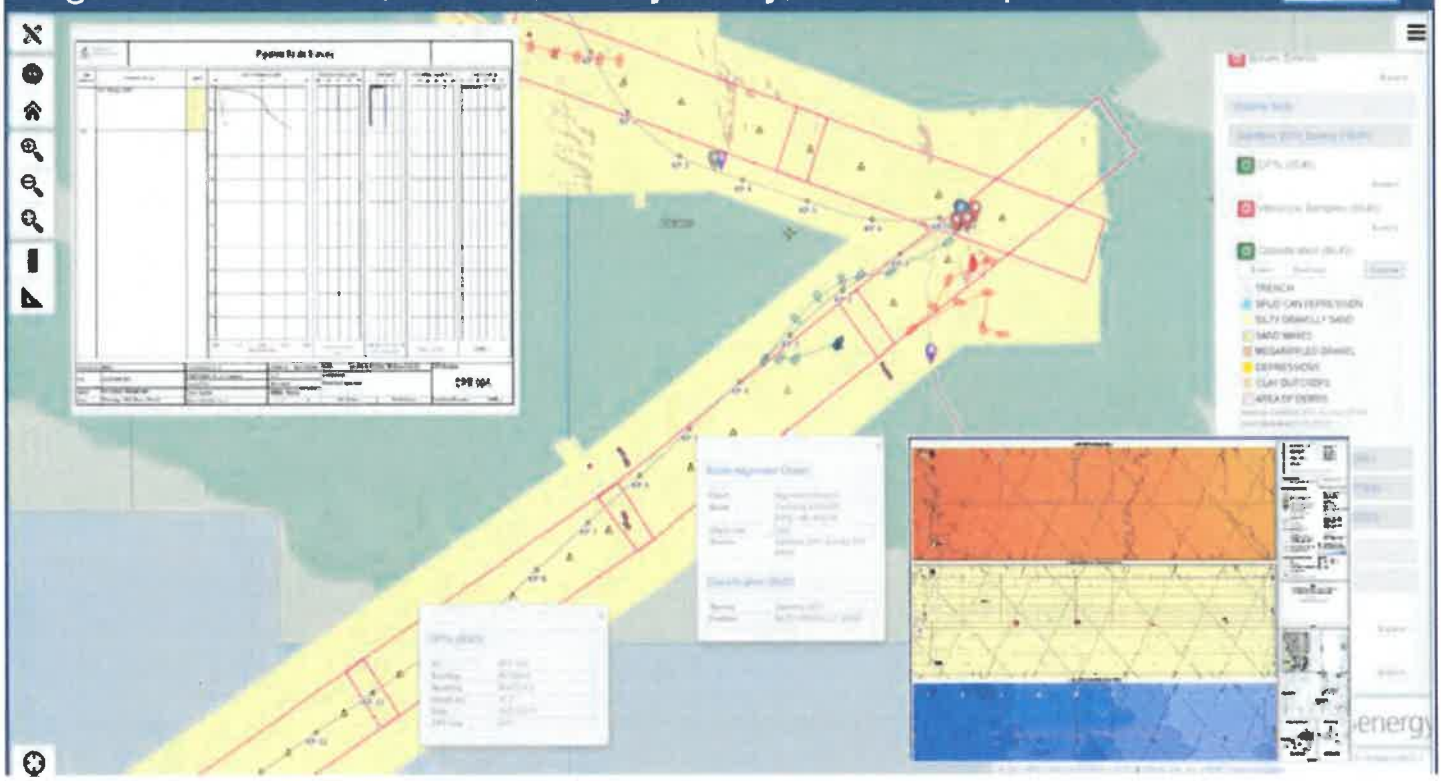
- Wealth of global and regional mapping layers.
- Public domain & commercially licensed spatial datasets;~600 and counting.
- Hydrographic charts, regional bathymetry, oil & gas licenses, offshore wind farms, wells, subsea cables, google imagery, BGS data, LR integrated and styled offshore reference map.
- Nightly auto-build of spatial database, ensures currency.
- Fast delivery through "tiled map" service (similar to Google Maps).



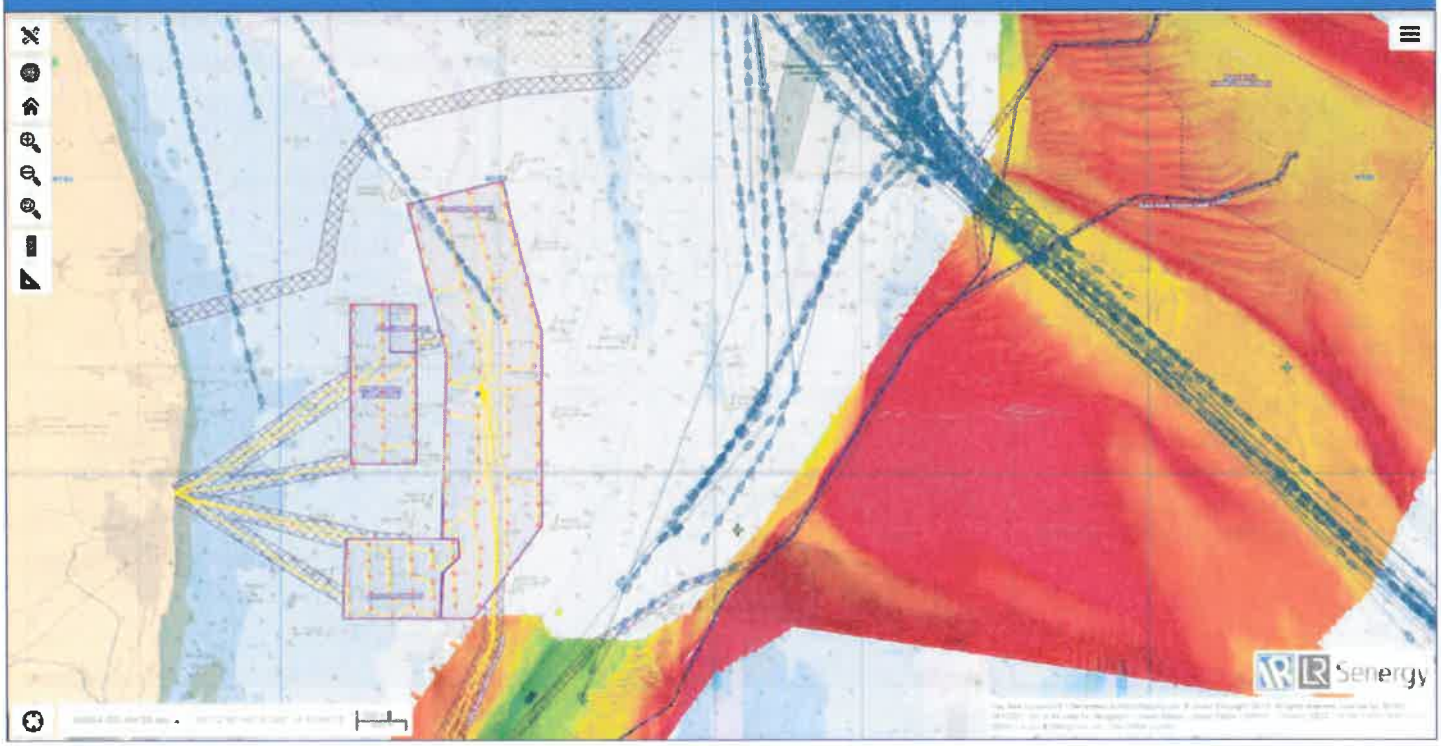


Add Project-Specific Data

e.g. Seabed soils, CPT's, bathymetry, charts, reports, video

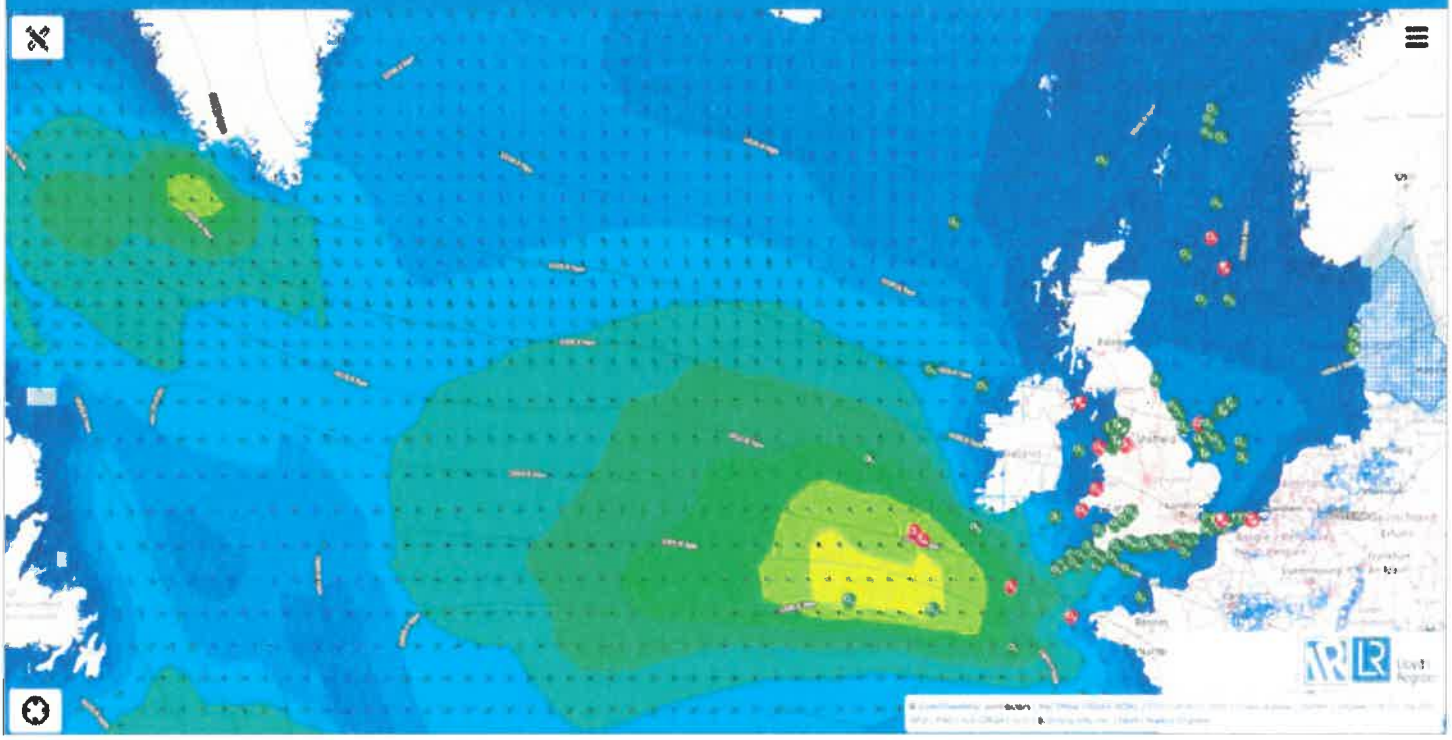


We source multiple marine datasets and keep them current & updated e.g. cables, wrecks, pipelines, wind farms, aggregate areas, Crown Estate bathymetry, etc



Global Metocean forecast

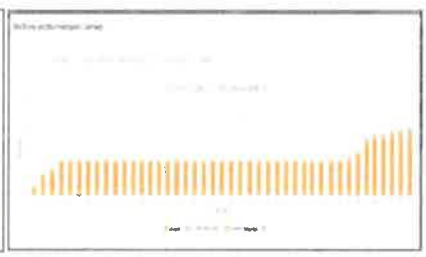
NOAA Wave Watch 3 and GFS global models : swell, wave height, atmospheric pressure etc; forecast up to 10 days, issued hourly. Hind-cast data up to 10 years available for user selectable periods; intersect with vessel track for best 'as-seen' metocean information.

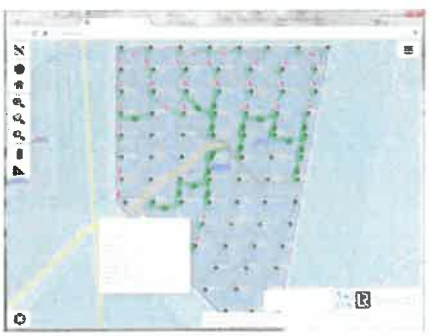


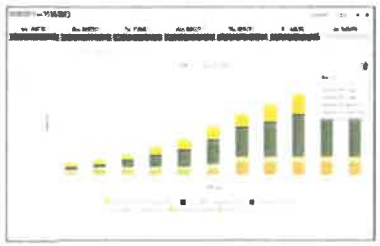
IRIS App Key Feature 5

HSEQ & Performance Monitoring

- HSE and project performance KPI's visualised in "Project Status" dashboard.
- "Geo-status" through traffic lighting features on a map, e.g. wind farm cable installation status.
- Geo-tagging for documentation/reports
- Dashboard data accessed through file synchronisation or "auto-scrape" of spreadsheets attached to emails.
- Minimal onshore intervention once initiated.

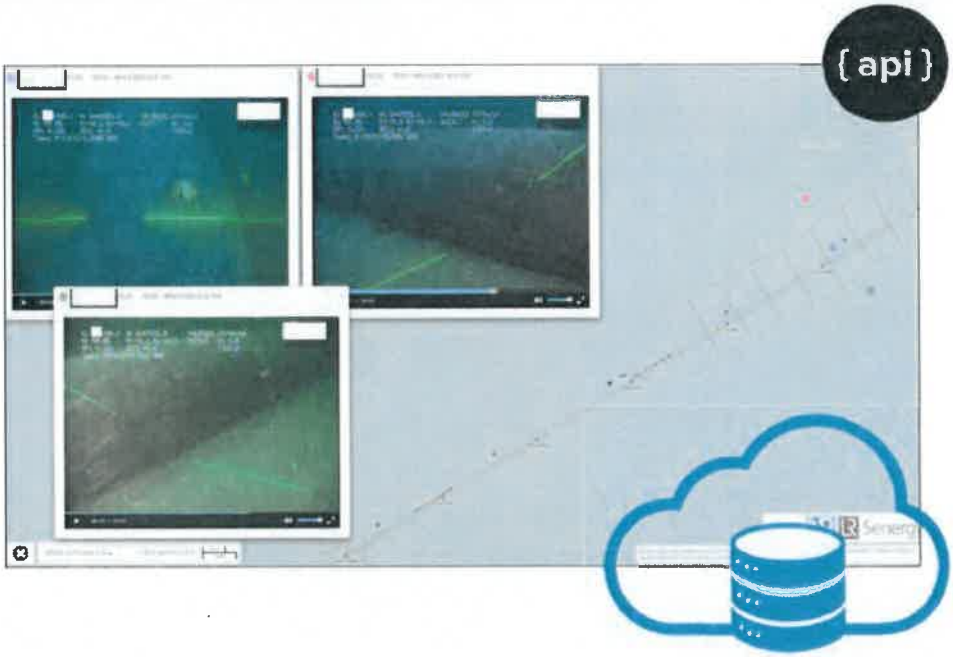






IRIS App Key Feature 6
Cloud Data Management

- Cloud data storage.
- Our philosophy is that client acquired/provided data is securely & easily viewed, accessed and downloaded without request or need for notification.
- All client data is held in industry standard and non-proprietary formats (e.g video, shape files, PDF charts, listings); readily delivered or client-downloaded from the database.
- Audited secure & scalable resources.
- In-built database replication, disaster recovery etc.
- Tabulated data export via API.
- Some datasets can be downloaded directly using tools programmed into the website.



For further Information : http://www.lr.org/en/services/software/iris.aspx

Please contact : Martin Day, Head of Survey & Geospatial
Lloyds Register, 71 Fenchurch Street, London, EC3M 4BS
Martin.Day@LR.org
07711 008176 ; 0207 438 4700

Lloyd's Register

Working together for a safer world

Assurance of Digital Twins for Health Management

June 2019

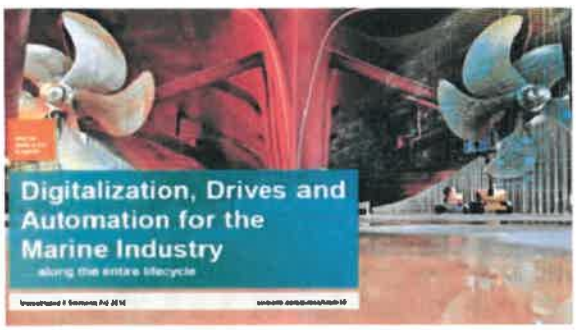
Lloyd's Register

Gradually then Suddenly

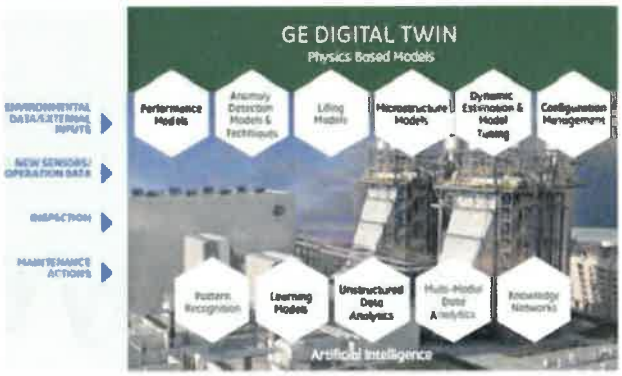
Gradually then Suddenly: The New World Order

Source: Visual Capitalist

Industrials are Adopting the Digital Playbook



Source: Siemens



Source: General Electric

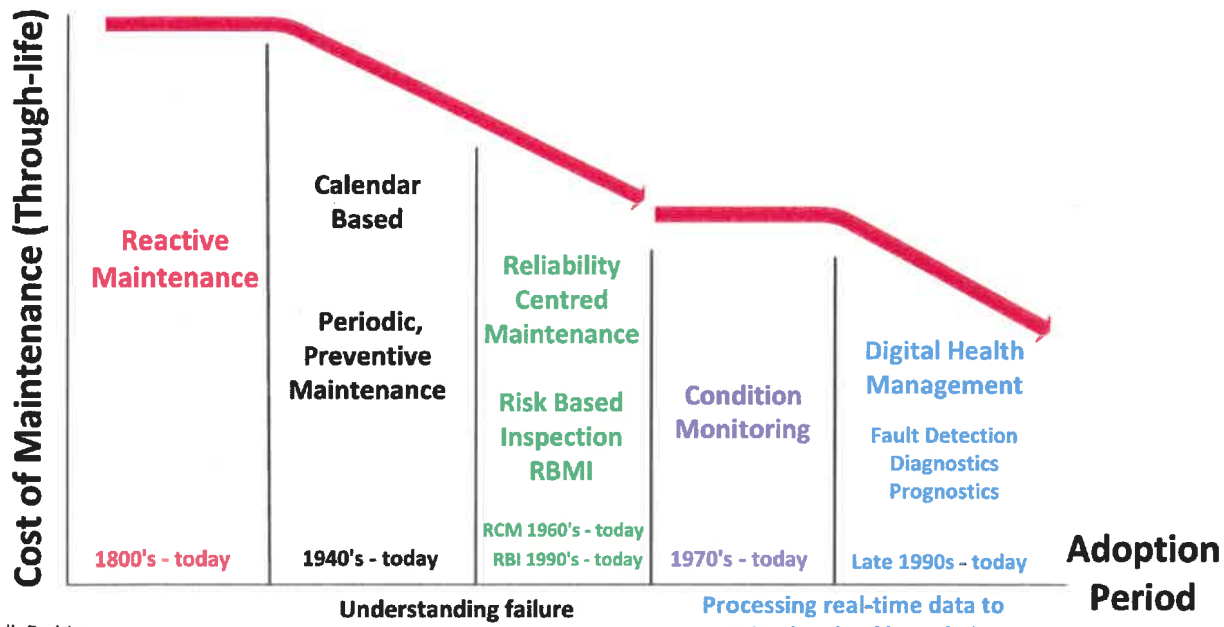
New MAN CEON Platform Provides Robust Connectivity and Real-Time Data Analysis

Digital platform uses intelligent analysis tools for further development of solutions and services

Source: MAN B&W

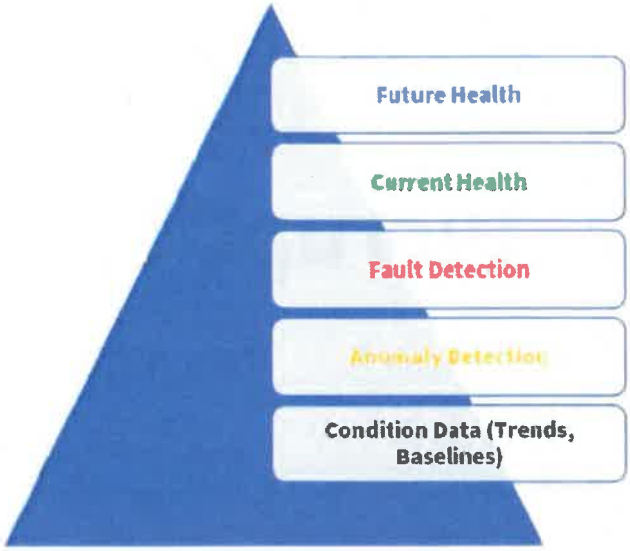
Disrupting Maintenance

Evolution of Maintenance Technology



What is Digital Health Management?

Digital Health Management (DHM) is the term LR coined for analytics and digital technologies that gather data and generate insights on an asset's health.

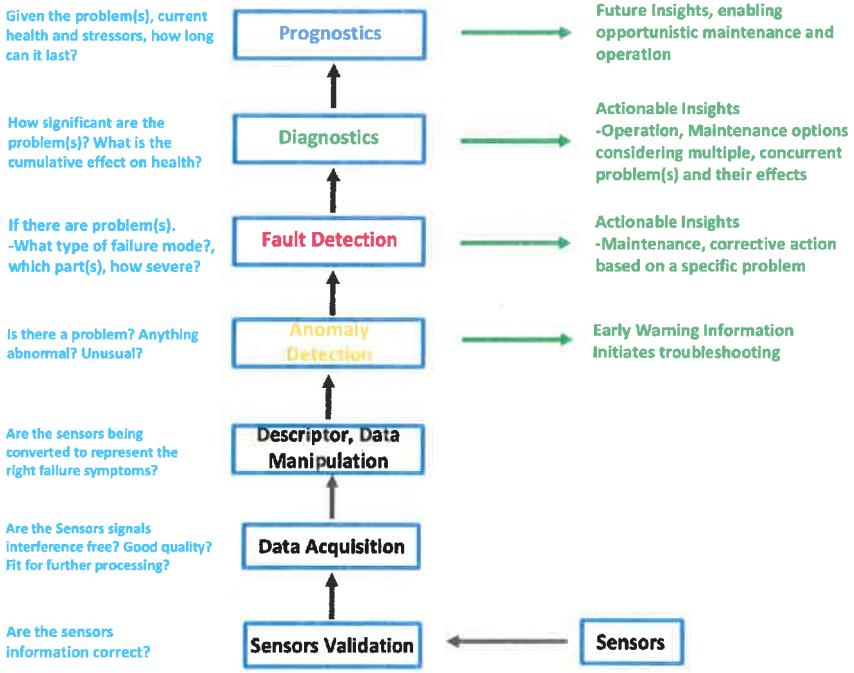


Operational Reality

-All Electrical, Mechanical, Structural, Systems will wear, age, experience failure mechanisms.

-Damage accumulation (phenomena) are irreversible chemical, electro-chemical, physical processes.

Peeking Under the Hood of a DHM System



Why Assurance of Digital Twins?

LR Digital Twin Assurance

Legibly explains the capability (and limitations) of each digital twin and DHM provider, including performance monitoring of digital twins in the field.

Source: Dilbert

Who Benefits?

DHM Developers

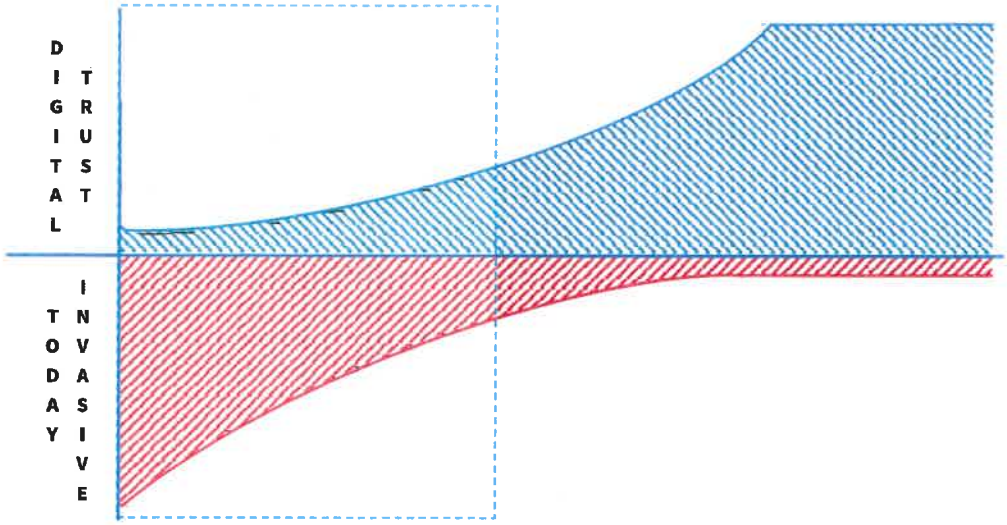
- Independently establishes their **"street cred"** to design, develop, test, integrate and support digital twins in the field.
- Establishes the capability of their digital twins in terms of component, failure mode coverage and insight sophistication.
- Independently corroborates the premium pricing of sophisticated twins.

End Users (Ship Owners, Charterers)

- Provides an independent view on DHM providers and the capability of their twins, helping ship owners decide and invest in the right technology.
- Ship owners and operators want business outcome (The Twin generating consistent true positives) not just technology.

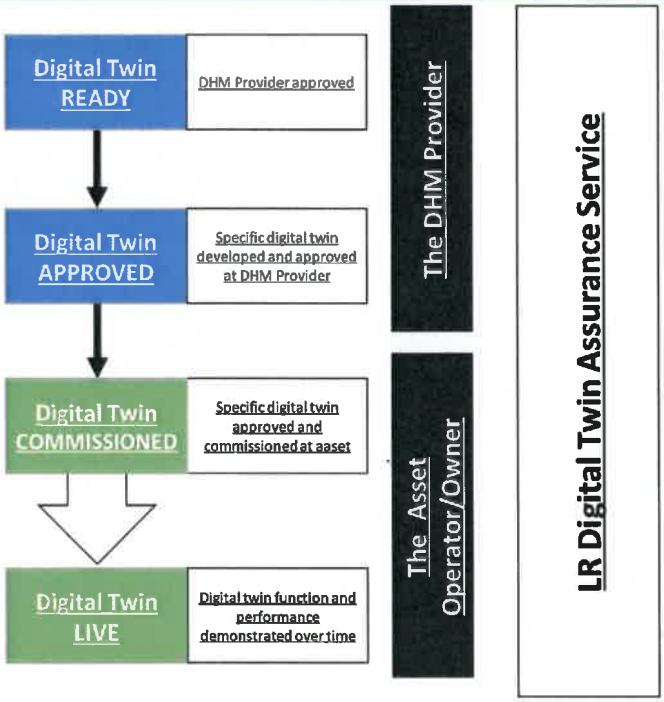
Enabling Confidence in Digital Twins

Builds the Trust and Confidence in Digital Health Management Technology and Digital Twins



High Level Description of the Assurance Process

End to End Digital Twin Assurance

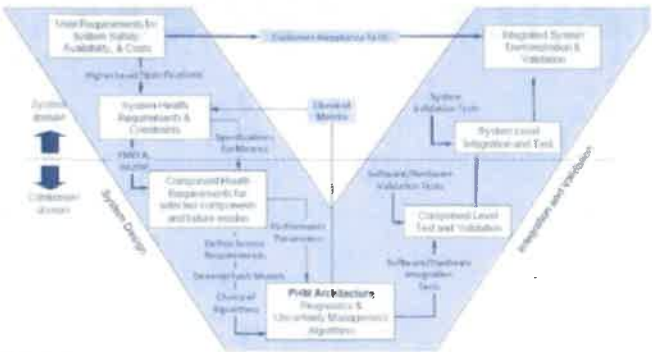


Digital Twin READY

Can the DHM developer design, test, integrate, deploy and support digital twins in the field?

Do they have well defined procedures, processes? Are the SMEs proficient, knowledgeable using the procedures?

- "Vee" Model for PHM system design



Source: NASA Prognostics Centre of Excellence

ADS-79D-HDBK

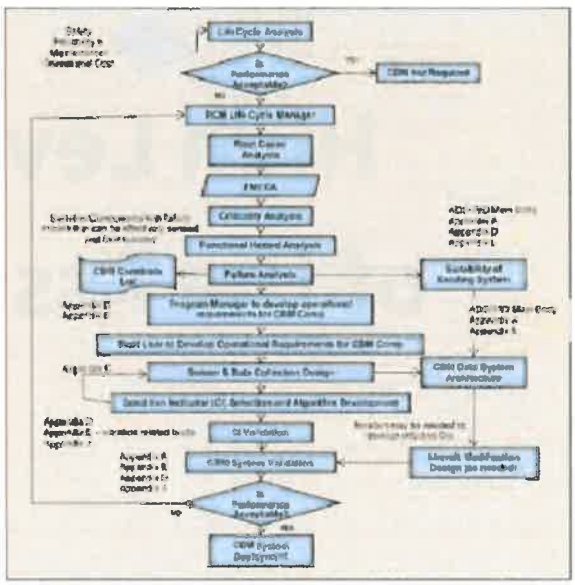
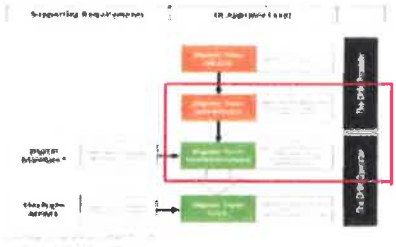


FIGURE 4 CBM development for legacy aircraft

Source: ADS 79 HDBK

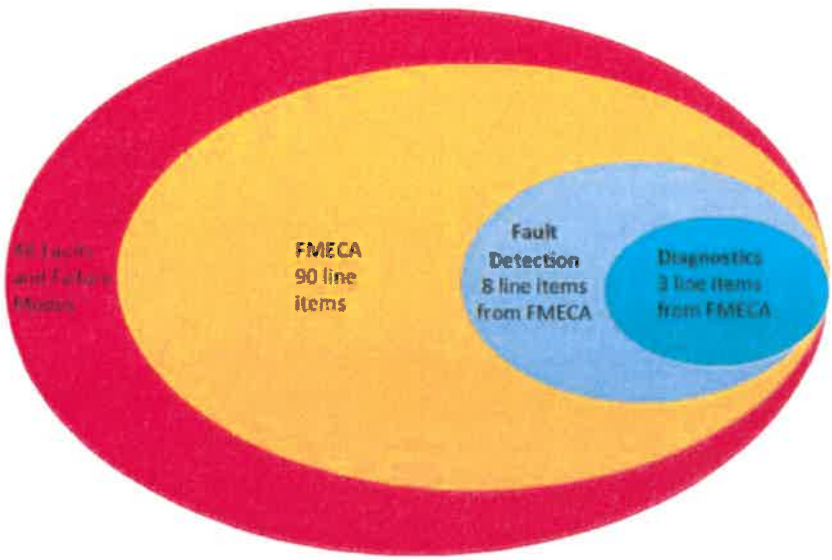
Data and Algorithms Paradigm



Poor Quality Algorithms

Good Algorithms

Digital Twin APPROVED



-Bounds what a Digital Twin can do in terms of coverage and sophistication of insights.

-Applies a 7-11 stage verification process to review the Twin's capability to monitor each failure mode.

Digital Twin COMMISSIONED

Risk Based approach covering 9 domains (risk areas) to understand how "False Negative Events" involving Catastrophic and Major failure modes can materialise.

True Positive

Reality: There is a failure

DHM/Digital Twin: Identifies the failure correctly

The DHM, DT is a hero. End users and management are very happy buying DHM.

False Negative

Reality: There is a failure

DHM/Digital Twin: Misses the failure

Serious consequences. End users severely affected. Digital Twin recalled and investigated

False Positive

DHM/Digital Twin: Incorrectly cries "failure"

End users complain to Management. Unnecessary shutdown affects productivity, profitability

True Negative

Reality: There is no failure

DHM/Digital Twin: With no failure detected, the DT do not initiate any alarm.

Just another day. Management begins to question the value of DHM/Digital Twins

Digital Twin APPROVED, COMMISSIONED

Good Algorithms

High Quality Data → DAQ | Descriptors | Fault Detection → Correct Results??

"Digital Twin Commissioned"

"Digital Twin Approved"

Proving Digital Twin Performance via Digital Twin LIVE

Good Algorithms

High Quality Data → DAQ, Descriptors, Fault Detection → Measuring "Correctness of Results"

"Digital Twin Commissioned"

"Digital Twin Approved"

Measuring "Correctness of Results" + Consistent Correct Results

"Digital Twin Live"

= Increases the Credibility of the Digital Twin

Evaluating Digital Twin Performance via Digital Twin LIVE

	Digital Twin: Failure Present	Digital Twin: No Fault/Failure
Reality: Yes	**True Positive** Bearing Damage: 33 Shaft Damage: 5 Mechanical Seal Damage: 75 Motor Winding Damage: 32 Stator Damage: 15 Cavitation Damage: 188	**False Negative** Bearing Damage: 5 Mechanical Seal Damage: 8 Stator Damage: 3
Reality: No	**False Positive** Bearing Damage: 13 Shaft Damage: 2 Mechanical Seal Damage: 55 Motor Winding Damage: 49 Stator Damage: 5 Rotor Damage: 15 Motor Bearing: 15 Cavitation Damage: 17	**True Negative** 7400 Events *Opportunistic validation of DT monitored parts during calendar based or risk based inspection/ maintenance

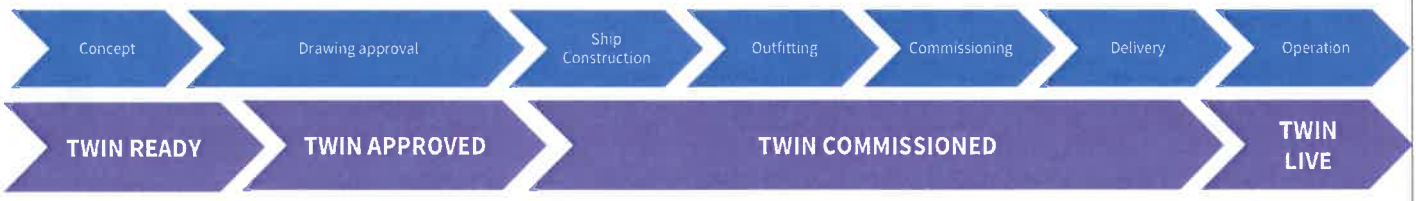
DHM Provider Z,
Centrifugal Pump Digital Twin:

Deployment: 230 Digital Twins
10 years

Coverage:
8 Failure Modes

Sophistication
8 Fault Detection,
3 Diagnostics,
No Prognostics Capability

Continuous Performance Improvement via Assurance



- Trust the individual Twin
- Achieve confidence in the performance of each digital twin
- Improve the performance of each digital twin through continuous field validation – enabling investigation and correction in view of False Negatives and False Positives.

Comments and Questions

ShipRight
Design and Construction

Digital Compliance

Procedure for the Approval of Digital Health Management Systems

September 2018

ShipRight
Design and Construction

Digital Ships

Procedure for assignment of digital descriptive notes for autonomous and remote access ships

March 2019

Thank you

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Lloyd's Register Global Technology Centre

Southampton SO16 7QF, UK

History of LR

LR has been engaged with naval ships for many years. And was the first classification society to develop full Naval Ship Rules in 2000.

History - LR and naval ships

LR's engagement with Navies spans over 70 years

1940

Loch, River

1980

Westralia

Sir Bedivere

1980

Ocean

Chaku Neru

Patrol Boats

1990

Albion
Wave Ruler
Rotterdam

LCVPs

Ref: Lloyd's Register's Approach to Naval Ship Classification RV Pomeroy

History – Naval Rules

LR works with Navies to develop relevant Rules

Application of Commercial Rules

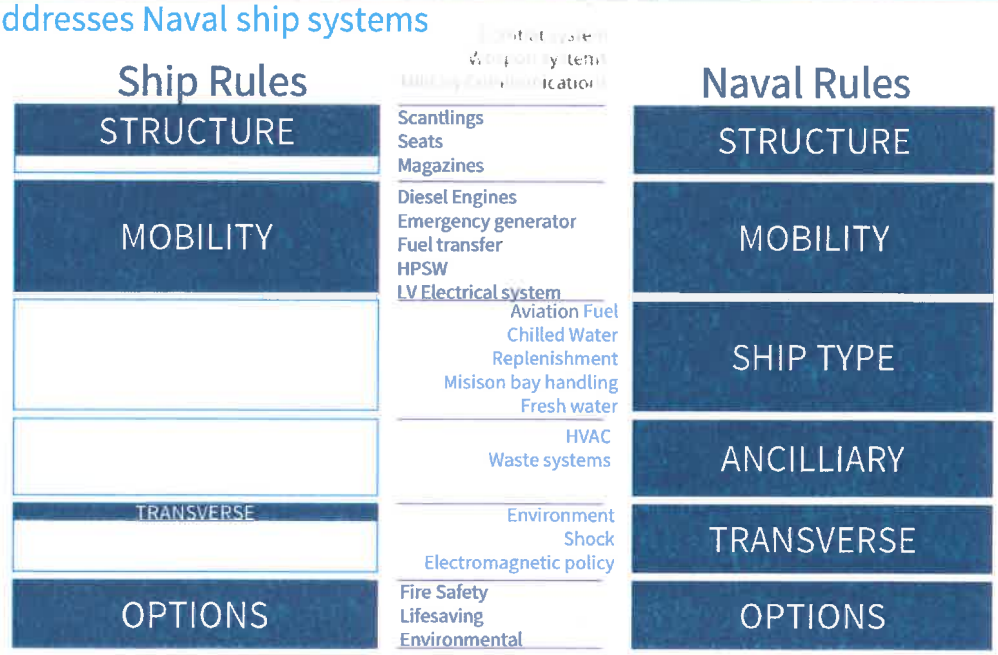
- Stretching the limits of application
- Applicability of IMO conventions
- Wide range of operating conditions
- More Naval ship systems to consider
- Technical resource to update standards

Comprehensive set of Rules for Naval Ships in 1999

- Covering all surface ship types
- Based on established ship classification process
- Facilitate use of COTS supplies
- Military loads and Military operational requirements,
- Military engineering systems

LR Naval Rule

Enhanced scope that addresses Naval ship systems



Classification Process

An assurance process for naval ships equivalent to commercial classification but recognising the naval operational context.

LR Naval Classification Process

Naval Rules utilises the established classification assurance process

Naval Assurance Guide s4.1

LR Naval Classification Process

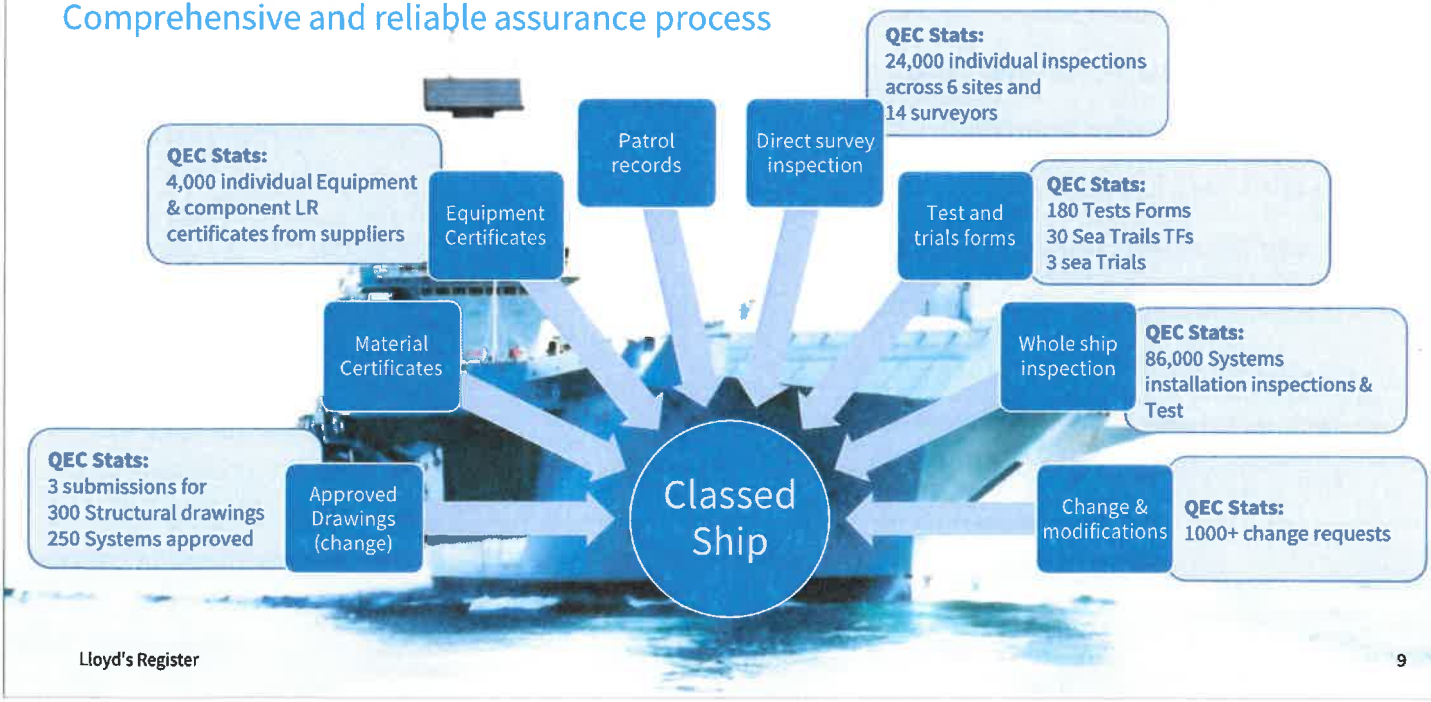
Tailoring allows a flexible approach to standards to meet naval operational requirements

- INCREASED SCOPE
  Walkways to BS5395 Part 3
- ADDITIONAL STANDARDS
  Shaft to Def Stan 02-304 Parts 1 & 2
- ADDITIONAL MOD/CLIENT REQUIREMENTS
  F.O. Pumping rates and capacities
- EXCEPTIONS/NON-COMPLIANCES
  Emergency generator not below main deck
- INTERPRETATIONS
  Gas Turbine controls

Alternative approaches and operational practices

LR Naval Classification Process

Comprehensive and reliable assurance process



Experience

LR class have classed the widest range of naval ships and platforms.

Front Line Vessels

Frigates and Destroyers

- Type 23 Frigates for UK and Chile – acceptance into class
- Type 22 Frigates for Romania
- Type 45 Destroyers for UK
- Queen Elizabeth Class Aircraft Carriers
- Type 054 Frigates for Algeria
- Type 26 Frigates for UK, Australia, Canada
- Type 31 Frigate for UK and export
- Avanti 2000 Frigate for Saudi Arabia

Patrol Vessels/ Corvettes

Large numbers of Patrol ships are built to LR Naval and Commercial class NS(SSC)

Recent Projects

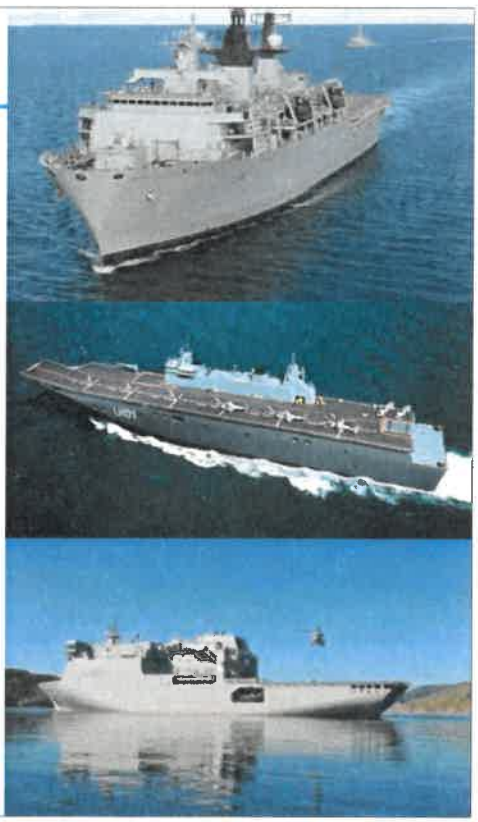
- Royal Thai Navy OPV's – 2 off
- Chilean Patrol Vessels – 20 off
- Canadian Patrol Vessels – 9 off
- Moroccan Corvettes – 4 off (110m)
- Indonesian Corvettes – 3 off (110m)
- Vietnamese Patrol Vessels – 2 off (90m)
- Chilean OPV's – 2 +1 off (90m)
- Irish OPV's – 2 off (90m)
- Omani OPV's – 3 off (90m)
- Sri Lankan OPV's – 2 off
- UAEN Baynunah Missile Patrol - 6 off (70m)

Landing Platform Dock Type Ships

Since 2000, 113 RoRo Cargo/ Passenger ships built to LR Class (commercial ships)

In addition, built or in construction for Naval service

- 6 Lighthouse Class RoRo Cargo (United Kingdom)
- 2 Albion Class Landing Ship Dock (United Kingdom)
- 2 Enforcer Class Multi Purpose Ships (Netherlands)
- 4 Bay Class Landing Ship Dock (United Kingdom)
- 2 Galicia Class Logistics Ships (Spain)
- 2 Landing Helicopter Dock (Australia) (assessed MISTRAL for compliance with NSR)
- 2 Logistics Ships (Indonesia)
- 1 RoRo Logistics Ship (New Zealand)
- 3 Joint Support Ships (Canada) – design stage



Submarine Rescue Systems

To LR Submersible and Lifting Rules

- Ex UK SRS, LR5
  Now in use with Australian Navy – Classed LR
- DSAR 5 Korean Navy.
  Built to LR Rules, not maintained in Class.
- DSAR 6 Singaporean Navy.
  Built to LR Rules , not maintained in Class
- LR7 SRV Chinese Navy,
  Built to LR Rules, now being maintained in Class
- NATO Submarine Rescue System UK, Norway and France
  Built and maintained in LR Class (entire system)

Other Naval Ships

LR's new grey code released for the survey and certification of small boats, assurance appropriate to role and risk

Landing Craft
- LCVP Mk V – UK
- LCUM Mk 10 – UK
- LCM1E – RAN

Training Vessels
- Archer Class – UK

Fast Attack Craft
- FAC – India

Patrol Craft
- Chile (AiC)
- Inshore Survey – UK

Small Boats
- Grey Code – UK/ SWE/ NTH

Submarines

Submarine Assurance framework available covering design, supply chain, manufacturing and through life condition.

Astute and Dreadnought Project

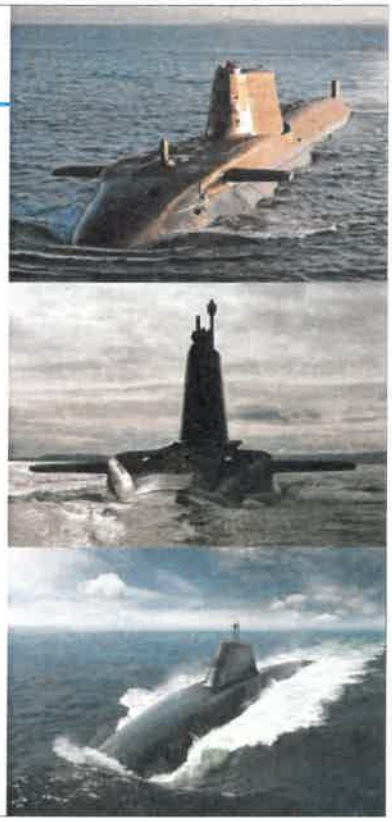
- Review of secondary structure
- Materials and welder certification
- Product verification/ certification

Submarine Rules

- Provides Certification Framework
- Utilises Naval and Shipyard design Standards
- Assurance built on Naval Classification Process

Naval Submarine Code

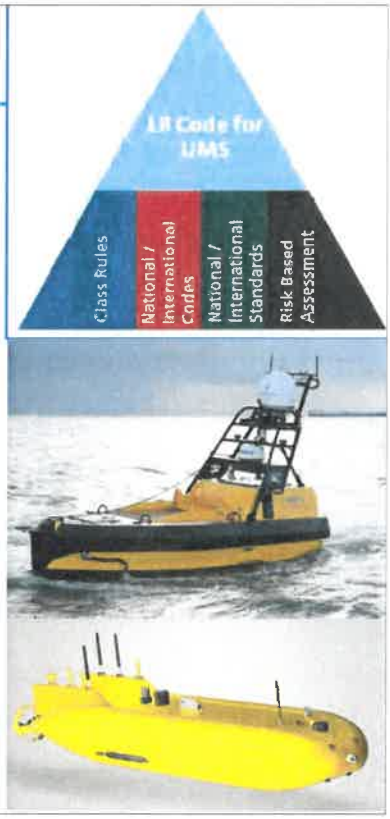
- Developed by INSA



Unmanned Systems Code

A new goal-based code that provides an efficient and structured approach to the assessment of unmanned systems (UMS)

- Allows for the certification of novel and emerging technologies
- Scalable from the very small or simple to the very large or complex.
- Complements our existing work on cyber-enabled ships and supports future regulatory development.
- Support innovation by outlining various requirements, which operators will have to demonstrate.



LR Naval Classification Process

Effective training courses

- Naval Classification * 2.5 Days
- Naval Ship code 1 Day
- Equipment Certification 0.5 Day
- Naval Small Boat Surveys * 3 Days

- Classification and Statutory 2 Days
- Hull Damage and Repair 2+1 Days

General Training

Effective training courses

- Electrical and Control Engineering 3 Days
- A Practical Approach to Port State Control 1 Day
- ISM and ISPS internal audit 2/3 Days
- Cyber security awareness training 1 Day
- Electrical control engineering battery/hybrid 3 Day
- Compliance with ballast water Legislation 1 Day
- Ship Type Introductions, Bulk, Tanker, LNG, Yacht, LPG, Navy
- Leadership and management of ships and ship owners.

Technology

LR is engaged in research and development activities with Navies and Naval Ship builders. We benefit from research undertaken in the commercial marine industry, and wider engagement by the LR foundation.

Naval Standards

LR works with many navies helping to update and maintain technical standards. We are able to rationalise the standards set by identifying overlaps with commercial standards reducing the maintenance burden on naval specialists and cost.

- Naval Administration Support Service for UK MoD
- Review of Canadian CFTO technical standards
- Support to shipbuilder implementing German Navy standards
- Development of Navy electrical propulsion standard
- Standards Gap analysis for goal based codes
- Impact assessment
- Standards selection and definition
- Justifying alternative arrangements

INSA

LR is a founder member and secretariat of the International Naval Safety Association (INSA) which develops and maintains the Naval Ship code and Submarine Codes.

LR influences and supports the development of Naval Ship Safety through engagement in ANEP77 the NATO Naval Ship Code. Balancing Naval Operations with safety requirements to ensure naval personnel are protected.

INSA Work programme 2019

- Environment – Application of MARPOL to naval ships
- Seamanship – Anchoring, mooring, boats, RAS.
- Aviation- Safe aircraft and ship integration
- Integration – Complex integrated systems assurance
- Polar Code – Safe Antarctic operation
- Maintain Capability – Naval Ship Survivability

www.navalshipcode.org

INSA
INTERNATIONAL NAVAL SAFETY ASSOCIATION

Rules

LRs Rules are continuously updated with changes to legislation, experience from new building projects and lessons learned from naval and commercial ship building projects.

LR NSTC October

Intersessional Working Groups ISWG (Jan, April, Jun)

- Ship Design
- Engineering systems
- Human Factors
- Submarines

Ship Design ISWG Planned Work for 2019

LR Project List

- Davits and lifting appliances (Develop 2019)
- Volume 3 Code Alignment (in progress)
- Survivability notation (Develop 2019/2020)
- Aviation notation update (INSA development)
- NSR software upgrade (Hold 2019)

Emergent issues

- Critical Structure assessment
- Sonar Dome Loads
- Update CEPAC Notation
- Review MARPOL Interpretations (NSCA)
- Review Human Centred Design notation (ISWG)
- POLAR – (INSA development)
- Impact of crew and integration into safety (HFG)

Engineering Systems ISWG Planned Work for 2019

LR Project List
- Software Rules
- Safety Shutdowns
- Electrical Equipment IP Ratings
- Digital Ships

Emergent issues
- Requirements for Cyber security;
- Requirements for hybrid power systems;
- Impacts of MARPOL & IMO 2050 goals;
- Review of energy storage technologies;
- Incorporation of NSC goals and functional requirements
- Feedback & lessons learnt from QEC project;
- Valve Requirements.

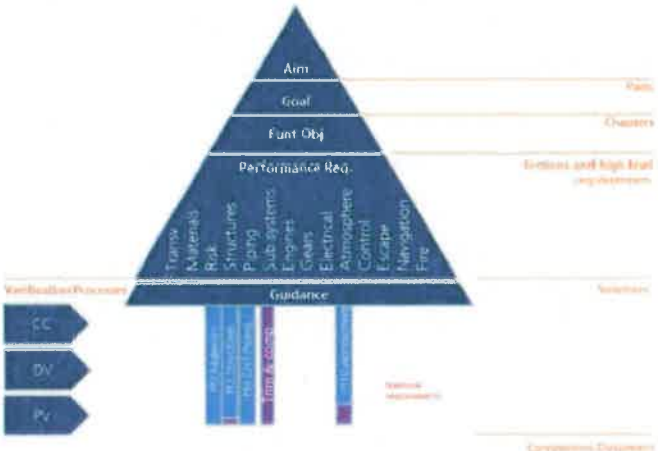
Category	Effects	Typical System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	Monitoring function for informational/ administrative tasks
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	Alarm and monitoring functions Control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	Control functions for maintaining the vessel's propulsion and steering Vessel safety functions

Submarines ISWG Planned Work for 2019

LR Project List
- Submarine Code Development

Emergent issues
- Materials HY80 Q1N NAB
- Pressure Hull Design
- Supply Chain Equipment Assurance

ISWG Priority List (NSTC)
- Publish Submarine Assurance Framework



Grey Boat Code

LR has developed a standard which allows the assessment and certification of Naval Small boat. Which is appropriate flexible and provides assurance of high risk activities.

- Origin
  - Based on UK Codes of practice for vessels under 24m
  - Modified and updated based on 10+ years of experience applying codes to naval boats
  - Reflect naval modes of operation and risks
- Publication January 2019
- Satisfies the UK Naval Boat Code

Unmanned Marine Systems Code

A new goal-based code that provides an efficient and structured approach to the assessment of unmanned systems (UMS)

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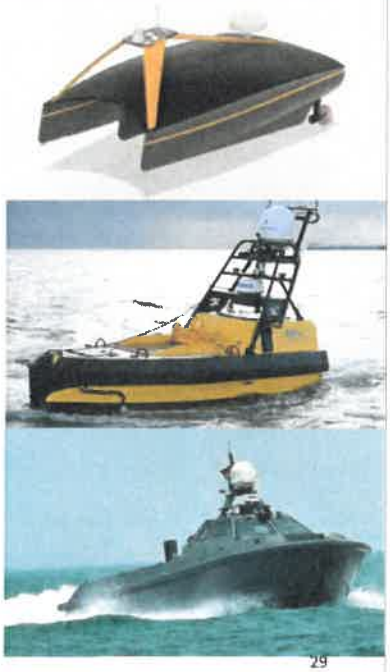
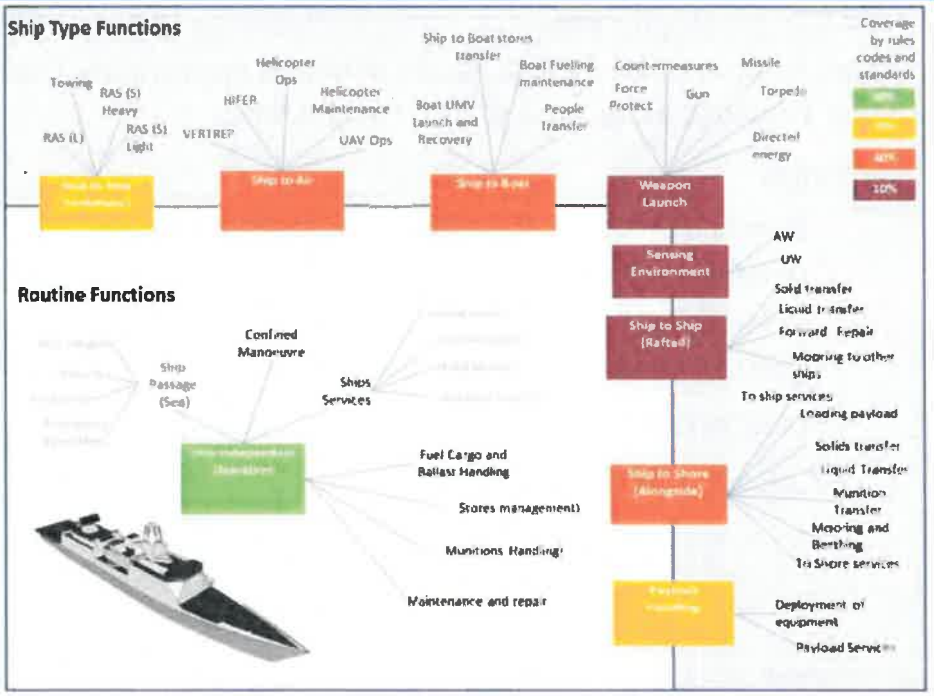


Functional Safety Map

Focussed approach

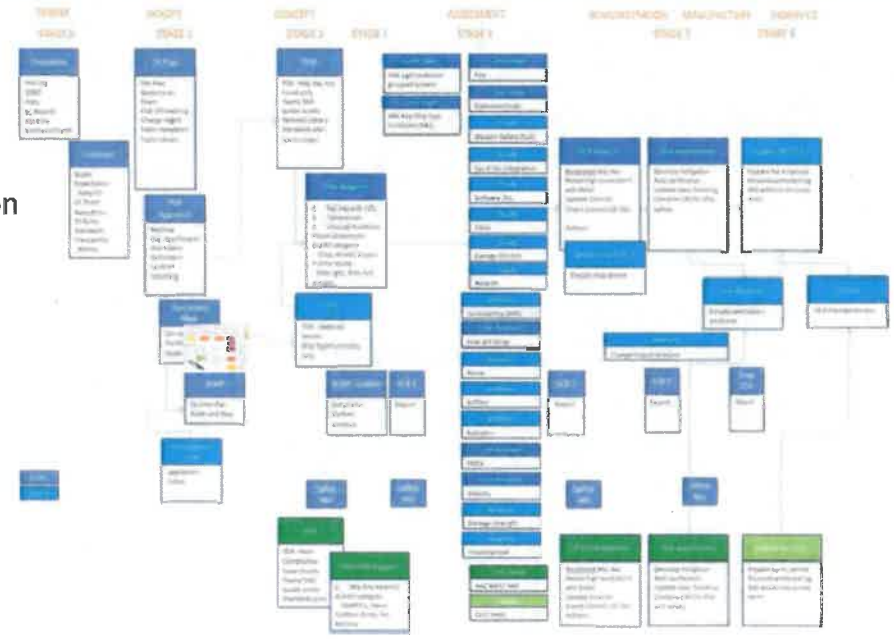
- Ship functions
- Operational modes
- Agree approach



Safety Assessments

Staged approach

1. Strategy
2. Preliminary workshop (PHA)
3. Preliminary Hazard Evaluation
4. Assessment
   - System/Functional Workshops
   - Supplementary Studies
   - Engineering Analyses
5. Risk Assessment/evaluation



Technical Analysis

LR provides technical support to assist in the design and analysis of naval ships and to help when things go wrong.

Examples

- Shipyard had identified a possible issues the with aircraft lifts opening and closing beyond the abilities of the guide mechanism. LR analysed the hull structure and took measurements during sea trials to determine the maximum deflections in extreme sea states.
- A Designer requested LR assist with the fatigue design assessment to satisfy the requirements of the Rules specified for a new frigate design. FDA2 Assessments were undertaken for the specific operational areas of the ship. The results provided the designer with confidence in the design and identify simple changes to improve the fatigue performance.

Technical Analysis

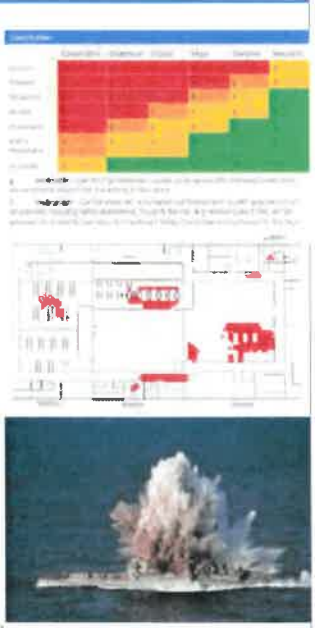
Examples (cont.)

- LR class was selected, extreme strength notations were requested. LR undertook the longitudinal and extreme strength analysis providing the shipyard with confidence in the design and a means of satisfying the navies contract requirements.
- The novel application of high strain-rate sensitive polymer materials for defence protection systems required preliminary proof-of-concept numerical tests before full scale testing. optimal orientation of the steel-polymer layers and showed that the modelling and analysis procedure in this work was highly reliable. Allowing effective numerical assessment
- A Ferry operator commissioned a shipyard to build two ro-ro ferry vessels to operate on a challenging route the shipyard was required to integrate human factors best practice into the design process. LR provided assessment to help optimise the bridge design. The equipment layout and design meant that safety and efficiency were maximised at turnaround and provided assurance that operationally critical tasks were supported.

Technical Analysis

Examples (Cont.)

- LR has provides several ship yards with safety and environment assessments such that they meet the Naval Regulatory requirements. LR's approach utilising the standards and codes as mitigation allows safety and environmental cases to be more robust, easily validated and half the cost of a traditional approach.
- In addition to whole ship safety assessment, LR has undertaken Fire safety studies required by Naval Regulatory requirements. These have also utilized the standards and codes used on the project to simplify the process and only add effort where it makes a difference.
- LR have worked with an expert partner to assess and delivery Explosive and Magazine safety assessment required by many navies. Engaging LR ensures that the risk are properly addressed and LR can help counter any excess demands from the Navy.



Benefits

An assurance process for naval ships equivalent to commercial classification but recognising the naval operational context.

Summary

LR Naval Classification is a Scalable, Flexible, Assurance process

- Classification of Naval Ships through design, build and in service is now a mature process
- LR has significant experience of all ship types and is working with a wide range of navies
- Having a flexible process essential to dealing with naval project complexities
- International Conventions difficult to apply in totality
- Understanding a navy's requirements is a critical part of the process
- Integration of specified Naval Standards is fully allowed for in the process
- LR can offer significant advanced assessment support for military aspects of naval ship design

Thank you

Please contact:

Paul James
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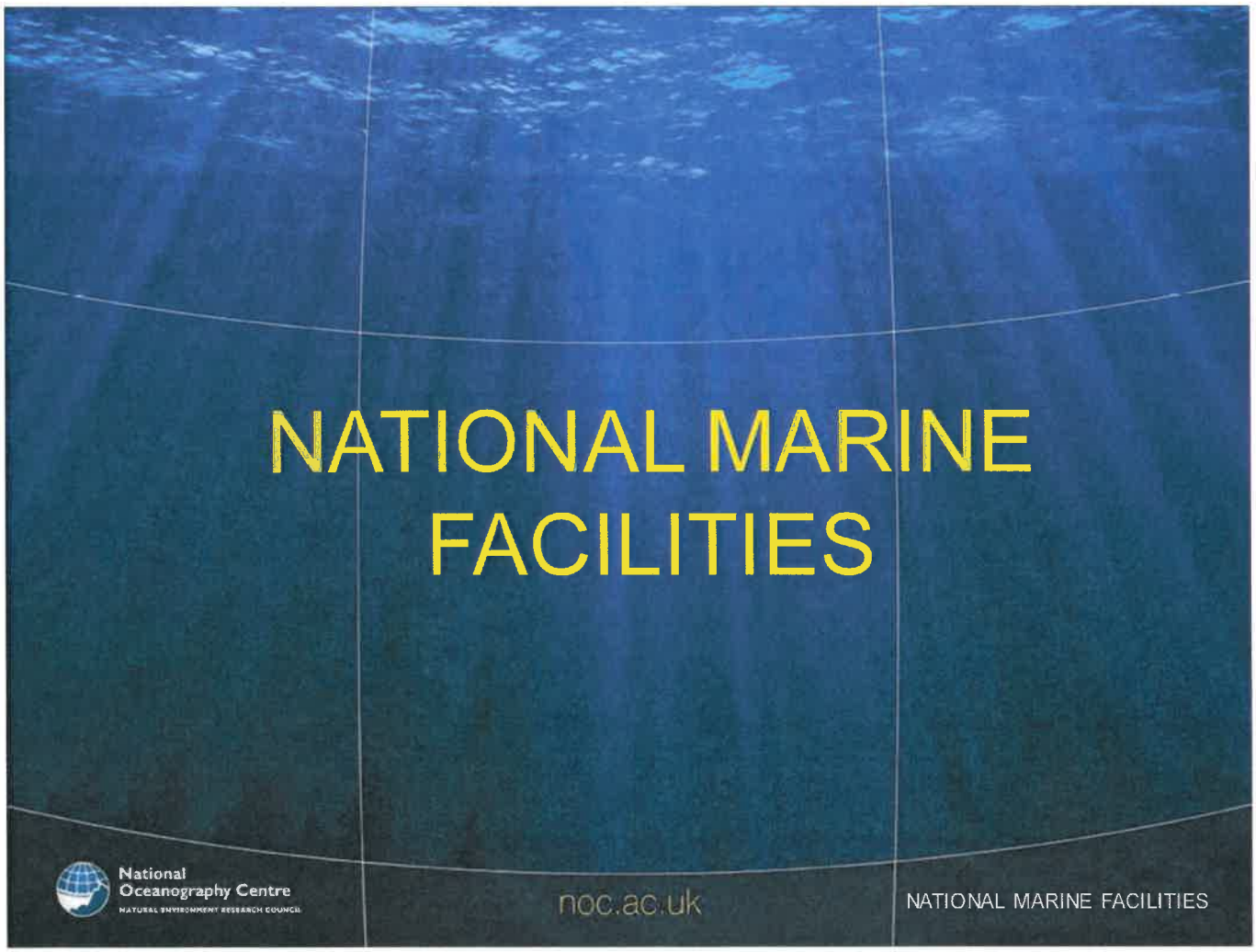
Paul.james@lr.org



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NATIONAL MARINE FACILITIES

THE NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

NATIONAL MARINE FACILITIES

Marine Autonomous & Robotic Systems (*MARS*)

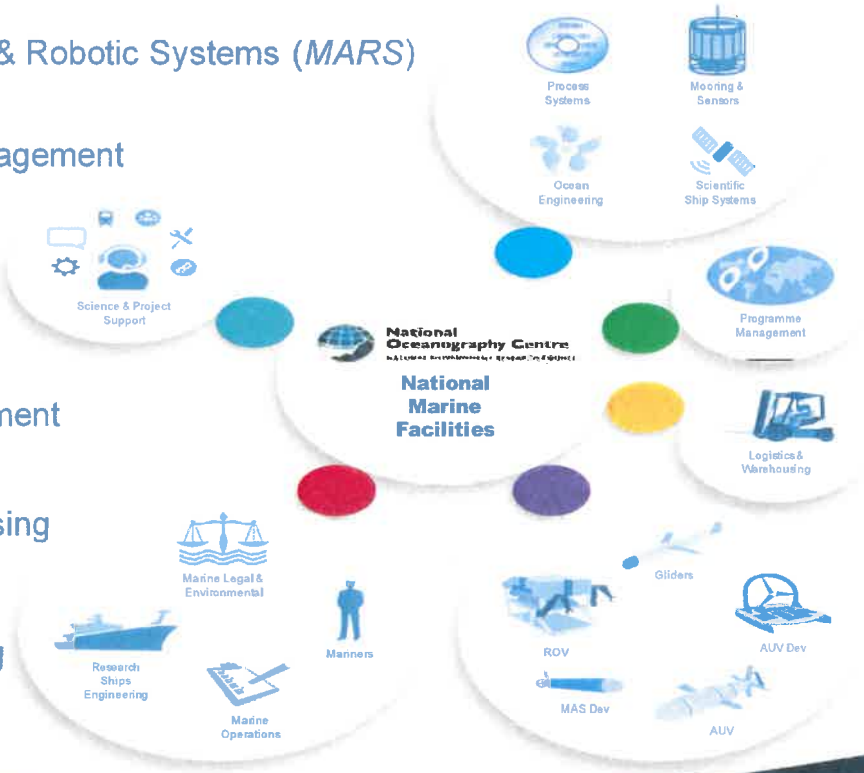
Research Ships Management

Science & Project Support

Programme Management

Logistics & Warehousing

Scientific Engineering



ROYAL RESEARCH SHIPS

RRS *James Cook*

89.2 m
50 days endurance
All oceans, including ice-edge
Scientists and technicians: 32
Marine crew: 22 officers and ratings

RRS *Discovery*

99.7 m
50 days endurance
All oceans, including ice-edge
Scientists and technicians 28
Marine crew: 24 officers and ratings

SHIP CAPABILITIES

SINGLE AND MULTIBEAM ECHOSOUNDER SURVEYS

INTEGRATED DATA LOGGING

SEISMIC SURVEYS

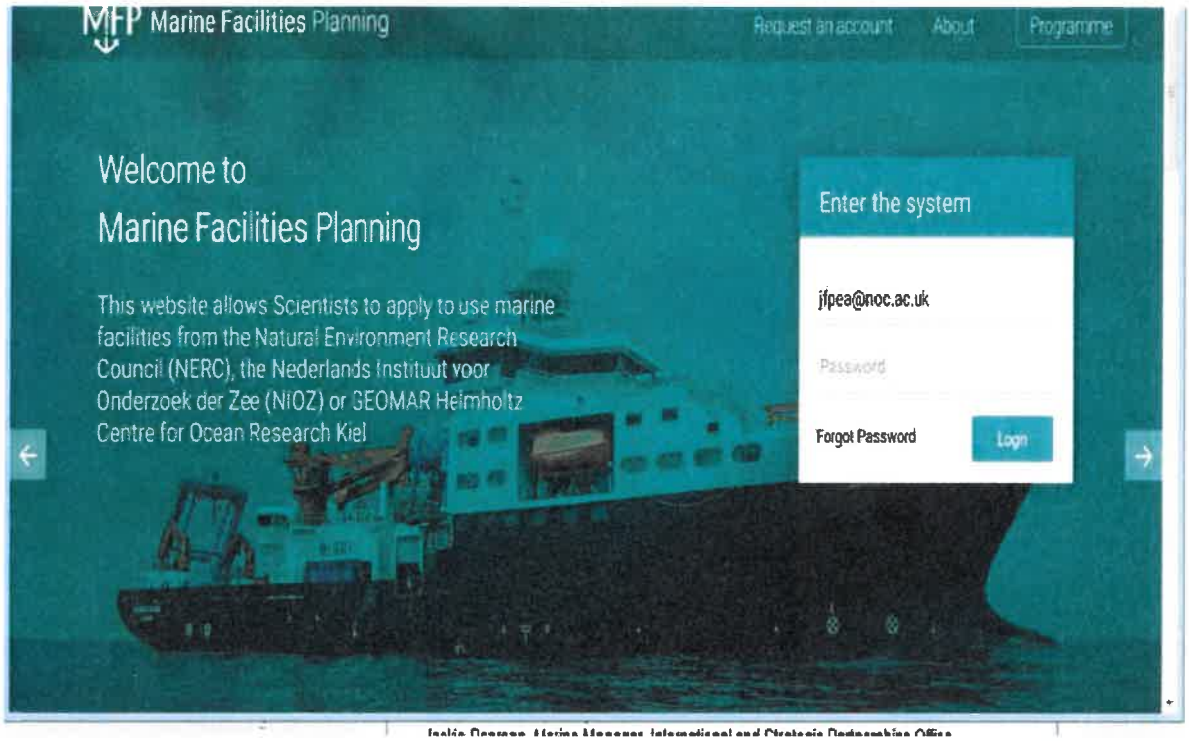
CLEAN SEAWATER SAMPLING

REMOTELY OPERATED VEHICLE OPERATIONS

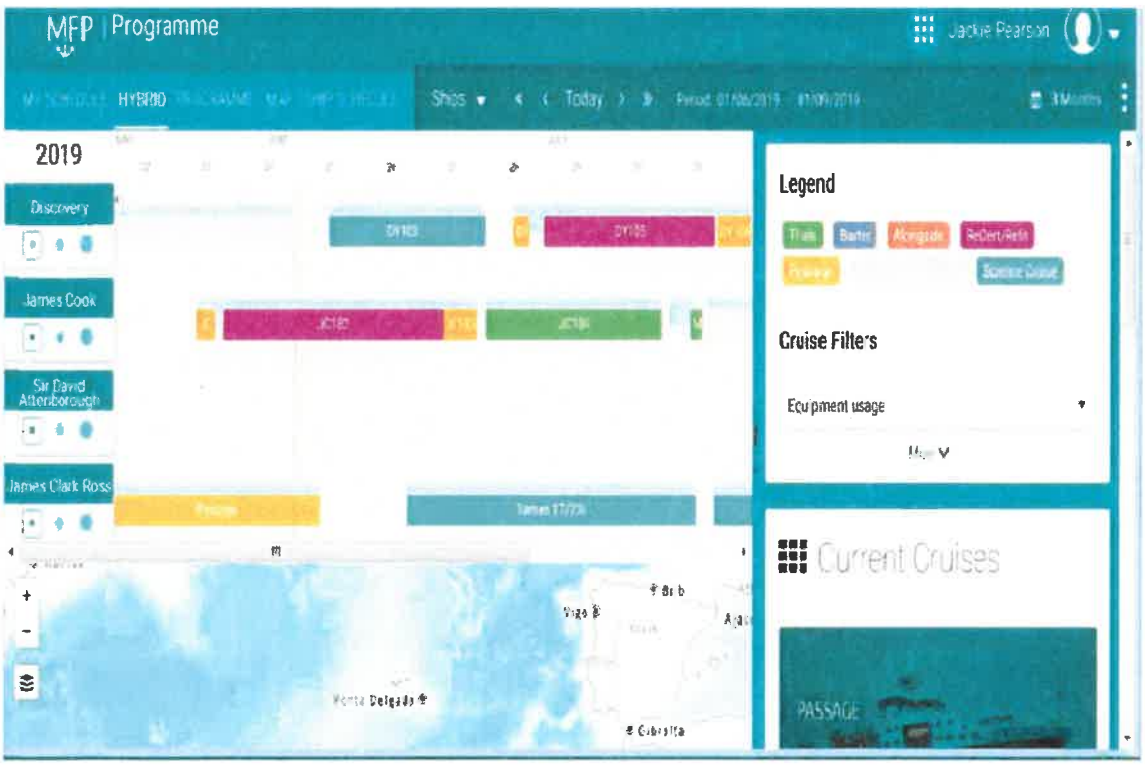
CTD SURVEYS

DEEPWATER CORING, TRAWLING AND TOWING

NATIONAL MARINE EQUIPMENT POOL



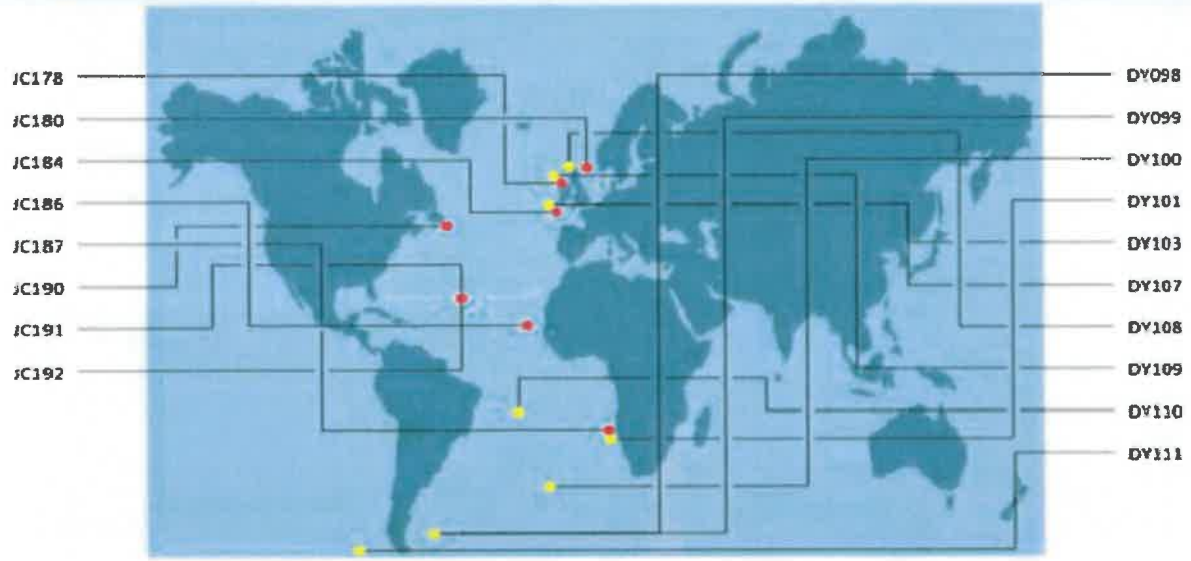
MARINE FACILITIES PLANNING



Royal Research Ships Expeditions 2019 - 2020

RRS *James Cook*

RRS *Discovery*



MULTI-DISCIPLINARY EXPEDITIONS

FEEBDACK FROM OUR COMMUNITY

EXPEDITION P.Is

MARINE FACILITIES ADVISORY BOARD

EXPEDITION PROGRAMME REVIEW GROUP

EXPEDITION PLANNING EXECUTIVE BOARD

INTERNATIONAL BARTER

UK SCIENCE COMMUNITY

INTERNATIONAL MARINE FACILITIES

= > 20 RESEARCH SHIPS AND MARINE FACILITIES

NO-COST EXCHANGES OF SHIP TIME

ENJOY YOUR VISIT TO RRS *Discovery*

Credit: Chou Pesqueira CNP Freire, S.A

visit by the National Academy of Marine Research, Taiwan

19th June 2019

Alan Evans

Head, International and Strategic Partnerships Office

National Oceanography Centre, UK

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The six NERC "Sector Centres" within the UKRI

NERC SCIENCE OF THE ENVIRONMENT → Grant funding to Universities and Research Institutions

Research Centres

British Antarctic Survey, NATURAL ENVIRONMENT RESEARCH COUNCIL	Polar
British Geological Survey, NATURAL ENVIRONMENT RESEARCH COUNCIL	Earth
Centre for Ecology & Hydrology, NATURAL ENVIRONMENT RESEARCH COUNCIL	Terrestrial & Freshwater
National Oceanography Centre, NATURAL ENVIRONMENT RESEARCH COUNCIL	**Marine**
National Centre for Atmospheric Science, NATURAL ENVIRONMENT RESEARCH COUNCIL	Atmosphere
National Centre for Earth Observation, NATURAL ENVIRONMENT RESEARCH COUNCIL	Earth Observations

Marine science research drivers:

Human population is growing to 9 billion by 2050, concentrating in low-lying coastal plains and coastal mega-cities. Attention is turning to the ocean to:

secure natural resources
food, energy, minerals, natural products, genetic resources

increase resilience to marine related disasters
especially flooding

protect the ocean's productive capacity
90% of ocean direct economic value depends on healthy ecosystems

make sense of global change and variability
heat, carbon absorption and redistribution, biodiversity loss

Be more continually aware of the ocean's processes, change and variability
research, sustained ocean observation through advanced technologies

One of the world's top oceanographic institutes

The National Oceanography Centre

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

- The UK's leading institute for integrated ocean research and technology
- From coast to the deep ocean
- Based at two sites (Southampton and Liverpool)
- 647 staff (525 Southampton, 122 Liverpool), £60 million annual budget

The National Oceanography Centre

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long term marine science capability including:

- sustained ocean observing
- global and regional modelling
- major marine facilities
- data management
- mapping and survey
- instrument development
- marine autonomous systems
- scientific advice
- working with business

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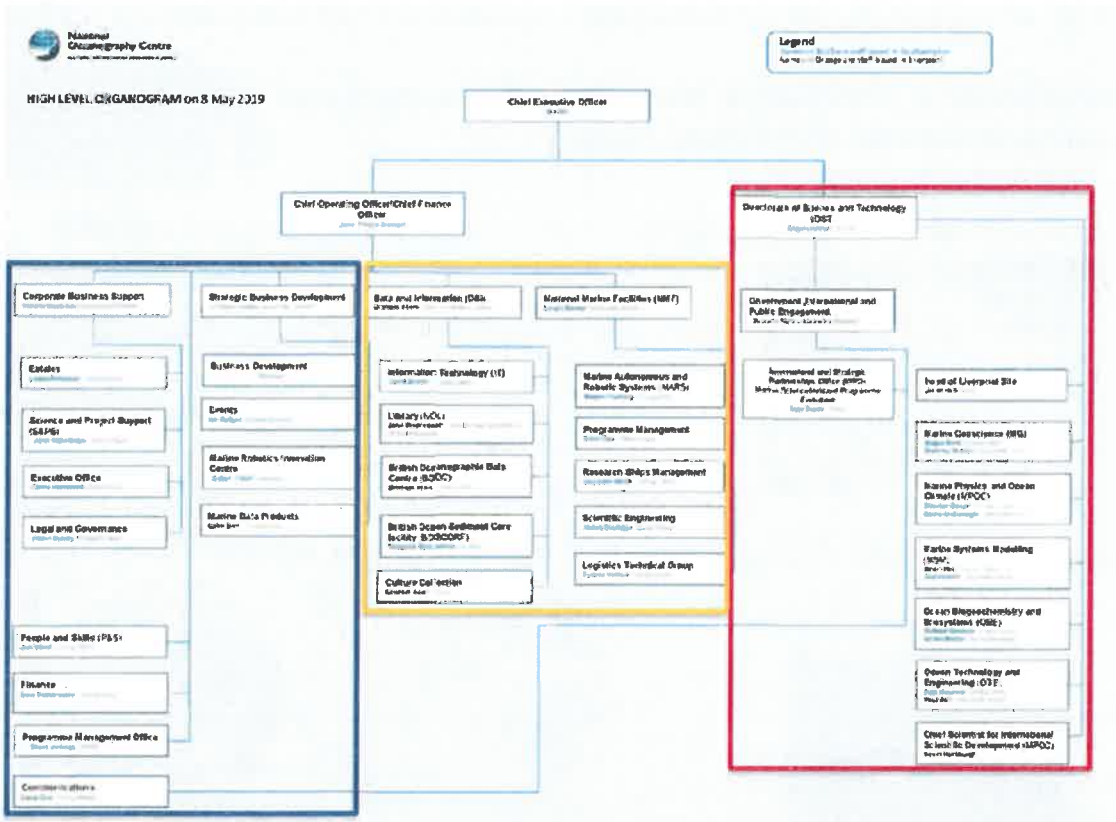

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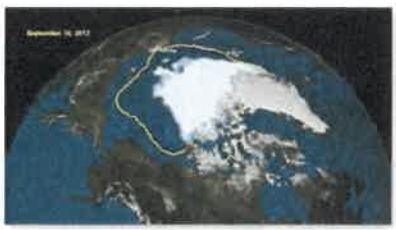
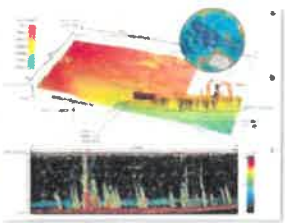
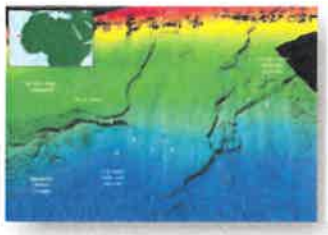
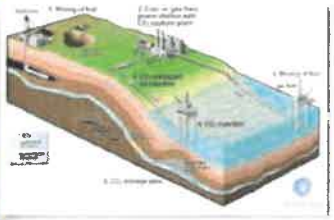
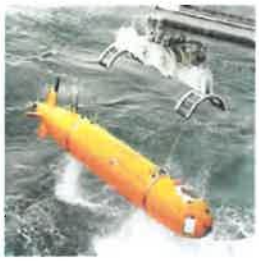
Marine Geoscience Group

"To discover the secrets of seabed interactions with the geosphere and biosphere; to deliver world-class science addressing marine geological impacts on global change and the marine economy."

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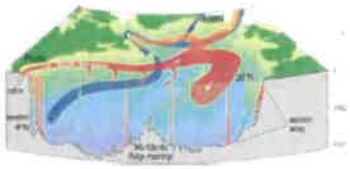
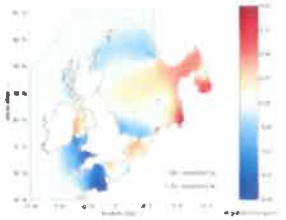
Marine Physics and Ocean Climate Research Group

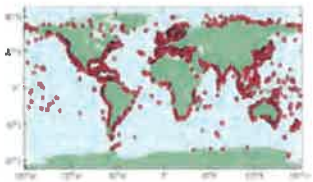
fundamental physical processes in the marine environment and their influence on the rest of the Earth system



Underpinning coastal flood forecasting

leaders in sea level science

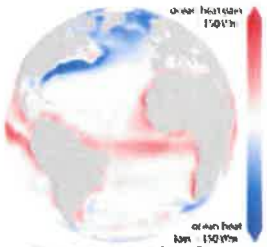




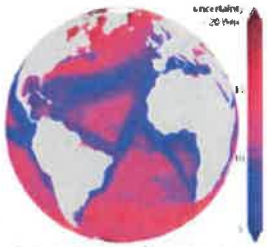
PSMSL

Marine Renewable Energy

Climate-quality surface fluxes



42-year average net heat flux



Estimated net heat flux uncertainty

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Delivering knowledge to manage flooding risk

- £150 billion assets and 4 million people are at risk from coastal flooding in the UK
- Insured annual losses due to coastal flooding – £1 billion

NOC leads on coastal hazards within the Natural Hazards Partnership (NHP), reporting to Cabinet Office and the Chief Scientific Advisor

An independent report (DTZ) estimated the impact of storm surge prediction on the UK economy as:

- Safeguarding property in the Thames Estuary: **£2 billion per year**
- Safeguarding the London economy: **£94 million per flood day**

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Marine Systems Modelling

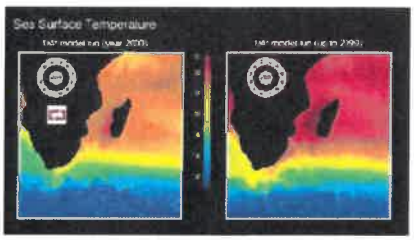
Mission Statement:

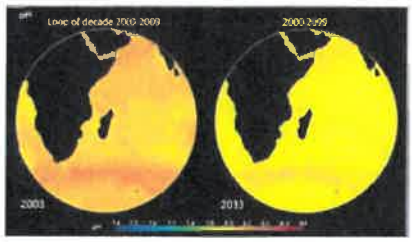
To advance our understanding of the marine environment and improve our ability to predict the Earth System.

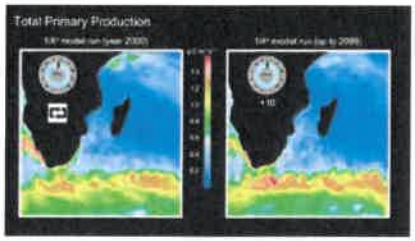
We work at national, regional and global scales and on timescales of days to centuries.

We achieve this mission through the development, application, assessment and analysis of world-leading ocean models.

We aim to exploit this understanding and capability to address societally relevant issues and deliver clear and traceable impacts.







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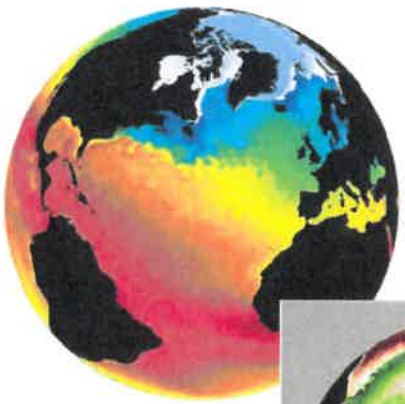
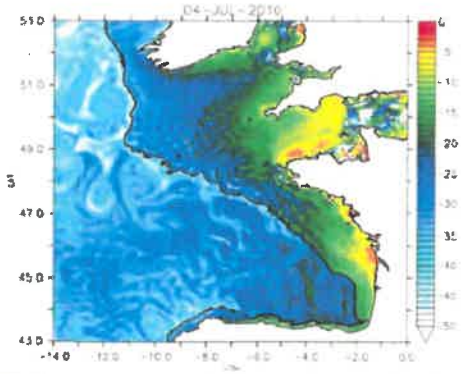
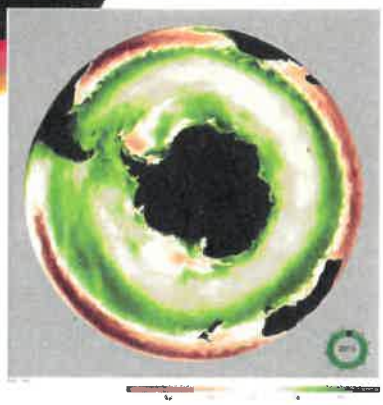
A hierarchy of scales and processes

Global ocean physics:
predictions from days to decades

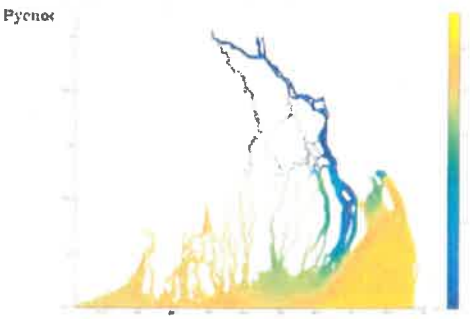




Fine-scale coastal-ocean processes for climate impacts and environmental health



Global ecosystems for carbon cycle processes and impact



Coastal-scales for direct human interaction

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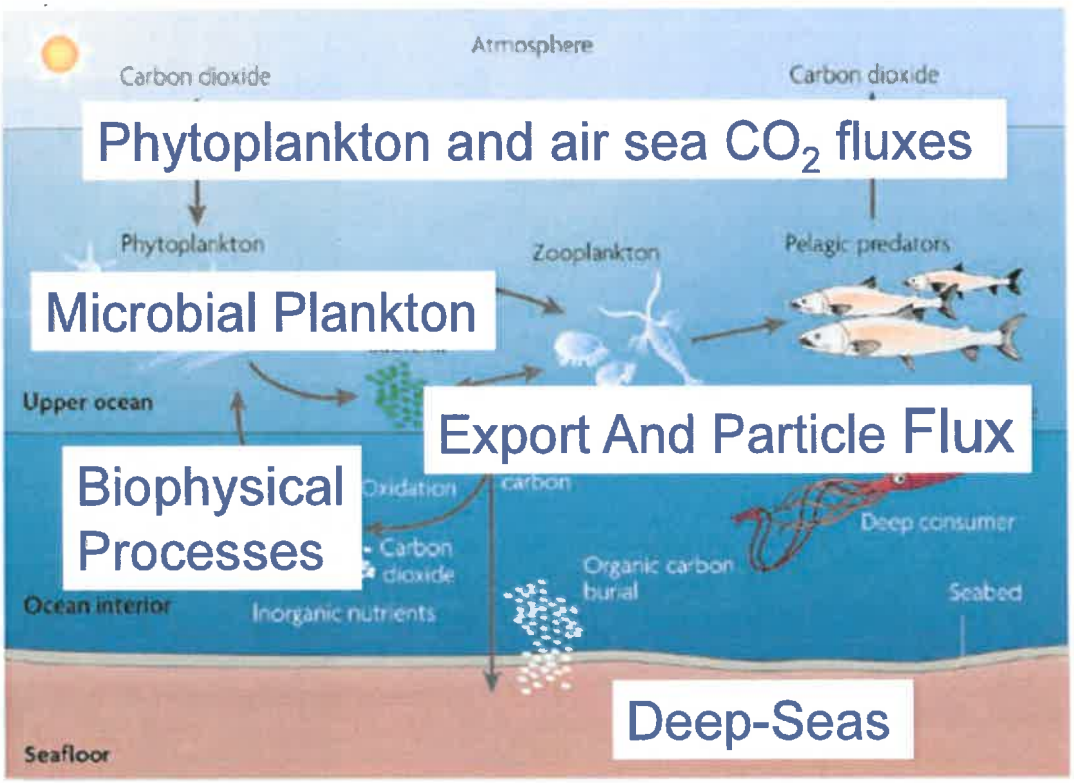
Ocean Biogeochemistry and Ecosystems



Nature Reviews | Microbiology

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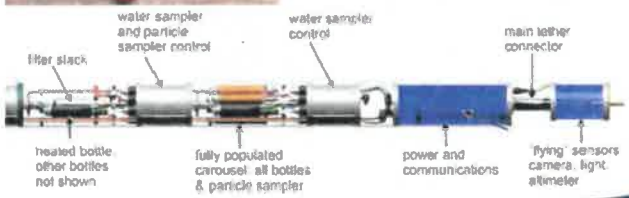
Ocean Technology and Engineering Group

Sensors

- Water physics (CTD)
- Water chemistry
- Water biology
- Sediment flow and properties
- Wave height / breaking
- Sea surface fluxes

Enabling systems

- Metrology standards
- Interoperability and metadata
- Comms & Data flow
- Sensors on platforms



Samplers

- Continuous water
- Gas tight water
- Particles
- Genomics
- Landers and benthic systems
- Communication systems
- Sterile probes / vehicles
- Vehicles: Gliders

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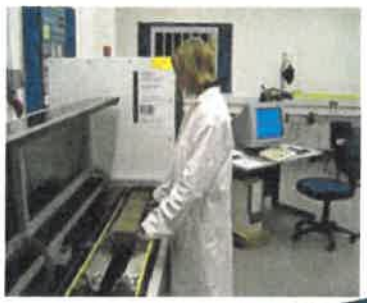
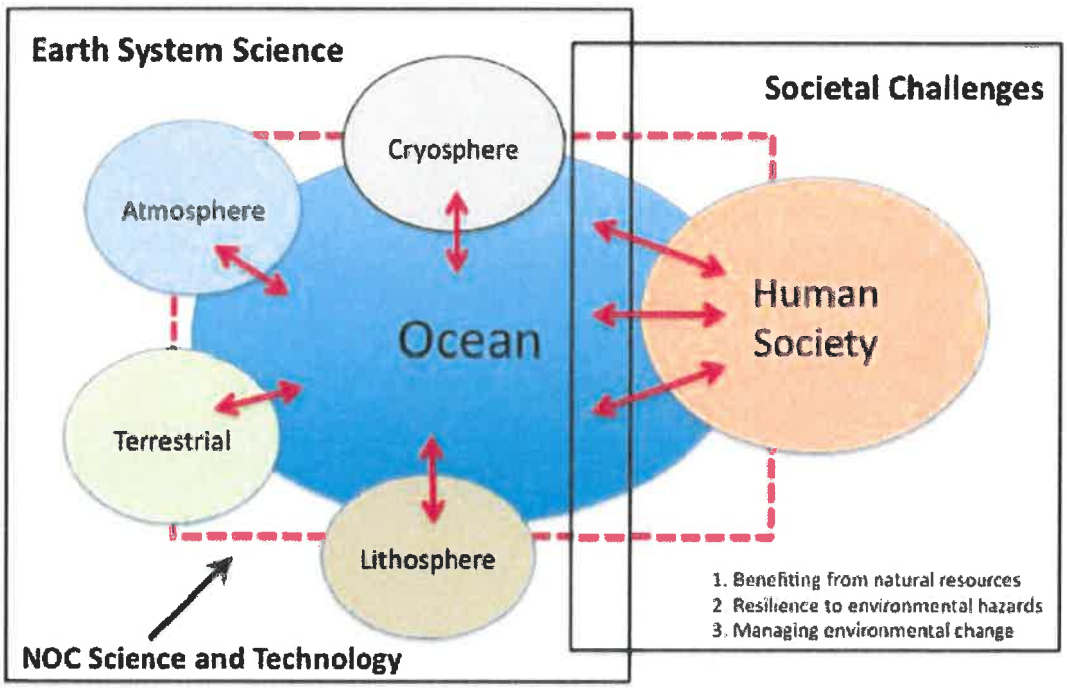
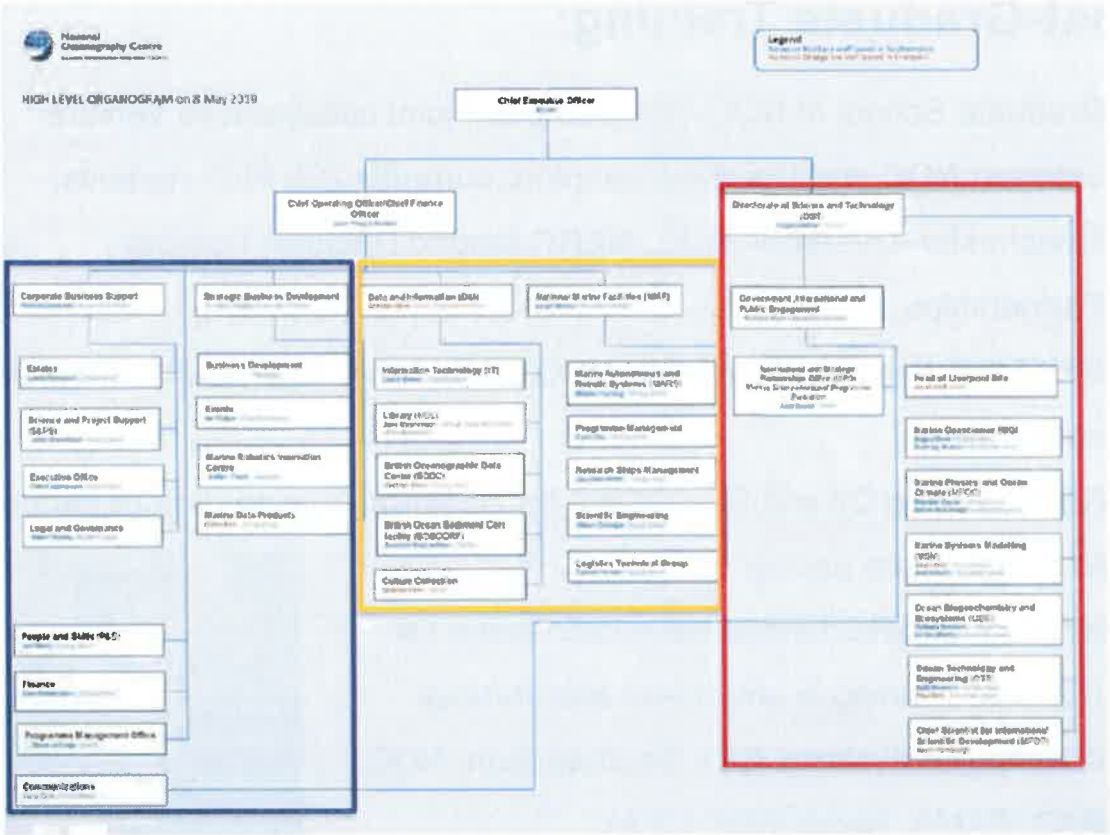
Post-Graduate Training:

- Graduate School of NOC–Southampton; joint collaborative venture between NOC and Uni. Southampton; currently 205 PhD students;
- Manchester–Liverpool–NOC, NERC-funded Doctoral Training Partnerships;
- SPITFIRE (Uni. Southampton, NOC, PML, MBA, BAS, NHM, SAHFOS, and Cefas);
- NERC funded Oil and Gas Centre for Doctoral Training (7 core partners, NOC Associate partner);
- NERC + EPSRC funded NEXUSS Centre for Doctoral Training in smart and autonomous observation systems (Uni. Southampton, NOC, BAS, SAMS, Heriot-Watt, UEA).





NOC research (red dotted box) addresses both the fundamental research of the oceans, and its interaction with other components of the Earth System, and the "Societal Challenges" of food and natural resource exploitation, resilience to environmental change, and managing environmental change from a human society perspective



World Class Research Vessel Fleet

National Marine Equipment Pool - Marine Autonomous Systems

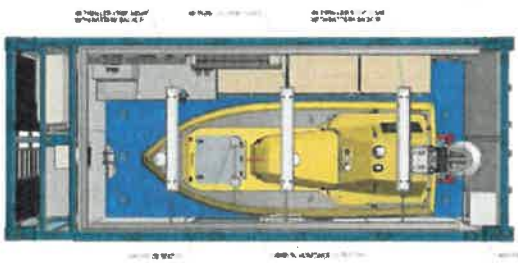
The NOC hosts the largest research fleet of marine autonomous vehicles in Europe, and has over 20 years experience of developing and deploying such vehicles in challenging and hazardous coastal and deep sea environments

Developments:

- Long Endurance Marine Unmanned Surface Vehicles (USV)
- Autonomous Underwater Vehicles (AUV)
- Fully integrated autonomous surface and sub-surface survey system
- Autonomous Adaptive Ocean Sensing Networks – software coordinating a suite of marine autonomous vehicles
- Subsea gliders

CAMEL facility

(Containerised Autonomous Marine Environmental Laboratory)



BOSCORF

British Oceanographic Data Centre (BODC)

Permanent Service for Mean Sea Level

The National Oceanographic Library

NOC International

'traditional' high seas research

- Long term observations
- Deep water exploration

Representation and Partnerships

(International and Strategic Partnerships Office (ISPO))

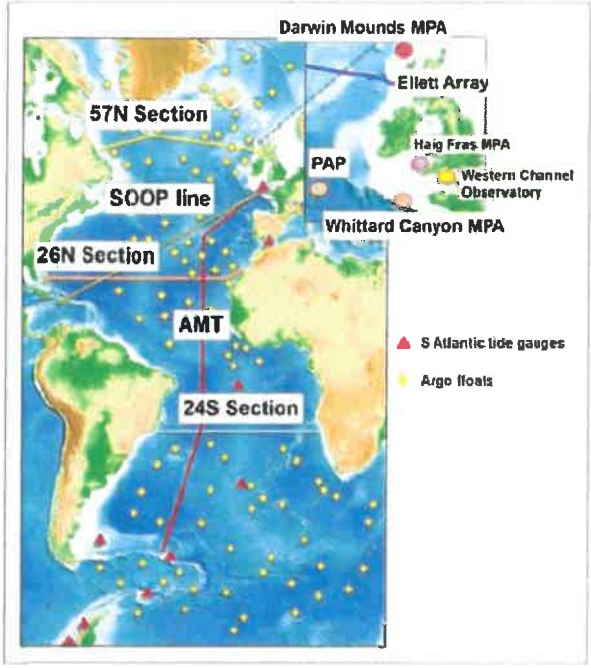
- Science into Policy
- Government support & advice
- UK Delegation(s)
- UK Marine Science Coordination

Official Development Assistance (ODA)

(Chief Scientist for International Development)

- SOLSTICE – UKRI GCRF
- CME Programme - Prosperity/CSSF
- ACCORD – NERC NC-ODA
- C-RISE – UK Space Agency
- MarineE-tech - Newton

High seas, deep water exploration



Observing arrays underpin evolving understanding of ocean circulation and climate

Mid-oceanic, abyssal plain and seamount mineral resources

Thank you

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Sustained observing of the oceans

Brian King

National Oceanography Centre,
Southampton, UK

Visit by the
National Academy of Marine Research,
Taiwan

19 June 2019

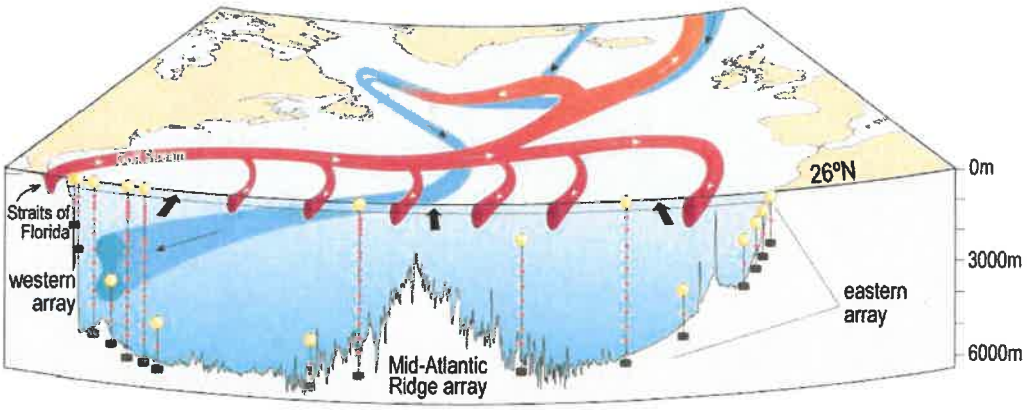
We observe the open ocean using

Moored time series: example is the Atlantic 26N array

Global in situ measurements with ships: GO-SHIP

Global in situ measurements without ships present: Argo

Moored time series: the Atlantic 26N array



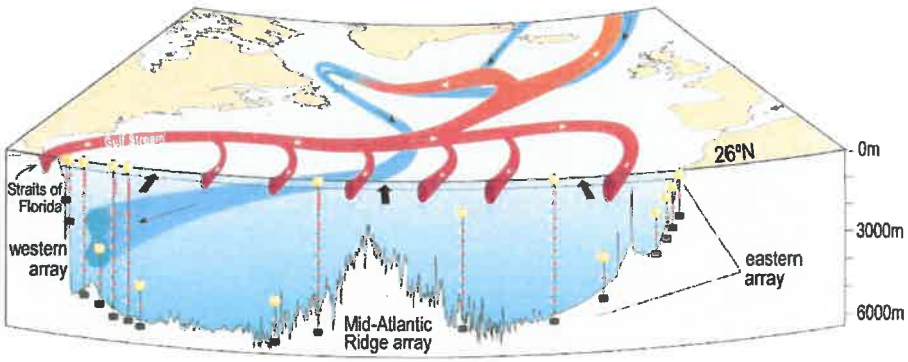
A large array of moorings, with mainly physical oceanography instruments: current meters and T & S sensors, but recently have added BioGeoChemical measurements:
pCO2, oxygen, pH, and water samplers

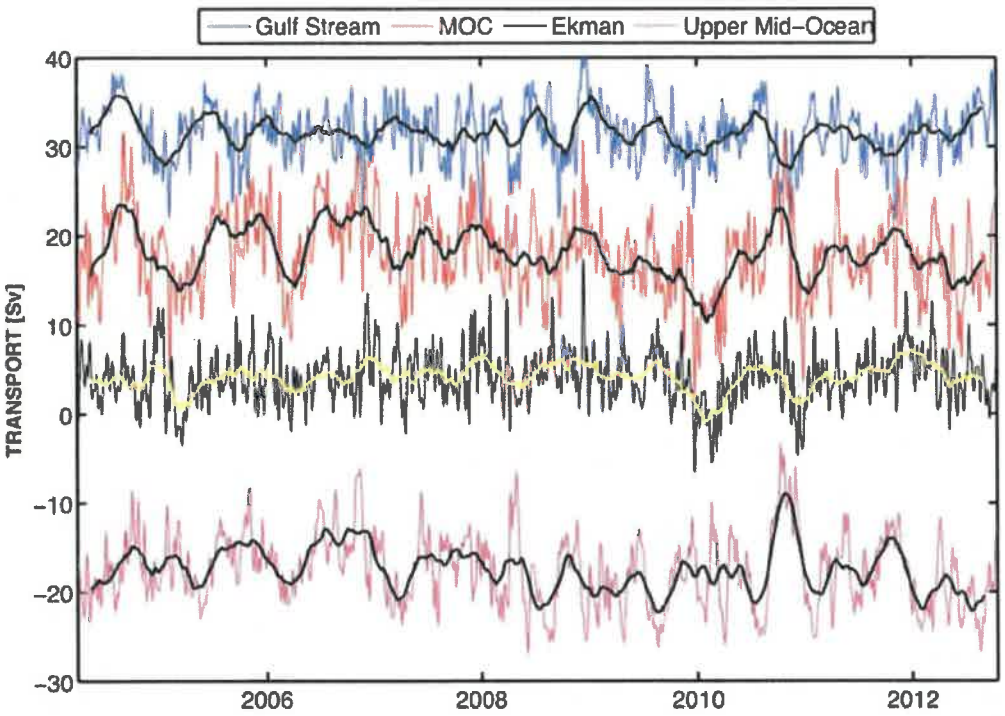
Moored time series: the Atlantic 26N array

www.rapid.ac.uk
www.oceansites.org

Characteristics of moored time series:

- Very good time resolution (hours), but less good spatial resolution
- Very good in boundaries
- Limited parameters, but improving with latest technology
- Data may be recovered only once per year or two years; sometimes available in real time.



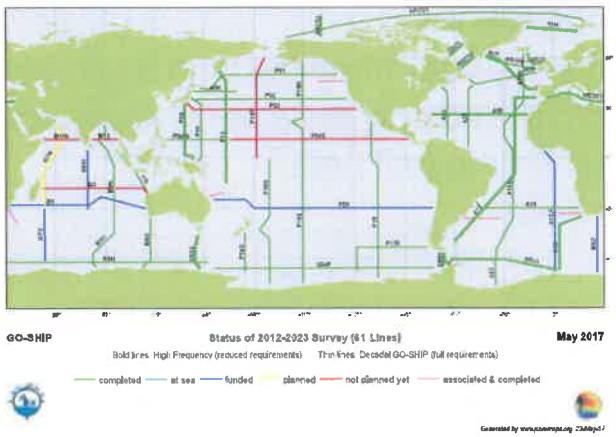


Time series of different components of the Atlantic Meridional Overturning Circulation (AMOC) from the 26N mooring array

Global in situ measurements with ships : GO-SHIP

www.go-ship.org

- Decadal repeat
- Coast-to-coast and full-depth
- Station spacing of 30nm



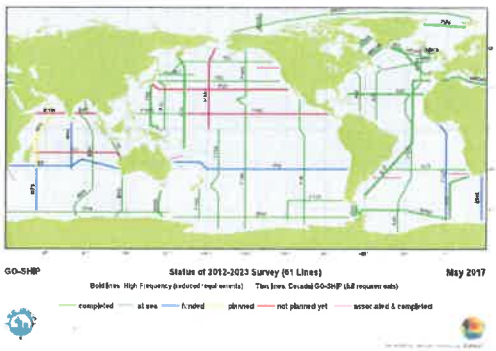
- Climate quality data
- Data release policy
- Level 1 (required), level 2 (desirable) and level 3 (ancillary) data

Global in situ measurements with ships : GO-SHIP

www.go-ship.org

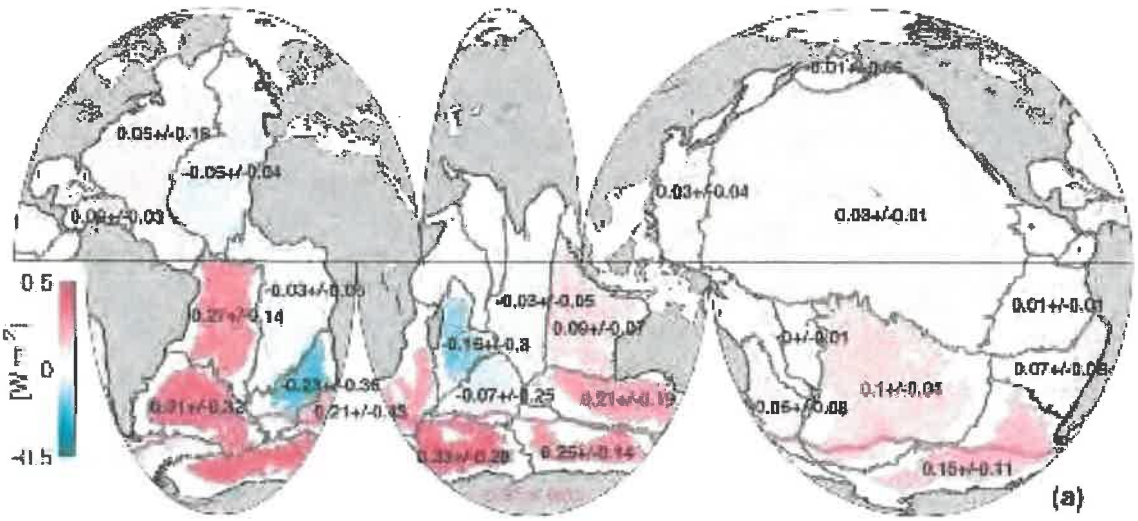
Characteristics of ship-based observations:

- The best spatial resolution, time resolution limited by resources – GO-SHIP is once every 5 years
- Very good in boundaries
- Very big range of parameters, the only way to make some measurements
- Data can be made available as soon as data are collected or water samples analysed.



Heat content trend: red areas are warming below 4000m.

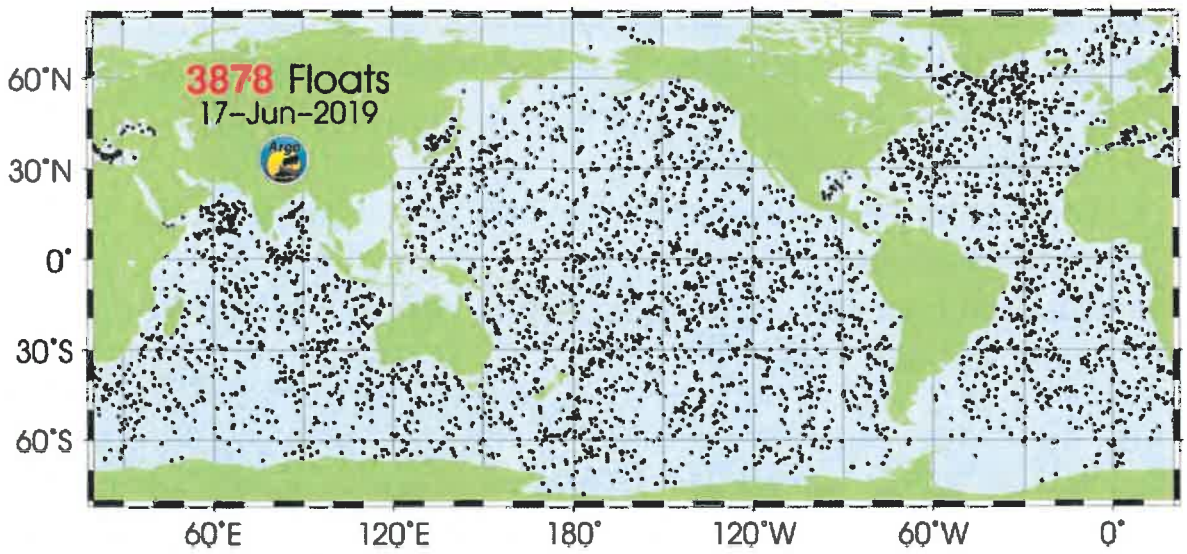
The NE Atlantic was the only deep basin that was cooling at a rate greater than the uncertainty



Purkey and Johnson , 2010

Global in situ measurements without ships present : Argo

www.argo.ucsd.edu



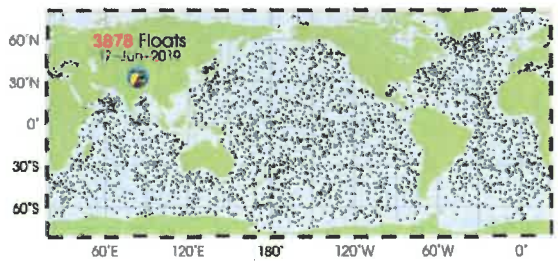
Around 30 countries working by international cooperation

Global in situ measurements without ships present : Argo

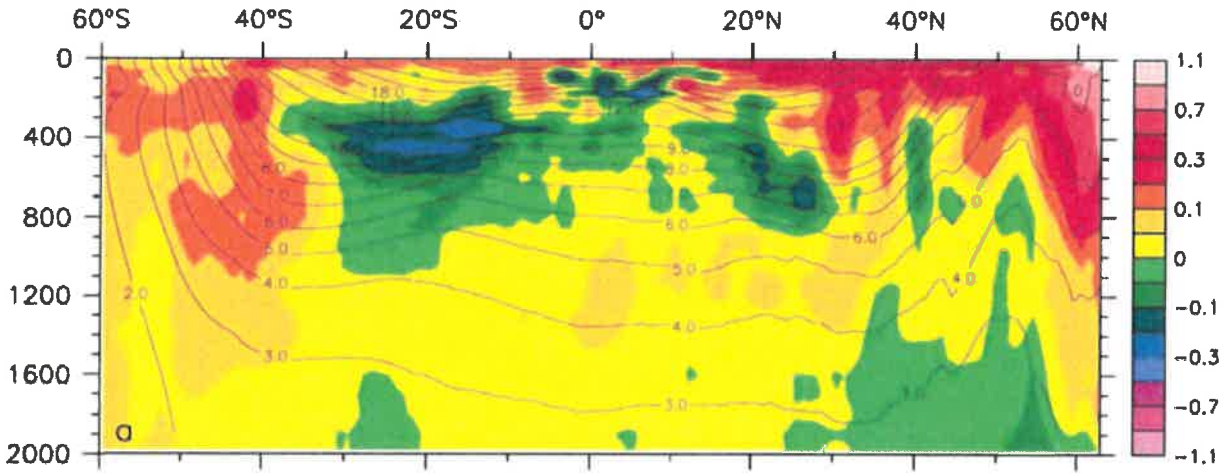
www.argo.ucsd.edu

Characteristics of Argo observations:

- Spatial resolution suitable for capturing climate signals, time resolution very good – every 10 days
- Not good in boundaries – floats run aground and get swept away
- Limited range of parameters – originally T&S, now Oxygen, pH, nitrate and bio-optics
- Data freely available within 24 hours.
- Argo still depends on ships for deployment opportunities and calibration reference data



Global data from Argo makes change detection much more robust



Geographical variation of temperature change

Yellow and red is warming, green and blue is cooling

- *The observation station planning, maintenance, and data transmission*

All our programs are planned by international coordination.

GO-SHIP and Argo have international leadership panels, and 20 or 30 international partners.

Our moored arrays tend to be UK only or multi-lateral efforts with a smaller number of partners.

Data transmission can be by satellite, often Iridium.

- *Sharing mechanism of observation data between the public sector and academic research organisations*

Data are shared on web sites with public access. We do not distinguish between public sector and academic organisations.

Argo data (and some ship data) are also distributed on the GTS – Global Telecommunication System, accessible to national meteorological agencies

All our data are made freely available to all users as soon as possible:

A few hours for Argo float data
A few weeks for GO-SHIP data
Usually 6 months for moored measurements. The careful calibration of moored instrument data takes a considerable staff effort and expertise

- *Forms of observations data and observations type*

Data can be from

- Electronic sensors - there are a growing range of parameters available
- Water samples analysed on board ship (eg CO2) , or in labs ashore (eg stable isotopes)

We follow protocols for instrument preparation, water sample analysis and data processing and quality control published by the co-ordinating programs, eg GO-SHIP and Argo

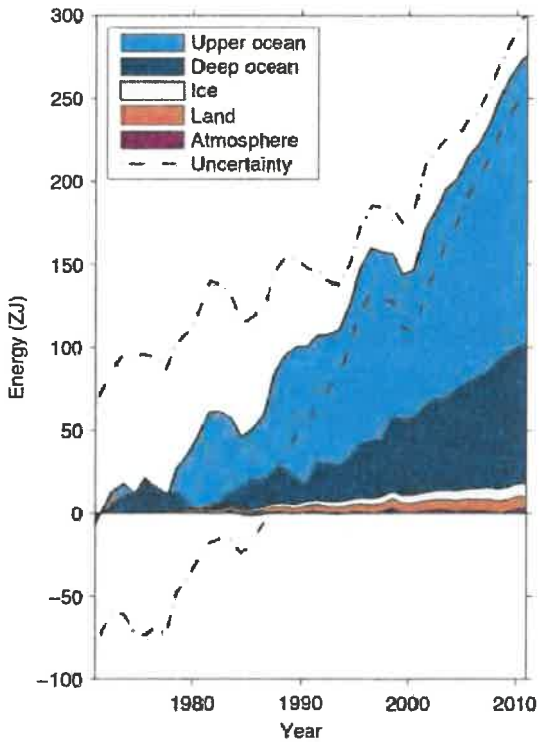
- *Application of AI in marine hydrological observation*

We consider Argo to be a form of AI – the floats are autonomous

There is a growing use of *ocean gliders* for sustained observing. These have some autonomous decision-making capability on board, but require piloting for successful missions.

Gliders are more suitable than floats in boundary, coastal and enclosed regions. Gliders usually require ship or small boat access to service the vehicles. Floats are cost-effective in the open ocean where random/statistical distributions provide the required spatial coverage.

The suite of self-propelled Autonomous Underwater Vehicles are not yet used for systematic observation of the ocean, but are used for process-study programs, investigating local and regional phenomena.



The British Oceanographic Data Centre: Managing National Marine Data

HELEN SNAITH – HEAD OF BODC SOUTHAMPTON SITE

BODC's Role

A National Facility for storing and distributing data concerning the marine environment (since 1969)

A resource for science, education and industry, as well as the wider public

Sole responsibility is data management

Starting premise - **data must be secure** and **readily usable** in the long term **without reference to the originator**

We are part of NOC, meaning:

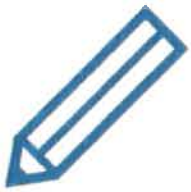
- Added value from shared infrastructure support
- BODC serves the entire marine community
- Close collaboration with ship operations to develop end-to-end solutions

BODC Core Service

Data delivered to BODC

Check the data for completeness

Archive a copy (in future proof format)

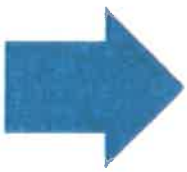


Record all ingestion steps and decisions

Research and Record the context

We document details of the dataset

What happens to data?



Convert the data to a standard format

Review the quality control of the data

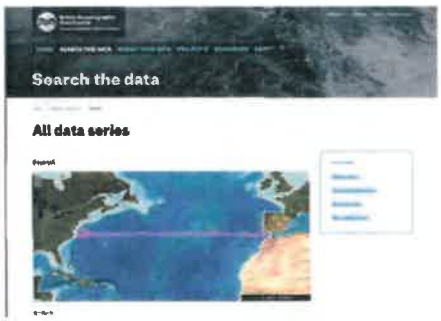
Tag with metadata from controlled vocabularies

Check our processing

Bank the final version

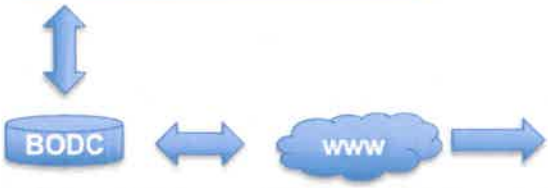
Expose the dataset online

The end result



Data available via Web User Interface

www.bodc.ac.uk/data/bodc_database/nodb/



Data available via other systems/networks

FAIR Data Principles

The FAIR data principles state that data need to be:

- Findable
- Accessible
- Interoperable
- Re-usable

Services - NERC Vocabulary Server - NVS

Problem: The Curse of Free Text

- rain
- precipitation
- ppt
- preciptaoin

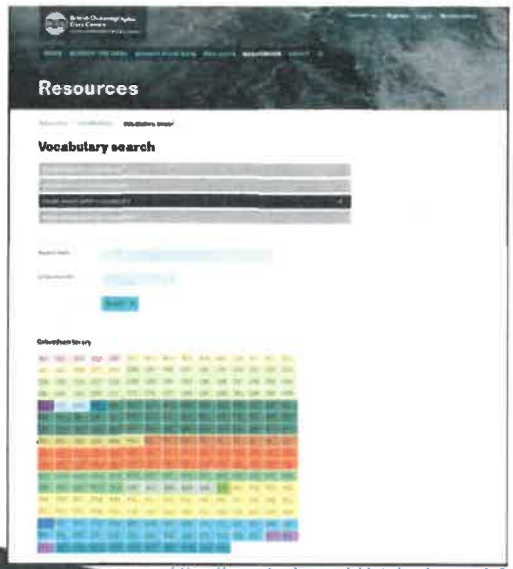
Solution: Controlled vocabularies

Controlled vocabulary =

- '..the use of predefined, authorised terms that have been preselected.'

Specified when entering metadata

Services - NERC Vocabulary Server - NVS

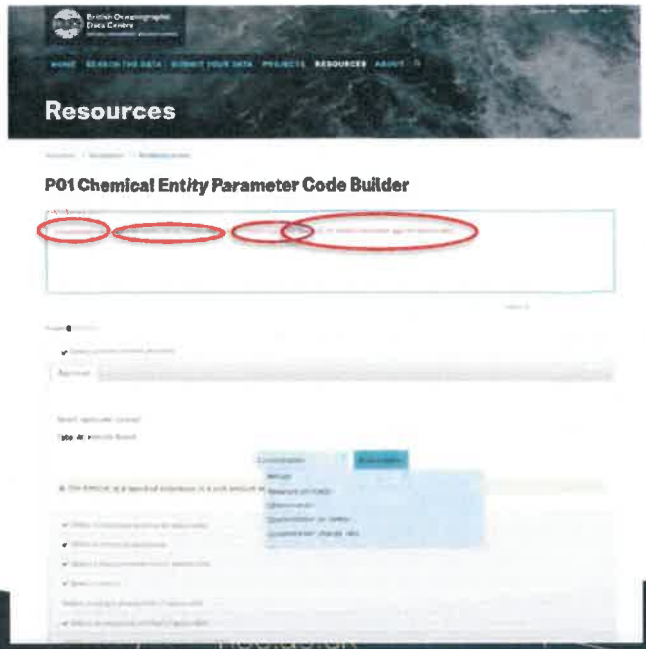


https://www.bodc.ac.uk/data/codes_and_formats/vocabulary_search/

Ontologies:

- Salinity is a specific type of observable parameter
- e.g. water is a generalization of sea
- e.g. Rain is a specific type of precipitation

Services - NERC Vocabulary Server - NVS



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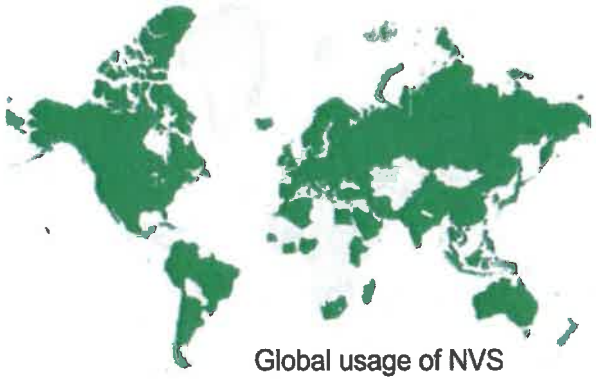
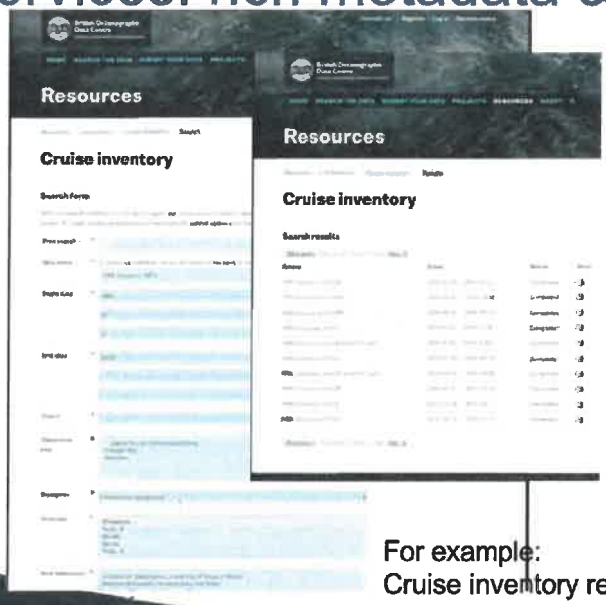
Services - NERC Vocabulary Server - NVS



Global usage of NVS

Submitted to the IODE Ocean Data Standards and Best Practices Project (ODSBP) as **the European regional standard for controlled vocabularies in** metadata and data formats descriptions of Marine and Oceanographic Datasets.

Services: rich metadata & marine information



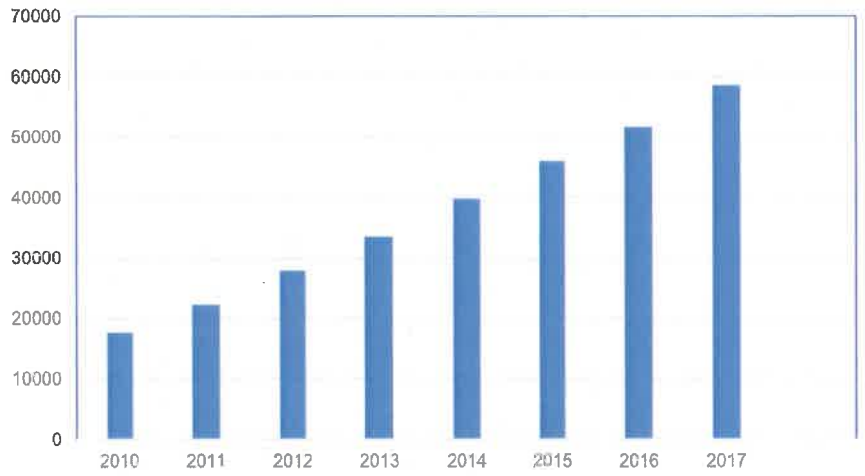
For example:
Cruise inventory reports

Services: Provide a near real time delivery system for marine autonomous systems

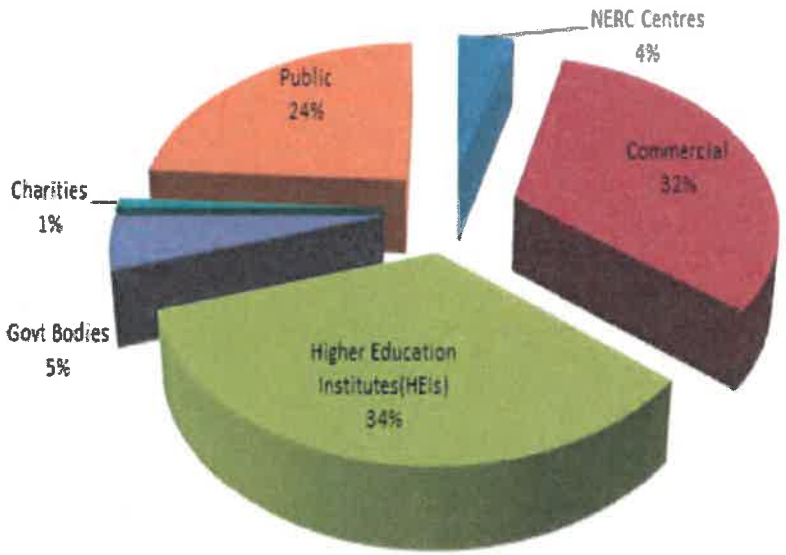
BODC in numbers

	2015	2016	2017	2018
Datasets downloaded	74,000	101,187	142,086	111,507
Datasets available online	97,674	110,063	115,607	127,036
NVS calls	350,000	570,950	545,904	850,826*
GEBCO grid downloads	34,000	20,985	28,143	40,652
GEBCO WMS calls	2,375,147	4,018,361	5,382,96	8,528,618*
Web hits	920,000	979,686	839,942	1,091,526

Registered users



BODC user types



Who are we ?

- 50 people
- Liverpool and Southampton (41:9)
- Data managers: Software engineers (35:15)
- Gender: F-M: 31:19
- Tenure: days to 44 years

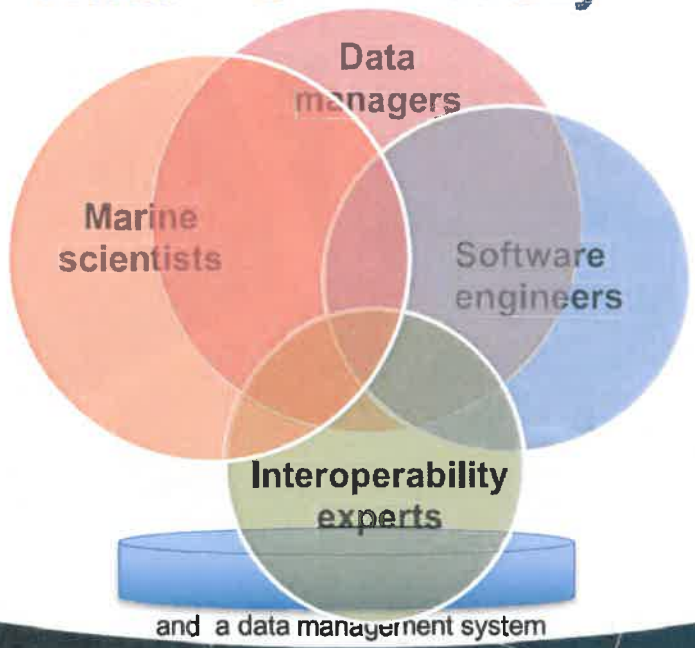
Expertise: Biological, chemical, physical and geophysical data

- data bases contain measurements of over 42,000 different variables

Staff have a wide range of research backgrounds, with direct experience of marine data collection and analysis (PhDs, MScs and degrees)

Data managers work alongside information technology specialists to ensure that data are documented and stored for current and future use

What is BODC Today ?



BODC

Measure once, use many times

MEDIN

marine environmental data & information network

A network of UK marine data centres

Structure: SeaDataNet – EU marine data network

BODC was very actively involved in SeaDataNet and SeaDataNet II

We not only provide data and metadata but are also involved in

- Managing Vocabularies for data processing, communication and quality assurance
- Developing European standards for metadata
- European wide metadata directories
- Designing and implementing interoperable systems

Structure: A network of networks

IODE International Oceanographic Data and Information Exchange

NERC Science of the Environment — Data Catalogue Service — sharing NERC data

MEDIN

EMODnet European Marine Observation and Data Network

SeaDataNet

ICSU WORLD DATA SYSTEM

BODC Data Portal

GEO GROUP ON EARTH OBSERVATIONS | GEOSS Portal

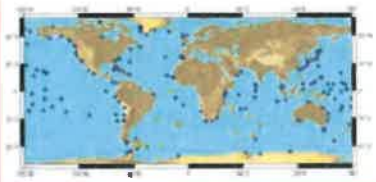
esa

Data out

International: GEBCO, GLOSS and Argo

General Bathymetric Chart of the Ocean (GEBCO)

- Global Centre for the Nippon Foundation – GEBCO Seabed 2030 Project
- Distribution of GEBCO Digital Bathymetry



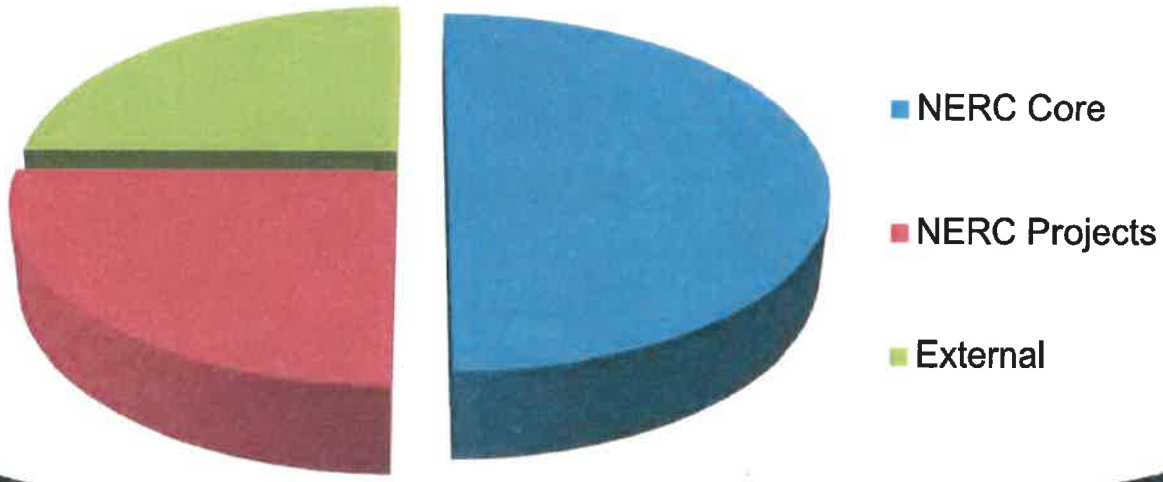
Global Sea Level Observing System (GLOSS)

- Delayed-mode data centre
- Station Information Handbook
- Member of expert group

Argo profiling floats

- Near-real-time processing
- Delayed mode quality control
- Southern Ocean Regional Centre

Funding our activity



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Data ingestion Projects

Biological, chemical, physical and geophysical *water column* data

Data in

Embedded data management

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Data management & system projects

PSMSL

Radiatively active gases from the North Atlantic Region and Climate Change

UK Tide Gauge Network

UK Ocean Acidification

FASTNEt

Fluxes Across Sloping Topography of the North East Atlantic

iGlass

SeaDataNet

SHELF SEA BIOGEOCHEMISTRY

DIMES

Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean

GEOTRACES

Biogeochemical global cycles

ENVRI

AtlantOS

EMODnet

RAPID-watch

Atlantic Meridional Overturning Circulation

OSMOSIS

Ocean Surface Mixing, Ocean Sub-mesoscale Interaction Study

MERMAN –

Clean Safe Seas Environmental Monitoring Programme (CSEMP)

marc

SYSTEM OF INDUSTRY METOCEAN DATA FOR THE OFFSHORE AND RESEARCH COMMUNITIES

Sense OCEAN

ANDREX

Ocean Data Interoperability Platform

National Oceanography Centre

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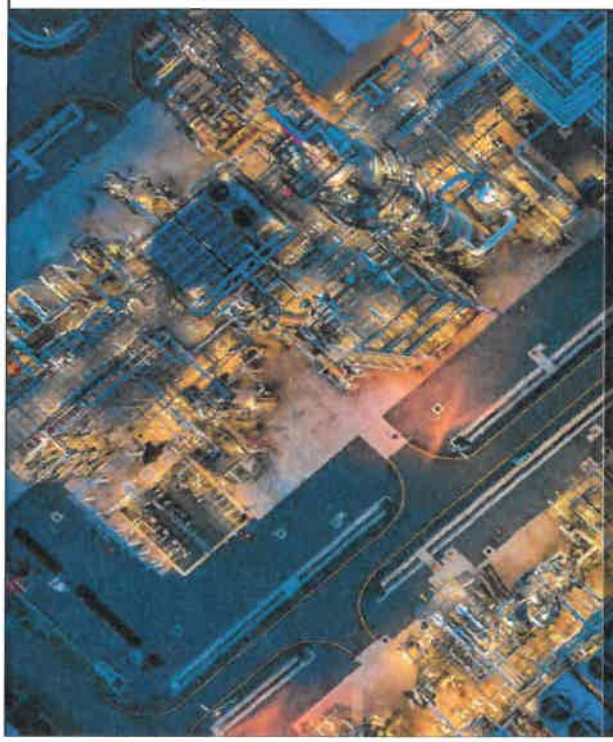

The 1980s & 1990s

- Gill Electronic Research & Development was established by Mike and Lesley Gill in 1985 to deliver innovative engineering solutions.
- Gill Instruments was formed in 1988 to focus and grow on the success of the ultrasonic anemometer products in the meteorological and commercial weather measurement markets.
- In 1991 Gill partnered with British Gas to develop and supply the first ultrasonic gas meter, which was to be installed to measure gas flow into domestic properties. Mike & Lesley founded Eurometers which went on to manufacture over one million meters, of which, tens of thousands are still in service today.
- In 1996 Mike & Lesley expanded the research and development operation and formed the limited company Gill Research & Development with a vision to create innovation in the field of measurement technology.

gillinstruments.com

The 2000s & 2010s

- In 2004 the business unit Gill Sensors was set up to promote proprietary inductive, ultrasonic and capacitive measurement products.
- In 2010 Gill won a contract with the British Ministry of Defence for the supply of specialist detector products. Gill invested in a new manufacturing facility to manage the increase in production capacity.
- In 2013 Gill won a contract with the Federation Internationale de l'Automobile (FIA) for the sole supply of an ultrasonic fuel flow meter, to allow the FIA to regulate fuel usage by the Formula 1 and World Endurance Championship (WEC) teams in the 2014-2016 race seasons.
- Gill Sensors became a new limited company, Gill Sensors & Controls, in 2014 and expanded to a new office and manufacturing facilities.
- In 2015 Gill acquires Labcal Ltd., a bespoke calibration service company..

Our Markets

Today Gill offers a wide portfolio of precision instrumentation and sensing products which are designed for use in a diverse range of industries:

- Renewables
- Infrastructure
- Utilities
- Marine
- Aviation
- Security & Defence
- Operational & Structural Safety
- Government & Emergency Bodies
- Scientific Research

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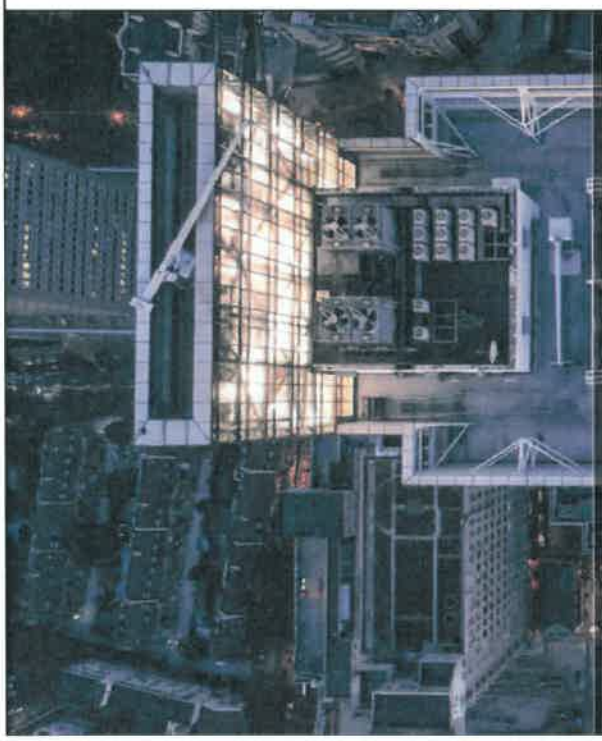

The Gill Group

The Gill Group as it is known today is made up of four companies:

- Gill Research & Development is an engineering company committed to product innovation with a focus on developing proprietary measurement technologies to solve challenging market problems.
- Gill Instruments is focused on providing ultrasonic anemometer and weather station products to the meteorological and commercial weather measurement markets.
- Gill Sensors & Controls is a leading manufacturer of specialist level sensing, oil condition, position sensors and engine control products focused on the off-highway,
- process control, utilities, motorsport and defence markets.
- Labcal provides specialist calibration services, with over 20 years' experience providing UKAS accredited calibrations in a wide range of parameters.

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GILL

Our Capability

The Gill Group has invested in significant internal capabilities to allow it to provide product innovation, quality and exceptional service and support to its customers:

- 4,500m2 of engineering, manufacturing and office facilities
- CNC machine prototyping facility
- Environmental test chambers
- Pre-compliance EMC facility
- Temperature chambers
- Bespoke test equipment
- Printed circuit board surface mount manufacturing capability
- Assembly lines for precision electronic products
- UKAS accredited high speed wind tunnel for test and calibration
- Liquid level, liquid flow, gas flow, pressure, temperature, humidity and air velocity calibrations equipment and services

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GILL

Our Accreditations & Approvals

The Gill Group has numerous industry specific accreditations and approvals:

- ISO 9001:2015
- ISO 14001:2015
- ISO/IEC 17025
- UKAS
- ATEX IECEx
- Canadian Standards Association (CSA)
- Lloyds Register Type Approval
- UK Civil Aviation Authority (CAA)
- US Federal Aviation Administration (FAA)
- Chinese Certification Society (CCS)

Our Customers

The Gill Group provides products and services to some of the most recognised brands in the world:

- National Aeronautics and Space Administration (NASA)
- General Electric Company
- Caterpillar Inc.
- Mercedes AMG
- Ferrari S.p.A.
- Apple Inc.
- Scania AB
- Triumph Motorcycles Ltd.
- Numatic International Ltd.
- British Ministry of Defence
- US Department of Defense
- North Atlantic Treaty Organisation (NATO)

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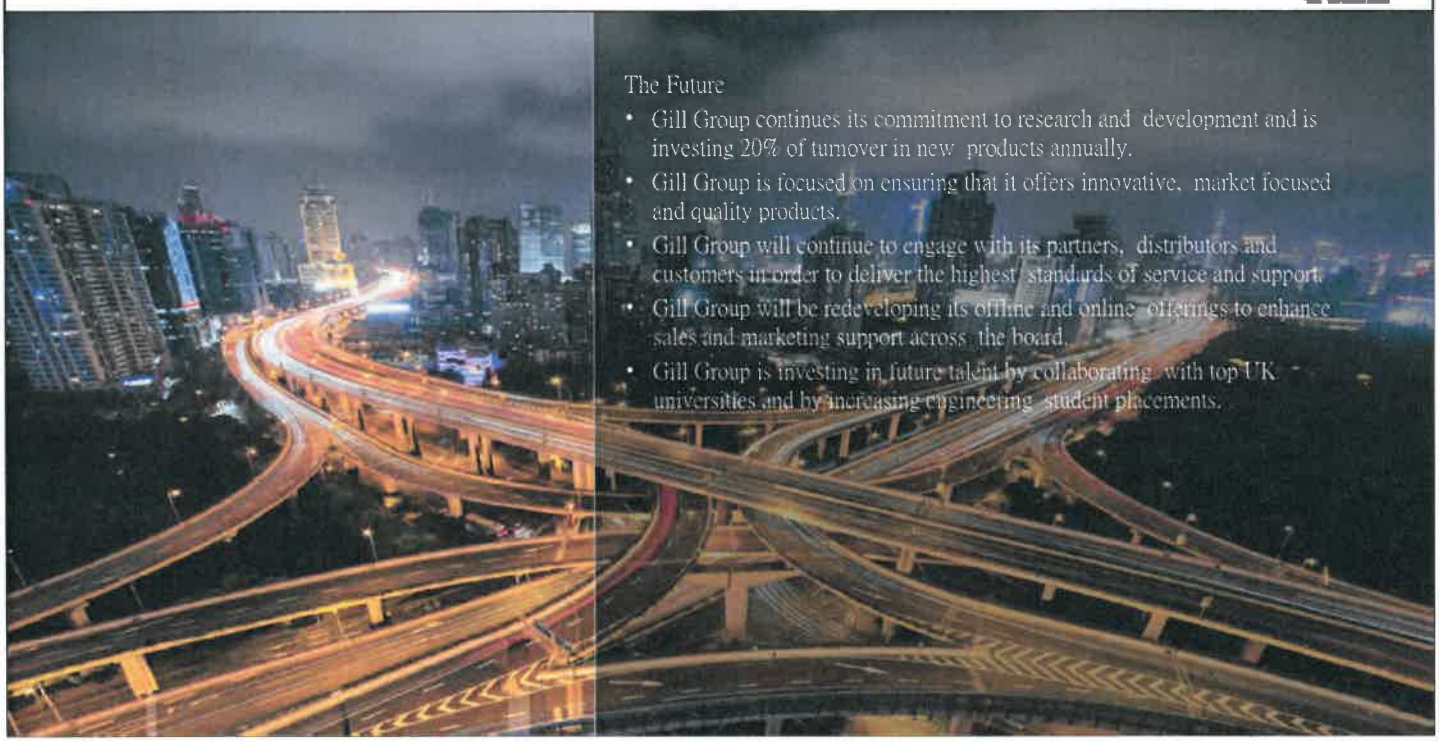
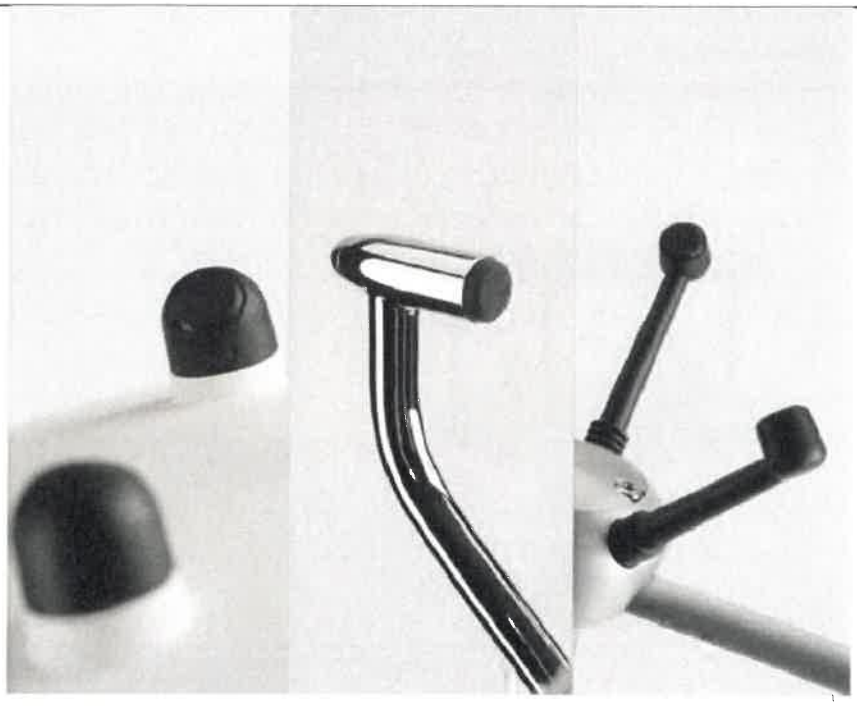


The Future

- Gill Group continues its commitment to research and development and is investing 20% of turnover in new products annually.
- Gill Group is focused on ensuring that it offers innovative, market focused and quality products.
- Gill Group will continue to engage with its partners, distributors and customers in order to deliver the highest standards of service and support.
- Gill Group will be redeveloping its offline and online offerings to enhance sales and marketing support across the board.
- Gill Group is investing in future talent by collaborating with top UK universities and by increasing engineering student placements.

Meteorological Technology

Ultrasonic Anemometers vs Mechanical



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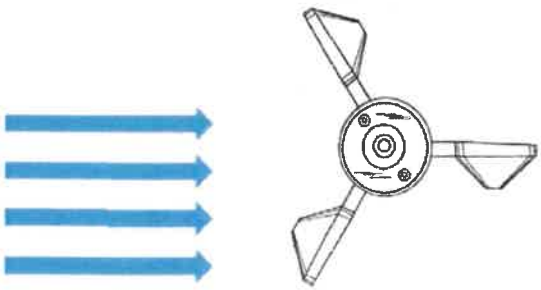
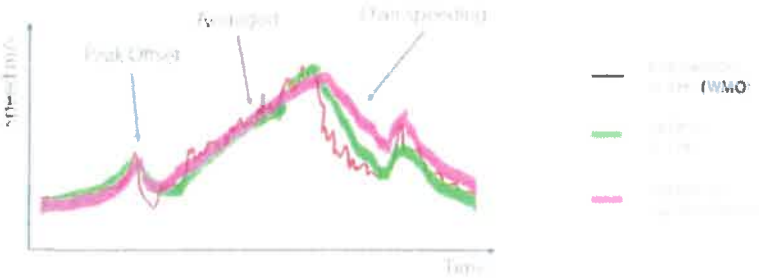
Aerodynamic Drag & Bearing Wear



4Hz vs 1Hz vs Cup Anemometer



Further Benefits

- Wind speed and direction from a single sensor avoids multiple mounts, cables and connections to a datalogger
- No moving parts: No wear & tear to effect data and increase the ongoing costs of ownership
- No requirement for expensive yearly/bi-yearly recalibration and servicing costs
- Self-checking via digital status codes provides users with confidence in the data and knowledge of whether a sensor has failed
- Intelligent processing (as used by Gill) avoids the possibility of incorrect data and therefore provides users with confidence
- Robust sensors to survive installation and extreme conditions worldwide
- Multiple output types from a single sensor offers flexibility when selecting dataloggers or when making network connections, for example to SCADA systems
- User selectable outputs allow a choice of output frequencies and formats, including options such as Modbus and NMEA as standard
- Ultrasonic sensors measure without any resistance ensuring accurate measurements are made, even at low speeds
- Instantaneous measurements are possible allowing for accurate recording of fast and slow speed / direction changes

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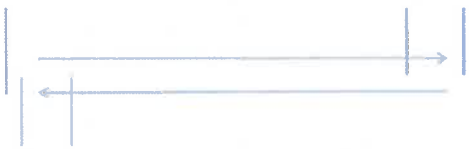
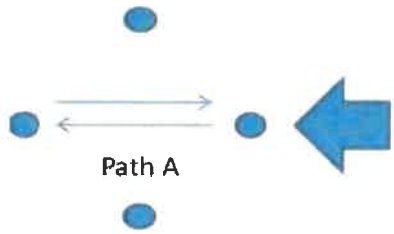


Intelligent Signal Processing

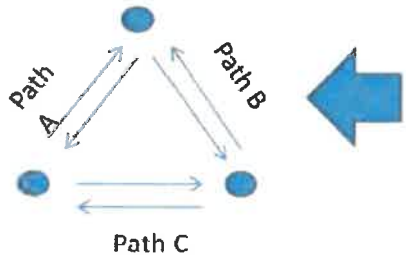
Although many 2 & 3 axis ultrasonic anemometers appear similar and in ideal measurement conditions produce similar results, the difference is in the detail and when the measurements really count, in challenging or changing environmental conditions. Gill anemometers use innovative intelligent processing to provide more accurate velocity measurements, efficient power management and extend the life of transducers.

Most 2 & 3-axis anemometers use 'simple time gating'. However, all Gill 2 & 3-axis anemometers benefit from 'intelligent signal processing' and 'adaptive gain control' to maintain high quality performance in different environmental conditions and changing extreme conditions.

Only 2 measurements needed



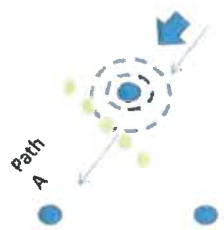
Requires 6 measurements



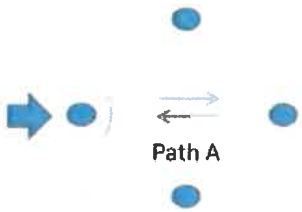
Why 4 Transducers?

Gill anemometers require fewer measurement i.e. just Path A (which we refer to as T1 & T2) is required to check that the signal is valid. Whereas 3 transducer models need to check all 3 paths (A,B & C) and could then find the data is invalid.

Competitor 2-axis Wind Sensors



Gill 2-axis Wind Sensors



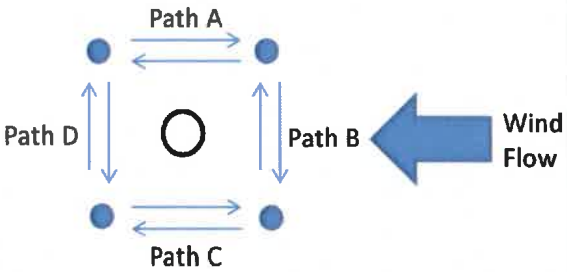
Using a well-known competitor to Gill, which uses the transducer set-up shown to the left as an example, it should be noted that there are some difficulties to be aware of with this set-up. The main issue is that they transmit in all directions, which can mean for this omni-directional, simple time gating approach, it makes it very hard to identify leading edge of pulse correctly.

Depending on which direction and how strong the wind is, this 3 transducer design could see a pulse that went in a different direction but was blown back to the receiving transducer, which would then provide incorrect wind data.

Therefore there is a potential for incorrect wind data to be indicated when pulses are incorrectly processed, i.e. a loss of wind data or indicating wind is too low or even indicating wind is too high indicated.

Using the Gill 'Intelligent Signal Processing' with its uniquely identifiable pulse, firstly sent across one axis (Path A) whilst varying the amplitude to save power and then across the other axis makes the pulse easy to identify.

No potential for an incorrectly processed pulse and thus better, more repeatable, more reliable performance in all weather conditions.



Further Competitors

Some sonic wind sensors deploy different tactics to measure wind data whilst offering compact solutions. In the example below you can see that some use a central column for support and transmit from transducer to transducer (the signal is still reflected of off the lower surface), however, this then requires higher frequency sampling, and greater processing to cope with 4 sets of bi-directional time-gating signals.

The use of 4 completely separate paths requires more complicated processing before valid wind data can even be confirmed. This along with the narrow entrance to the measurement area limits the wind angle of attack and measurement during turbulent / changing conditions.

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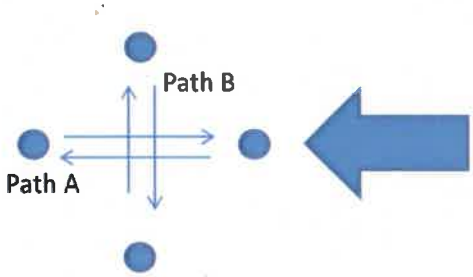
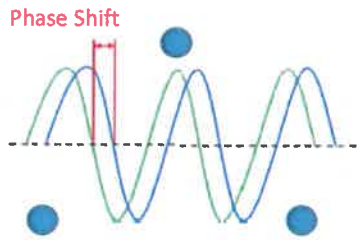


Further Competitors

Some sonic wind sensors deploy different tactics to measure wind data whilst offering compact solutions. In the example below you can see an example transmitting from transducer to transducer (the signal is still reflected of off the lower surface), which is a similar method used by us (however, we use the top surface), however, this manufacturer relies on simple time-gating.

This manufacturer requires more processing before valid wind data can even be confirmed as they need both Path A & B before confirmation of valid wind data. This along with the narrow entrance to the measurement area limits the wind angle of attack to near horizontal and measurement during turbulent / changing conditions or high wind speeds. Also reflecting the signal off of the lower surface will allow debris (rain or ice) to disrupt the signal.



Further Competitors

Some sonic wind sensors deploy different tactics to measure wind data whilst offering compact solutions. In the example below you can see that multiple resonances / reflections over a narrow frequency band are used to produce a complex wave distribution that can be thought of as a "vertical quasi-standing wave".

The net phase between any transducer pair is indicative of the airflow along the axis of the pair. With all three diaphragm pairs measured the component vectors of the airflow along the sides of the triangle (formed by the diaphragms) are determined. These vectors are combined to give the overall speed and direction.

The use of 3 separate transducers requires more complicated processing before valid wind data can even be confirmed. This along with the narrow measurement area limits the angle of attack and measurement during turbulent or changing conditions. Due to this concept, there is a need to ensure constant temperature during measurement (it can vary but it needs to vary uniformly over the measurement time and area) and no icing / water or change in surface can occur as this is important for the resonance principal.

Settling Chamber

Straightens the airflow. Uneven turbulent flows cause unpredictable forces. Can include a honeycomb flow straightener and wire mesh smoothing screens to produce a smooth airflow.

Merlin Recirculating Wind Tunnel

Contraction Cone

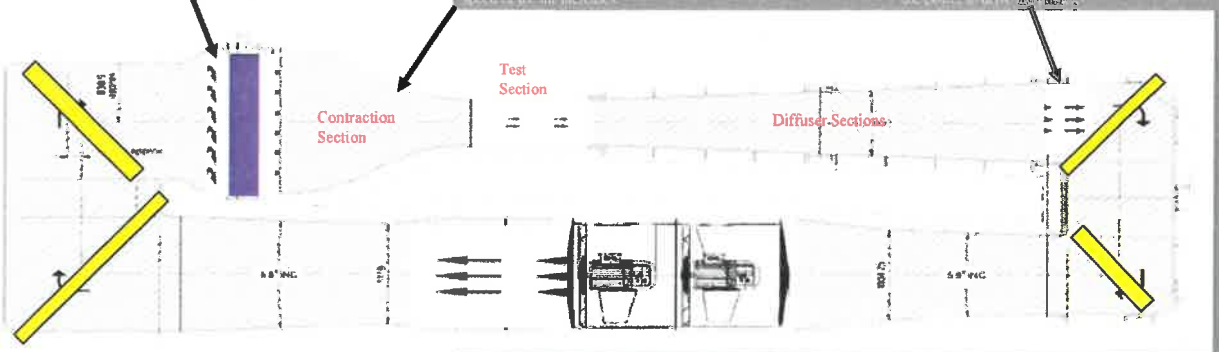
Converts large volume of low-velocity air into small volume of high-velocity air. As the cross-sectional area decreases, the speed of the air increases.

Diffuser Section

Air slows down prior to recirculating

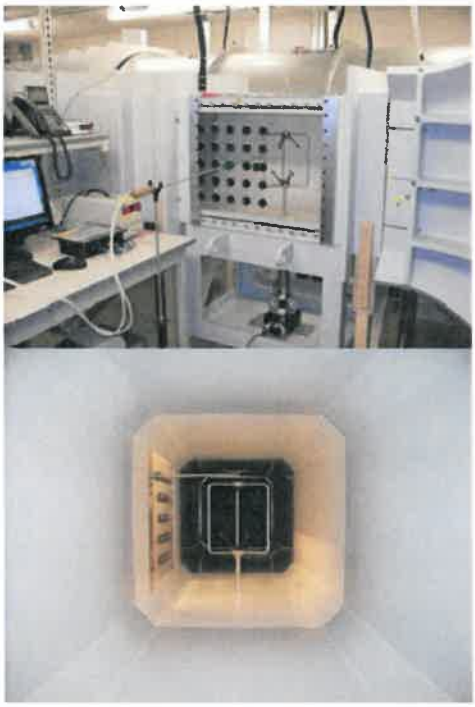
Recover pressure that occurs from entry to the contraction cone

The recovery of static pressure from kinetic energy reduces the power to drive



Motor Drive Section

Two 22kw contra rotating axial fans supply wind power



Merlin Recirculating Wind Tunnel
>110 m/s 400kph 215kt
Production test
Product development
Simulation - Angle of attack / tilt

Environmental Testing
- Freezing Rain
- Rime Icing
- Condensing
- Hoar Frost

Unheated control test

Environmental Testing
Intelligent heating prevents build-up of ice
- Mist spray, heavy rain, windblown

Quality Measurements
- Rain, fog, drizzle, strong winds

Chambers
- Salt, humidity, solar UV (ext), temperature

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Environmental Testing
Academic Collaboration
- Norway
- Iceland
- Austria
- Germany
- Poland

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2D Anemometers Applications

- Weather Monitoring Stations
- Building Controls & Structural Safety
- Wind Turbine Control
- Aircraft Landing Systems
- Environmental Field Sites
- Marine Vessels

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Product Highlights - WindSonic

- Up to 75m/s
- 4 transducers
- Intelligent processing
- 100W Heating -40 +70oC
- 4Hz
- RS232/485/422. NMEA
- SDI12 customisation
- Analogue
- 60945 vibration
- Status codes and self checks
- Lightweight
- Polycarbonate or aluminium
- Made in UK
- 8 options
- Accuracy 2% at 12m/s
- Resolution 0.01 m/s
- Direction Accuracy 2˚
- Black or White

Standard Met Measurements

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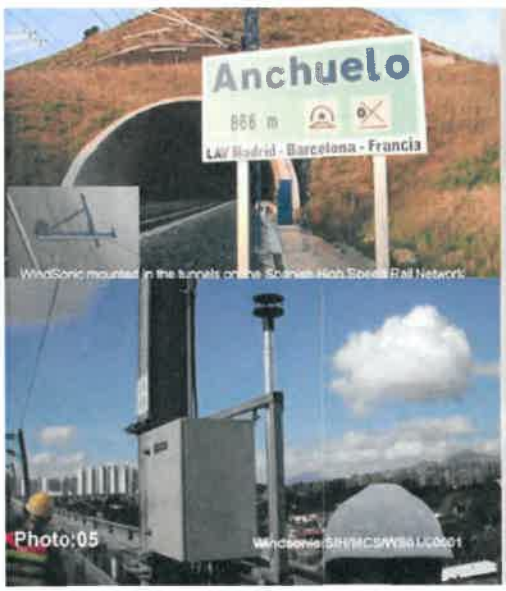
Research Projects

Specialised

WindSonic on board Fire Brigade Command Vehicle

Road/Rail/Tunnels



Wind Energy

Noise/Air Quality Monitoring Stations

Power Line Monitoring

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Ocean Buoy Weather Monitoring

Surface Gliders

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Product Highlights - WindObserver

- Up to 90m/s
- 4 transducers
- Intelligent processing
- Up to 170W heating -55+70C
- 10Hz
- RS422/485*, NMEA
- SDI12 customisation
- Lloyd' s Register
- Status codes and self checks
- Averaging (RWA)
- Stainless steel
- Made in UK
- Lightweight
- 8 options *
- FAA & CAA accepted (WO70)
- Multiple base mount options

Utilities Monitoring Efficiency

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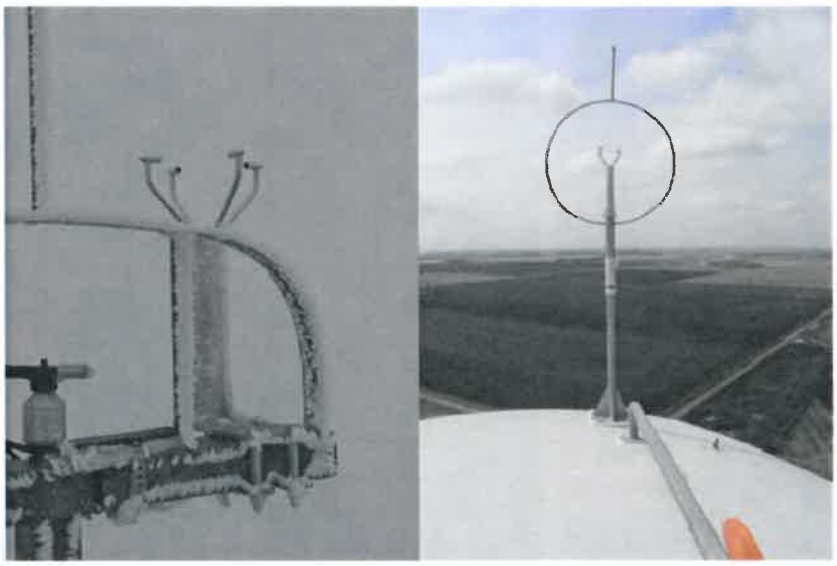
Wind Turbines



Road & Rail Tunnels

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Ocean Data Buoys

Air Quality Monitoring

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Product Highlights - ISWindObserver

- Up to 75m/s
- 4 transducers
- Intelligent processing
- 4Hz
- RS422, NMEA
- ATEX & IECEx certification
- Low Voltage or Mains Voltage
- Status codes and self checks
- Mains PCI & LVPCI now +60o operation
- Stainless steel
- Made in UK
- Lightweight
- Oil Rigs, FSPO & vessel usage

Hazardous Areas

Vehicle Paint Spray Booths

3D Anemometers Applications

- Wind Profiling Stations
- Building Controls & Structural Safety
- Wind Turbine Site Survey
- Flux Measurement
- Micro-Structure Studies
- Marine Research

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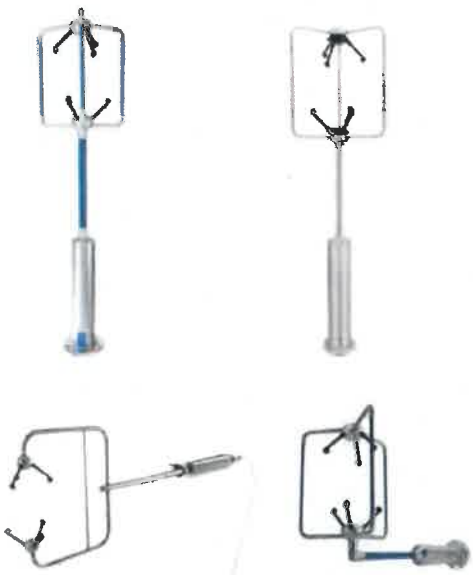

Product Highlights – WindMaster/WindMaster Pro/WindMaster RA/ WindMaster HS

- Up to 65m/s (WMP)
- 6 transducers
- Intelligent processing
- Up to 32Hz
- Accuracy <1.5% RMS @ 12 m/s
- RS232/485*/422
- Aluminium / Carbon Fibre or Stainless Steel
- Analogue Inputs / Outputs
- Custom calibration
- Averaging

Wind Turbines

Flux Measurement

Autonomous Vehicles

Meteorological Observatory

Product Highlights – R3-50/R3/HS-50/HS

- Up to 45m/s
- 6 transducers
- Intelligent processing
- Up to 100Hz
- RS232/485/422
- Accuracy <1% RMS
- Aluminium / Carbon Fibre or Stainless Steel
- Analogue Inputs / Outputs
- Set the industry standard worldwide

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Polar Flux Stations

Urban Flux Monitoring

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MaxiMet Applications

- Building & Industrial Controls
- Authorities
- Transport
- Coastal
- Offshore
- Agriculture
- Energy
- Education

Product Highlights – MaxiMet Compact Weather Stations

- 60m/s Wind Speed & Direction via 4 transducers - Intelligent processing
- Temperature / Relative Humidity
- Air Pressure
- Rainfall
- Solar Radiation ISO9060 2nd Class
- 1Hz
- RS232/485/422, NMEA, MODBUS
- SDI-12
- Compass
- GPS
- IEC 60945 vibration
- Status codes and self checks
- Lightweight
- Polycarbonate
- Made in UK
- 14 models

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Agriculture

Solar Parks

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Marine Buoys

Portable Systems

Temperature Change Research

Product Highlights – MetPak Professional Weather Stations

- Wind
- Temperature
- Humidity
- Pressure
- Optional Rainfall
- Optional analogue inputs
- Optional PRT input
- 60m/s to 70m/s with WO
- 4 transducers
- Intelligent processing
- 1Hz
- Base Station
- Status codes and self checks
- Lightweight
- Polycarbonate
- Made in UK
- Accuracy 3% at 12m/s
- Resolution 0.01 m/s
- Direction Accuracy 3
- IP65
- RS232/485/422, NMEA, MODBUS
- SDI-12
- 60945 vibration
- Averaging

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Air Quality Monitoring

Solar Parks

Basic Stations

Ports

Thank you.

Contact us at;
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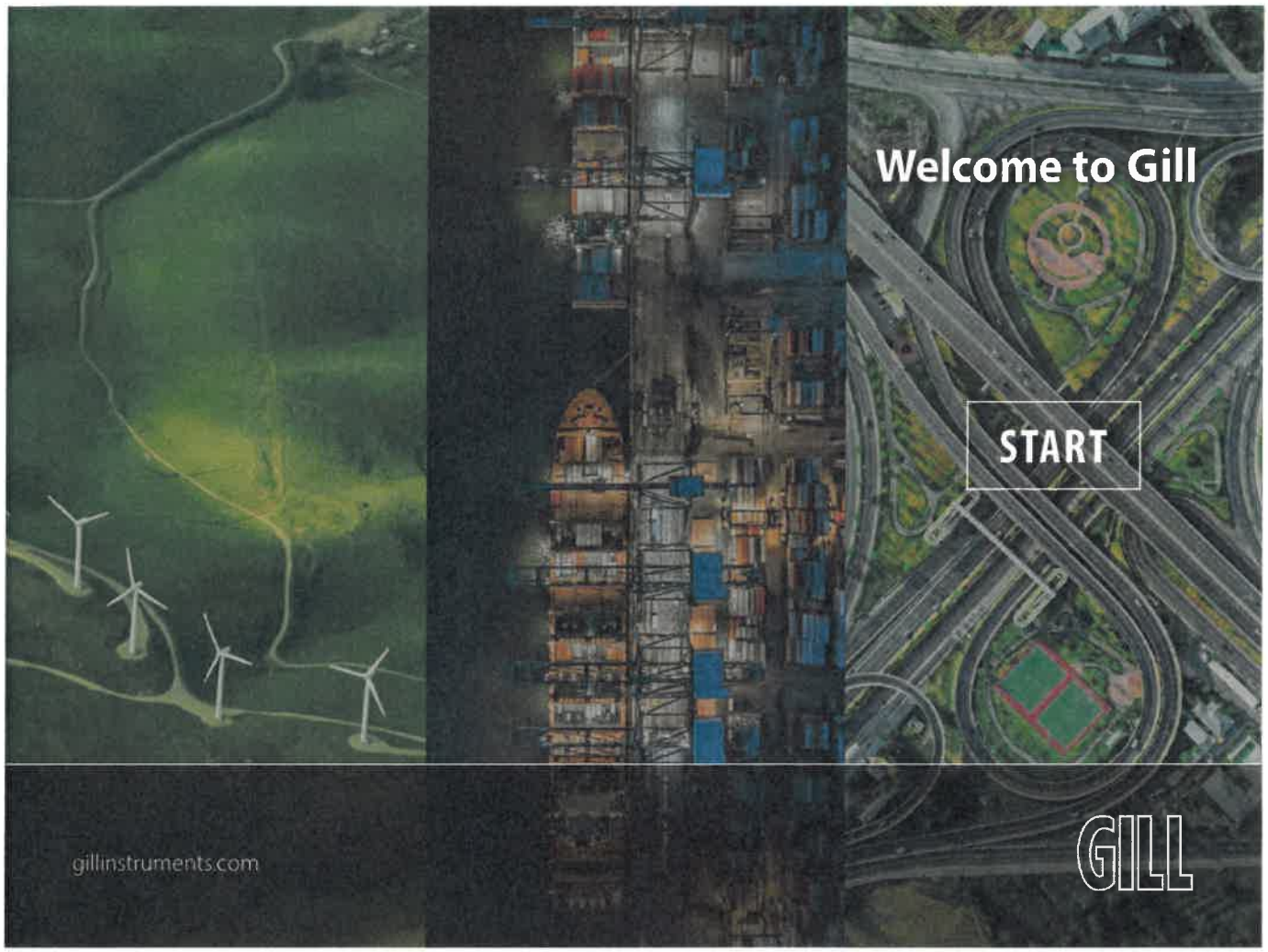
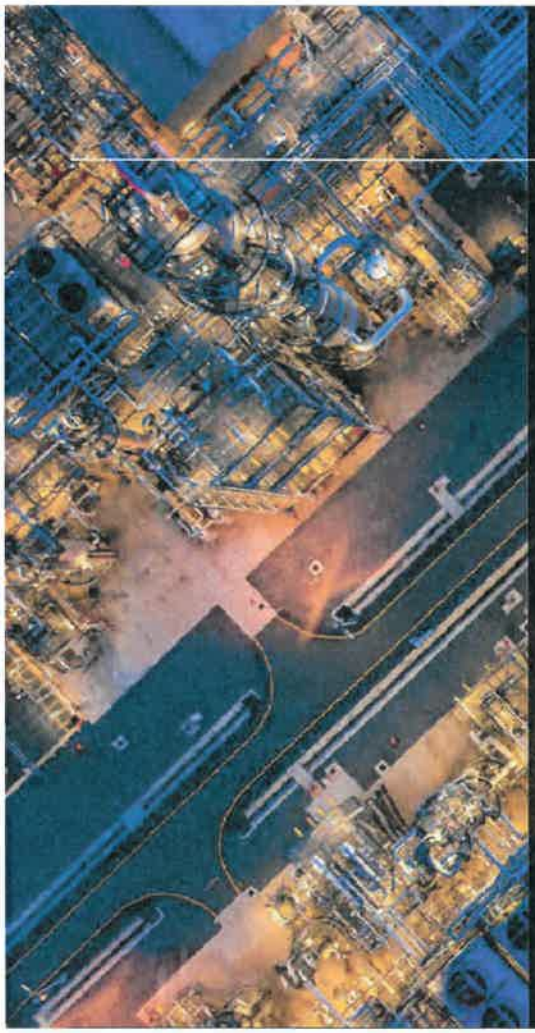
contact@gillinstruments.com
+44 (0) 1590 613500


Welcome to Gill
START
gillinstruments.com
GILL


GILL
Our background
NEXT



GILL

THE 1980s & 1990s

- Gill Electronic Research & Development was established by Mike and Lesley Gill in 1985 to deliver innovative engineering solutions.
- Gill Instruments was formed in 1988 to focus and grow on the success of the ultrasonic anemometer products in the meteorological and commercial weather measurement markets.
- In 1991 Gill partnered with British Gas to develop and supply the first ultrasonic gas meter, which was to be installed to measure gas flow into domestic properties. Mike & Lesley founded Eurometers which went on to manufacture over one million meters, of which, tens of thousands are still in service today.
- In 1996 Mike & Lesley expanded the research and development operation and formed the limited company Gill Research & Development with a vision to create innovation in the field of measurement technology.

NEXT

GILL

THE 2000s & 2010s

- In 2004 the business unit Gill Sensors was set up to promote proprietary inductive, ultrasonic and capacitive measurement products.
- In 2010 Gill won a contract with the British Ministry of Defence for the supply of specialist detector products. Gill invested in a new manufacturing facility to manage the increase in production capacity.
- In 2013 Gill won a contract with the Federation Internationale de l'Automobile (FIA) for the sole supply of an ultrasonic fuel flow meter, to allow the FIA to regulate fuel usage by the Formula 1 and World Endurance Championship (WEC) teams in the 2014-2016 race seasons.
- Gill Sensors became a new limited company, Gill Sensors & Controls, in 2014 and expanded to a new office and manufacturing facilities.
- In 2015 Gill acquires Labcal Ltd., a bespoke calibration service company.

NEXT

GILL

Our position today

NEXT

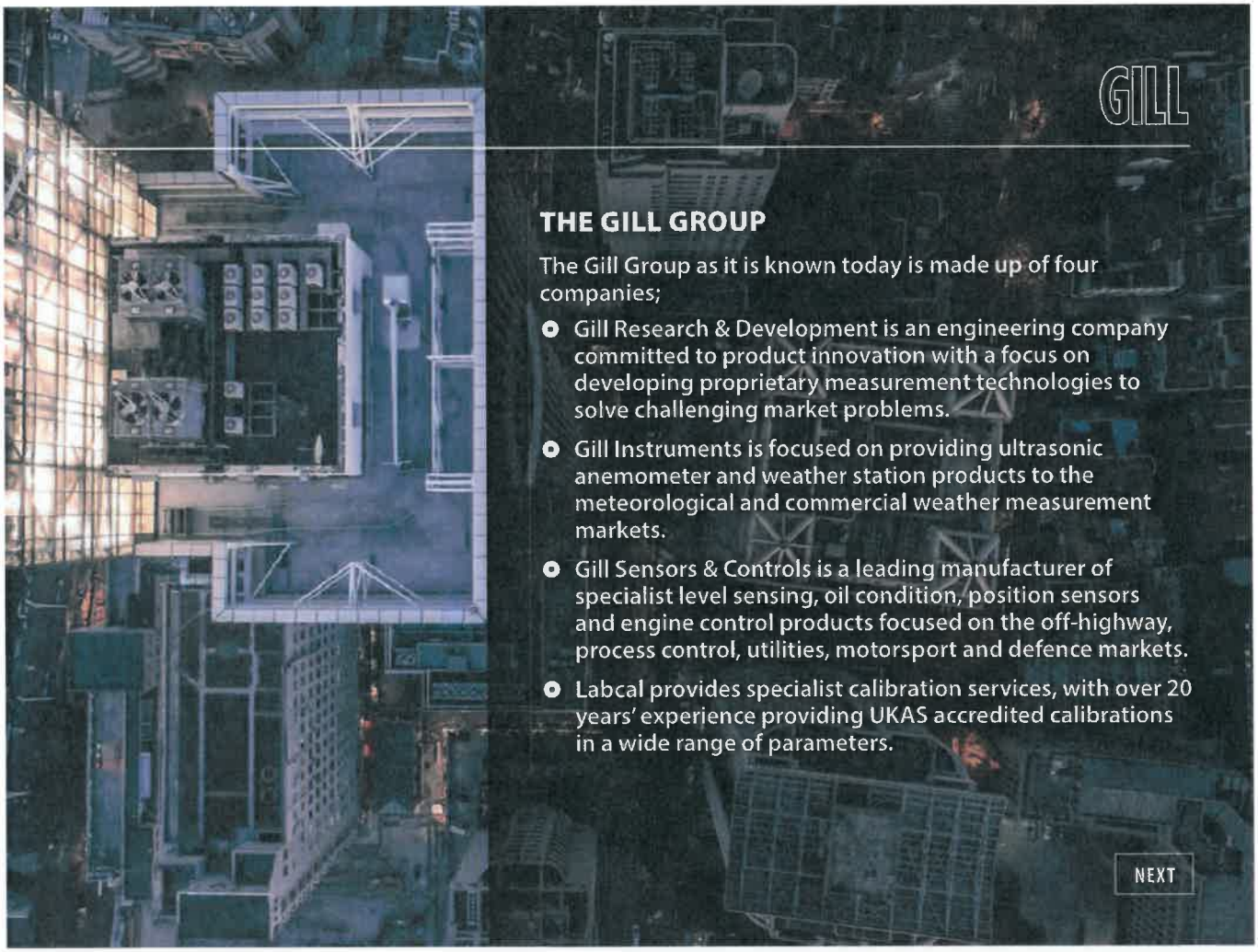
GILL

OUR MARKETS

Today Gill offers a wide portfolio of precision instrumentation and sensing products which are designed for use in a diverse range of industries;

- Renewables
- Infrastructure
- Utilities
- Marine
- Aviation
- Security & Defence
- Operational & Structural Safety
- Government & Emergency Bodies
- Scientific Research

NEXT



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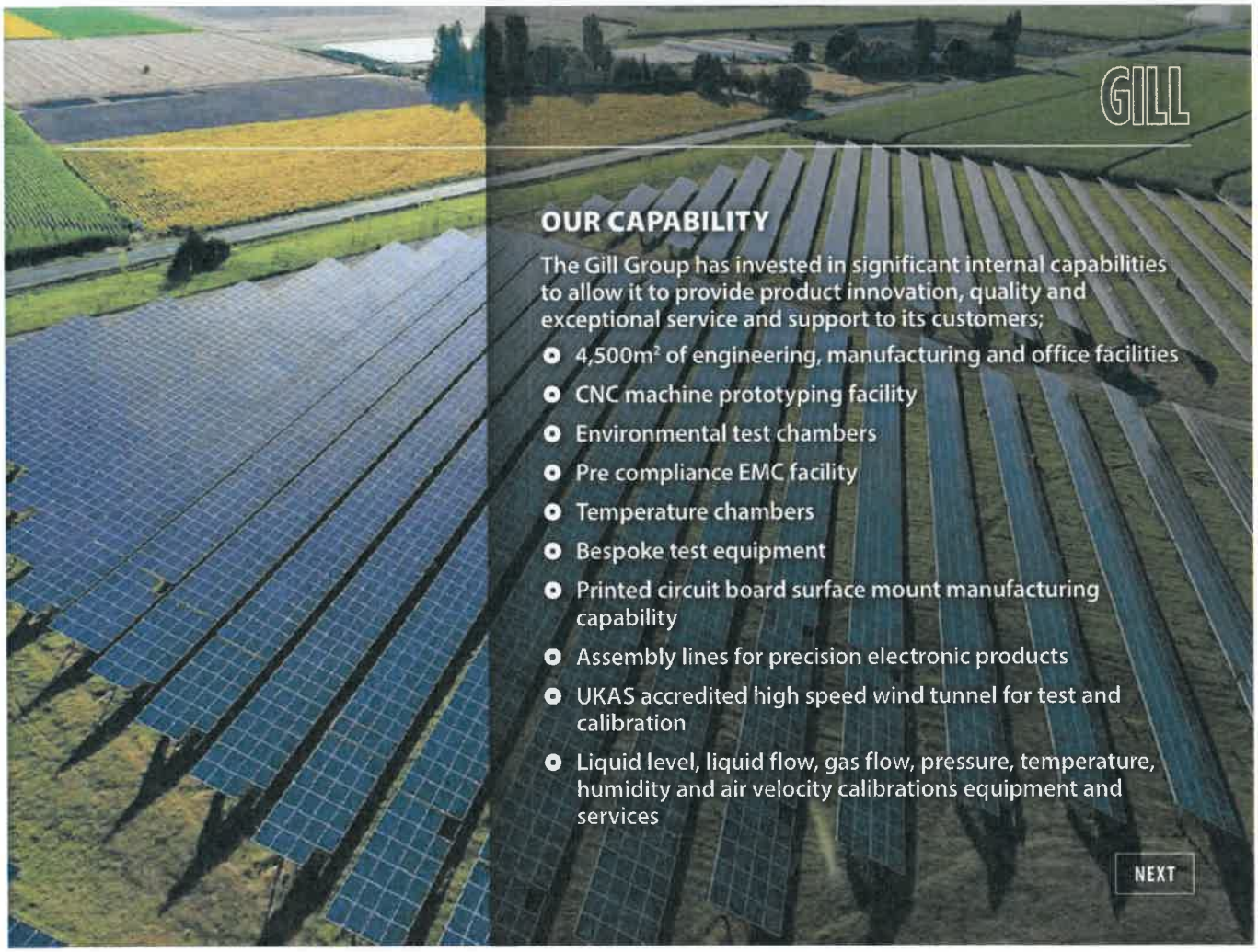
NEXT



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- Pre compliance EMC facility
- Temperature chambers
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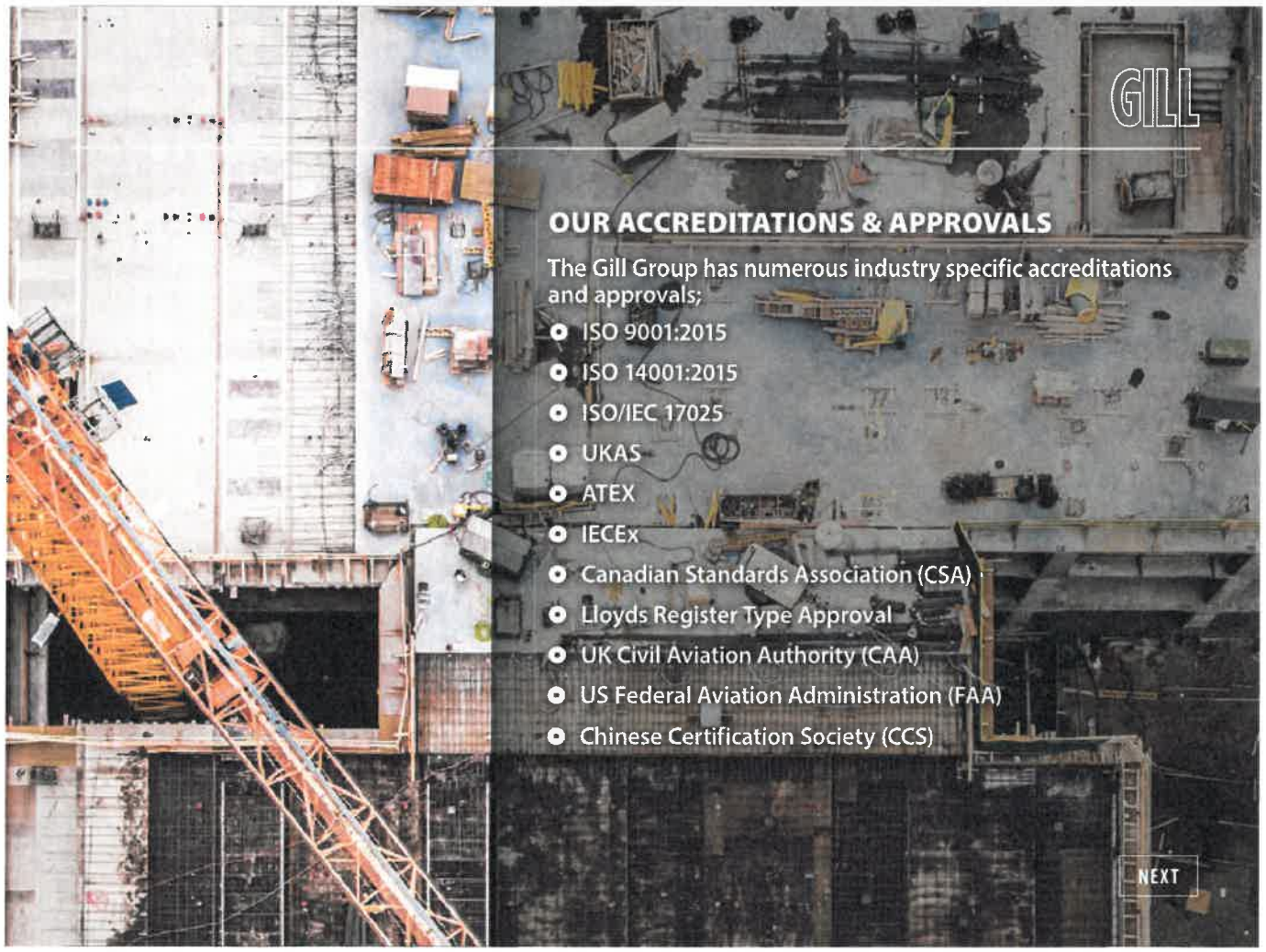
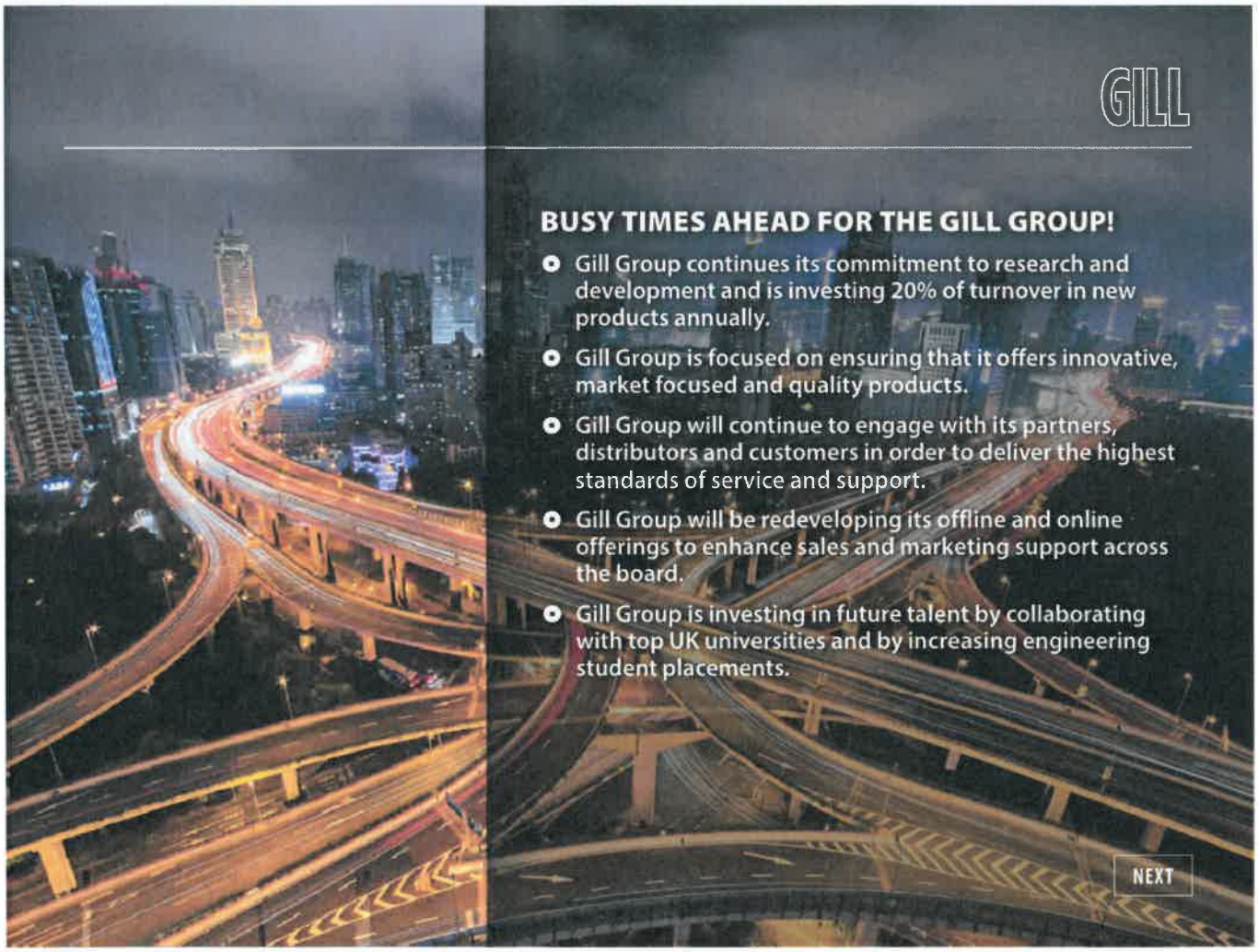
- Printed circuit board surface mount manufacturing capability
- Assembly lines for precision electronic products
- UKAS accredited high speed wind tunnel for test and calibration
- Liquid level, liquid flow, gas flow, pressure, temperature, humidity and air velocity calibrations equipment and services

NEXT


GILL
OUR ACCREDITATIONS & APPROVALS
The Gill Group has numerous industry specific accreditations and approvals;
ISO 9001:2015
ISO 14001:2015
ISO/IEC 17025
UKAS
ATEX
IECEx
Canadian Standards Association (CSA)
Lloyds Register Type Approval
UK Civil Aviation Authority (CAA)
US Federal Aviation Administration (FAA)
Chinese Certification Society (CCS)
NEXT


GILL
OUR CUSTOMERS
The Gill Group provides products and services to some of the most recognised brands in the world;
General Electric Company
Caterpillar Inc.
Mercedes AMG
Ferrari S.p.A.
Apple Inc.
Scania AB
Triumph Motorcycles Ltd.
Numatic International Ltd.
Hewlett Packard (HP) Company
British Ministry of Defence
US Department of Defence
National Atlantic Treaty Organisation (NATO)
NEXT


GILL
Our future
NEXT


GILL
BUSY TIMES AHEAD FOR THE GILL GROUP!
Gill Group continues its commitment to research and development and is investing 20% of turnover in new products annually.
Gill Group is focused on ensuring that it offers innovative, market focused and quality products.
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Gill Group is investing in future talent by collaborating with top UK universities and by increasing engineering student placements.
NEXT

HR Wallingford
Working with water

Welcome & Introductions

National Academy for Marine Research

21st June 2019

Simon Tiedeman

HR Wallingford
Working with water

P20321: National Academy of Marine Research, (NAMR) Kaohsiung, City, Taiwan

Wave Generation Laboratory Equipment

24th May 2019

Simon Tiedeman

HR Wallingford
Working with water

HR Wallingford Ltd

Introduction

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Introduction

HR Wallingford Ltd

- A world leader in the development and supply of laboratory wave generation systems and a major user of these systems for research and consultancy studies.
- More than 60 years experience in physical modelling of the coastal and offshore environment.
- One of the world's leading hydraulics laboratories.
- Completed over 180 physical model studies in five years.
- More than 25 years experience in the supply of equipment and instrumentation for hydraulics laboratories throughout the world.
- Limited by guarantee, non profit distributing, and independent

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Introduction

HR Wallingford

- Turnover ~ £24 million (2018/19)
- 60% of projects from overseas
- Over 220 staff including many world leading experts
- Offices in Houston, Kuala Lumpur, Mumbai, Abu-Dhabi, Shanghai and Perth
- Clients in over 60 countries
- Physical modelling facilities
- Extensive software tools

Track Record – Wave Generation Systems

Asia

- Institute of Harbor and Marine Technology (IHMT) - Taiwan
- Shanghai Ship & Shipping Research Institute (SSSRI) - China
- Shanghai Jiao Tong University - China
- Institut Teknologi Bandung (ITB) – Indonesia
- University of Hasanuddin – Indonesia
- Naval Science and Technology Laboratory – India
- Institute of Hydraulics Research – Vietnam
- Haiphong Maritime University – Vietnam
- UTP – Malaysia
- National Hydraulic Institute Malaysia (NAHRIM) – Malaysia
- National University – Singapore
- Nanyang Technological University – Singapore
- IIT Mumbai – India
- Vietnamese Shipbuilding Association – Vietnam
- Southern Institute of Water Resources Research (SIWRR) – Vietnam

Europe

- Flanders Hydraulic Research – Belgium
- QinetiQ – United Kingdom
- University of Southampton – UK
- Kazan State University - Russia
- University of Swansea - UK
- Universita Degli Studi di Palermo – Italy
- University of Oporto – Portugal
- University of Liege – Belgium
- IST Lisbon – Portugal
- University of Padua – Italy
- University of Naples – Italy
- Università Politecnica delle Marche, Ancona – Italy
- Université du Havre – France
- University of Liverpool – United Kingdom
- University of Nottingham – United Kingdom
- LWI, Braunschweig – Germany
- Southampton Solent University – United Kingdom
- Universidad Politecnica Madrid (UPM), Spain
- INUEM – Albania
- Universidad de Granada – Spain
- Bari Polytechnic – Italy
- Hull University – United Kingdom

Americas

- UNAM – Mexico
- Cordoba University – Argentina
- University of Miami – USA
- Universidad de Colima – Mexico
- Naval Research Laboratories – USA
- University of Alabama – USA
- Universidad Nacional Colombia – Colombia
- IPN Mexico City – Mexico
- Instituto Nacional de Canalizaciones – Venezuela
- Drexel University – USA
- Texas A&M

Rest of the World

- University of New South Wales
- University of Western Australia
- Australian Maritime College – Australia
- Swinburne University – Australia
- Griffith University – Australia
- CSIR – South Africa
- Stellenbosch University – South Africa
- Manly Hydraulics Laboratory – Australia
- Niger Delta University – Nigeria

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Appreciation of what is required within the available budget

- The ability to provide state of the art equipment for wave generation within 3D physical models.
- Wave generators specifically designed for a range of physical modelling applications:
  - Shallow water coastal wave basins
  - Deep water offshore wave basins
  - Flumes
  - Towing tanks
  - Tsunami generator
- Able to accommodate the technical sophistication and accuracy demanded by researchers and the commercial expediency required for consultancy studies

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Froude Modelling Hall

24th May 2019

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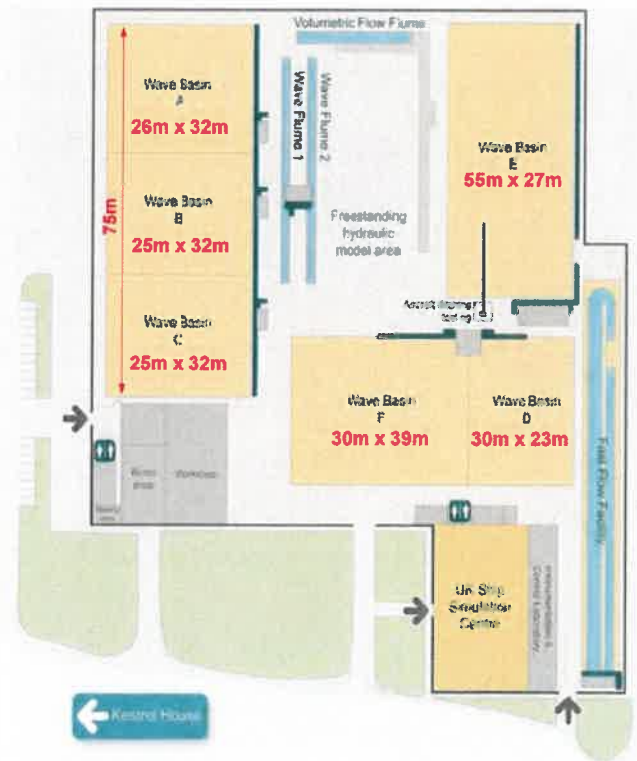
HR Wallingford Froude Modelling Hall



Wave basins

- Six basins of varying sizes with maximum water depth of 1.0m
- Basins A,B and C can be joined to create a 75mx32m
- Wave basin E has flow capability
- Maximum wave heights mainly depth limited rather than wavemaker performance constrained

Flumes

- Two flumes 45m long, 1.2m wide

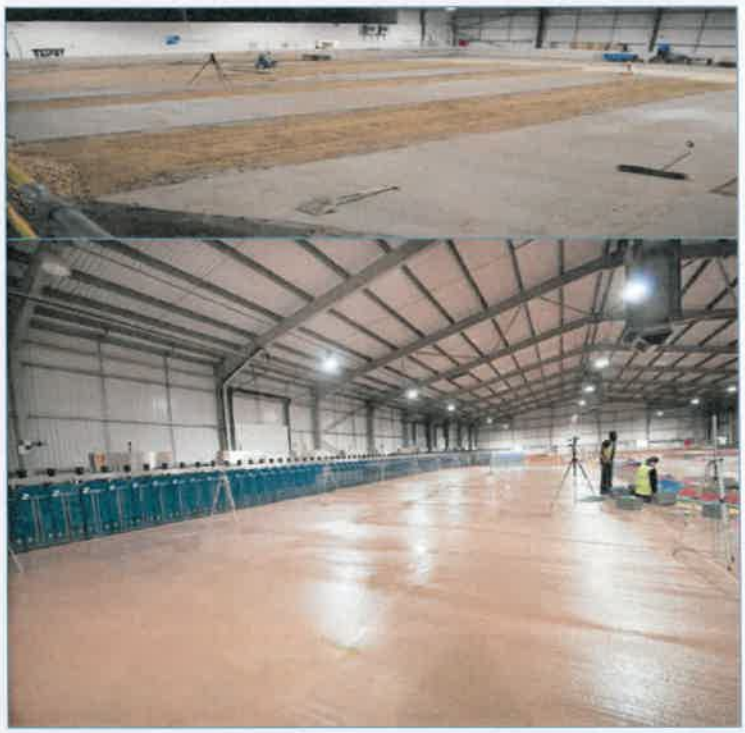
Fast Flow Flume

- 4m wide flume with both wave and flow capabilities

24th May 2019

Typical Tests (Combined A,B & C Basins)

- Basin bathymetry prepared to client requirements; (Video)
- Wavemakers moved into position;
- Instrumentation set up;
- Wave calibrations conducted;
- Test model constructed;
- Testing begins with the wave test series increasing in intensity;
- Data analysis conducted between each tests until the structure fails;



Wave Basin A,B&C 75m x 32m – 96 paddles

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Wave Generation & Absorption Systems

Installation processes for WGS & WAS systems

21st June 2019

Simon Tiedeman

HR Wallingford
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Wave Generation & Wave Absorption Systems (WGS/WAS)

Contents

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Wave Generation

Wavemaker systems

- Each wavemaker system is designed to meet the requirements of each client;
- Hinged flap type multi-element wavemakers are dry tested at HR Wallingford prior to FAT and shipment to site for installation.
- MDCPs are designed to meet client requirements for location and local electrical regulations;

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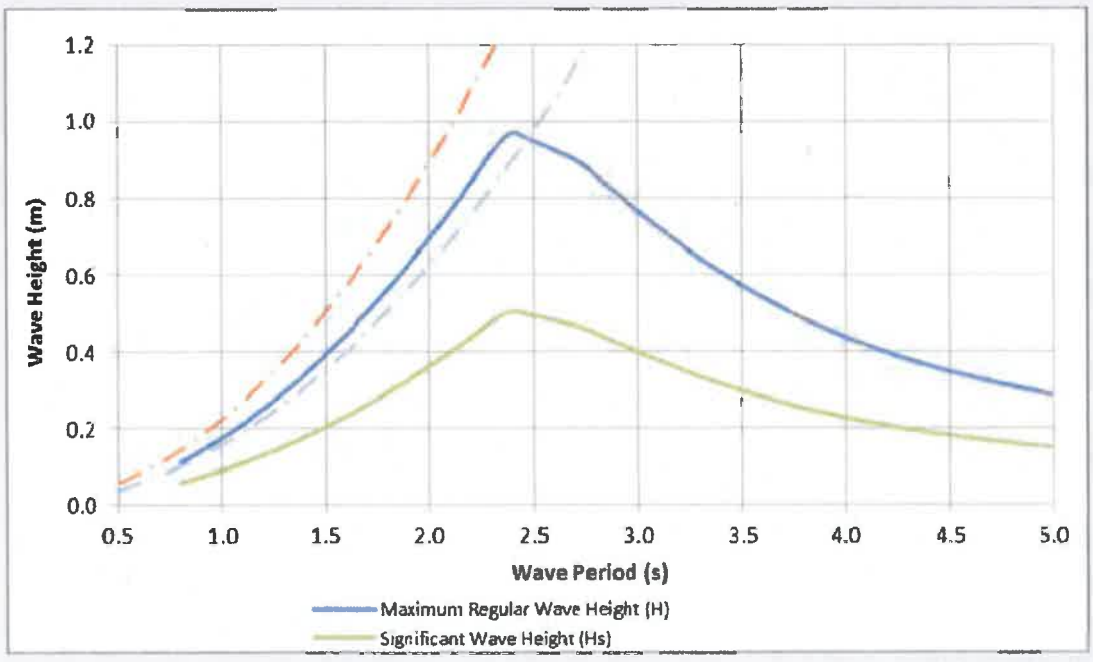
Wave Generation

Wavemaker proposed predicted performance graph



Key data :-

- Water depth - 6.0m
- Paddle width - 0.5m
- Drive actuators p/p - 1
- Drive actuators p/m - 4
- Max Paddle stroke - 1.1m
- Max paddle velocity - 1.4m/s
- Max paddle force - 5.9KN
- Max motor rms power - 6.1kW

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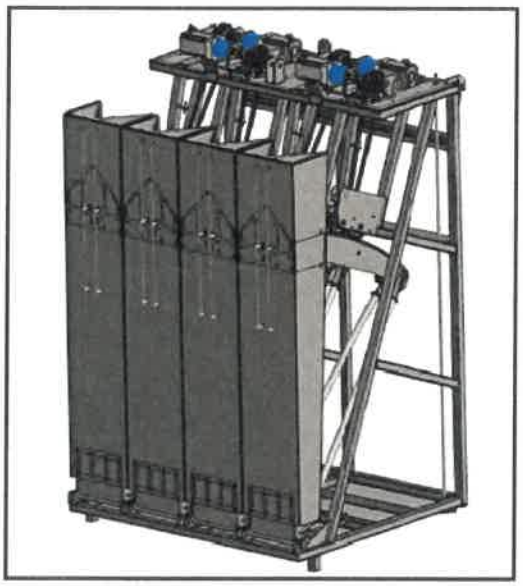
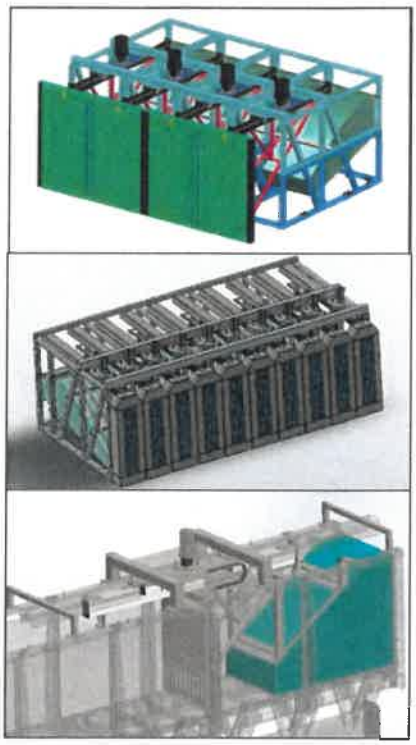
Wave Generation

Wavemaker systems

- Design is developed using 3D Solidworks software





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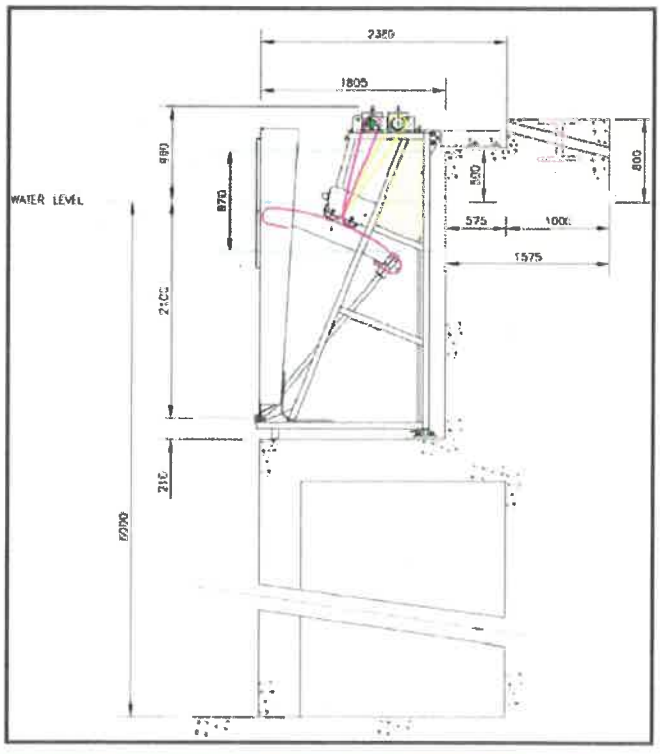
Wave Generation

Mechanical Components

- System is fabricated and assembled in the UK;
- Modular frame each with x4 paddles
- Materials from high quality, type 304, stainless steel;
- Electric servo drive actuator fitted with gearbox;
- Flexible belt attached to the quadrant at each end;
- Absorbing beach within the frame;



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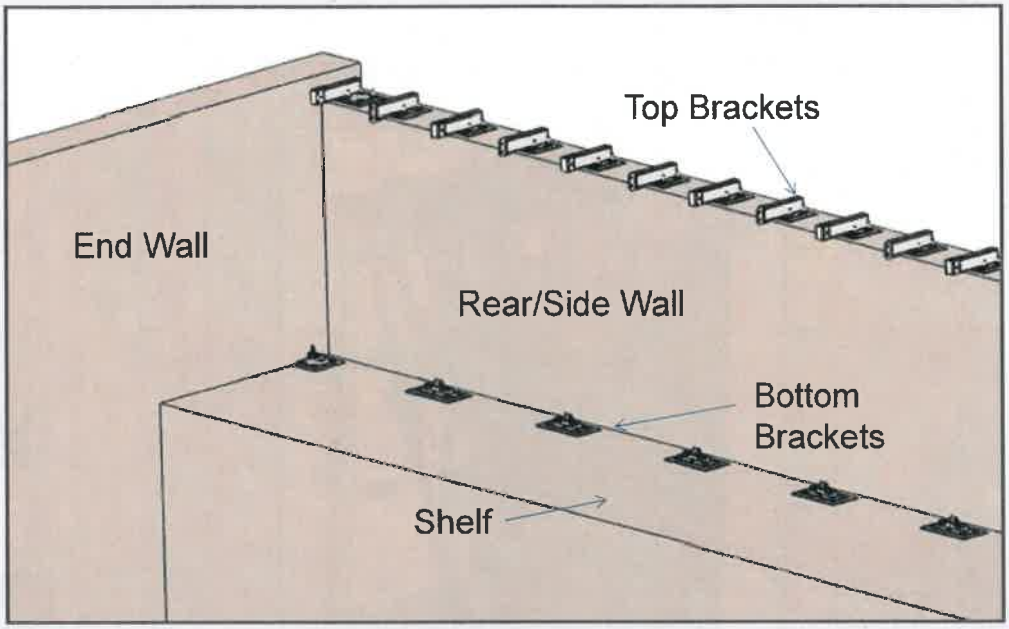
Wave Generation

Civil Design

- Interface with rear and side walls with Shelf;
- Top and bottom brackets shown;
- Top brackets nominally every 1m;
- Bottom bracket nominally every 2m;



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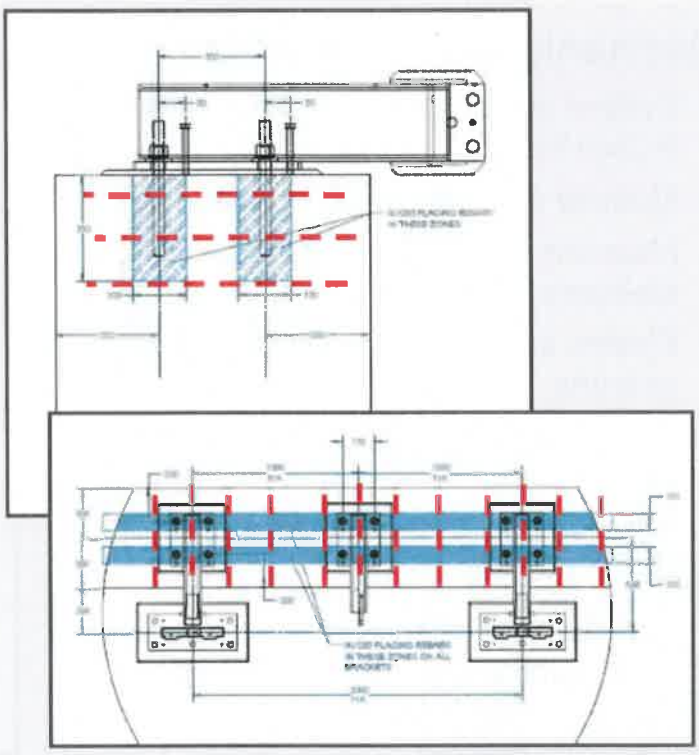
Wave Generation

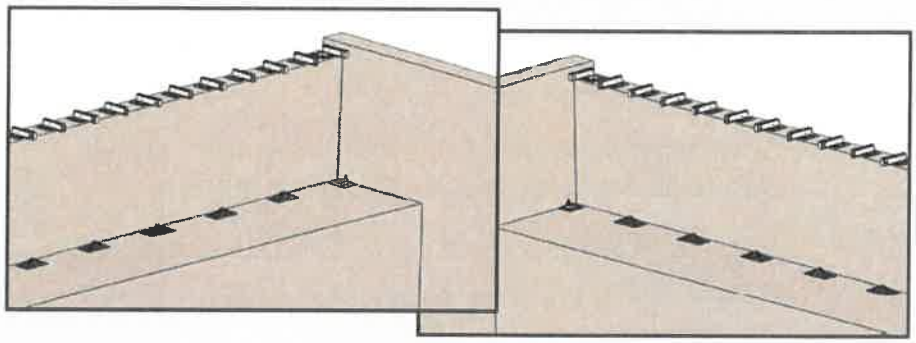
Civil Design

- Static & dynamic loadings provided within the Civil Interface Report;
- Fixing mechanism will utilise Chemical Anchors (Hilti);
- Holes located and drilled using hydraulic core drill system;
- Beneficial to have areas within the wall where rebar is minimised;
- The indicative example shown for the Top bracket is for a towing tank;
- Note there will be a requirement for rebar to cross the free areas;



Basin Inspection

- Set up a measurement network (Leica Nest);
- Determine the high point along the top bracket and bottom bracket lines;
- Measure how square is the basin, short side WGS square to carriage rails;
- Finished floor and wall surfaces;
- Conduct settlement & leakage test;
- Re-inspect nest after the water is drained;



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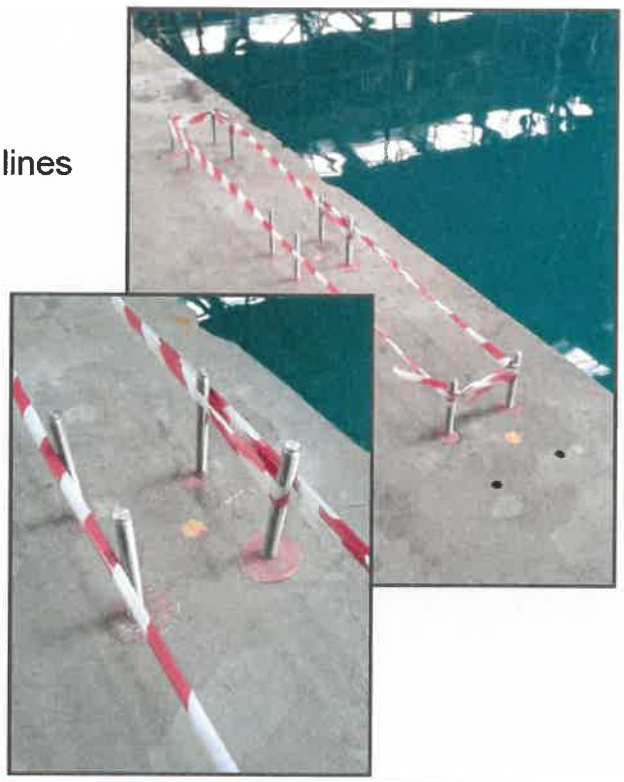
Wave Generation

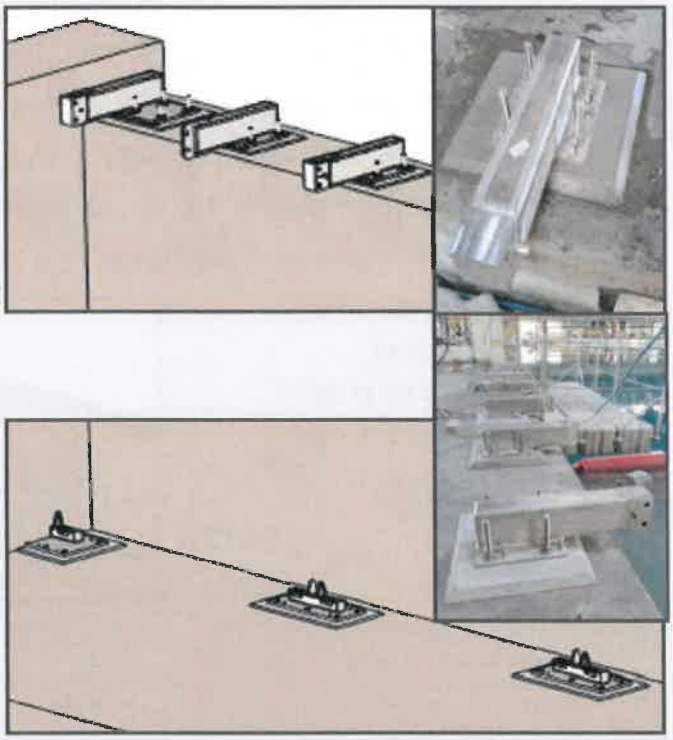
WGS Installation - 1

1. Conduct detailed survey:-
   - Re-survey the basin and establish datum lines and levels along the installation runs;
   - Determine bracket positions;
   - Determine packing requirements;
   - Leica tracker measurement systems;
2. Core drill and place fixings:-
   - Utilise jig/template to mark hole locations;
   - 'Hilti' Chemical anchors;
   - Drill, roughen & clean holes;
   - Water cooling for drill bits;
   - Inject resin and place anchor bolts;
   - Resin allowed to cure;
   - Any excess resin removed;



WGS Installation - 2

3. Locate & secure top brackets:-
   - Place estimated packing material;
   - Position bracket & adjust using levelling screws & tracker;
   - Semi tighten fixings & check with tracker;
   - Pour grout beneath each bracket;
   - Allow to grout to cure;
   - Remove nuts one at a time, fill annulus with resin then torque to required setting;
4. Locate & secure bottom brackets:-
   - Follow same process as top brackets;
   - Can commence installation once sufficient top brackets completed;



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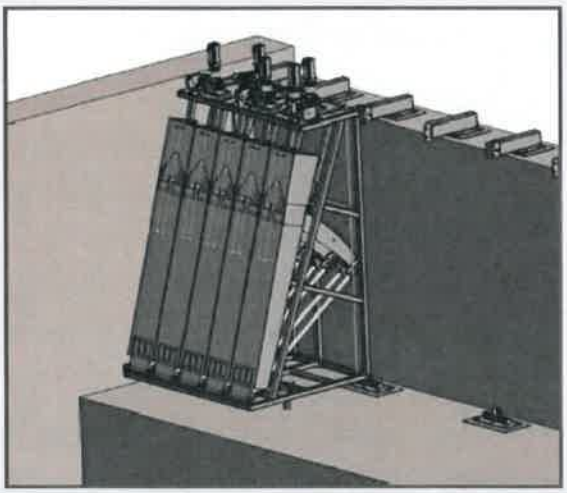
Wave Generation

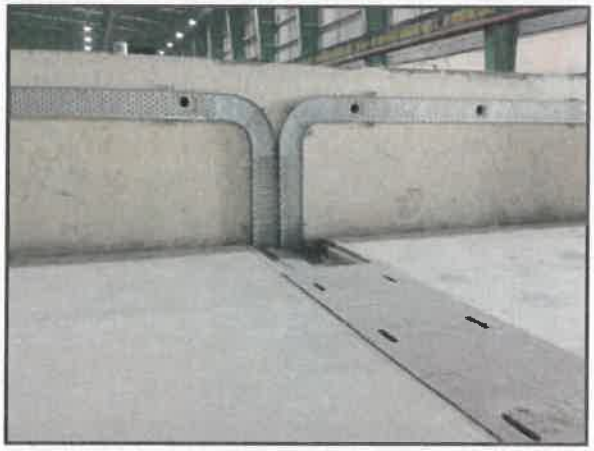
WGS Installation - 3

5. Place Modules:-
   - Use the building crane to manoeuvre modules above the placement location;
   - Lower module to locate the frame onto the bottom and top brackets;
   - Apply fixings and torque to the required Nm values;
   - Continue with adjacent modules;



WGS Installation - 4

6. Electrical installation:-
   - Install cable tray between Modules & the MDCPs;
   - Note cables will pass through the SMB wall and also the mezzanine floor to reach the panel room, therefore cable ducts will be required;
   - Power supply to each MDCP provided by SSSRI;
   - Requirement is 3Phase +N+E, 380VAC rated at 380A per MDCP;
   - Strict requirements for the Earth, must comply with TN-C-S requirements, i.e. the earth should be provided back to the transformer with the Earth cable diameter similar to one of the phases;



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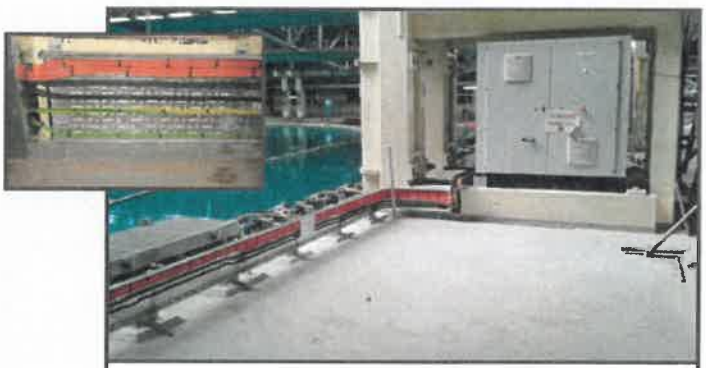
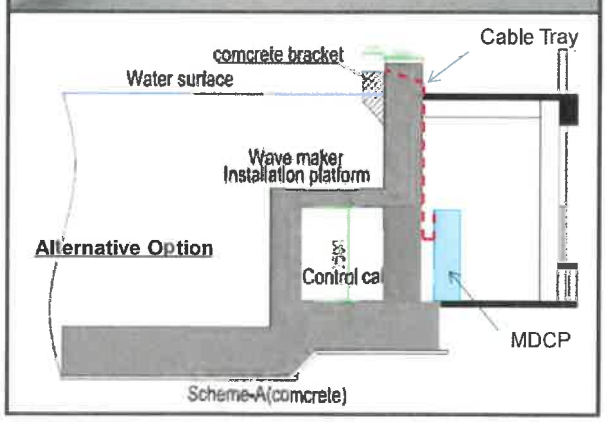
Wave Generation

WGS Installation - 5

6. Cable installation:-
   - Connect and run cables back to the MDCPs;
   - Cables will include (per module):-
     - x4 Motor power & signal cables
     - x1 Combined limit switch cable
     - x1 Combined wave probe cable
     - x1 Earth cable
   - Cable entry to the MDCPs will be from above;
   - Review of panel room should be considered as it could be located beneath the mezzanine floor if this makes basin construction easier;





Wave Absorption

Passive Wave Absorbing Systems

- Stainless steel perforated parabola;
- Lightweight space frame can be assembled and installed locally;
- Removable to the floor of the tank or easily mounted onto a concrete shelf;
- Perforated parabola allows water to pass into the beach, note permeated water will return to the tank at lower level;

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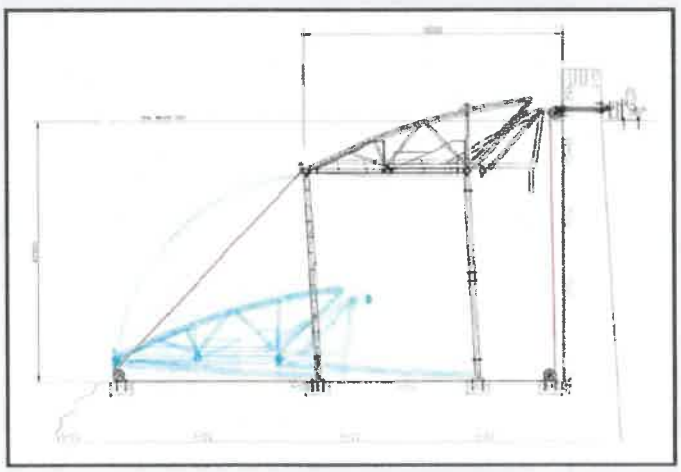
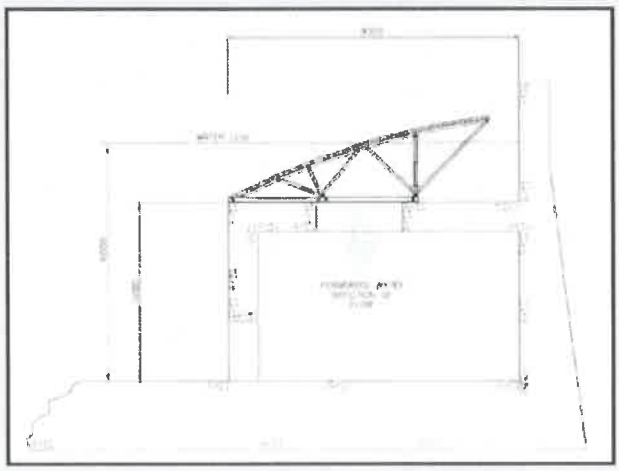
Wave Absorption

Mechanical Design

- Design will be subject to period of research to enhance beach performance;
- Removable beaches are buoyant and fold to the floor when not required;
- Winch system located outside the basin;





21st June 2019
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Wave Generation

Civil Design

- Static & dynamic loadings provided within the Civil Interface Report;
- Fixing mechanism will utilise Chemical Anchors (Hilti);
- Holes located and drilled using template and hydraulic core drill system;
- Again beneficial to have areas within the floor and wall where rebar is minimised;

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Wave Absorption

Basin Inspection

- Determine the high points along the floor and longside rear wall bracket lines;
- Measure locations for through wall connections (laser scanner?);
- Determine the high points for for the short wall shelf;
- Conduct settlement & leakage test;
- Re-inspect nest after the water is drained;

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Wave Absorption

Installation

1. Conduct detailed survey:-
   - Leica tracker / laser scanner measurement system to measure as built structures;
   - Establish datum lines and levels;
   - Determine bracket positions;
   - Determine packing requirements;
2. Core drill and place fixings
   - Utilise jig/template to mark hole locations;
   - 'Hilti' Chemical anchors;
   - Drill, roughen & clean holes;
   - Water cooling for drill bits;
   - Inject resin and place anchor bolts;
   - Resin allowed to cure;
   - Remove excess resin where necessary;

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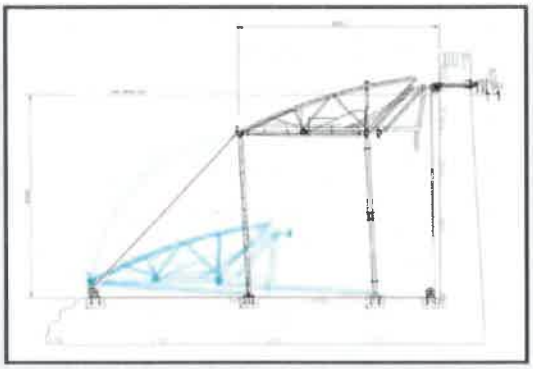
Wave Generation

Installation - 2



3. Locate floor brackets and cable sheaves:-
   - Place estimate packing and position brackets;
   - Adjust brackets using levelling screws & tracker;
   - Semi tighten fixings & check again with tracker;
   - Pour grout beneath each bracket;
   - Allow to grout to cure;
   - Remove nuts one at a time, fill annulus with resin then torque to required setting;
4. Assemble removable beaches
   - Add front and rear support legs with hinge pins added;
   - Assemble the front panels and rear cross beams then torque all panel fixings;
   - Assemble the parabola support and rear locking frame and tighten fixings;
   - Assemble the parabola (space frame, buoyancy tanks & panels) & tighten fixings;
   - Install the cable mechanism, wall sheaves and winches;
   - Raise the beach to locate the through wall locking mechanisms;

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Wave Generation

Installation - 3

5. Test beach rotation mechanism:-
   - Grease all points of movement;
   - Raise the beach using the overhead building crane to test rotation of the structure;
   - Leave beach raised to locate the through wall locking mechanisms;
   - Lower the beaches to allow for basin fill;
6. Electrical installation
   - Pull motor and limit switch cables through the cable ducts;
   - Interconnect communications for each beach MDCP;
   - Power supply to each beach MDCP provided by SSSRI;
   - Requirement is 3Phase, 380VAC rated at 40A per MDCP;

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Wave Generation

Operations

- Main operational control room will be located with view of the entire WGS;
- Remote control can also be made available on the carriage;