VOLVO OCEAN RACE INDEPENDENT REPORT INTO THE STRANDING OF VESTAS WIND

The Vestas Wind Report (Version 1.2)

An Independent Report that was convened by the Volvo Ocean Race following the stranding of the yacht Vestas Wind on 29 November 2014 on the Cargados Carajos Shoals 240 nm north east of Mauritius while competing in the 2014 – 2015 Volvo Ocean Race round the world.

Chris Oxenbould, Stan Honey and Chuck Hawley

31 January 2015

Cover photo:

Credit: Shane Smart/Volvo Ocean Race

Table of Contents

List of Acronyms

A3	A Gennaker downwind sail
AIS	Automatic Identification System – based on VHF radio system
B&G	Brookes and Gatehouse
cm	centimetres
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
ENC	Electronic Navigation Chart
ERS	Equipment Rules of Sailing
FMCW	Frequency Modulated Continuous Wave
FR0	Fractional Code Zero sail
GM	Green Marine Limited – the builder of the Volvo Ocean 65
GPS	Global Positioning System
HO	Hydrographic Office
IHO	International Hydrographic Office
IMO	International Maritime Organisation
ISAF	International Sailing Federation
J1, J2 and J3	Jib sails Numbers 1, 2 and 3
LFP	Lithium Ferrophosphate – batteries ($LiFePO_4$)
m	metres
m^2	square metres
MFD	multi-functional display
MH0	Masthead Code Zero sail
mm	millimetres
MRCC(s)	Marine Rescue Coordination Centre(s)
nm	nautical mile
NCG	National Coast Guard of Mauritius
NOR	Notice of Race
OA	Organising Authority - VOR
OBR	Onboard Reporter
OSR	Offshore Special Regulations

PDF	Portable Document Format
RRS	Racing Rules of Sailing
RYA	Royal Yachting Association
SAT C	C-Band Satellite Communications
Satphones	Satellite Telephones
SI	Sailing Instructions
UKHO	United Kingdom Hydrographic Office
UTC	Coordinated Universal Time
VCA	Volvo Ocean 65 Class Authority
VHF	Very High Frequency
VO 65	Volvo Ocean 65
VOR	Volvo Ocean Race S.L.U.
ZOC	Zone of Confidence
ZOC B	Position accuracy +/- 50m, depth accuracy 1m +/- 2% of depth, full area search not achieved, uncharted features hazardous to surface navigation not expected but may exist
ZOC D	Position accuracy worse than +/- 500m, depth accuracy worse than 2m + 5% of the depth, full area search not achieved, large depth anomalies may be expected

This page has purposefully been left blank

INTRODUCTION

All times are local time.

Cargados Carajos Shoals local time is UTC (+4).

Terms of Reference

1. The Volvo Ocean Race S.L.U. (VOR) provided Terms of Reference in December 2014 for the preparation of an independent report into the stranding of *Vestas Wind* that occurred on Leg 2 of the 2014-2015 Volvo Ocean Race round the world.

2. The specific incident occurred at about 1916 on Saturday 29 November 2014 when *Vestas Wind* ran aground and was subsequently stranded on the Cargados Carajos Shoals, about 240nm northeast of Mauritius. All nine crew members were eventually evacuated and some suffered minor injuries.

3. The report is to investigate what happened to *Vestas Wind* and why. Findings and recommendations are to be provided to ensure any lessons to be learnt are captured. Importantly the report is not to apportion blame. The team is not limited to whom they may talk but they have no powers to compel people to respond to their questions. A copy of the Terms of Reference is at Annexure A.

Report Team

4. VOR committed to prepare an independent report into the incident on Friday 5 December 2014 and approached a number of prospective report team members. The organising authority was keen to conduct a thorough investigation and publish a report to provide good guidance for sailors and race organisers in future events. Time was critical as the crew from the yacht were on their way to Abu Dhabi. They were keen to return home following their ordeal and it was important to talk with crew members before they dispersed.

5. Rear Admiral Chris Oxenbould AO RAN (Rtd) was nominated as chair of the report team. Stan Honey and Chuck Hawley agreed to complete the team. Brief resumes of the three team members are at Annexure B.

6. Stan Honey was, however, committed in Australia until late December with the Rolex Sydney to Hobart Yacht Race and Chuck Hawley was unable to travel from the US until the following weekend. Chris Oxenbould was available immediately and travelled to Abu Dhabi arriving early Monday 8 December to commence the interviews.

7. This restricted availability required some ad hoc arrangements. All interviews were recorded and notes prepared. These were provided to all team members. In preparation for the interviews there was a series of telephone discussions and an exchange of emails to agree on the items to be covered and the questions to be asked.

8. As well as the *Vestas Wind* crew, all skippers and all but one navigator from the other boats in the race, plus the CEO of VOR and the Race Director were interviewed in Abu Dhabi. The *Vestas Wind* interviews were conducted by Chris Oxenbould and he was joined by Chuck Hawley for the remaining meetings in Abu Dhabi. The navigator of *Vestas Wind* was unable to meet with the team at this stage due to the uncertainty of his situation with the insurer. This was subsequently resolved and a teleconference was conducted with the navigator and all three team members.

9. Teleconferences were held with managers from Jeppesen (C-Map), Expedition, and the *Team Vestas Wind* Shore Manager. Emails were exchanged with meteorologist and race adviser, Roger Badham as well as the part owner and the creator of Adrena. Chris Oxenbould met with the Director of Charting Services at the Australian Hydrographic Office which was followed with a series of email and telephone exchanges.

10. A total of 26 people were interviewed by the report team and additional questions were dealt with through email exchanges. A list of those questioned and submissions received by the team is at Annexure C. Generally, all people approached were very open and helpful with the information they provided. This was greatly appreciated by the report team.

11. Jeppesen responded to the report team's initial enquiries and two teleconferences were conducted. Following these discussions a set of specific questions were forwarded on 10 January and a further teleconference was planned for 31 January. This conference did not take place but an email response was provided which insisted on the right for Jeppesen to review the report. This could not be accepted by the report team. The information provided by Jeppesen in its email has not been used in the report.

DEDUCED FACTS

The Race

12. The Volvo Ocean Race was formerly the Whitbread Round the World Race which was first contested in 1973 and it has evolved a great deal in the past 41 years. The race was initially sailed every four years but now starts every three years in October. This current, 2014-2015, race is the 12th Edition. The route has been changed to accommodate different ports of call and in recent editions, since 1997, has had either nine or ten legs, with in-port races at the stopover cities.

13. The class of competing boat has also changed a great deal since 1973. Initially there were a wide variety of designs with vessels ranging from 9.8m to 24.4m in length. In the next five races there continued to be a diversity of boats and a new design, the Whitbread 60 (60 feet in length), appeared in the 1993-1994 event. Subsequently this 60 foot design was changed into what became the Volvo 60, when Volvo took over the sponsorship for the 2001-2002 edition. After this race the Volvo 60 was considered to have been optimised as far as it could without a step change in design.

14. The Volvo Open 70 (70 foot) Class was then developed as a larger, lighter boat with a canting keel and more sail area. The Volvo 70 was the single class in the next three editions of the race,

competing in its last race during 2011-2012. The Volvo 60 and 70 classes were regulated in major speed-defining parameters such as length, beam, draft, displacement, keel bulb size and sails. There was considerable scope to refine the design, the build, the rig and the sails. The boats became very expensive to campaign and some boats were not as competitive as others. This detracted from the competition between the sailors because the teams competed also on the basis of boat, rig, and sail design and build.

15. During the 2011-2012 race it was announced that a strict one-design class would be developed, the Volvo Ocean 65 (VO 65, 65 feet in length), and compete in the next two editions of the race. The aim was to enhance the competition between the sailors on this most challenging course, round the world, and to constrain costs.

16. Important changes have also been made to the course. Initially a large part of the race was sailed in the Southern Ocean with its extremes of wild weather and seas. Since 2008-2009 the race has been diverted to the north of the Indian Ocean and visits have been included in India, Singapore, China and the United Arab Emirates. This introduces its own challenges, racing through areas like the Malacca Straits, the South China Sea and the Pacific archipelagos as well as crossing the equator and passing through the tactically demanding doldrums four times each race.

17. The current race will visit eleven ports, covering about 39,000nm and taking over nine months. The racing is close and after the first two legs and sailing 13,000nm, the fleet of six boats had three joint leaders.

18. The nature of the race is very physically and mentally demanding. The race is marketed as 'Life at the Extreme'. Indeed over the past 41 years five crew members have tragically lost their lives, three in the first race. Organisers have strived to improve safety and maintain demanding standards of compliance.

19. Over the years the crew size has reduced. The Volvo 60s sailed with 12 or 13, the Volvo 70s with 10 in the 2004-2005 race and later with 11, and now the Volvo 65 has a sailing crew of 8 men or 11 women. This places extreme demands on the crew when racing and as much pre-planning as possible is required when in port.

20. This is particularly important for the navigator and most teams are well supported by meteorologists and experienced navigators to develop a roadbook[1] for the next leg to assist the

[1] A book that breaks the leg into several stages defined by the expected weather patterns. It contains forecasts of what to expect and what routes would be most favourable in a range of weather conditions that may be experienced. It also includes advice on predicted ocean currents and provides extracts from the Pilots or Sailing Directions on navigational dangers.

navigator and skipper. This support ceases from the 'preparatory' signal five minutes before the start of a leg. The navigator is then restricted to using the planning material carried onboard, the supplied navigation equipment and the common weather package provided to all boats by the Race Control. There is no limitation on additional charts, navigation publications and systems, or safety equipment that is commercially available and added prior to the start or between legs. The supplied equipment provides a comprehensive fit and capability but it is a minimum requirement that must be carried.

21. The boats are denied Internet access or any private shore support when racing.

22. Throughout the history of the race, media coverage and the involvement of sponsors have been upgraded dramatically, aided by technological improvements. In the current and recent races each boat carries an onboard reporter (OBR) who is not able to participate in the sailing of the boat and is very restricted in what he or she can do onboard.

23. The OBR's daily content production is controlled by the 'watch producers' based in the VOR offices in Alicante. There is a specified minimum requirement in the Sailing Instructions (SI) to provide at least four minutes of video, five to eight photos and 200 words of text each 24 hours. The boats have installed cameras and microphones, some of which can be remotely controlled by Race Control. The latest video, satellite and multimedia content production technology is employed by each OBR to allow the public to follow the race. All this is necessary to feed the media centre at Alicante and generate the Volvo Race website, promoting the race as an attractive marketable product.

24. In addition to this exposure there was a necessity to provide more for sponsors and to take advantage of such a challenging sailing event. A program of in-port activities was initiated and has grown to include a practice race, three Pro-Am events where guests can participate in the sailing of the boats and an in-port race competition with full racing crews and a few guests. In addition some brave guests are able to join the boats for the start of the next leg and complete a short harbour course before the boats head to the next port. At this point the guests have to leap into the sea and are quickly recovered by support craft. Truly a series of unique and memorable experiences.

25. The *Vestas Wind* grounding occurred on Leg 2 of the race from Cape Town to Abu Dhabi, 10 days after departure from Cape Town and approaching the mid-way point of the leg.

Race Organisation

26. The Organising Authority (OA) for the Volvo Ocean Race 2014-2015 is Volvo Ocean Race S.L.U. in conjunction with the Real Club de Regatas de Alicante and the International Sailing Federation (ISAF). The OA is a wholly owned Spanish company based in Alicante, Spain.

27. The race is conducted under the ISAF Racing Rules of Sailing (RRS), Equipment Rules of Sailing (ERS) and Offshore Special Regulations (OSR) as a Category 0[2] race with additional special standards applied for the race through the Notice of Race (NOR) and SI. Addendums to the SI are produced for each leg of the race and for each series of in-port races that also includes the practice and Pro-Am events. Amendments are issued to the race documentation as required.

VO 65 – One-design Concept

28. What is unique to the VOR is the Volvo Ocean 65 (VO 65) Class Rules. These rules have been produced for this race and the next edition to administer an extremely strict one-design regime. The seven boats of the class have reportedly been built to within a 1 millimetre (mm) tolerance, which applies to design dimensions, fittings and even any hole on the boat. This compares with a 2mm to 3mm tolerance for the hull dimensions of an Olympic Class Laser dinghy. These extraordinary efforts even specify the exact lengths of wiring permitted to set up the boats' systems. On completion of the boats and before branding by the participants[3] the hull and appendages were weighed and compensators fitted to ensure all boats were the same.

29. The VO 65 Class Rules established a class association (VCA) to administer the one-design and it has been very active. In such a strict regime it is not surprising that many queries have arisen. By late November 2014, 97 permitted changes and additions had been added to the rules as Appendix F. These included minor details such as drilling additional holes in the boat, additional shackles, fitting of chafe pads and use of replacement deck screens. These demonstrate the strictness of the rules.

30. All defects in the boats have to be notified in routine reports and a very close monitor is kept of the material state of each boat. Any changes to the boat or repairs have to be approved by the VCA. Any approved replacement has to use the design specified equipment.

31. The VO 65 Class Rules are closed class rules where if it does not specify that you may – then you shall not.

32. In order to manage the race and class rules, question and answers forums are in place for both the NOR and the VO 65 Class Rules. They provide a means for participants and crews to voice

---

[2] Category 0 - Trans-Oceanic Races, including races which pass through areas in which the air or sea temperatures are likely to be less than 5 degrees Celsius other than temporarily, where boats must be completely self-sufficient for very extended periods of time, capable of withstanding heavy storms and prepared to meet serious emergencies without the expectation of outside assistance.

[3] Defined in the NOR as: 'The syndicate company, the owners of a Boat entered in the Race, the entity that runs sponsors or funds a Boat and the entity/entities that enters or intends to enter into the *Commercial Participation Protocol* relating to a Boat. For the purposes of the RRS, the Participant signatory shall be considered a competitor.

issues and either seek clarifications or propose amendments to the rules. By late November 2014, 37 questions had been processed regarding the Class Rules and 22 related to the NOR.

33. Other initiatives have been introduced in pursuit of the one-design philosophy and to constrain costs. The number of sails is limited to no more than seven (Main, J1, J2, J3, A3, FRO and MHO) plus a storm jib. This compares with 11 sails on a Volvo 70 and 18 for a Volvo 60. Each boat was provided with one set of pre-race and one set of race sails. Throughout the race a boat is only permitted to replace four sails, not including the mainsail. All repairs to the boats, rigs and sails are carried out in a common boatyard and sail loft, with a full inventory of specialists and spares. These facilities are owned by the teams and setup at each port by VOR. The teams share the costs for the work completed and spares used. The practice provides very significant savings in support crews and the holdings of spare parts.

34. All the sails were produced by one sailmaker, North Sails. The race sails were built in batches so the same mould is used for the production of eight sails of the one type. Each sail type was finished in the same loft by the same team in one go to ensure an identical shape and production quality. The one-design philosophy was taken to the extent of distributing the race sails to boats by a form of lottery. Southern Spars produced the masts, booms and rigging using ECsix carbon fibre. All 10 rigs (including the spares) are identical in terms of dimensions, weight and stiffness. Across the first seven rigs bend tested, there has been a discrepancy of just 1.4mm.

35. The VO 65 was designed by Farr Yacht Designs and built by a consortium of four European boatyards. The hulls were built by Persico in Italy, the decks by Multiplast in France, parts of the internal structure by Decision in Switzerland, while Green Marine in the UK carried out the final assembly. Again this has produced a more affordable boat than previous generations by having one set of plans and one team of builders.

36. Farr Yacht Design, the builders and VOR developed a very comprehensive fit of supplied safety, navigation, communications and media equipment. All items are well proven and tested and the boats were presented as a very complete near-identical ‘sail away’ package. Although there were some varying opinions from crews on the ideal boat for the race, there was a strong consensus that the VO 65 provided a robust, safe and ‘fit for purpose’ boat to race round the world in a very even competition. A list of the main technical specifications of the VO 65 is at Annexure D.

Race Control

37. In Alicante, VOR has a sophisticated Race Control Centre as part of its office headquarters. The centre is permanently manned while the boats are racing with at least one duty officer and monitors the boats very closely. All communications to and from the boats, with the exception of

voice radio in the relatively close vicinity of the boats, are passed through Race Control. This includes email correspondence that is restricted to three 'whitelisted[4]' accounts for participants to send emails directly to the boat.

38. The boats are tracked continually by several methods that receive information generated by systems fitted to the boats. One system provides a report from each boat every 15 minutes via Sat C and these are condensed into a public report on the Volvo website every three hours and a report to the other competing boats every six hours. The longer time interval for competitors is designed to minimise any tactical advantage of knowing where the opposition is and what conditions they are experiencing when not in close company. The Sat C terminal itself provides a separate messaging report every 15 minutes that includes position, course and speed

39. There is a telemetry system that takes readings from the boats every 10 seconds with position, course, speed and wind and every third report (at 30 second intervals) includes some additional meteorological data and some loadings on the boat that include the tensions on the forestay, bobstay, backstay, mainsheet and C1, D1 stays, in order to analyse the boat's performance for future modifications and designs. Further to this there are Yellow Brick trackers onboard as a backup if there are difficulties with the satellite coverage, these normally report every 30 minutes or one hour unless continuous reporting is required. The positions of the boats are well known.

The East African Exclusion Zone

40. A major constriction on the permitted racing area of Leg 2 was the East African Exclusion Zone. This was first established during the 2008-2009 race in order to minimise the risk from pirates. During the 2011-2012 race boats were diverted as far east as the Maldives and then transhipped to Sharjah where they resumed racing to Abu Dhabi. The initial NOR and leg SI reaffirmed the previous exclusion zone with the expectation that boats would sail north along the Indian coast and on to the Gulf of Oman and the Strait of Hormuz.

41. The threat from pirates had diminished during the past three years. The OA was receiving information from DRYAD Maritime, a UK based commercial operator that advised the maritime industry of international security risks among other things. During a briefing at Alicante on 30 September 2014, before the start of the race, competitors were advised of the likelihood that the exclusion zone would be reduced in size shortly before the start of Leg 2 in Cape Town. A change in course for a leg, even while boats are racing, is permitted by the NOR (2.6) that amended RRS 32 and 33

42. Discussions continued with DRYAD and the company proposed a new exclusion zone on 11 November. This cut off a large sector of the zone north of Mauritius by limiting the eastern

[4] Only email from those on the whitelist will get through the corollary of a blacklist

boundary to 65°E. The new zone (Figure 1) was discussed with skippers and navigators at a meeting on 12 November and was agreed subject to resolution of some issues on the Iranian coast. These were resolved and an amended SI was sent to the teams on 15 November.

Figure 1 – East African Exclusion Zone Proposed 12 November

43. About this time, 15 November, a tropical system was forming in the vicinity of Diego Garcia and was threatening to transit the course and interfere with the fleet. The system could have a major influence on the race as the exclusion zone restricted the options to avoid the potential cyclone. A course passing to the east of the depression would be circuitous and force boats to remain in the dangerous semi-circle and quadrant for a longer time as well as confront strong headwinds. The safer course would be to attempt to get to the north of the depression as quickly as possible, passing to the west which would most likely involve entering the exclusion zone.

44. Confidence in the track of the tropical depression improved on 16 November, confirming the earlier predictions. Discussions were held with DRYAD on the 17 November with a view to opening the exclusion zone (Figure 2) between Madagascar and Mauritius to allow boats the option of passing to the west of the depression. This was agreed by DRYAD on 17 November and a SI amendment was issued at 1836 on 18 November.

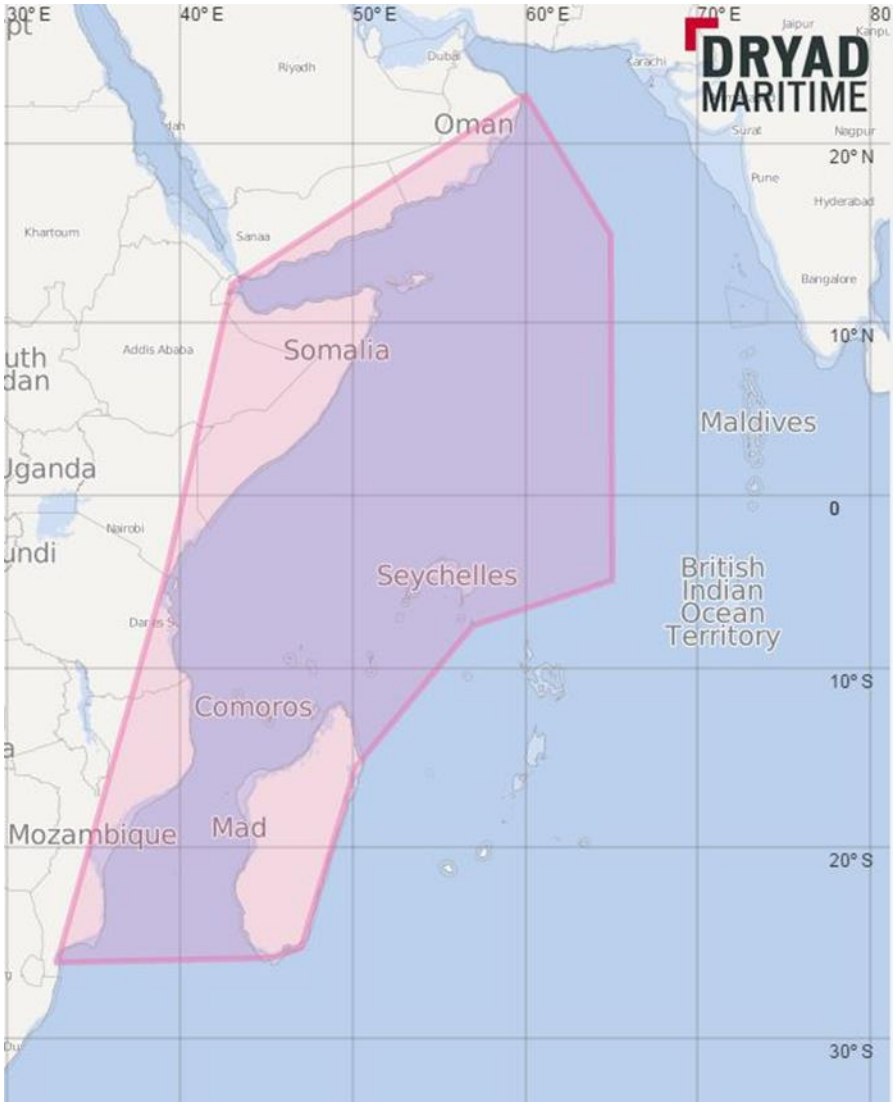

Figure 2 – The amended East African Exclusion Zone promulgated to boats at 1836 18 November

45. In supporting the new exclusion zone, DRYAD expressed concern about making the zone public and advising pirates the most likely track the fleet would follow, well in advance. They recommended a subterfuge with the eastern boundary being promulgated in the amended SI as 60°E when the true boundary and course to be sailed had an eastern boundary of 65°E. This was agreed and advised confidentially to the boats when the amended exclusion zone was given to them at 1836 on the 18 November. All boats were asked to confirm receipt of the email and acknowledgement that the SI attached was the SI applicable for Leg 2 and was to replace the version promulgated publically. This did cause some confusion for one team as to which version applied but was clarified by resending the SI previously sent at 1836 on the 18 November by email to all competitors shortly after the start of the leg.

46. The race started at 1800 on 19 November with an amended East African Exclusion Zone and now included the Cargados Carajos Shoals in the area that competitors were permitted to sail

The Boat – *Vestas Wind*

47. *Vestas Wind* was boat number six of the seven boat build but due to some late changes in the sponsorship arrangements it was the last of the boats to be commissioned and commence its race campaign. There was a fortunate coincidence with VOR preparing a boat, the core of a crew that expected to be sailing with another team until it withdrew in May and an emerging prospective sponsor. VOR facilitated a deal with *Team Vestas Wind* and it was finalised in July 2014 and formally announced in mid-August a few days before the boat was launched. Sea trials commenced about 19 August.

48. All boats had to assemble in Alicante by 8 September for compulsory briefings, safety demonstrations, overhauls and compliance checks in preparation for the in-port racing to commence on 3 October and the Leg 1 start on 11 October. For *Vestas Wind* the race had already started. Such an ambitious program had never been achieved in a round the world event with a new and competitive boat. It would not have been possible if it was not for the one-design concept and that there had been few issues in getting the other new boats on the water. By comparison the timetable would be unimaginable for a custom-made Volvo 70.

49. The risk was further offset by the crew mix that was brought together. The skipper, Chris Nicholson, had over 20 years of professional sailing experience. He had competed in four previous VORs; three as a watch captain and the last as skipper. Chris was a dual Olympian and has six world championships to his credit in the 49er and 505 classes. Four other crew members were VOR veterans and two of them had sailed with the skipper during the 2011-12 race onboard *Camper* where they gained a second place. All told there was a total experience of 14 previous VORs onboard. The other three crew members were young, fit and had excellent competitive sailing experiences. In addition, the vital role of shore support manager was to be filled by Neil Cox, who had three prior campaigns working with the skipper.

50. The important position of navigator was filled by Wouter Verbraak: a very experienced sailor, navigator and weather router. Wouter started sailing at an early age and gained the equivalent of a Yachtmasters qualification by the age of 18. He co-skippered the Open 60 Hugo Boss in the 2010-2011 Barcelona World Race (double handed). In 2001 he had completed two legs in the Volvo Ocean Race as co-navigator. In the 2008 Volvo Ocean Race he sailed nine out of ten legs as navigator. His sailing credentials included an America's Cup, Admirals Cup, TP52 Med Cup, Middle Sea Race, Fastnet, TransPacific, Cape Town to Bahia Race, two TransAtlantic Races and the Sydney to Hobart. He co-skippered in the Volvo Baltic Race and advised sailors on strategy and weather in the Vendee, Route du Rhum, the Jacques Vabre and the Olympics. Wouter had a Master's degree in physics, completed in Sydney with sea breezes as his thesis. Wouter and Chris Nicholson sailed together as skipper and navigator on *Rambler 90* in the Maxi-Worlds in 2007 and on the same boat in the same year as watch captain and navigator in the TransAtlantic Race.

51. There was a lot to be done in a short period. Initial sea trials were completed on the Solent, sailing out of the Green Marine facilities at Hythe near Southampton. The mandatory sea survival course for all crew was completed at Newcastle, UK on 25-26 August. After a few more days sailing,

the boat departed for Alicante on 31 August. There was a race requirement to complete a 2,000nm non-stop open ocean qualification with at least 5 of the crew for Leg 1. The boat also had to be at Alicante by 0900 on 8 September.

52. *Vestas Wind* arrived at Alicante on the due date, with a few hours to spare, but had not experienced winds exceeding 25 knots during the qualifying passage. The crew began a busy program of crew training, boat preparation, safety demonstrations and races. While the crew had met their qualifying requirements, other boats had sailed more than six times the distance, with some completing double Atlantic crossings and being race-hardened by the Sevenstar Round Great Britain and Ireland Race. *Brunel*, for example, had sailed 16,000nm before the race. *Team SCA* was the first boat delivered in October 2013 and had an extra 10 months preparation. *Mapfre,* though, had only about four weeks longer than *Vestas Wind* to prepare for the event. There was no low-mileage advantage for either boat as all boats were hauled out and brought to a pristine condition before the race and fitted with a new race set of sails.

53. The first major commitment was a 400nm Leg 0 race from Alicante to Palma, Majorca and return that started on 12 September. The race did not count in any score and was primarily to test all the systems and equipment supplied by the OA. Surprisingly the race was won by *Vestas Wind*, less than four weeks since it was launched and beating *Brunel* by only 10 seconds. The first five boats finished within 20 minutes, demonstrating the closeness of the one-design racing.

54. After the Leg 0 race all boats were taken out of the water and, in the boatyard, all the outstanding permitted changes and additions to the VO 65 Class Rules were completed. Fortunately, there was no major construction or performance changes required. The galley and toilet were modified, more handholds were fitted in the cabin, and the keels were re-painted with a different finish. The boats were meticulously screened for one-design compliance and thoroughly overhauled.

How the boat was raced

55. *Vestas Wind* was raced using two watches of three, with the skipper and navigator 'floating' outside the watch system. Each watch was four hours. Either the skipper or navigator was always available to attend to the navigation and weather routing as well as to assist on deck for sail changes and reefing. Often both would be awake and they consulted frequently about their best route options and race strategy. The skipper often assisted the watch transition by driving the boat for the last half hour of the old watch and the first half hour of the new. The watch captains were briefed by the skipper or navigator before they came on deck for their watch and remained aware of the navigation situation. The prime task of the watch captains, however, was to sail the boat as fast as possible within a cone of courses provided and updated by the skipper or navigator.

56. There are not many available permutations with a crew of eight but the fleet used a variety of watch systems. There were straight watches of four and rolling reliefs where half of the watch was changing every two hours. Some crews treated the skipper and navigator as a member of a specified watch, and others used them as 'floaters'. One boat described its system as 'Latin' – not rigid and having a great deal of flexibility.

57. There was also considerable variation in the way navigation was managed in the boats and the role the skipper played. Some skippers were very closely involved and studied the charts in detail checking some aspects very thoroughly; essentially a 'co-navigator' role. Others delegated far more and had a 'hands off' approach. Some skippers stood a watch and navigated the boat while on watch allowing the other watch captain to navigate during his watch. *SCA*, the all-female boat, was fortunate with its crew of 11 to have two watches of five, with the skipper as one watch captain and the navigator 'floating'.

58. The skipper of *Vestas Wind* did not profess to have a detailed knowledge of navigation and all the navigation systems available in the boat. Clearly with his round the world experience he had very good general navigation knowledge. He was keenly aware of his inescapable responsibility, as the person in charge, for the safety of the boat and the persons onboard. He exercised this responsibility for navigation through delegation to the navigator. This was not formally stated or documented but was generally well understood between the two of them. The skipper had told the navigator that his number one priority was to keep the boat 'off the bricks'. The navigator, if asleep, expected to be woken whenever there were any questions about the boat's navigation or before crucial points in the race.

59. The specifics of how this relationship was to be managed was still being refined with respect to tactics and race strategy as they worked together in this important partnership. The navigation relationship was clearer; if there was something the boat had to 'navigate around' they would both be involved. The navigator would be in the nav station and the skipper would help to manage on deck. The skipper would have access to the chart plotter inside the hatch but it was primarily used as an Automatic Identification System (AIS) tracker to see other vessels. A portable deck screen was available but was not used much.

Navigation setup onboard

60. All boats were supplied by the OA with a good and comprehensive suite of instruments, navigation systems and hardware that was robust and contained a good deal of redundancy. There were three GPS receivers, three heading sources, three speed paddle wheels and two sets of masthead wind units. A list of the supplied equipment is at Annexure E.

61. The main components of the navigation station were:

- Brookes and Gatehouse (B&G) WTP3 Pack and CPU
- 2 Panasonic Tough Book computers – CF53
- Expedition navigation and routing software
- Adrena navigation and routing software
- One Adrena USB license dongle
- B&G Deckman for Windows navigation and routing software
- C-Map Charts for the entire region of the VOR, licensed to one dongle and usable in one laptop at a time
- 2 Deckman C-Map USB license dongles
- 2 B&G Zeus 7, 6.4" MFD Touch Screens

- B&G Broadband 4G Radar
- HS 70 GPS Compass
- Halcyon Gyro Stabilised Compass
- Depth Sensor
- 10" Tough Pad

62. Onboard *Vestas Wind* the navigation station was setup with one laptop for weather and routing and the other for performance assessment and navigation. The weather/routing laptop used Adrena software and had only the C-Map default World Map Coverage of the entire world at a small scale and highly generalized with little detail. The performance and navigation laptop ran Expedition and had the Deckman/C-Map dongle that was licensed to enable the use of the detailed C-Map charts worldwide. License codes for the detailed C-Map map data were not acquired for the second Deckman C-Map USB dongle, or for the Adrena USB dongle that were used in the weather/routing computer.

Figure 3 – Nav Station on board Alvimedica. A MFD display is located above and centred between the laptop screens. Nav station rotates on a vertical axis when boats are on the other tack.
Photo by Chuck Hawley

63. The allocation of functions between the computers varied between boats. One boat used only a single laptop and had the other stowed and kept in waterproof plastic as a spare. Some boats reported significant problems with the computers crashing and programs becoming frozen. Much appeared to depend on how the equipment was used to avoid overburdening the computers. Several of the other boats acquired an additional C-Map license allowing detailed charts to be used simultaneously on both computers.

64. Generally the supplied navigation equipment was accepted as being good but not universally accepted as the best. Some strong personal views were expressed by some competitors regarding preferences for other chart systems and hardware.

What happened to *Vestas Wind* – The Incident

Cape Town to the Grounding

65. Leg 2 of the race started at 1800 on Wednesday 19 November following a busy few days in port:

Date	Time	Event
Wed 12 Nov	0930	Skippers and Navigators Briefing
Fri 14 Nov	0930	Press Conference (Skippers)
	1300	Practice Race
	1500	Pro-Am Race 1
	1900	Life at the Extreme Award Night (All Crew)
Sat 15 Nov	1400	In-Port Race
Sun 16 Nov	1300	Pro-Am Races 2 & 3
Tue 18 Nov	1500	Press Conference (Skippers)
Wed 19 Nov	1800	Leg Start

Figure 4 - Final Week Race and Briefing Program at Cape Town

66. Following the change and reduced size of the East African Exclusion Zone, the permitted racing area was dramatically different than before. Previously competitors were forced to remain further to the south and sail further east leaving the Island of Mauritius and the Maldives to port before heading to the North Arabian Sea. The change was significant and although a forewarning was provided, several boats complained that a lot of their pre-planning was wasted and no longer relevant to the course being sailed.

67. The Leg from Cape Town started with strong headwinds from the southeast of about 35 knots and a tough beat to round the Cape of Good Hope. Two days of hard running conditions followed with the wind veering to the southwest causing difficult sailing conditions since the wind was blowing against the Agulhas current. This was typical and expected for the area and produced some fast downwind sailing. The fleet made ground to the east looking for the best weather opportunity to head north. This produced close tactical racing in the fleet of evenly matched boats and the lead changed often.

68. Several splits developed but the fleet came back together and was grouped very tightly on 24 November as they tried to get north of the Southern Indian Ocean High with an associated ridge. *Vestas Wind* tried a few independent moves without separating a great deal from the pack. About eight days out from Cape Town a front group of four boats had gained about a 20nm lead over the remaining boats that were led by *Vestas Wind*.

69. The skipper and the navigator on *Vestas Wind* routinely discussed the expected weather and its influence on their track. At least two days before they reached the area, they noted the Cargados Carajos Shoals and that they would most likely pass very near to them. They discussed the bottom topography and its very uneven nature along the arc of features from La Reunion to the Seychelles, with depths changing from thousands of metres to seamounts in a short distance. A watch captains was involved in one of these discussions during a change of watch.

70. The Cargados Carajos Shoals were investigated on the electronic chart and were determined incorrectly to be a 40m seamount. At different times the navigator zoomed in on the electronic chart and came to the same incorrect conclusion. This was likely due to a prominent spot charted depth in the north-central area of the 200m depth area that was 46m (Figures 9 and 11). It is unclear whether this zooming in on the Cargados Carajos Shoals took place on the navigation/performance computer or on the weather/routing computer. The navigator said he used both. The weather/routing computer did not have detailed charts and therefore was unable to display the islands and drying areas associated with the shoals, but would have shown the 46m and a 20m charted depth at the south end of the shoals.

71. The skipper was quite wary of the steep seas that could be experienced in the vicinity of seamounts and the navigational danger, especially with a tropical depression close by. He asked the navigator about the depth, current and sea state to understand if there was a safe passage. He was informed the minimum depth was 40m, the current was negligible and the sea state would be monitored as *Vestas Wind* approached the shoals. Besides the navigational danger, his concern was that the seas could damage the boat and also reduce the boat speed – slow sailing. Two of these three questions (current and sea state) would have been answered using the weather/routing computer. The answer to the third question (depth) would have required the navigation/performance computer, because the weather/routing computer did not have detailed map data. It is not known which computer was used to investigate the depth.

72. The tropical depression that had been influential in changing the exclusion zone was now coming into play. The depression was unlikely to develop into a cyclone but it still had a significant weather system around it and the possibility of strong winds and high seas. The lead group were the first to come into its influence providing fast sailing while the trailing pack was in light winds. The 20nm lead quickly became a 120nm lead.

73. The group led by *Vestas Wind* eventually came into the good breeze generated from the depression. As boats got to the north of the depression they gybed to port and headed to the north. The low-pressure system was relatively stationary and brought all of the fleet close to the Cargados Carajos Shoals. The lead group passed to the west of the shoals during daylight. One boat purposefully passed very close to the southwest tip and the islands to the north for tactical reasons.

74. *Vesta Wind* gybed on to the port gybe and a northerly course at 1440 on 29 November. They were due to be in the vicinity of the shoals in about four hours, shortly after sunset, when it would be dark. The day had been busy and intense for the navigator in assessing the optimum time to gybe and monitoring the development of the depression. One of the other boats described this period as the 'hardest section of the leg'. The skipper and navigator discussed their track and were

happy to sail over the Cargados Carajos Shoals that they thought, wrongly, to have a minimum charted depth of at least 40m.

75. The navigator went to sleep about 1600 and the skipper remained on watch, assisting the crew on deck with reefing as the boat sailed through and near some heavy rain squalls.

The Grounding

76. What happened is fairly clear. There is a great deal of information from interviews and statements by the crew, the data routinely collected by Race Control and some vivid video (https://www.youtube.com/watch?v=qi0S1eoG-Ts&feature=em-share_video_user)

77. Shortly before 1916 on Saturday 29 November *Vestas Wind* was racing normally and experiencing pleasant tropical sailing. The skipper was awake monitoring the navigation and weather and assisting the watch of three on deck with taking or shaking reefs in the main. The navigator was asleep. The wind was from the west and the boat was on the port gybe with a FR0, J3 and one reef in the main, sailing roughly north between 358^{o} and 032^{o} with a true wind angle of about 100^{o} and a true wind speed of 14-16 knots. The boat's speed was averaging about 16 knots with bursts of 21 knots. The sea and swell conditions were slight to moderate. The sun had set at 1821 and there was a short tropical twilight that ended about 1845. There were heavy persistent passing showers in the area and the boat entered one shortly before sunset. When it emerged the night was dark. There was a half-moon high in the sky behind the boat to the south but it was often obscured by the passing clouds and rain squalls with only slivers of moonlight getting through to the sea.

78. There had been some discussion in the past 10 minutes of approaching some seamounts and a possible change in the sea state. The crew on deck noticed some disturbance ahead in the water, possibly accentuated by the moonlight. While peering into the night to investigate there was a sharp crack which was the dagger board breaking. There was alarm on deck trying to find out what had happened. Most surprisingly, rocks were sighted to starboard. Immediate action was taken in an attempt to furl the FRO and J3 to depower the boat. The keel was canted to port and at a shallower depth than the dagger board. When the bulb struck the bottom it must have caught on a rock pinnacle and caused the boat to pivot to port sharply turning through 50^{o} in 10 seconds. It then steadied on a westerly heading for about 50 seconds before continuing to pivot to port and settling on a southeast heading about 90 seconds after first striking the reef. In doing so *Vestas Wind* came head to wind and tacked on to the starboard tack with the wind ending on the starboard beam.

79. There were quite big breaking waves about two metres high. At one stage as the boat was turning they were breaking over the bow before the boat settled on a southeast heading and roughly head to sea.

80. Fortunately the coastline was not a solid wall of rock. Although the reef was quite pronounced the seabed to seaward was gradually shelving and contained a series of gutters or ruts (Figure 5) radiating out to sea and deeper water. There were isolated rock dangers lying off the edge of the reef. From the 10 second telemetry data being recorded by Race Control, *Vestas Wind* was

sailing at about 16 knots at the time of impact. The boat did not stop dead as if it had crashed into a brick wall but did pull up very quickly, reducing speed to less than 3 knots within 10 seconds and stopped within the next 10 seconds. This slight cushioning effect of the breaking daggerboard and the multiple impacts on the reef probably prevented serious injuries.

81. When the boat had settled on a southeast heading and pointing to sea it would appear that the bulb was constrained in one of the gutters. The boat maintained its heading but was being pushed back towards the reef face. The hull was to starboard of the keel and heeled to starboard. With the boat now on the starboard tack, the keel was on the wrong side and the pressure from the sails was driving the keel harder on to the seabed and effectively jamming the boat on to the reef. By this stage the rudders had gone – broken off after striking the bottom when the boat pirouetted around the keel bulb.

Figure 5 – The day after from the air – showing where the boat ended up, the reef face ahead of it with the breaking waves and the gutters in the seabed bottom where the keel was caught
Credit: National Coast Guard of Mauritius

82. A couple of attempts were made to cant the boat up and over with the keel mechanism to get the bulb on the right side. This was a long shot and it did not work. The situation was dire. They had no steering. The sails were needed if they were to get the boat off the reef but the sails were holding the boat on to the reef. The engine was started but was ineffective. Within a couple of minutes *Vestas Wind* was stranded.

83. The crew got the sails under control. This was a very difficult task as there were waves breaking over the boat – sometimes they would break over the bow and sometimes over the side. The motion was very violent and jolting – it was hard enough to hold on, let alone deal with the sails. The motion was horrendous and never ending. Chris Nicholson is quoted as saying "We were caught in deep ruts that run up to the edge of the reef. We felt like we were hooked in them and the boat would surge forwards and backwards – maybe only half a metre, but the blow that the boat would get after that half metre had no give in it at all. The boat would do a little surge and then come to an abrupt halt"[5].

84. Contact was made with Race Control within about six minutes of the grounding to advise that *Vestas Wind* had hit the reef. A 'Mayday' call was also made on VHF radio and acknowledged by the local coast guard station and a local fishing vessel. Both indicated they were unable to assist at night but would at first light in the morning. Chris Nicholson summed up the situation succinctly in his first phone call to shore manager Neil Cox "We're on a reef, we're not getting off, we're f….d."

The Night that Followed

85. The night that followed has been described by Chris Nicholson as "the worst night of my life". Fortunately, through his leadership and the collective training and experience of the crew they survived the night and all emerged the next morning safe and well. There was no panic and the situation remained calm and purposeful as the crew tried to regain control of their circumstances. The combination of the experienced 'old salts' and the young crew, who responded to the challenge, worked well.

86. The crew quickly realised that the boat had been so severely compromised that there was no chance for them to get it off the reef. The priorities turned to rescue and survival. They all got into their survival suits and started to consider how they could get off the boat. At that stage there were two options and both appeared bad. One was to leave across the bow and try and get into the safety of deep water. This meant passing through breaking waves of at least two metres that would be impossible to negotiate in a liferaft. The second was across the stern and crossing the gap between the boat and the reef face before clambering on to the reef proper in breaking surf and hopefully reaching the calm water beyond.

87. The darkness made it difficult to assess the alternatives. The best option appeared to be to remain with the boat at least until daylight and then reassess the situation, hopefully with the knowledge that some rescue support was available to standby. There were good communications with Race Control, the teams support manager, Neil Cox, and the local coast guard. *Alvimedica* who had been about 50nm astern of *Vestas Wind* was diverting to the shoals and expected to be there about midnight to standby to collect the crew or provide any other support that might be needed.

---

[5] Sail World – Volvo Ocean Race: Chris Nicholson Interview – Part 2 – On the Rocks: 30 December 2014

Race Control was coordinating support from external authorities such as the National Coast Guard (NCG) of Mauritius.

88. The watertight compartments fore and aft had been sealed but some water had entered the aft compartment, presumably from damaged rudder bearings. There was also a minor problem in securing a watertight seal with the hatch aft. Initially the main cabin was relatively dry and it was possible to use the boat's main communications systems.

89. The motion remained dreadful as the boat was pitching and rolling in the seas breaking on the reef and the surge of the backwash. The crew were being thrown about and it was very difficult and tiring just to hold on. The movement was accompanied by an 'awful carbon sound' as the boat was being bashed on the rocks. The stern was taking the worst of the thumping and was starting to break up. The crew was kept busy assessing the situation and developing a plan of how they would leave the boat and what equipment they would take in the grab bags. There was no intention to leave the boat before daylight. But prudently they wanted to be ready to go at very short notice. At least one of the crew had to watch and call the waves all the time so others could brace as the water broke on to the boat. It was a tiring struggle to hold on.

90. Within a couple of hours the starboard side of the hull was breached and water was inside the hull with a dangerous free surface and floating gear. About 2115 all the crew were brought on deck and it was no longer safe to work below. Around 40 minutes later all main battery power was lost in the boat. Race Control reported the cessation of telemetry data at 2156. External communications were now limited to mobile satphone and hand held VHF radios. The latter only had a relatively short range of about 5nm.

91. The crew continually re-evaluated the best way to get off the boat. They were unsure if the hull could continue to withstand the pounding and there was also a fear that the rig could fail and the deck stepped mast come crashing down onboard. The transom had lost its structural integrity and the running backstays had to be resecured to the mainsheet traveller.

92. It was difficult to see what was on the reef astern. Flares were used to illuminate the area. A Jonbuoy[6] was later deployed to see if it would be swept over the reef face and on to the calmer waters of the reef or possibly a lagoon. This proved successful and was followed with one of the two liferafts that was deployed in its canister and connected to the boat by a spinnaker sheet. It was swept over the reef by the waves and a sharp tug on the sheet inflated the raft in the calmer waters. This was achieved by midnight, nearly five hours after the grounding, and the raft was observed by *Alvimedica* who was now on the western side of the reef and in communications on VHF radio.

[6] An inflatable man overboard recovery module fitted with a light.

93. The relentless pounding and motion continued. The boat was continuing to break up and it was a question of whether it would stay together until daylight. About two and a half hours before dawn the bulb broke off the keel and the motion changed as the boat was lifted and bounced around more by the waves. The boat stayed in roughly the same alignment with its head to sea but was being forced back closer to the reef face. This was good news but the moon had set and there was even less light. The second life raft was deployed in the same manner as the first.

94. The stern of the boat was being destroyed (Figure 6) and there was concern that the second liferaft could be lost if it was not released. A lot of gear from the aft watertight compartment, including the anchors and emergency water supplies had already been lost when the compartment was opened to the sea. The spare first aid stores had also been lost from the emergency locker which is forward of the aft watertight compartment, when the bottom of the boat was damaged in that area.

95. Without the bulb the boat began to roll more. There were two particularly heavy rolls with the boat heeling to about 45°. The rig was becoming even less stable with the bulkhead supporting the mainsheet traveller beginning to fail and the running backstays losing tension. The Lithium Ferrophosphate (LFP) batteries were beginning to smoke due to their immersion in salt water and the extraordinary likelihood of a fire became a possibility.

Figure 6 – A telling shot of the damage sustained to the starboard quarter
Credit: Shane Smart/ Volvo Ocean Race

96. The worst outcome was seen as the boat rolling over, the rig breaking and all the crew being swept into the sea with no support close at hand. The crew would have to get clear of the boat,

clamber over the reef face in the dark while being buffeted by breaking waves in order to get to the liferafts. *Alvimedica* was over 2nm away on the western side of the reef. By this stage the stern of the boat, or what was left of it, was nearly hard against the reef face and it would only require a good well-timed jump to be on the reef and relative safety.

97. Shortly before 0300 the decision was made to abandon the yacht – still with about two hours until first light.

Abandoning *Vestas Wind* and the Rescue

98. This action had been thoroughly discussed and planned throughout the night, being frequently amended with the changing circumstances. The crew had gone through the drill at least 15 times. The plan worked well.

99. The skipper was up on the bow watching the waves and looking for a relatively calm set and an opportunity for someone to jump ashore, one at a time. Other crew would be using their torches to illuminate the reefs edge and the best spot to get on to the reef. The 'jumper' would use the line to one of the liferafts as a guide. Tom Johnson, a keen surfer and somewhat used to clambering around rocks and waves was first to go. Once ashore he found the best spot for the others to land and tensioned the line to the boat as best he could. All crew were in survival suits, some wore boots and some shoes and all had leather gloves to protect their hands.

Figure 7 – *Vestas Wind* the day following the grounding with the crew starting the retrieval operation
Credit: Brian Carlin/Team Vestas Wind/Volvo Ocean Race

100. The process continued one crew member at a time, without major incident and the grab bags and other essentials were also passed ashore. The skipper's own departure was the last and a bit more challenging with nobody to call the waves or shine torches on the reef but it was achieved successfully.

101. By 0315, eight hours after the grounding, all nine crew were safe with the liferafts and no injuries other than a few bruises and some minor abrasions. *Vestas Wind* withstood the pounding for nearly eight hours demonstrating the strength of the design and construction. In doing so the boat protected the crew and permitted an orderly departure.

102. Initially the plan was to head for *Alvimedica* and the crew started to walk the liferafts across the relatively shallow water. After about half an hour the water became deeper and the transit more difficult. The crew then came across a rock where they could secure the liferafts and did so to await the local coast guard.

103. *Vestas Wind* was itself lifted over the reef's edge and onto the reef shortly after the crew left the boat – possibly about 0400 – and came to rest in the well photographed position at Figure 7. The next day the crew were amazed by where the boat had moved to from where it was abandoned.

104. At 0536 the crew from the local NCG of Mauritius station arrived at *Alvimedica* and were directed to the rock where the *Vestas Wind* crew were secured. The crew were collected and transported to the Ile du Sud coast guard station and small fishing village to regroup and consider their options.

105. *Alvimedica* left its holding area in the lagoon at 0630 and proceeded to rejoin the race after providing excellent communications support, a rescue option and a great deal of comfort to the crew of *Vestas Wind*.

106. The next two days were spent by the crew retrieving as much as they could from the yacht and minimising any environmental risks. One point of note was that the crew discovered that at least one of the LFP batteries which had been relocated to a beach had burnt and self-destructed. The removal of the batteries from the yacht had been a sensible precaution.

107. On the morning of Tuesday 2 December, the crew started the 20 hour trip in the local supply vessel arriving in Mauritius on Wednesday 3 December.

Emergency Management

108. VOR takes emergency management very seriously as is required in conducting such an extreme event. This is their fifth edition of the race and the company has been involved with a number of emergencies during that time, gaining experience from each one. VOR has a very detailed Crisis Operations Plan that was updated immediately before the race and included the latest contact details. The current Version 8.4 is dated 1 October 2014.

109. A template for a crisis management plan is provided to each team and they have to complete the plan and return it to VOR before the race start. As part of the pre-race program a meeting was held with all teams in Alicante where the plans were discussed and a number of emergency situations considered. The participants included all crews plus representatives from the teams' shore support and sponsors as well as race management. All the people likely to be involved in an actual crisis are engaged and it was a valuable session.

110. The Race Control Centre is well setup to meet any emergency with well-practised standard operating procedures. The centre is equipped to communicate with all necessary participants in an emergency and good relationships are established with the key Marine Rescue Coordination Centres (MRCCs) around the course.

111. *Team Vestas Wind* contained considerable experience and they had a mature crew many of whom had worked together on a number of previous campaigns. The key players knew each other and worked well together as a team. There was a great deal of mutual trust. From the experience of earlier campaigns and the problems that did arise, they took emergency management seriously and had a comprehensive, practical and tested crisis management plan.

112. The split of responsibility was for Race Control to maintain communications with the boat and coordinate activities with external agencies such as the MRCCs. The team's Support Manager was responsible for keeping the families and sponsors informed of developments as well as coordinating any logistical planning to support the boat. These are all challenging and demanding roles that were very capably filled by Neil Cox. He is the type of person you would like to have on hand in an emergency.

113. The comprehensive communications network performed well. The primary systems remained in place for at least the first two hours. All the people who needed to know, did know very quickly and there was a clear picture of what had happened and where. There was no search in 'Search and Rescue'. The Crisis Management Team at Race Control convened quickly and took charge.

114. Neil Cox established a busy cycle of calls to keep all the crews' families informed and updated with factual information as it came to hand. He knew a few of the families from previous campaigns and this was a help. At the same time he was keeping the sponsor informed and had direct access with the skipper on the boat and Knut Frostad, the CEO of VOR and Chair of the Crisis Management Team. With his spare time he was looking at the logistics needed for the rescue and salvage in such a remote part of the world, about 230nm from the nearest main centre at Port Louis, Mauritius.

115. There was some confusion about the NCG of Mauritius with Race Control talking to the Headquarters at Port Louis and the boat's crew speaking to a very small and remote coast guard outpost on the Ile du Sud. Initially not everybody had the same information and possibly different perceptions of what support the outpost could provide. This was resolved fairly quickly and did not hamper the rescue in any way.

116. When the boat lost all power, nearly three hours after the grounding, the backup communications using handheld satphones came into use and worked well. Sensible schedules were established to preserve batteries in the handhelds while also maintaining the vital link and moral support to those on the boat. When *Alvimedica* arrived at the shoals about midnight they provided a valuable communications link through the VHF radios, a first-hand observation of the situation and direct support should it be required.

117. The Emergency Management functioned well.

Experience of Other Yachts in the Cargados Carajos Shoals Area

118. All boats had the same notice regarding the amended exclusion zone and the change to the permitted racing area. Even though some boats had very comprehensive support for the navigator with meteorologists and other navigators, they had little opportunity to put these resources to work and to review the change. The boats had to rely on their own planning and the equipment and data that they had onboard.

119. Most boats became aware of the danger presented by the Cargados Carajos Shoals through their use of the supplied electronic charts and navigation software systems. Most navigators said they were alerted to the danger by the 'chart bounds' or 'caution areas and limits' overlays on the Expedition software or the blue colouring of the shoals. This triggered a further investigation and they were then generally surprised to find the detail at the higher levels of zoom with reefs, islands and many dangers to navigation that were not marked at all on the smaller scales.

120. One navigator was alerted by reading the US Sailing Directions[7] that he carried onboard as a PDF document.

121. Those boats passing the shoals in daylight said they provided little visual warning. The dangers had little elevation and were only able to be observed at close range – within a few miles. *SCA* was the only boat to pass the shoals to the east. They were aware the general area was poorly surveyed and of the hazard presented by the shoals and allowed a wide berth passing over five miles from the reef.

[7] Sailing Directions is a 42-volume American navigation publication published by the National Geospatial-Intelligence Agency (NGA). Sailing Directions consists of 37 Enroute volumes, 4 Planning Guide volumes, and 1 volume combining both types. Planning Guides describe general features of ocean basins and country-specific information such as firing areas, pilotage requirements, regulations, search and rescue information, ship reporting systems, and time zones, to name a few; Enroutes describe features of coastlines, ports, and harbors.

ANALYSIS and FINDINGS

Why did *Vestas Wind* run aground

The Reason Why

122. The simple cause of the stranding was that the crew was completely unaware of the presence of any navigational danger in the vicinity of the boat. Consequently no avoiding actions or precautions were taken that would have prevented the grounding. The Cargados Carajos Shoals were incorrectly thought to be safe to pass over and incorrectly thought to have a minimum charted depth of 40m.

123. Contributing factors were:

- deficient use of electronic charts and other navigational data and a failure to identify the potential danger, and
- deficient cartography in presenting the navigational dangers on small and medium scale (or zoomed out) views on the electronic chart system in use.

124. The failure to identify the danger had a very significant consequence in this event. The VO65 is a powerful ocean racing boat that is being sailed close to its limits, in an extreme race with a relatively small crew. In managing this complex arrangement a single error can have a multiple and catastrophic impact in the organisation of the scarce available resources and the best use of the equipment available in the boat.

125. As in most accidents there were a number of other factors which did not directly cause the incident but they did influence the environment in which it occurred. These include:

- the late formation of *Team Vestas Wind*,
- a short preparation time at Cape Town for the next leg,
- a hectic last few days of program pre-race at Cape Town,
- a late change to the SI with an amendment to the exclusion zone and the permitted racing area,
- the position and timing of the tropical depression,
- a taxing routine for the skipper and navigator during the race, and
- no access to planning support after the start.

126. The Report Team is of the view that these factors are an integral part of the race and make up its character as 'Life at the Extreme'. All but one is common for all boats in the Volvo Race and did not create a unique situation for *Vestas Wind*. The remaining factor was an informed decision and a risk to its competitiveness that was accepted by *Team Vestas Wind*. At no time did the crew believe that their short preparation time decreased their safety. They had high levels of confidence

regarding the experience within the team and in the boat. The risk was considered to be their competitiveness due to their initial unfamiliarity in how to race the boat.

General Navigation

127. The most significant mistake in the navigation of the boat was the failure to be alerted to the hazards at the Cargados Carajos Shoals. The triggers were available in *Vestas Wind* but were overlooked in planning the boat's track and monitoring its safe navigation. Some were relatively clear but were missed. Others were available but were limited in their effectiveness. They could only provide a warning if a danger was anticipated and the navigation aids were being operated and closely monitored.

128. Areas of the western part of the Indian Ocean are known to be poorly surveyed and heavily reliant on old surveys dating back to the nineteenth century and the use of leadlines. There is a likelihood of chart anomalies and even undetected isolated dangers. There is also a known weakness in some forms of electronic charts in the digitising of data and the possible omission of dangers. These combine to require access to as much additional information as is practicable to consult in planning a passage in this area.

129. Safe navigation depends upon continually checking different sources of information and, if they do not agree, finding out why. In a harbour this can be a simple check that what you are seeing with your eyes confirms what is displayed on a chartplotter. There is always a risk if the navigator relies on a single source of data. In preparing major passages most electronic chart presentations should be checked against the paper charts and the Sailing Directions. Unfortunately, the attractive presentation of electronic data creates a misplaced air of confidence in the accuracy of what is presented. There can be a false sense of security and a belief that further checks are not necessary. This can be a mistake.

130. Producers of electronic charts and navigation software systems provide cautions about the use of their products. As an example, Jeppesen, the manufacturer of C-Map, has the following warning as part of the Jeppesen Data License Agreement:

> "UNLESS OTHERWISE SPECIFIED BY NATIONAL MARITIME AUTHORITIES, THE DATA LICENSED HEREUNDER IS INADEQUATE AS A PRIMARY MEANS OF NAVIGATION, AND SHOULD BE USED ONLY AS A SUPPLEMENT TO OFFICIAL GOVERNMENT CHARTS AND TRADITIONAL NAVIGATION METHOD"

131. Some people dismiss these warnings as 'the Lawyer's page' and what is necessary in today's litigious society. This may have some validity but it is stated very clearly and the manufacturers of private electronic chart and navigation systems stand by the statements and use them to protect their interests.

132. The best source of additional information is paper charts with a proven record of the generalisation of dangers between different scales. In particular mid-scale charts are extremely useful for passage planning especially when used in conjunction with Sailing Directions. This

demonstrates good seamanship, good navigation and follows the advice of the manufacturers, to identify any dangers and ensure that they are displayed on the electronic navigation systems. The route planning software usually allows the dangers to be noted as 'race notes' or 'pins' or 'marks' that show through on all levels of zoom and draw attention to the danger.

133. Both the Sailing Directions and the Pilot Books[8] provided warnings of the dangers at Cargados Carajos Shoals. They are described as an extensive group of reefs, islets and shoals. The east side is reported to be most dangerous to approach under any circumstances. Some of this information is dated and superseded by the latest chart (IN 5203). However, the advice is cautious and clearly advises the mariner of the danger and the need to avoid the area or obtain later and more detailed data.

134. The boats also have other sensors and equipment that include the multi-functional display, depth sounder, radar, and visual lookout that could indicate the danger. These aids, however, provide an inner layer of defence and are not continuously monitored and their warning can be easily missed – especially in a short crewed, high speed racing boat. They provide protective mechanisms to ensure a boat's safety when the danger has been recognised. If the alarm is un-alerted it is usually too late or with too little directional guidance to identify a safe route for a sailboat traveling at 20 knots.

The Quality of Hydrographic Survey

135. The quality of the survey of the Cargados Carajos Shoals was good. The survey was recent, 2008 to 2010, and conducted to an appropriate zone of confidence (ZOC) B[9] standard by the Indian Hydrographic Office (HO). The initial new edition chart (IN 2503) was published on 14 August 2011, there was a further edition on 31 March 2012 leading to the current edition on 25 March 2014. The rapid series of editions would probably reflect the charts being published as new blocks of assessed survey became available. The scale of the chart, IN 2503, is 1:75,000 providing a detailed chart of the area.

136. The Indian HO has responsibility for the area and the appropriate practice is to use the latest and best quality survey available. The Indian chart should have been used for the C-Map product subject to the necessary licensing agreement being in place. Based on the source data information on the Expedition system, the C-Map largest scale data would appear to be derived from the IN 2503

[8] The UK Hydrographic Office version of the US Sailing Directions with 74 volumes providing world-wide coverage

[9] ZOC B - Position accuracy +/- 50m, depth accuracy 1m +/- 2% of depth, full area search not achieved, uncharted features hazardous to surface navigation not expected but may exist

paper chart. While the Sailing Directions for the shoals indicated that it might have been inaccurately shown on charts, it was in fact accurately geo-referenced.

137. The broader area in the vicinity of Mauritius is the responsibility of the South African Naval HO. Much of the ocean area in the vicinity of Cargados Carajos Shoals is based on earlier British and French charts and the current official ENCs have a ZOC grading of D[10]. Importantly ZOC D is based on poor quality data or data that cannot be quality assessed due to the lack of information and large depth anomalies may be expected. The seabed topography is very interesting and extreme with depths of 4,000m rising rapidly to small islands and seamounts with several shoals and trenches in an arc of features from Ile de La Reunion to the Seychelles. The area presents as one where caution should be exercised.

Figure 8 – A collage of official paper chart presentations of the Cargardos Carajos Shoals – From top left hand corner clockwise 1:45 Million (UKHO 4000); 1:20M (UKHO 4005); 1:10M (UKHO 4070); 1:3.5M (UKHO 4702)

[10] ZOC D is position accuracy worse than +/- 500m, depth accuracy worse than 2m + 5% of the depth, full area search not achieved, large depth anomalies may be expected

138. The true position and charting of the reef did not contribute to the grounding of *Vestas Wind*. Although the Cargados Carajos Shoals are well surveyed, the general area and caution on the C-Map product should have required referral to the paper charts and Sailing Directions. The paper charts would not have to be used for plotting and laying out tracks in order to have helped the crew avoid the grounding. They would simply need to have been viewed to identify dangers in the vicinity of prospective tracks. On paper charts of every scale that cover the area the hazard was clear (Figure 8).

Passage planning

139. The navigator was very experienced and prepared for the leg by doing a large amount of pre-planning during the previous stopover. He identified areas of navigation significance and prepared detailed files with additional information including notes from reviewing the paper charts, tidal and current data and satellite images from Google Earth.

140. Roger Badham, a renowned and well-respected meteorologist, had previously prepared a roadbook for the *Camper* campaign that mainly covered the meteorological aspects of the planning but also included extracts from the Sailing Directions. Roger was engaged to update this reference document and did so through a series of emails, Skype and phone calls. Of note, the Sailing Direction extracts related to the 2011-2012 course and the original East African Exclusion Zone that did not include the Cargados Carajos Shoals in the permitted race area.

141. This level of shore support for the navigation planning was less than the other boats. Most boats had both a meteorologist and a very experienced navigator to assist in the pre-planning and they spent as many as six days working closely with the skipper and navigator in the departure port immediately prior to a leg. In the strict one-design racing this was one area that some identified as providing a race advantage and some teams chose to make the investment. One team estimated that the pre-departure navigation specialist added $250,000 to the budget of the team.

142. *Vestas Wind* had a large resource of paper charts from the *Camper* campaign in the previous VOR. These were consulted as part of the passage planning and some additional charts were obtained. From these a folio of about 21 charts was selected to take on the leg. The paper charts were carried to permit the boat to “continue to sail competitively” in the event of a complete failure of the navigation systems and to facilitate a port diversion on the leg should it be necessary.

143. Normally, satellite images from Google Earth were used to check a passage for dangers but this was not available when racing as there was no Internet access and Google Earth data was not loaded onto the computers before the race to allow off-line access during the race.

144. The navigator received advice about the change to the East African Exclusion Zone late on the 18 November, about 2100, the night before the start. He plotted it on his personal laptop and was not alarmed by the change or its consequences. He was more concerned with the immediate strong wind forecast and conditions for the start and the first days of the race. The navigator did, however, note the Cargados Carajos Shoals were now part of the permitted racing area and as

displayed on Expedition (Figure 9) using the world map chart, the minimum depth was about 40m. He did not have detailed charts installed on his personal computer and so could not see either the reef or that the 'chart bounds'[11] feature to indicate large scale cartography was available for Cargados Carajos Shoals.

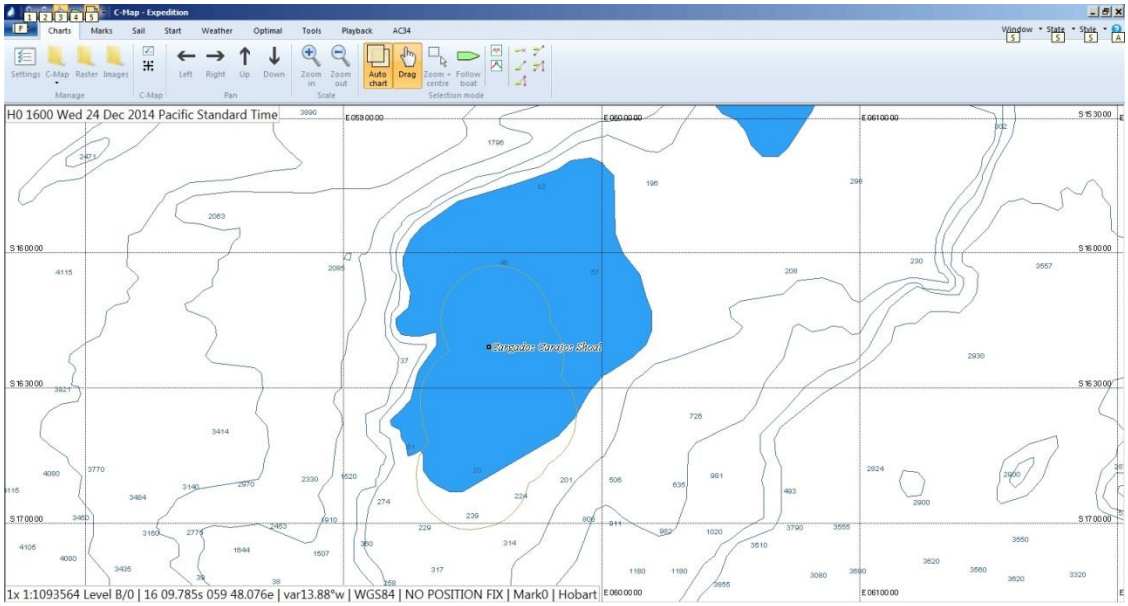

Figure 9 –- World Map Coverage in C-Map of Cargados Carajos Shoals – what was presented on Adrena and Expedition without the detailed C-Map dongle – the presentation the navigator had on his personal computer

145. After the start he reviewed the amended exclusion zone and permitted racing area more closely and was aware the boat may pass in the vicinity of the Cargados Carajos Shoals. He did zoom in and investigate part of the shoals on the navigation/performance computer using the Expedition system without zooming in far enough to see the detailed large scale chart that includes a clear presentation of the reef (Figure 10). He went through this process several times and once when both he and the skipper were at the navigation station reviewing the weather and their track options. Reviewing weather and routing would normally be done on the weather/routing computer which did not have detailed charts installed and so the dangers of the Cargados Carajos Shoals would not have been visible.

[11] 'Chart Bounds' on Expedition, 'Chart Contours' on Adrena and 'Chart Outlines' on Deckman all provide the same feature. They are polygons that define the area where more detailed survey and charts are provided. The bounds have small tics extending towards the area of larger scale data. The navigator can display the feature or switch it off. More details at paragraph 194

146. The navigator stated that he used the 'chart bounds' display feature on the Expedition system as there were not many charts along the route and they did not clutter the screen. This is confirmed by photos taken onboard the boat shortly after the grounding. This feature is known to experienced navigators as a trigger that a larger scale chart is available and there are potential dangers worth investigating. Unfortunately this did not alert the navigator to the fact that there was large scale detailed chart data available covering the Cargados Carajos Shoals and he did not zoom in and so gain access to the large scale chart of the dangers.

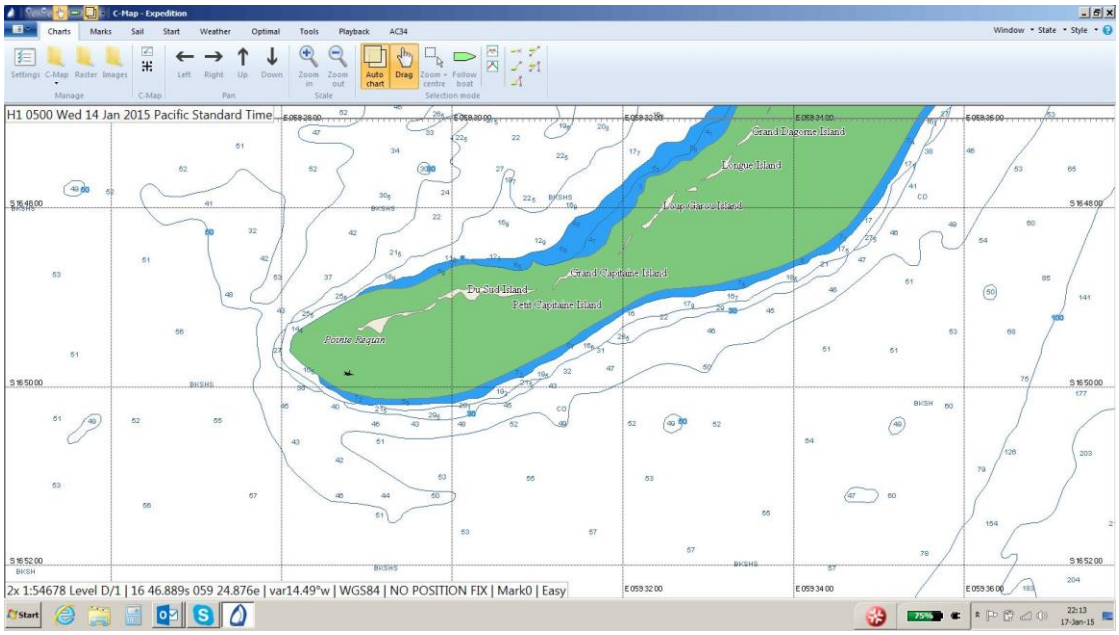

Figure 10 – Part of the large scale chart available at Level D/1 on Expedition/C-Map – but was not available without the detailed charts installed

147. The navigator did not use the paper charts carried onboard to check for any dangers that were not apparent on the electronic chart systems. He did not have access to the US Sailing Directions or Pilots other than the extracts in the roadbook prepared by Roger Badham that did not cover the Cargados Carajos Shoals. From the navigator's several investigations, the Shoals were assumed to be a sea mount with a minimum charted depth of "40m or 42m" and another charted depth of "80m".

148. During the watch before the grounding the skipper also checked the chart and did not note anything less than "40m or 42m" which related to what he was previously briefed by the navigator. The skipper carried out this check of the chart by viewing what was being displayed on the routing laptop with the Adrena software that did not have the detailed C-Map chart data.

Figure 11 – A magnification of World Map Coverage in C-Map of Cargados Carajos Shoals that was embedded in the Expedition and Adrena systems

149. Figure 11 shows the C-Map Max chart as displayed on Expedition at about the 1:1.09M scale, on the World Map Coverage without the detailed C-Map dongle. The same presentation is available at Zoom Level B/0 with the detailed dongle and has the option of enabling 'chart bounds'. Close examination reveals five charted spot depths at the Cargados Carajos Shoals. Clockwise from the south, they are 20m, 51m, 46m, 82m and 57m. The faint circles are the arcs marking a cautionary area that defines the Territorial Seas surrounding the Mauritian Islands that are part of the shoals. These arcs provide a clue of the navigational danger in that they are based on a land boundary but they are faint and easily missed and can be confused with the depth contour lines.

150. At Figure 11 and as displayed on Levels A, B and most of C of the C-Map chart system, there is no indication of any islands, reefs, drying dangers or any depth of water less than 20m. The 20m depth was also significantly less than the '40m' mentioned by the skipper and navigator and, if detected, might have raised the level of concern in transiting the area. The 46m depth is the most prominent in its central position. The lack of contrast between the black charted depths and the mid-blue colour fill tends to blend the charted depths in the background and they do not stand out. Also without magnification, those close to the 200m contour line blur with that feature and are not easily distinguished, particularly the 51m and 20m depths.

151. After the boat gybed to port to open from the depression, the sea and swell conditions were moderate and not likely to produce dangerous seas over the expected seamount. The navigator and skipper were willing to sail over the 40m depth that they mistakenly believed to be the minimum depth of the Cargados Carajos Shoals.

152. The assessment that *Vestas Wind* could sail safely over the Cargados Carajos Shoals was a mistake as was the failure to consult the paper charts available and the Sailing Directions or Pilot Book. These mistakes had significant consequences.

Multi-Functional Display

153. The 6.4 inch Zeus touch screen multi-functional display (MFD) was used in the boat to control electric systems and lights, display the radar and AIS pictures and also could be used as a chartplotter. The latter was not used for navigation and only contained the standard world coverage chart fitted to the off-the-shelf product. The boats have two MFDs, one at the navigation station (Figure 3) and the other fitted on the 'tunnel' just inside the main hatches from the cockpit (Figure 12). The second display can be accessed by the crew on deck and swivels so that it can be viewed from either the port or starboard hatch.

Figure 12 - Photo of the 'tunnel' MFD just inside the cabin available to crew on deck
Credit: Photo by Chuck Hawley

154. The chartplotter default world-coverage map does include a depiction of the Cargados Carajos Shoals. When the navigator awoke after the grounding he went to the nav station and could clearly see the reef on the MFD and the boat next to it. This was possibly his first indication of what had happened.

155. The main use of the MFD was for AIS in shipping lanes and also to monitor other race yachts when in range. The typical AIS range was about 12nm and the MFD would be set at a range where all AIS contacts would be seen at 15nm. This means that if the MFD was set to display the chartplotter, possibly with AIS and radar overlays, it could have provided 45 minutes to an hour's warning of the reef being on the track ahead. This would have to be observed to be of any use; but was not. Radar was not in use: there was no shipping in the area and no other yachts in AIS range. The 'tunnel' MFD could have last been used to switch on the navigation lights and remained on that page. The navigation station was unattended and even though the reef was possibly being displayed it was unobserved.

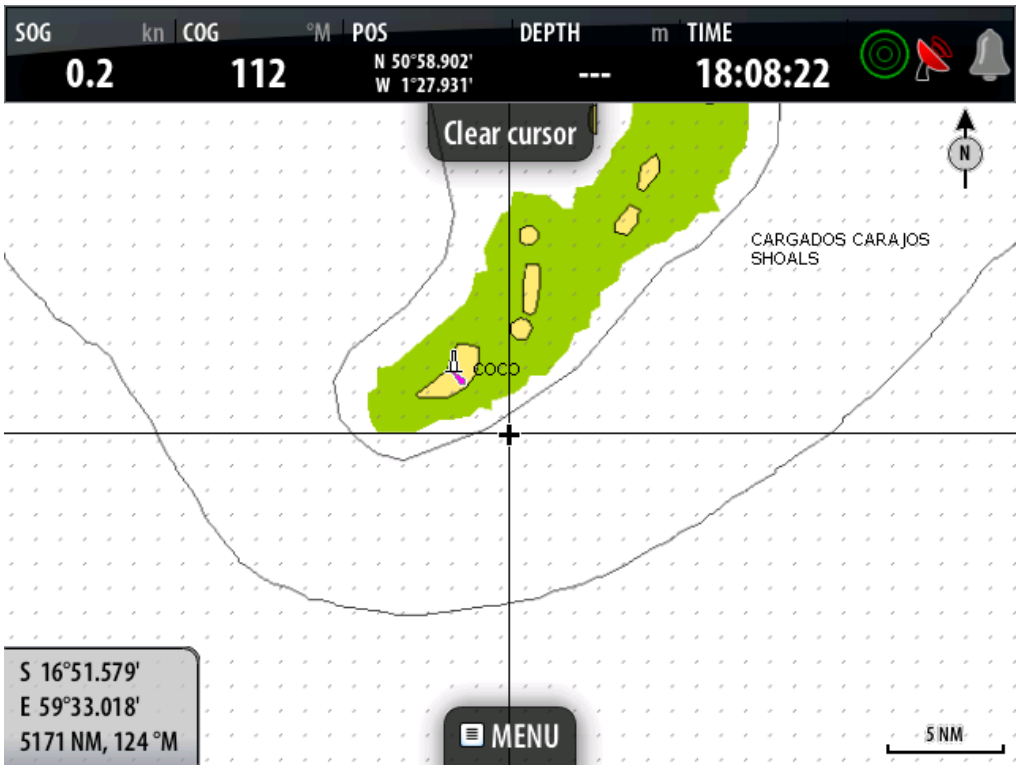

Figure 13 – Screenshot from the B&G Zeus 7 MFD – Showing the base chart presentation of the Cargados Carajos Shoals – scale bottom right hand corner

156. With a watch on deck of three plus one, the crew is very busy sailing the boat. This is especially true when three sail reaching in the vicinity of heavy showers and the need to put reefs in and out of the main. The 'tunnel' MFD is awkward to observe from the cockpit and requires a crew member to purposefully put his head into the cabin to sight the display.

157. Since there was no expected danger, the non-observance of the danger on either chartplotter is understandable and considered reasonable.

Radar

158. The radar was used infrequently and mainly to monitor squalls when initiated by the navigator or, by the skipper or watch captain, when the navigator was asleep. *Vestas Wind* was fitted with a B&G 4G Broadband radar that was displayed on the MFDs. As discussed in regard to the chartplotter, the 'tunnel' display was not easily visible.

159. The radar was not generally used for navigation. It is a FMCW radar with high resolution and relatively short range compared to the pulse radars common in the past. If it was operating, the expected detection range of the breaking reef from seaward would be in the order of 3nm or 4nm. Again it is possible that some warning could have been provided but only if it was operating and if it was observed.

160. In the prevailing circumstances the decision not to use the radar is considered reasonable.

Depth soundings

161. In some circumstances the monitoring of the depth sounder is prudent but again it depends upon there being an expectation of danger and the suitability of the sounder. Monitoring soundings can present a challenge on a VOR yacht when passing through very large areas of poorly surveyed water and sailing with a small crew and a limited number of instrument displays. Depth sounders used to be an integral part of a boat's navigation but less so these days with GPS and other aids and systems that are available. Today's depth sounders are relatively simple with a single high frequency transducer. They are not as capable of measuring deep soundings as earlier models that had higher power and lower frequency transducers.

162. Modern race boats, such as the VO 65, generally only use the sounder for in-shore races, for short-tacking along coastlines, and in harbour to ensure there is sufficient water to berth. The transducer is fitted as far forward as necessary to avoid getting an echo from the bulb when the bulb is on centreline. This forward location exacerbates the problem of the sounder becoming non-functional due to aeration in the water under the sensor.

163. The sounders suffer from aeration when the boat is sailing fast; typically speeds above 14 knots cause the depth readings to be lost. Also, in deep oceanic waters there can be false soundings

occasioned by thermoclines[12]. There is a tendency with depth sounders like the one used on the VOR boats to often read shallow depths when they are 'off-soundings', when operating in depths too deep to read. At other times there are even false returns from the bulb in spite of the transducer's forward mounting location. This makes setting up a depth alarm impractical because the many false alarms generally result in crews turning off the alarms, when no dangers are expected, so as not to be a nuisance.

164. Monitoring of soundings can still be of value when there is a risk of shallower waters, close to known navigational dangers. The most effective watch is to caution the crew on deck of the minimum sounding expected and the action to be taken should the depth of water be less. There is a need to be careful not to overdo this as the crew on deck are busy with many things to watch and monitor. If the crew are asked to monitor depths unnecessarily the precaution will be unlikely to be effective when it is needed.

165. While the ability of depth sounder is limited to assist navigation in these circumstances the navigation systems can be of help. Adrena and other programs provide a depth alarm that is based on the charted depths within a defined arc along the boat's current course and within a specified time or distance limit. Adrena advises that these features are available even on the World Map Coverage embedded in the system but this alarm, although available, was not used onboard *Vestas Wind*.

166. The charts reveal a shelving of the seabed on the approach to the Cargados Carajos Shoals from the southeast. The 40m contour is represented as being about 0.5nm from the edge of the reef. If the depth sounder was providing depths and was being monitored an alarm could have been raised and provided a warning of one or two minutes prior to the grounding.

167. Noting that *Vestas Wind* was approaching a seamount in an area of poor survey it is arguable that a watch of the depth sounder should have been required but in the sailing conditions is unlikely to have been effective. No direction was provided to the watch on deck nor did the navigator think it significant enough to be awake and monitor. No alarm was set on the Adrena system. Again the decisions regarding soundings and alarms taken onboard *Vestas Wind* are understandable in the context of the incorrect determination that the minimum charted depth was 40m and not a danger to the boat. The Adrena alarm, however, would have been a useful safety net in the prevailing circumstances.

[12] An abrupt temperature gradient in a body of water, marked by a layer above and below which the water is at different temperatures. This prevents mixing between the surface waters and those beneath the thermocline which can reflect sound waves and produce false depths on depth sounders.

Visual lookout

168. A visual lookout provided the last line of defence but was reduced in effectiveness at night. There was a half-moon high in the sky and behind the boat that might have assisted but it was covered at times by clouds. Reportedly only streaks of moonlight came through the clouds and these confused what was being observed on the sea surface.

169. Those on deck did sight a disturbance in the water at quite close range. It was considered to be associated with the expected seamount and thought to be a possible tideline that the more experienced crew had encountered many times before. The video of the incident shows those on deck peering over the port bow at the disturbance and it was only about 23 seconds before the grounding. There was very little time to react to the unanticipated danger.

170. The mistaken briefing of the crew to expect to sail over a 40m seamount and to expect disturbed seas compounded the problem. The crew was not alarmed by what they saw and took no last minute avoiding action. The only option available to the helmsman would have been to crash gybe and steer away from the reef. Even this would have been difficult with no idea of the extent of the danger and the direction in which it lay. The decision threshold for an emergency manoeuvre such as a crash gybe is high.

171. A planned gybe needs about 5 minutes of preparation to get additional crewmen on deck, and 30 minutes to final completion with the need to rearrange the stacked stores. A crash gybe risks shredding the FR0, breaking the battens in the main and in some circumstances, with high winds, breaking the rig. Also if the keel is left on the wrong side, the boat can end up on its beam's end and out of control. The manoeuvre has the possibility of being very messy. Unless the helmsman is extremely certain of an imminent danger, such as sighting a ship at very close range, he is unlikely to risk the potential damage.

172. In the circumstances that evening the decision threshold was not reached and the reactions of the crew are considered reasonable.

The boat's organisation

173. The way *Vestas Wind* was sailed in the race is discussed at paragraphs 55-59. Although there were other variations within the fleet, the setup onboard *Vestas Wind* was fairly conventional and well accepted. A possible weak link was the relationship and interdependency between the skipper and navigator that was not well developed and is critical with the small crew of eight sailing a 65 footer as a fully crewed boat.

174. Once the boats were racing, the routine of both the skipper and navigator were very demanding with typical estimates of only five to six broken hours of sleep for each of them each day. They were the first call to assist in any sail changes on deck. The skipper has to remain alert to every change and ensure the right decisions are made in the boat. He is torn between helping on deck to

reduce the burden on the on-deck crew and working with the navigator to make difficult weather and routing decisions.

175. The navigator was tied to a strict routine of weather data with position reports and forecast data available every six hours. The weather and its impact on the race strategy had to be analysed and monitored. The navigator and the skipper needed to consult and discuss the options. Sleep deprivation was cumulative and they got progressively tireder throughout the leg.

176. The skipper had a tendency to being on deck when fulfilling his role opposite the navigator. Similarly the navigator probably had a tendency to migrate to the nav station when he was in the counter position. This means that it is likely that there was a reduced amount of attention to the boat's navigation in the three-hour period leading up to the grounding when the navigator was asleep. During this period *Vestas Wind* would have covered about 50nm. This was a long sleep for the navigator who normally gained his rest through power naps of about 45 minutes.

177. Once again in the situation of no expected danger and the busy preceding day, a long break for the navigator is considered reasonable.

Electronic Charts and Navigation Software Systems

The types of Electronic Charts

178. The term 'electronic chart' is generic and could refer to any chart in one of several electronic formats made by either a national HO or a commercial company. Of the electronic charts there are two types of format: 'raster' and 'vector'. Raster is relatively old technology that is being phased out by some HO and provides a scanned image of an official paper chart with exactly the same information as the paper chart. These charts require a lot of storage and the zoom in and out either magnifies or reduces the size of the fonts and features without providing more or less data.

179. Vector charts provide a digital data format in which the charts are provided in a more schematic manner. The screen presents less information about land and other features and as you zoom in and out the information changes. As you zoom in more depths and details are displayed. Often as the scale of the display is adjusted the chart appearance changes smoothly and appears seamless. They present the data in a more user-friendly manner and most systems provide the ability for the mariner to manipulate the data to customise the display to what the navigator requires.

180. Of the vector charts there are two different groupings: 'official' and 'private'. The official vector charts have a specific name of Electronic Navigation Chart (ENC) and are produced by the national HOs around the world under the auspices of International Hydrographic Organisation (IHO). They are subject to very strict IHO standards and the quality and integrity of the data is guaranteed by a warranty. The primary customers are commercial shipping of the world and naval forces.

181. The private editions come under several names for the same product and include ‘unofficial’ and ‘private electronic editions’. They are produced by private companies who are licensed to reproduce contents from the official paper charts, provided by government HOs, for use in chart plotters. The main market is an affordable product for the world’s fleets of recreational boats. The chart information is digitised and prioritised to be placed into the vector format in several overlapping levels each with a different amount of detail corresponding to a different range of scales. These are very challenging and important processes that involve dealing with vast amounts of data.

182. The private companies also draw on other sources of data where paper charts are either not available or are known to be inaccurate. Other sources include privately created charts, aerial and satellite imagery, Coast Pilots, digital databases of depth information, and private surveys. Generally these additions fill in areas that are popular for recreational boaters but not important for commercial shipping. As discussed at paragraphs 130-131 private charts are accompanied by cautions and not considered suitable for navigation without reference to official navigation products from the HOs. There are no commonly agreed standards for the transfer, prioritisation and display of data between the various commercial products.

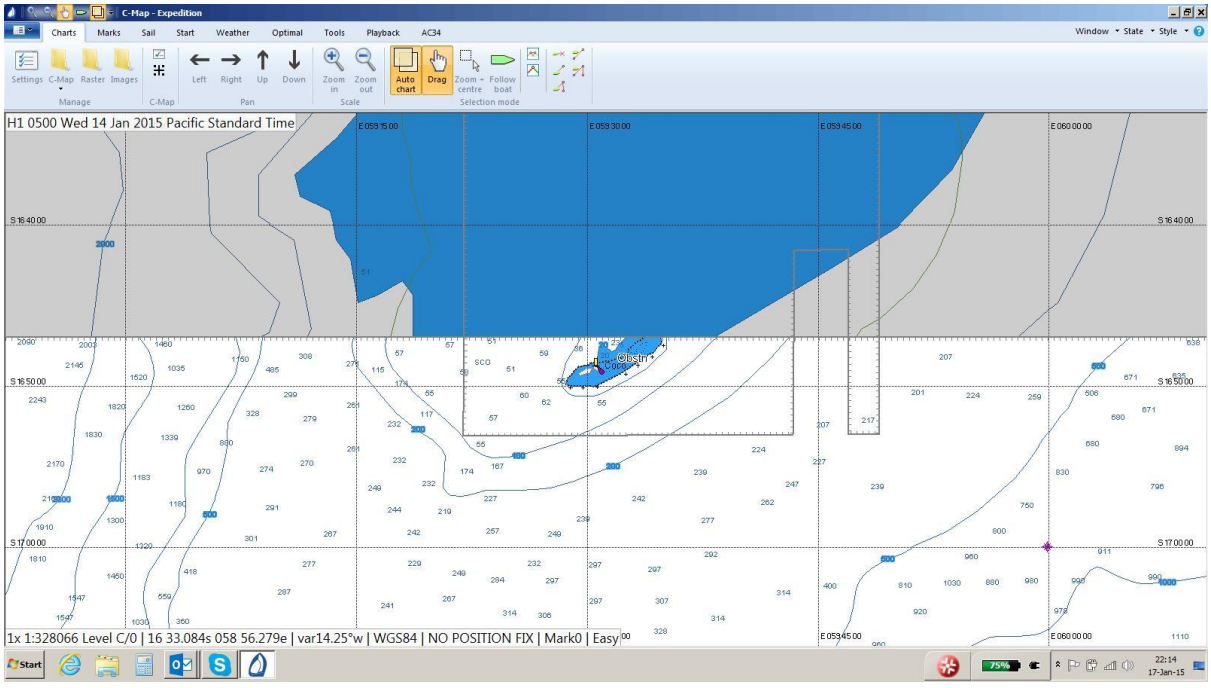

Figure 14 – Southern tip of Cargados Carajos Shoals – showing the chart by chart display on C-Map/Expedition at Level C/0 Scale1: 328,066 and displaying a small segment of the larger scale chart

183. Private chart suppliers attempt to faithfully capture all of the information that is present on the official source charts. C-Map's practice is to 'tile' adjacent charts together to give a seamed chart presentation that has 100% coverage. The private edition suppliers control how cluttered or sparse the information presented to the user is by providing several layers of charts to the hardware or software providers. Each layer[13] covers a range of scales and with different levels of detail – small scales, large area, less detail – large scales, small area, more detail. A user may be able to zoom in once or twice or more, on a single layer or level, but the information shown is simply diluted in density and covers a smaller area.

184. As the electronic chart displays are 'zoomed in', digitized versions of larger scale source charts are shown on the display. In many cases large and small scale chart data are shown simultaneously in adjacent tiles which make visible the different cartographic standards on the two charts, as well as different densities of information. See Figure 14. An interesting point from this figure is that there is no indication of the northern part of the reef even though it is apparent on every paper chart that the report team has seen; at every scale.

185. Chart display software systems allow the user to select various layers of data to overlay. The user can also de-select certain sets of data to simplify the presentation of especially dense charts. Unimportant features may be eliminated in favour of navigationally important ones, such as navigation aids, reefs, shorelines, traffic schemes and prohibited areas.

186. Land features may also be simplified to reduce apparent complexity at the smaller scale/ larger area presentations, to allow the navigator to focus on the important features. This is normally done by the chart vendor – the cartographer. The translation from a paper chart that may be close to 1m² in size to a small display that is 20cm across and which has far less resolution does present problems. As part of general navigation and passage planning, charts are often viewed on electronic displays at a small scale so that the "big picture" is seen. Due to the lack of resolution and area of the smaller displays, the cartographer must make decisions to eliminate details that are not deemed as important. This is referred to as prioritisation.

[13] The C-Map chart layers are given an alpha designation: W-Z for the "World Map" and A-D for the increasingly larger scale data. In the Cargados Carajos Shoals area Zoom Level A would be the first level of more detailed charts after the World Map, about 1:3.3M or so. Zoom Level B would be the next layer of charts, perhaps 1:1.1M or so. Since some of these differences in scale are large (3:1 in some instances), intermediate levels of scale are given numeric designations e.g. A/1, and B/1. These are mere magnifications of the A/0 or B/0 scales (in these cases) and do not contain additional data. In fact, the content is diluted due to the magnification of the original chart.

The supporting Navigation Systems

187. The chart system provided to the VOR boats is a private edition, vector chart produced by C-Map. The boats are also provided with three navigation software systems – Expedition, Adrena and Deckman. These systems provide the functions of a chartplotter, display of advanced weather presentations, weather routing, tactical sailing programs, performance analysis and instrument calibration. Individual skippers and navigators have their preferences for different systems for different tasks. All three navigation systems use C-Map and all are embedded with a C-Map default World Map Coverage with little detail.

188. *Vestas Wind* had a single Deckman/C-Map dongle that was licensed to enable the use of detailed C-Map charts for the entire VOR course. This could be used on either of the boat's two laptops, but only one at a time. This dongle that permitted use of the detailed chart data was sensibly fitted to the performance and navigation computer that was running Expedition and was used for detailed navigation.

189. Expedition and Adrena were the two prime systems for navigation, routing and performance analysis within the boat. Deckman was mainly used for the management of the B&G WTP3 computer processing unit. Expedition and Adrena are both produced by small businesses, with excellent pedigrees in yacht racing. They are popular among the top racing yachts in the world but this is a relatively small market. Both products provide a powerful set of tools to the navigator and skipper to analyse the current situation, decide the best routing option and assess their performance in the actual conditions.

190. For navigation the two systems provide many valuable tools for the navigator to optimise the display of data and customise what appears on their screen. They are also able to insert 'race notes', 'danger circles' or 'marks' to highlight dangers and allow the navigator to incorporate information from other sources, such as paper charts and Sailing Directions. The systems have the ability to set alarms for navigation dangers and the avoidance of collision with other vessels. Adrena is commonly used by single-handed ocean racers and has a very comprehensive set of alarm options based on charted depths and hazards on the vessel's heading, some of which were available with the embedded World Map Coverage.

What was presented at the Cargados Carajos Shoals

191. In the specific instance of Cargados Carajos shoals, the C-Map presentation inexplicably omits the reef shoreline, drying areas, and land features at multiple chart scales. Using the scales according to Expedition software, the reef is not shown at Levels A or B or any magnifications of those scales and also Level C except for a glimpse of the reef at the southern tip of the shoals (Figure 14). What is shown instead is a large blue area corresponding to depths 200m or less, five spot charted depths, the name of the shoals and an economic zone corresponding to a 12 mile boundary around the actual landmass of the shoals. However, no land or reef is apparent. The land and reef are apparent on all scales of official paper charts reviewed by the report team (Figures 8 and 15).

192. This is no minor omission. It is not a small isolated danger. The north to south extent of the dangers and off-lying islands, between Albatross Island in the north and Coco Island in the south is about 36nm. The east to west spread is about 15nm creating a total area of over 500nm². The length of the eastern side of the reef edge is more than 35nm. The Cargados Carajos Shoals have been well known to mariners for many years and appear on charts dating back to the 17th Century.

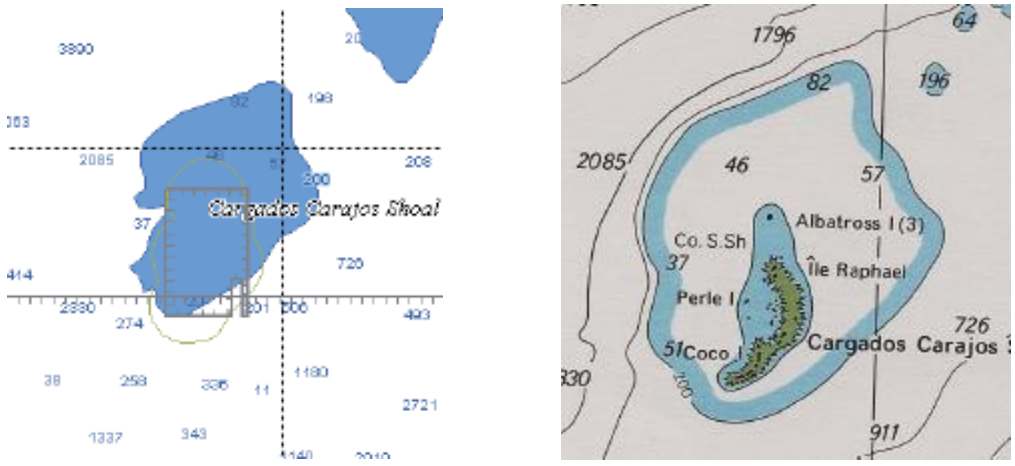

Figure 15 – A comparison between the detail shown on Expedition/C-Map Level A/0 1:3.3 million and UKHO Chart 4702 Chagos to Madagascar 1: 3.5 million

193. According to the navigator and the skipper, they looked at the area surrounding Cargados Carajos Shoals several times over the preceding days, and never comprehended that it was a source of danger other than the sea state might be worse due to the rapidly changing water depth. The lack of an apparent landmass at the scales at which they observed the chart (Figures 9 and 11) lulled them into a false sense of security. Following careful consideration of what they observed, it would be reasonable to conclude that the minimum depth of water across the shoals was 20m in the southern portion even though it was assessed at the time by the navigator and skipper as 40m.

194. One of the features available on C-Map electronic charts is 'chart bounds', which can be enabled or disabled. These are polygons surrounding areas where larger scale (more detailed) cartographic data is available. See the example at Figure 16; the small tic marks extend in the direction in which more detailed data is available. Chart bounds are well known among practising navigators as an indication of a danger or at least something that is worthy of further investigation. It is not known why the navigator and skipper did not increase the magnification of the region that was indicated by chart bounds to have larger scale data.

195. A peculiarity of Expedition is that to obtain the detail available from the larger scale chart the user has to zoom in within the area marked by the chart bounds. For example, if a user zoomed in to the north of the shoals, outside the chart bounds, in the vicinity of the 46m sounding (Figure 16) to the highest level of detail (Level D/4), she or he would not access any more detail as it is not available. However if the navigator, at Level D, panned to the south so that the display was in the area marked by the chart bounds they would still not access additional data even though it was available. The user will only obtain the larger scale chart if they position the display within the chart bounds area at a smaller level (A-C) and then zoom in to Level D.

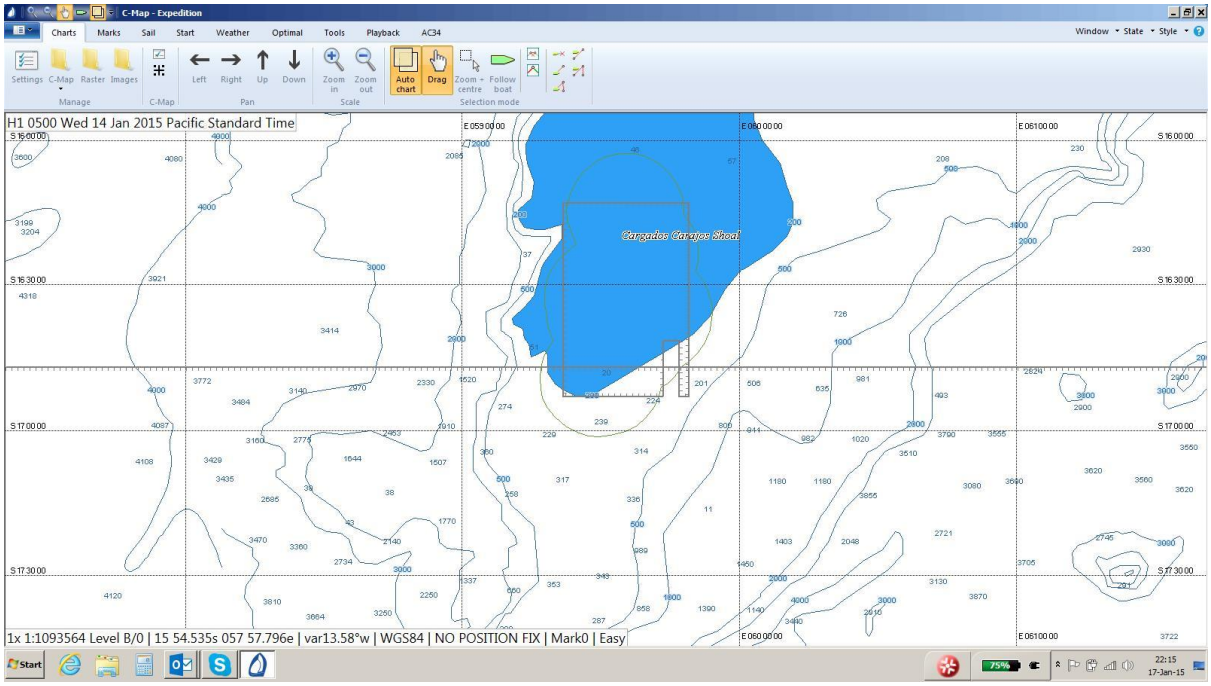

Figure 16 – Expedition/C-Map presentation of Cargados Carajos Shoals at Level B/0 (1:1.1million) Displaying the 'Chart Bounds' of the reef and dangers and the 'Cautionary Areas' marking the Territorial Sea

196. The Adrena system behaves somewhat differently. The boundaries of larger scale C-Map chart data can be shown by enabling the display of 'Chart Contours' in the view menu. The terminology is different from the 'Chart Bounds' on Expedition, but the displayed polygons are the same. These boundaries or contours only reflect the charts available in the system. If a C-Map dongle that is licensed to access detailed charts was not in the computer, as was the case in *Vestas Wind* on the computer running Adrena, the user would not see the chart contours around the reef and the islands. If a detailed C-Map dongle was used a navigator would observe the chart contours and the larger scaled more detailed chart one level earlier than presented on Expedition when zooming in. The display of more or less detailed charts can be changed by the user on a configuration page to adjust the complexity of the chart image.

197. Adrena is also more accommodating when panning towards an area of large scale chart data. If the user zoomed in to the north of the Shoals outside of the chart contour area and then panned to the south and entered the chart contour area they would see the more detailed data and have a clear presentation of the reef and islands.

198. Adrena appeared to provide some useful navigation features but was not favoured by some navigators for this task.

199. As discussed at paragraph 135-136, the survey of the Cargados Carajos Shoals was recent, 2008 to 2010, and conducted to an appropriate ZOC B standard by the Indian HO. There was one error in the C-Map chart, however, in addition to the deficient prioritisation. The light on Coco Island

was shown at Level C on C-Map (Figure 14), but it was removed by a small correction[14] to the larger scale charts of the area in 2012.

200. *Vestas Wind* ran into Cargados Carajos Shoals not because they were inaccurately depicted on official paper charts, and not because they were missing entirely from the C-Map database, but because they were not shown at several scales when the C-Map data was displayed on Expedition software (Levels A and B and most of C).

201. In addition the route planning onboard *Vestas Wind* was ineffective and failed to respond to the indicators within the system. These included:

- chart bounds outlining the Cargados Carajos Shoals reef,
- the name Cargados Carajos Shoals is shown providing an alert to shallow water,
- the economic boundaries are shown, although when using the default colour pallet, they are difficult to see against the blue 200m depth area and can also be confused with depth contour lines, and
- at one location to the south of the shoals, a small piece of a larger scale chart can be seen at Zoom Level C (Figure 14).

202. The economic boundaries are shown as part of the World Map Coverage, so they would have been visible onboard *Vestas Wind* on the weather/routing computer running Adrena as well as on the performance/navigation computer running Expedition. They would also have been visible on the navigator's personal computer when he initially reviewed the amended SI and the change to permitted race area, in Cape Town.

203. The report team considers the cartography in this particular case to be deficient. The omission of the islands, reefs and dangers at display levels A, B and most of the C presentations of C-Map data failed to fulfil the primary function of a chart and warn the mariner of a potential danger. When using a properly designed chart display system, navigators should be confident that land would be displayed at all scales. The expected reliance on chart bounds or economic boundaries to alert a mariner to a danger is not considered to be a sound practice or good cartography.

204. The report team also considered that the panning feature on the Expedition software requires improvement so that if a user pans into an area of larger scale map coverage, that coverage is visible.

[14] BA Notice 3330/2012 – source of update IC 2503

205. Furthermore the report team considers that it was a mistake for *Vestas Wind* to fail to obtain a C-Map detailed chart license for the Weather and Routing laptop that ran the Adrena system.

What is required of a Chart Display System

206. An ideal chart display system needs to be:

- accurate – with an appropriate display of all dangers to navigation for the particular scale in use with sensible prioritisation of data between the different scale levels,
- current – as far as practicable corrected to date,
- clear presentation – using standard international symbols that are well known and understood, with flexible controls to allow the navigator to customise the display to meet individual requirements,
- compatible – with other systems used on the boat including all onboard instruments and the navigation system with weather display, routing and regatta tactics,
- coverage – provide full cover of the permitted area to race and its surrounds, and
- affordable –reasonable cost for the total system of charts, software and hardware.

207. There should be no weak links in the individual components. These are demanding requirements for a limited market that is continually evolving. The report team has been impressed by the approach of some of the manufacturers to adapt their products quickly where bugs or needed improvements are identified. While the current systems are good the report team considers there is room for improvement.

Current Developments and Opportunities

208. The official versions of vector charts are now more available and show promise as an alternative source of charts. The availability of ENC has been driven by an International Maritime Organisation (IMO) roll-out programme of the Electronic Chart Display & Information System (ECDIS). ECDIS is a computer-based navigation information system that complies with IMO regulations and is unnecessarily sophisticated for a racing yacht.

209. Smaller systems that are based on and display ENC are referred to as Electronic Chart Systems (ECS). They may have a place on a yacht and are a close variant of existing systems. The ENC contains all the information that is on the official paper charts and may contain supplementary information to further aid safe navigation.

210. The IMO coverage requirement was for the world's top 2000 ports, and all routes in between, to have ENC coverage at least equivalent to paper charts, by 2011. The Australian HO advises that this requirement has been met.

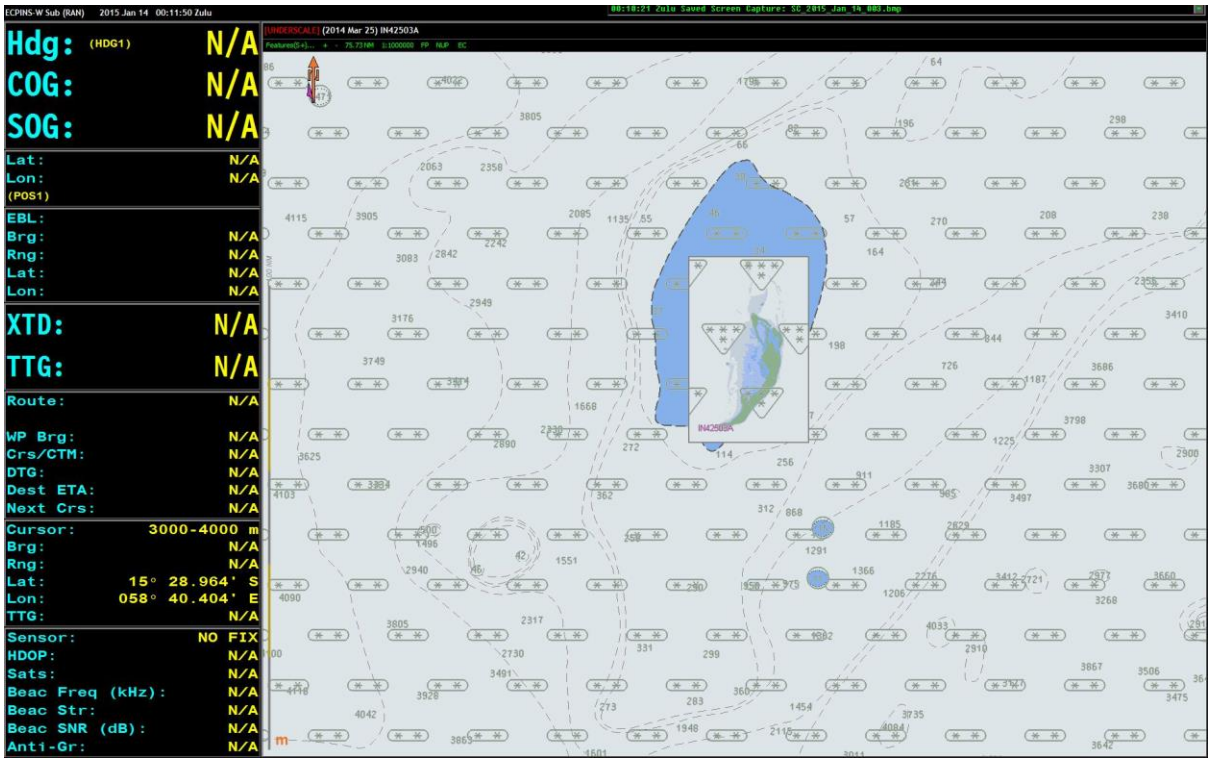

Figure 17 – The ENC data quality feature. An ECDIS screen shot of French ENC FR274880 Zoomed in on Cargados Carajos Shoals – with ZOC switched on displaying 4 stars ZOC B at the reef and 2 stars ZOC D in surrounding ocean

211. Some of the claimed advantages of ENC are:

- produced in a highly regulated environment, controlled by the IHO, with strict standards for format, content, encryption, display and performance using internationally agreed chart symbology,
- strict control of prioritisation to determine the minimum display scale at which each feature will still be displayed,
- certain features, such as reefs and islands, cannot be become “hidden” at any display scale as they are part of a base display requirement set by the IMO,
- very comprehensive three tiered process of quality control,
- very clear and simple presentation of chart data quality with a selectable display of ZOCs across the chart, and
- corrections to all licensed charts advised weekly or fortnightly and available for download.

212. ENC have the hallmarks of good quality charts with the backing of the IMO and IHO. Currently the popular ocean racing navigation systems are not able to use ENC.

What's Next

213. There appear to be two possible alternatives for an improved chart and navigation system. The first would require the navigation systems to be modified to use a number of alternative digital data chart products. This might be quite a challenge to the small businesses that produce the systems. Alternatively commercial ECS would need to be modified to cater for the racing yachtsman and extend their navigation programs or obtain an application to cover the racing needs including routing, weather, performance analysis and tactical regatta sailing.

214. The VOR is operating at the extreme end of the recreational boating spectrum and stretching the existing navigation systems to their capability limits, if not beyond – with boats of 20m in length, displacing about 15 tonnes, with nearly 5m draft, often sailing at speeds of more than 20 knots and with a crew of 9 or 12 people onboard. The boats are sailing round the world passing through large swathes of ocean that are poorly surveyed. They need the best chart and navigation systems that are available. This is indeed an appropriate aspiration for all recreational mariners and the VOR, as a leader in the sport, may be able to assist in its achievement.

215. The report team considers that VOR should use its influence and leverage in the yachting industry to encourage the development of one or more navigation systems – charts and software – to meet the needs of professional ocean racing. Ideally there would be a choice of quality products so that ocean racers would not be dependent on a single supplier for any component of the system. These systems may be enhancements of the current race navigation systems, building on what is already provided.

Some Suggested Guidelines

216. At Annexure F the report team has prepared some recommended guidelines for passage planning using electronic charts as a means to address some of the known issues using these charts and associated systems. These are designed to capture the lessons learnt from the *Vestas Wind* incident.

217. The review team is very conscious of the fact that the VOR attracts some of the best ocean racers and most skilled yacht navigators in the world – it is an elite event. All the navigators know what is required and have done it before in similar races, if not previous VORs; some in even more demanding circumstances. Nevertheless it is easy to overlook a step or process and the results can be catastrophic.

218. The aviation industry provides an interesting example with a religious use of checklists. Even experienced pilots with tens of thousands of flying hours will go through a checklist in a routine manner to ensure nothing is overlooked or forgotten or a switch is left on the wrong setting. Just as a pilot cannot afford the aircraft to malfunction in the air, the VOR navigator has little margin for error and a simple mistake or omission can have disastrous consequences.

219. While it should always be encouraged by navigators, there is little opportunity in the setups observed on the VO 65s to check the navigator's work – the navigator needs to conduct his or her own checks and these guidelines could assist the navigator in developing a suitable checklist.

220. The review team is not professing to have all the answers or any superior knowledge. Indeed many of the ideas came from the interviews held with the crews. Nor is the team suggesting this is the only way to navigate a VOR 65 type boat. The guidelines are offered as just that; a guide for a navigator to check he or she has done all that is considered appropriate in the pre-planning, detailed planning and racing phases of fulfilling the onerous responsibilities of the role.

221. Any guidelines benefit from feedback and experience gained in their use. If the list is adopted and provided to race navigators, a poll is suggested at the end of the 2014-2015 race to gather comments on the usefulness of the guide and seek any observations for its improvement. A similar review, among a few experienced navigators, could be conducted prior to the next edition of the race with a view to including the latest version as an Appendix to the next NOR.

222. The guidelines focus on seamanship. Each navigator will have additional items that are key to the competition such as developing sail crossover charts, routing polars, sea state sensitivity matrices, start acceleration tables, start rate of turn tables, up wash corrections for various headsails. These aspects have not been included.

Race Organisation – Administration, Procedures, Documentation

223. VOR follows a well-developed structure for the conduct of the race. Most of the organisation is standard and what you would expect for such an event. The Report Team has had no involvement with the broader organisation of VOR and its setup at Alicante and has no comment to make on that aspect.

224. Our general observation was that a good and mutually respectful relationship existed between the teams and VOR. The setup in Abu Dhabi was impressive and very businesslike with the boatyard swinging into action to overhaul the boats for the next series of in-port races and the leg to Sanya.

225. The unique and ambitious part of the race was the implementation of a one-design event of this magnitude. This required the establishment of the VO 65 Class Rules and the VCA. Again from the team's observation this appears to have been very successful and must have created a very significant diversion from the normal preparation of a Volvo Ocean Race.

226. Following our review and the associated exposure to the race organisation, its documentation, procedures and administration, nothing emerged that contributed to the *Vestas Wind* grounding. From the interviews with the crews there were two consistent comments that

emerged on race organisation that are included for completeness and consideration by the OA. They concerned the NOR and the resources available to the Race Director.

Notice of Race

227. The NOR was criticised for lacking an organised structure and being a random mixture of items that are undoubtedly important for the conduct of the race. The NOR appears to have grown over recent editions of the race with a series of add-ons to reflect the significant changes that have taken place. This was acknowledged by Race Management.

228. The report team considers that VOR should prepare a fresh NOR for the next edition of the Volvo Ocean Race and that it aligns as far as is practicable with the Guide at Appendix K of the Racing Rules of Sailing.

Resources Available to Race Director

229. The majority of boats expressed concern about the resources available to the Race Director. The boats acknowledged the additional workload created by the implementation of the one-design regime and its strict policing. The concern was that with the emphasis on the one-design detail, such as tagging and weighing, some of the bigger race issues were being overlooked. Issues raised were hurried SI that required amendment and slowness in dealing with course issues such as the Strait of Hormuz and the Malacca Straits. Also without any administrative support, response or acknowledgement of emails was slow. The comment was also received that it would be helpful to have somebody in the Race Director's office that had experience of the 'modern era' race and current course.

230. Again this comment had no influence on the *Vestas Wind* incident but it was a commonly held view. The Race Director was well regarded and his efforts to meet the needs of the participants were appreciated. This issue was also raised with the Race Director who acknowledged the comment and was hopeful that many of the issues with respect to the one-design checks were now settled and more routine.

231. The report team considers that the VOR should review the level of support available to the Race Director to administer the race and respond to the teams in the race and the possibility of a member of the race management staff having experience in the modern era races and the course currently sailed.

Conduct of the Race

232. The main comments received by the report team on the conduct of the race related to the late change to the SI to amend the East African Exclusion Zone and the busy pre-leg programs in the stopover ports.

Changes to the Sailing Instructions

233. The changes to The East African Exclusion Zone are discussed at paragraphs 40 to 45. Without exception there was agreement that it was the correct decision to make and provided appropriate sea room to avoid the tropical depression. It represented good prudent seamanship. There was, however, criticism of the timing and lateness of the decision. The pre-race briefing at Alicante severely discounted the threat from pirates and provided the option and forewarned the likelihood to reduce the zone.

234. The influence of the potential cyclone was quite challenging to predict. The weather feature was unlikely to affect the fleet for about 14 days and typically it was unclear how the depression would develop within that time. There were alternative models with differing probabilities. The worst case was that a tropical cyclone would develop and block the western side of the permitted race area. The option to reduce the size of the exclusion zone and provide room to the west made sense with little increase to the pirate threat.

235. Because of the dependence on pre-planning with the availability of dedicated meteorologists and navigation planners the timing was important. The more notice the boats had the more assistance they could obtain from their shore planners. This planning support is aimed at reducing the pressure on skippers and navigators when racing and anything to detract from its effectiveness has an opposite effect. As it was, with the announcement made the evening before the start, the opportunity for this support was severely reduced. Also work done based on the previous course was now of diminished value. One boat complained they had wasted five days of planning effort because the routing options had changed so dramatically. While this might be true the Race Director did attempt to keep boats informed of the possibility of a change.

236. The change was permitted by the RRS and the NOR. No boat received any advantage from the change and it was the safest option in the circumstances. More advanced notice of the change was possible and would have been better. A decision could have been made at least one or two days earlier with little potential downside.

237. The report team considers VOR should provide any amendments to race documentation as early as is practicable, especially any amendments that involve a change of the course or of the permitted racing area

Shorter Port Stays with Increased Commitments

238. Several comments were received about the compact programs at the port stopovers. The complaints from a few boats were that the visits are shorter than past races and the program has more commitments. Race Management, however, advised that the race format has not been changed in the last three races and in fact the stopovers are slightly longer. Undoubtedly it is a tough demanding race, both physically and mentally and fulfils the promise of 'Life at the Extreme'

239. The programs are certainly full in the last few days with a practice race, three Pro-Am races and an in-port race plus a dinner and various media calls. The depth of feeling varied quite a bit among the crews interviewed. All acknowledged the importance of sponsors for the sustainability of the event and to support professional sailing.

240. A lot of the time pressure is placed on the navigator trying to access the planning support in the last few days before the start of a leg and digest the latest weather modelling and its impact on routing options. The navigator is attempting to maximise the benefit of the shore support team at this crucial stage. The rules regarding who can and cannot participate in the port races are strict and provide little flexibility unless you are changing crew in that port to sail the next leg. The crew of *SCA* does gain an advantage in that they plan to routinely change some crew at each port.

241. The report team considers VOR should allow the navigator of each boat to be able to stand-down from the 'In-Port' race to continue preparation for the next leg and be replaced by another member of the team who may not meet the current 'last leg' or 'next leg' requirements.

Emergency Management

242. The emergency management worked well and the outcome was very good. The incident reiterated the importance of having good plans in place and the advantages from training and preparation. In this particular emergency the strength and experience of *Team Vestas Wind's* Shore Manager, Neil Cox, proved to be a particularly valuable asset that made a significant contribution to the outcome. This again emphasised the need to have the right people in the right place when putting a team together.

Safety Equipment and Stowage

243. The VO 65 delivered to the teams contained a very comprehensive set of good quality equipment for each boat. There was a sensible amount of redundancy to cover failures and the 'sail-away' package could be regarded as state of the art and what you would expect to find on a similar top class ocean racing yacht.

244. The participants had some options with respect to providing or modifying some equipment including: foul weather clothing, life jackets, safety harnesses, paper charts, and constant wear

survival suits. There were no restrictions on carrying extra safety equipment but extra weight had to be balanced against any competitive disadvantage.

Crew Report

245. Following the *Vestas Wind* stranding the crew met and completed a post incident review with Ocean Safety, a UK firm that specialises in marine safety equipment and training. Ocean Safety is understood to provide the mandatory two-day sea survival course. This valuable feedback from the crew's unique experience is at Annexure G and it is expected that it will receive due consideration. The report team is aware that some items have already been actioned for Leg 3 of the Race.

246. Many of the items in the crew's report were raised with the report team during the interviews but there is nothing to add to the items reported by the crew in the Ocean Safety review.

LFP Batteries

247. The only point regarding equipment that is considered necessary to raise in this report concerns the LFP battery(s) catching on fire. The LFP batteries are reported to have started 'smoking' shortly before abandoning the yacht. This is believed to be as a result of their exposure or submersion in salt water. This did raise a concern of fire and was one of the factors that influenced the decision to abandon the yacht.

248. When retrieving gear from the boat, at least one battery continued to smoke quite profusely and was left on a beach as it was considered dangerous. When the crew returned sometime later there was burnt remains and the battery had self-destructed. This is beyond the expertise available to the report team but it is considered significant and worthy of further investigation.

249. The report team considers that VOR should review LFP batteries and the risk of fire when in contact or submersed in salt water.

Crews –Numbers and Training

Numbers

250. The report team received several comments about the permitted crew size and its adequacy. There was quite a divergence in opinion with some accepting the rules for what they are and others expressing concerns over safety in certain situations. Clearly racing the VO 65, round the world, with a sailing crew of 8 men or 11 women is challenging and requires careful management of the available resources. Others do it with less, noting the two-handed and single-handed events, albeit over different courses. There is a need to tailor the available resources to the task at hand.

251. Most sailors acknowledge that there is a clear priority listing when racing:

1. Safety of the crew and the boat
2. The race – to sail the correct course as fast as possible, and
3. The sponsor or media commitments

252. These priorities should not change in any situation. If you are short-handed additional resources may need to be allocated to the higher priorities at the expense of the lower. That is, more effort may need to be put into safety – the avoidance of shipping and navigational dangers – at the expense of sailing the optimum course for the race. More resources may be required to maintain a lookout, watch the AIS and radar at the expense of trimming sails. These are the choices that need to be made in an event such as the VOR, especially in some of the very congested waters the boats sail; areas such as the English Channel and the Malacca and Singapore Straits.

253. The report team does not make any recommendation with respect to the permitted size of the crews.

Safety at Sea Survival Training

254. A very strong vote of support was received from the crew of *Vestas Wind* with respect to the value of the two-day safety at sea and survival course and the importance of completing the course close to the race start. The subject matter was fresh in their minds and very helpful in their situation.

RECOMMENDATIONS

255. The stranding of the *Vestas Wind* clearly demonstrates the dangers associated with offshore sailing and the risks inherent in racing round the world. Fortunately no lives were lost which is remarkable considering the impact, the remoteness of the reef, the time of the grounding, the night the crew endured and abandoning the boat. The crew's survival training and initiative, the leadership displayed onboard, along with the support provided from ashore and many of the procedures in place for the VOR operated effectively. This led to a quick and safe recovery of all crew members on *Vestas Wind*. A great outcome after the initial catastrophe.

256. The report team makes the following recommendations for VOR to consider:

Navigation Practices

257. There are several valuable lessons to be learnt with respect to navigation planning and navigation practices while racing. The report team has prepared a short guide titled: *Recommended Guidelines for Passage Planning and Racing Using Electronic Charts.* The guide is aimed at capturing the lessons to be learnt and is attached at Annexure F. Despite the longstanding principles of navigation, leading practices in ocean racing are evolving quite rapidly.

258. The report team recommends that Volvo Ocean Race (Paragraphs 216 - 222):

1. **provides** the guidelines to competing boats and endorse their adoption in the Race,
2. **reviews** the guidelines on completion of the 2014-2015 Race,
3. further **reviews** the guide before the next edition of the Volvo Ocean Race, and
4. **includes** the latest version of the guide as an Appendix in the next Notice of Race.

Electronic Charting

259. The poor presentation of available data clearly contributed to the grounding of *Vestas Wind*. There were a number of deficiencies in the presentation of data and accessing it with the supplied navigation systems and limited access to detailed charts. The most significant problem was missing vital data on the majority of scales in the chart presentation of the Cargados Carajos Shoals that created a false impression that they were safe to sail across.

260. The report team recommends Volvo Ocean Race:

5. **informs** C-Map and Expedition of the perceived deficiencies with their products and seeks that they be rectified (Paragraphs 203 and 204), and

6. **uses** its leverage and influence within the yachting industry to encourage the development of one or more navigation systems – charts and software – to meet the demanding needs of professional ocean racing. Ideally such systems would provide a choice of quality products such as chart data, and not be dependent on a single supplier for any component of the system. These systems may be enhancements of the current race navigation systems, building on what is already provided. (Paragraph 215).

Matters Relating to the Conduct of the Race

261. Following a review of much of the race documentation and receiving comments from each racing team during the preparation of this report, the report team considers the conduct of the race and its administration were good.

262. From the issues raised with the report team, it recommends that Volvo Ocean Race:

7. **prepares** a fresh Notice of Race for the next edition of the Volvo Ocean Race and that it aligns as far as is practicable with the Guide at Appendix K of the Racing Rules of Sailing (Paragraph 228),
8. **reviews** the level of support available to the Race Director to administer the race and respond to the teams in the race and the possibility of a member of the race management staff having experience in the modern era races and the course currently sailed (Paragraph 231),
9. **provides** any amendments to race documentation as early as is practicable, especially any amendments that involve a change of the course or of the permitted racing area.(Paragraph 237),
10. **allows** the navigator of each boat to be able to stand-down from the 'In-Port' race to continue preparation for the next leg and be replaced by another member of the team who may not meet the current 'last leg' or 'next leg' requirements (Paragraph 242), and
11. **reviews** LFP batteries and the risk of fire when in contact with or submersed in salt water (Paragraph 250).

Chris Oxenbould Stan Honey Chuck Hawley

31 January 2015

ANNEXURES

Annexure A

Terms of Reference – Volvo Ocean Race Independent Report into the Stranding of *Vestas Wind*

Preamble

1. An incident occurred at about 1515 UTC (1915 local time) on Saturday 29 November 2014 when the boat *Vestas Wind* ran aground and was stranded on the Cargados Carajos Shoals, 240 NM northeast of Mauritius. All nine crew members were eventually evacuated and only some suffered minor injuries.
2. The Volvo Ocean Race S.L.U. (VOR) has resolved to hold an Independent Report into the incident on the basis of these Terms of Reference and has invited Rear Admiral Chris Oxenbould AO RAN (Rtd) to Chair the Report.
3. The Report is concurrent with an insurance inquiry and is limited in its extent to enquiring as to the incident without seeking to apportion blame on any person.

Constitution and administrative matters

4. Rear Admiral Oxenbould is to be the Chair, assisted by Stan Honey and Chuck Hawley.
5. VOR, through its CEO Knut Frostad, is to provide secretariat and administrative support as required by the Report team. The costs and expenses of the Report will be borne by VOR.
6. The Report has no power of compulsion on any person. Every person who gives evidence must be advised concerning their entitlements to privacy and privilege against self-incrimination.
7. The Report Team will meet at such times and in such places as the Chair shall determine in consultation with the CEO VOR. Sensible use of emails and teleconferences will be pursued to conduct the team's business.

Terms of Reference

8. The Report is to provide its final report to VOR by 31 January 2015. A preliminary report may be provided if, after consultation with VOR, it is considered necessary to highlight any safety recommendations that may require immediate attention.
9. The Report may seek input from crew on competing boats, members of the race committee, electronic chart providers, hydrographic and emergency services organisations and such other persons as the Report sees fit. The Report may receive written submissions.
10. Those that wish to provide oral or written submissions or comments to the Report should be advised that the findings and recommendations of the Report and submissions received may be made public.
11. The Report will examine all the circumstances pertaining to the stranding of *Vestas Wind* as a competitor in the 2014 - 2015 Volvo Ocean Race. In particular the Report is to:
    - (i) determine what happened and why *Vestas Wind* ran aground,
    - (ii) consider the relevant administrative procedures and documentation in place for the race - the VO 65 Class Rule, the Notice of Race and the Sailing Instructions for Leg 2 – and whether they contributed to the incident in any way,
    - (iii) examine the conduct of the race from the point of view of the Race Committee and the competing boats to see it there was any contributing factors to the incident,

(iv) review the emergency management procedures in place and their effectiveness,

and make findings and recommendations as to:

(v) any changes to the race rules, procedures, administration, documentation, boats or equipment that might serve to prevent a possible recurrence,

(vi) emergency management procedures,

(vii) the training or numbers in crews; and

(viii) such other matters relating to the conduct of the race as the Report considers appropriate.

12. VOR will accept a minority report.

13. VOR may from time to time provide additional terms of reference to the Report.

By direction of VOR

Knut Frostad

Chief Executive Officer

Volvo Ocean Race S.L.U.

Muelle nº 10 de Levante, Puerto de Alicante

03001 Alicante, SPAIN

December 2014

Annexure B

Report Team – Short Resumes

Rear Admiral Chris Oxenbould AO RAN (Rtd)

Chris Oxenbould had a distinguished career of over 37 years in the Royal Australian Navy, in which he specialised as a navigator and gained substantial command experience. On retiring from the Navy in 1999 he worked with the New South Wales Government in positions including the Chief Executive of Newcastle Port Corporation 2001-04 and CEO of NSW Maritime, the state's maritime regulator, from 2004-08. Chris has been an active sailor for most of his life, competing in 10 Sydney to Hobart races and several seasons of offshore racing out of Sydney and a season in England. He was Chair of the Sydney Hobart Race Committee in 2000 and 2001, Chair of the Flinders Islet Inquiry in 2009 and is currently Chair of Yachting Australia's National Safety Committee.

Stan Honey

As part of a career in navigation, digital mapping, and computer graphics, Honey led the development of the yellow first-down line widely used in the broadcast of American football, the "K-Zone" baseball pitch tracking and highlighting system, the tracking and highlighting system used in NASCAR, and the LiveLine system used in the 34th America's Cup. Honey has earned three Emmy's for technical innovation in sports broadcast.

Stan has wide experience as a professional navigator, having navigated ABN AMRO to first place in the 2005-2006 Volvo Ocean Race and having navigated Groupama 3 in setting the Jules Verne record for the fastest circumnavigation of the world in 2010. He has won line-honours or set records in all of the major oceanic passages and races. These efforts include 25 TransPacific races and 10 TransAtlantic races or record passages. Honey was awarded the 2010 US Sailing Yachtsman of the Year Award, and was named to the US National Sailing Hall of Fame in 2012.

Prior to co-founding Sportvision in 1998, Stan Honey worked as Executive VP Technology for News Corporation from 1993 through 1998. In 1983, Honey co-founded ETAK Inc., the company that pioneered vehicle navigation systems and digital street mapping which was sold to News Corporation in 1989 and is now part of TomTom. From 1978 to 1983 Honey worked as a research engineer at SRI International in the fields of Over-The-Horizon radar, underwater optical sensors, and radio positioning systems. Stan is an inventor on 8 patents in navigation and digital mapping technology and 21 patents in tracking and television special effects.

Chuck Hawley

Chuck Hawley is a lifelong sailor, having sailed over 40,000 miles on a variety of power and sail vessels ranging from ultralight 24 footers to the 125 foot catamaran PlayStation. He has sailed across both the Atlantic and Pacific Oceans, and has incorporated the lessons learned from those voyages into hundreds of videos and articles on safety and seamanship. This knowledge has also led to the development of improved safety gear, technical clothing, anchors, and marine electronics for the boating industry.

Chuck is a nationally known speaker on marine safety, and is the Chair of the US Sailing Safety at Sea Committee, a member of the US Sailing Board of Directors, as well as being a Powerboat Instructor for US Sailing. One of his goals has been to develop sailor-friendly safety equipment recommendations for racing and cruising sailors that are comprehensive, easily understood, and in widespread use.

Chuck worked for West Marine for 30 years and held senior positions in marketing, merchandising, stores, and internet divisions. He is currently a product development consultant and develops technical and educational videos for marine industry. He lives in Santa Cruz, CA with his wife Susan and five daughters, and is a partner in an Alerion Express 38 Yawl.

Annexure C

List of People Interviewed and Written Submissions

Date	Medium	Name	Representing/Expertise
8 Dec 14	Interview*	Tony Rae – Trimmer Rob Salthouse – Watch Captain Maciel Cicchetti – Watch Captain Nicholai Sehested – Trimmer	Team Vestas Wind
9 Dec 14	Interview*	Chris Nicholson – Skipper	Team Vestas Wind
14 Dec 14	Submission	Draft – Written Submission – Team Vestas Wind Ground Report – Race Control Alicante, Jack Lloyd, Gonzalo Infante	Volvo Ocean Race – Race Control
15 Dec 14	Interview^	Charles Caudrelier – Skipper Pascal Bidegorry – Navigator	Dongfeng Race Team
15 Dec 14	Interview^	Bouwe Bekking – Skipper Gideon Messenk – Director	Team Brunel
15 Dec 14	Interview^	Ian Walker – Skipper Simon Fisher – Navigator	Abu Dhabi Ocean Racing
15 Dec 14	Interview^	Iker Martinez – Skipper Jean-Luc Neilas – Navigator	Mapfre
15 Dec 14	Interview^	Sam Davies – Skipper Libby Greenhalgh – Navigator	Team SCA
15 Dec 14	Interview^	Knut Frostad – CEO VOR Jack Lloyd – Race Director	Race Management and Race Committee

16 Dec 14^	Interview^	Charlie Enright – Skipper Will Oxley – Navigator	Team Alvimedica
16 Dec 14^	Inspection	Alvimedica - Inspection of the Navigation Station onboard and its associated equipment and systems.	
23 Dec 14	Teleconference	Wouter Verbraak – Navigator	Vestas Wind
31 Dec 14	Teleconference	Martin Plumleigh – Sr Manager Aviation & Marine Safety	Jeppesen (C-Map)
31 Dec 14	Teleconference	Nick White – Software Developer	Expedition
Jan 15	Email Questionnaires	Chris Nicholson – Skipper Wouter Verbraak – Navigator Jack Lloyd – Race Director Chris Branning – Support Crew	Vestas Wind Vestas Wind VOR Alvimedica
5 Jan 15	Email Exchange	Roger Badham	Meteorologist – Race Adviser
8 Jan 15	Teleconference	Neil Cox – Support Manager	Team Vestas Wind
9/31 Jan 15	Teleconference + email	James Detar – Director Light Marine Solutions Martin Plumleigh – Sr Manager Aviation and Marine Safety	Jeppesen (C-Map)
13 Jan 15	Interview* + phone, email and submission	Mike Prince – Director Charting Services	Australian Hydrographic Office
17/30 Jan 15	Email Exchange	Michel Rodet – Owner/Creator	Adrena

* Interviews conducted by Chris Oxenbould

^ Interviews conducted by Chris Oxenbould and Chuck Hawley

Annexure D

VO 65 - Main technical specifications

The technical specifications for the boat are developed in conjunction with suppliers and the designers and full details can be found in the Volvo Ocean 65 Class Rules located in the race Noticeboard.

Hull Length (ISO 8666)	20.37 m (66 ft)
Length waterline (design)	20.00 m (65 ft)
Length overall (inc. bowsprit)	22.14 m (72ft)
Hull Beam overall (ISO 8666)	5.60 m (18.4 ft)
Max Draft (Keel on CL)	4.78 m (15.8 ft)
Boat Weight (empty)	12,500 kg (27,557 lb)
Keel arrangement	Canting keel to +/- 40 degrees with 5 degrees of incline axis
Daggerboards	Twin forward daggerboards, inboard triangulation
Rudders	Twin fixed rudders - composite stocks
Aft Water Ballast (Wing Tanks)	Twin 800L ballast tanks under cockpit sides at transom
Forward Water Ballast (CL)	Single centerline 1100L ballast tank forward of mast
Rig Height	30.30 m (99.4 ft)

Rig Arrangement	Twin topmast backstays and checkstays with deflectors
Bowsprit Length	2.14 m (7ft)
Mainsail Area	163 m2
Working Jib Area	133 m2
Upwind Sail Area	468 m2 (mainsail and masthead Code 0) 296 m2 (mainsail and working jib)
Downwind Sail Area	578 m2 (mainsail and A3)

Annexure E

Navigation Supplied Equipment

NUMBER	ITEM	INSTALLED	SUPPLIED
1	Navico CAN to USB converter	Diverse	Navico
1	NEP-2 Network expansion port	Diverse	Navico
5	WTP3 Serial interface	Diverse	Navico
1	**ZG50 Zeus GPS Antenna, 5Hz**	Diverse	Navico
1	**WTP3 Pack**	Diverse	Navico
1	**CPU ONLY,WTP3**	Diverse	Navico
5	WTP3 Analogue interface	Diverse	Navico
1	B&G 4G Broadband Radar Kit	Diverse	Navico
1	**HS70 GPS Compass**	Diverse	Navico
1	**HS70 Power/NMEA0183 cable 15m**	Diverse	Navico
2	**MFD 6.4" Touch**	Diverse	Navico
1	NAIS-400	Diverse	Navico
1	NSPL-400	Diverse	Navico
1	Fastnet Cable, 20m	Diverse	Navico
1	MHU angle bearing	Diverse	Navico
1	MHU direction bearing	Diverse	Navico
1	MHU Vane	Diverse	Navico
1	213 MHU PCB	Diverse	Navico
1	MHU cups	Diverse	Navico
1	Air Temperature sensor	Diverse	Navico
3	Remote Button	Diverse	Navico
1	Halcyon 2000 compass	Diverse	Navico
1	Clinometer	Diverse	Navico
1	Barometer	Diverse	Navico
1	**Halcyon Gyro-Stabilised Compass**	Diverse	Navico
2	**Deckman C-MAP USB**	Diverse	Navico
1	WTP3 Rate Gyro	Diverse	Navico
2	H3000 FFD Display	Diverse	Navico
2	H3000 FFD Bezel	Diverse	Navico
2	H3000 Sun cover	Diverse	Navico
2	MTG Template H3000 FFD & 20/20	Diverse	Navico
6	H3000 GFD Pack	Diverse	Navico
2	VOLVO SPEC 1450mm Vertical Masthead Unit	Diverse	Navico
1	VOLVO SPEC Fwd Masthead Unit	Diverse	Navico
5	Volvo Spec 20/20 HV Display Pack	Diverse	Navico
3	VMHU Mast Cable 36m w/ custom connectors	Diverse	Navico
1	MHU Mouldings	Diverse	Navico
1	MHU nuts	Diverse	Navico
1	**0183 Depth sensor with housing**	Diverse	Navico
3	H3000 Speed Sensor Plastic	Diverse	Navico
1	Paddle wheel spares	Diverse	Navico
2	ETHRNT YELW CBL 5 PIN MALE:RJ45 FMALE 2M	Diverse	Navico
2	Simrad NSS7	Diverse	Navico
2	BRACKET KNOBS PAIR – NSS/GEN2T	Diverse	Navico

2	GASKET DISPLAY	Diverse	Navico
2	ETHEXT-15YL	Diverse	Navico
1	ETHEXT-50YL	Diverse	Navico
1	SIMNET CABLE TO MICRO-C	Diverse	Navico
2	Flush Mounted Compass	Allspars	Silva
1	Forestay Pin	DIVERSE	Tropical
1	J2	DIVERSE	Tropical
1	J3	DIVERSE	Tropical
1	Mainsheet Pin – Loadcell	DIVERSE	Tropical
	Mainsheet Pin – Block		
1	Bobstay	DIVERSE	Tropical
2	Backstay	DIVERSE	Tropical
2	V1	DIVERSE	Tropical
2	D1	DIVERSE	Tropical
11	CAN amplifiers	DIVERSE	Tropical
2	String Pot	DIVERSE	Tropical
2	Rudder Angle	DIVERSE	Tropical
2	String Pot Enclosures	DIVERSE	
2	**Panasonic Tough Book - CF53**	DIVERSE	Panasonic
1	10" Tough Pad	DIVERSE	
1	Deck screen Charger	DIVERSE	
2	Power Supply – laptops	DIVERSE	Lind
1	Thermal Printer	DIVERSE	
2	Paper	DIVERSE	
2	8 Port Ethernet Switch	DIVERSE	
1	USB 5 Port USB Ehernet	DIVERSE	ANYWHERE
3	Access Point	DIVERSE	
3	Access Point Housing & Bracket	DIVERSE	
3	Wifi	DIVERSE	
3	POE	DIVERSE	
1	**Expedition**	DIVERSE	
1	**Adrena - 25%**	DIVERSE	
1	**C-Map**	DIVERSE	
1	Additional Install Labour	Diverse	
1	Echomax Bracket	DIVERSE	Tropical
2	VHF Antenna	DIVERSE	
1	Swivel Pod for Pedestal	DIVERSE	

Annexure F

Recommended Guidelines for Passage Planning and Racing Using Electronic Charts

Guidelines for navigators in preparing a long passage leg – directed at an event like the Volvo Ocean Race and a boat of similar capability to a Volvo Ocean 65

1 The VOR attracts some of the best ocean racers and most skilled yacht navigators in the world – it is an elite event. All the navigators know what is required and have done it before in similar races, if not previous Volvos; some in even more demanding circumstances. Nevertheless it is easy to overlook a step or process and the results can be catastrophic.

2 The aviation industry provides an interesting example with a religious use of checklists. Even experienced pilots with tens of thousands of flying hours will go through a checklist in a routine manner to ensure nothing is overlooked or forgotten or a switch is left on the wrong setting. Just as a pilot cannot afford the aircraft to malfunction in the air, the Volvo navigator has little margin for error and a simple mistake or omission can have disastrous consequences.

3 While it should always be encouraged by navigators, there is little opportunity in the typical watch arrangements on a VO 65 to have an independent and thorough check of the navigator's work – the navigator needs to conduct his or her own checks and these guidelines could assist the navigator in developing a suitable checklist.

4 The team who produced the list is not professing to have all the answers or any superior knowledge. Indeed many of the ideas came from the interviews held with the crews. Nor is the team suggesting this is the only way to navigate a VOR 65. The guidelines are offered as just that; a guide for a navigator to check he or she has done all that is considered appropriate in the pre-planning, detailed planning and racing phases of fulfilling the onerous responsibilities of the role.

5 Any guidelines benefit from feedback and experience gained in their use. Comments on their usefulness and any observations for improvement are encouraged and should be forwarded to the Race Director (Jack Lloyd, jack.lloyd@volvooceanrace.com)

6 Note that these guidelines focus on seamanship. Each navigator will have additional items that are key to the competition such as developing sail crossover charts, routing polars, sea state sensitivity matrices, start acceleration tables, start rate of turn tables, up wash corrections for various headsails etc.

Pre-Race Preparation

- Obtain a copy of the Notice of Race and Sailing Instructions as soon as practicable and study them in detail – ensure you have an expert knowledge of these documents. Memorise the key aspects.

- Check all the navigation charts, systems and instruments that will be on the boat and satisfy yourself that they are fit for purpose and satisfactory for the race, identify and rectify any deficiencies
    - Ensure you are a competent operator of all fitted systems, with a detailed knowledge of their full capabilities, how they work and how they are calibrated – be aware of any inadequacies in the equipment and how they can be covered. Consider any single point of failures.
    - Ensure you have adequate detailed electronic chart coverage for all navigation systems onboard – all laptops/computer systems to be used and other chartplotters – at least 2 USB dongles for which chart license codes are available (one for each main computer) for the entire course. Carry the DVDs and the license codes for each dongle so that the detailed charts can be reloaded if necessary.
    - Arrange to have personal access to the navigation system programs and detailed charts for your own planning and preparation away from the boat
- Ascertain the quality of hydrographic survey across the race course – identify areas of poor survey where extra precautions may be required and/or additional information sourced.
- Determine what paper charts are required and obtain up to date copies
- Initial review of the Sailing Directions and Pilot Charts to determine the weather expected at time of year and an overview of the passage and navigational hazards
- Prepare an electronic version of all user manuals for the nav station equipment to be available onboard
- Document changeover arrangements to secondary sensors and systems (masthead sensors, speed, GPS, communications systems) where fitted in case of failure or calibration issues with the primary source
- Discuss with the skipper the navigation setup, available equipment, and best practices for use of Electronic Charts with their known shortcomings
- Agree with the skipper how the navigation of the boat will be managed and how the working relationships between skipper, navigator and watch captains will work

Detailed Planning

- Review the best available weather data and its influence on the passage – continually update before the start
- Prepare a number of likely track options and review for navigational hazards or constrictions – refine leading up to the start
- Conduct a close check of intended tracks for navigational dangers using the detailed electronic charts – pay particular attention to rounding marks, capes, straits, traffic separation schemes and exclusion zones – get details of tides and currents – make notes for later access
- Check expected tracks and the whole of the probable area of the race course on the mid-scale paper charts (1: 1 million to 1: 3.5 million) – identify navigational dangers – check how the dangers are represented on the electronic chart system – make hand written notes on the paper chart which provides complete coverage of the leg at the best scale – use for crew briefings

- Check rounding points, straits, or areas of navigational interest on larger scale paper charts, review tides, currents, any cautions and notes
- Review tracks on Google Earth and obtain any satellite images that might be helpful,
- Enhance visibility of all navigation dangers on the electronic charts with 'race notes', 'pins', 'danger circles' or 'marks' that will remain visible at all levels of zoom. It is sometimes helpful to name the hazard by naming the mark or pin.
- Detailed review of Sailing Directions paying particular attention to cautions, navigational dangers and comments on major navigational features that you expect to pass close by
- Keep crew engaged with occasional briefings – provide an overview of the leg – update weather forecasts – highlight main sailing features, areas of expected steady winds, transitions, unusual local effects
- Identify potential diversionary ports
- Calibrate the boat's instruments, swing compasses, adjust barograph offset
- Set depth limit and guard sector in navigation systems, as well as AIS CPA limit alarm, and radar alarm for those situations of reduced visibility where the radar will be used
- Work out the best settings on the navigation systems for different scenarios – coastal, open ocean, close proximity to dangers, night, day, when you are awake/asleep – what to have enabled or disabled and when to change
- Plan what alarms you require to be set on the navigation systems for different situations

Racing

- Optimise the nav station setup for the actual conditions being experienced
- Establish a routine check list to check the navigation safety each time you come to the nav station – also a routine 6 hourly check of:
    - Dangers in immediate vicinity
    - Dangers along intended track for the next 6 hours
    - Check the accuracy of the prime GPS system against another source – resolve any discrepancy – monitor GPS quality
    - Consider the need for watches on additional sensors – radar, depth sounder, good visual lookout, chartplotter, AIS
    - Brief the watch on things to expect, raising a light, sighting land, any navigational marks
- Note weather reports – work out your watch routine around the receipt of important weather reports, typically brief the crew every six hours
- Keep "Chart Bounds" enabled; only disable when a lot of charts create too much clutter – when disabled frequently check screen with the feature enabled as a possible alert to any obscured danger
- Investigate larger scale coverage indicated by Chart Bounds in the vicinity – zoom in within the chart bounds area
- When navigating in an area where there is little colour contrast between the background, charted depths and other features, experiment with different palettes to obtain improved contrast and more distinctive depths and features. For example, the black and white palette sometimes works well particularly when a tablet is in use.

- Daily review with skipper, navigator, and watch captains of the next 2 days sailing on the 1:3.5M paper charts with attention to hazards
- Prepare an update brief for watch captains before watch – preferred course and limits, any significant navigation points, expected depths, expected weather, other known traffic
- Monitor your sleep – attempt not to get over-tired – identify periods of high intensity and attempt to rest beforehand
- Review alarms set and whether those enabled are still appropriate
- Maintain a log book

List of Equipment to have onboard

- Paper charts to cover.
    - A single chart that covers the entire leg at the largest scale possible (most probably 1:10 million or 1:3.5 million)
    - Large scale charts at 1:500k or larger for the areas of the start, finish, and any capes or straits required to be passed
- A complete set of Sailing Directions aboard for the region including and surrounding the race course – a digital version on the boat's computers is satisfactory

Annexure G

Safety Equipment Proposals – Vestas Wind Crew Recommendations

Report Prepared by Ocean Safety

Team Vestas Wind Grounding Safety Equipment Thoughts & Questions

Aim

The purpose of this document is to ensure that as manufacturers and suppliers of all the Volvo Ocean Race One Design specified safety equipment we are in a position to ensure that we are able to learn from the experience of Team Vestas Wind during the grounding and subsequent abandonment of the yacht. The aim of which is to ensure that the equipment specification and standard is altered as necessary such that the best possible equipment is supplied to the yachts in the future.

Equally important, is to ascertain how the Sea Survival Training, given to every crew member, can be modified to ensure lessons are learnt.

To minimise administration time this is a question and answer type document however additional information from the sailing team would be appreciate where applicable. With the information available the points attempt to be in some form of chronological order.

Thoughts and Queries

1. General
    - **a.** At the time of the grounding were any members of crew, who were on deck, wearing lifejackets? **No**
    - **b.** Did the lifejackets still have the R10 Personal AIS Transponders fitted **Yes**, the suggestion is to have two R10s per person, so you have one in the lifejacket and one to have in your pocket when you are not wearing a lifejacket. This will also help when you are not wanting to inflate the lifejacket yet want to be visible.
      We would recommend a rule in the NoR to specify that the survival suits and jackets have a shoulder pocket that is adequate to carry both a strobe light and a R10.
      All boats should have a list with the AIS numbers of R10s linked to each crew member.
    - **c.** Were all lifejackets in the 'Manual' activation mode **Yes**
    - **d.** Did the yacht have enough sources of light i.e. Torches to allow an appreciation of the surroundings **Yes,** we used Fenix 280 (Trae to specify) they were very good.
    - **e.** Did all crew rely on personal head torches to provide light such that they could work on deck safety **Yes**, this is a crucial point. And we all had good quality headtorches. We would recommend to have a three spares in the grab bags.
    - **f.** At the time of the grounding were any members of the crew wearing safety harnesses **No**

2. Immediate Action
    a. Once the situation had stabilised and an understanding of what had happened was in place please indicated which of the following actions were put in place:

i. All crew put on Survival Suits **Yes**
ii. All crew put on Lifejackets **Yes**
iii. Ships 406/121.5 EPIRB activated **No**
iv. Ship AIS SART activated **Yes**
v. Were any Red Rocket Flares deployed **Yes** ,we deployed two. The first to indicate our position, the second to illuminate the area. Tony Rae sliced his thumb open on the metal tag.
vi. If these were used has there been any indication from other parties that they were seen **Yes** by the coast guard and Alvimedica.
vii. Were any White Rockets Flares deployed **No**
viii. If these were used were they considered useful to gain a better observational awareness of the surroundings We used a red parachute flare to this end, which worked very well.

b. What additional equipment was it felt appropriate to put into the OS 'Roll Top' type grab bags – *Please comment separately if appropriate?*

We would recommend a tool bag size waterproof bag with a zip and compartments, so you can see the different items in the bag. On the outside we would recommend a carabiner so you can clip it onto yourself/a rope that leads to the liferaft.

We would also recommend to have a list of items on the outside of the bag.

Extra items we would recommend are two/three head torches, a spare R10, 2 spare strobes per grab bag.

c. Is the design/type of anchor provided appropriate **No**
   i. Should at least 1 of the anchors be assembled at all times with the appropriate line and chain attached There are other anchors on the market that are easier to handle and assemble and we would recommend to investigate these alternatives further. One example is the CQR anchor.

3. Abandonment
   a. On the assumption that the lifejackets had not been activated and therefore the attached lights were not visible, what type of personal lighting did the crew use to make sure others could see them:
      i. Head Torches **Yes**
      ii. Handheld Personal Torches **Yes**
      iii. Personal 'Strobe/Torch' combination or similar **Yes**
      iv. Chemical Cylume type stick **No**
      v. Other **No**
   b. Prior to deploying the Liferafts, were they removed inboard of the aft stowage on the transom **No,** that was deemed to dangerous.
   c. Was a knife available to cut the retaining lines **Yes**
   d. Was this considered an 'easy' process considering the angle of heel on the yacht after the grounding **Yes**
   e. It is understood that a Jonbuoy Recovery Module was deployed to establish drift across the reef.

i. Was the deployment successful **Yes**

ii. Was the inflation successful **Yes**

iii. Did the light activate **Yes**

iv. It was fine for the first ten minutes, but then deflated slowly and the top flopped down. We would suggest to reduce the height or have an arc over the top like in the liferaft.

v. During the Liferaft deployment was all the painter line (30m) deployed to allow the raft container to drift over the reef **Yes.** We recommend a red mark on the painter starting 5m from the end so one knows how much line is pulled out.

vi. Was the deployment successful **Yes**

vii. Was the inflation successful **Yes**

viii. Did the light activate **Yes**

f. When the crew had entered the liferaft can you confirm the following:

i. The Internal Light was activated Not Noticed

ii. The following items were easily found;

1. 3 x Pack Bags **Yes**
2. 1 x Paddles (pr) **Yes**
3. Drogue (it is assumed that in this particular liferaft deployment the Drogue was not deployed) **Yes**

g. Were all the Yachts flares taken into the liferaft in the provided yellow 'Poly Bottles' and if so did they remain watertight We put the flares in the grab bags and the used the Poly bottles for water bottles.

4. Liferaft Internal Pack Bags – *Please note that in previous correspondence it is assumed that the references to the Grab Bags leaking refers to the liferaft pack bags. This is noted and following action is to be considered by Ocean Safety Ltd;*

a. *Stronger bags required with a form of strop or handle, possibly to allow for attachment to the inflated Arch to keep them off the floor. See grab bag comments.*

b. *Better Resealing ability. See grab bag comments.*

c. *During Liferaft packing it is necessary to vacuum these bags to minimise their volume hence the requirement for the small valve, this valve requires a better closure. See grab bag comments.*

d. *Pack Bags are to have a list on each to identify their contents.*

e. *Food rations are to be removed from their outer cardboard packaging as is all other cardboard and paper.*

f. *Comment has been made regarding the colour of the liferaft tubes – it should be noted that all standard Solas liferafts have black tubes. The tubes get extremely hot and a visibility difficult. We would recommend a fluorescent colour.*

g. *It should be noted that during the Sea Survival Training in August 2014, the liferafts used in the pool session were 16 person (not 12 person) and contained a Bailing system fitted into the floor. This is not present in the 12 person rafts and a fabric type bailer is provided either in the pack or possibly attached to the internal lifelines – Investigation in to its whereabouts is needed. We would recommend a dinghy style bailer.*

h. Comment – Should future training include the pack bags being in the training liferafts during the pool sessions so that a better appreciation as to their management is gained? **We think it is crucial to use as much of the equipment that is provided to the boats as possible**.

It should be noted that alterations to the liferafts, their internal packs etc. is possible however the rafts must remain to the required SOLAS international standard

i. Which of the following items were used during the time in the liferaft

i. Liferaft 406/121.5MHz Epirb **No**

ii. S10 AIS Transponder **Yes**

iii. Emergency VHF Radio **No**

iv. Handheld Watermaker **No**

5. Training

a. Grounding was not a topic covered in detail during the training (specific mention is not required as part of the ISAF syllabus) clearly in the future this will need to be discussed under separate heading? Or should it be included in more in depth discussion regarding Abandonment? **Yes,** this would need further evaluation as much of the elements are already covered in the current content of the course.

b. Did crew members feel that they had enough in depth knowledge of how all the liferaft equipment worked. **No**

c. Would the training benefit from a more arduous open water liferaft session (this would be weather dependant and may lengthen the course duration by ½ a day and would be in addition to the pool session) **No**

Extra:

General comment:

We recommend that personal preference safety gear should be able to be supplied by the team (whilst complying to the rules).

- It was crucial that we had always had at least half a tank of fresh water.
- We would recommend a soft water container in each grab bag to fill before abandoning the boat as well as for use in the liferaft to collect and store water.
- Our experience suggests that you will not be paddling anywhere fast in a liferaft with any breeze.
- For the pool session we recommend to do the abandon ship drill with taking with you grab bags, spare water etc. Using a line the life raft painter to transfer the bags and having carbines.
- We suggest that the sat phones are checked to be packed in one package including proper plugs, an extension cord and the solar panel.
- The SART AIS unit didn't lock in properly onto the top of telescopic tube.
- We suggest a better handheld VHF with locked volume.
- We recommend that a lifting belt should be a standard item on the boat stored in the swimmer of the watch bag.
- The flippers for the swimmer of the watch should be able to be supplied by the team.
- We suggest a reel for the swimmer of the watch line.
- Equipment that we felt was not functioning properly are the strobes, grab bags, anchors, handheld VHF and flippers.