2^{ND}SUPPLEMENTAL EXPERT REPORT

PREPARED BY

DR. NEVILLE ANTHONY ARMSTRONG

Expert Witness appointed by the Commission of Inquiry into the Collision of Vessels near Lamma Island on 1 October 2012

25 January 2013

Dr. Neville Anthony Armstrong
Naval Architect of Fastships (Australia) Pty Ltd, Coogee, Western Australia

Introduction

1. I make this supplemental report further to my Report dated 3 January 2013 ("**My Report**") and my Supplemental Report dated 16 January 2013 ("**My 1st Supplemental Report**"). Documents referred to in this 2nd Supplemental Report are set out in Appendix III hereto. Sketches and diagrams integral to this report are included in Appendix IV. There are 4 additional photographs taken by me during my inspection of Lamma IV on 11 December 2012 and these 4 additional photographs are included in Appendix V.

Damage Stability and Ballast

2. In Paragraph 71 of My Report, I identified the role of ballast in changing the trim of the vessel and the effect on transverse stability. It has come to my notice that it is not clear that my intention was to refer only to intact stability, and that the effect on the damage stability is not adequately addressed in My Report. I therefore withdraw Paragraph 71 of My Report, and replace it with the following paragraphs:

Solid Ballast

3. Solid ballast is sometimes added to a craft to improve the intact transverse stability by lowering the centre of gravity. If ballast is added for this reason, then it can have serious outcomes if it is removed or re-located. On *Lamma IV*, 8.25 tonnes of solid lead ballast was added to the craft in October 1998 (and subsequently repositioned on 21 September 2005). According to the submission letter from Cheoy Lee Shipyard, the ballast was added to improve the running trim of the vessel[1]. Because the stability book indicates that *Lamma IV* had adequate stability characteristics before the ballast was added, and because it was added as far aft as possible, I am of the opinion that the solid ballast was added to improve the trim and not added to improve the intact transverse stability. As was required by the Marine Department, a new stability book and a new damage stability book were recalculated and submitted for approval when the ballast was added in 1998 and again in 2005 when

[1]Letter dated 10 March 1998 from Cheoy Lee to MarDep of ballast to be added to *Lamma IV*

it was shifted. A visual check of the solid ballast in *Lamma IV* indicated to me that all of the nominated ballast was in its designated position at the time of the collision.

Effects of Weight increase

4. According to the revised stability book[2], issued after the ballast was added, the lightship weight increased substantially from 48.7 tonnes to 63.6 tonnes, representing more than a 30% increase. I consider this to be a substantial increase. Although the ballast weighed 8.25 tonnes, there must have been additional changes made to the vessel to account for the remaining 6.7 tonnes, which are of unknown origin, although it is believed that additional fendering was added to the ship side. The effect of this large increase in lightship weight was for the vessel draught to increase, with a consequent decrease in the vessel freeboard. The vessel waterline length also changed, but this does not appear to be reflected in any of the documentation nor in the certification. Although the effect of the additional weight on intact stability was to lower the centre of gravity and hence increase the intact stability characteristics, the effect on damaged stability and on the watertight subdivision was that the floodable length reduced, and the margin line immersed at a much lower angle of heel or trim, subsequent to damage. This fact does not appear to have been fully appreciated by those carrying out the work, nor by MarDep in approving it.

Watertight Subdivision and Damage Stability Information

5. Both sets of Instructions[3] [4] refer to the need for watertight subdivision in accordance with Regulation 6 of CAP.369AM Merchant Shipping (Safety) (Passenger Ship Construction and Survey)(Ships Built on or after 1 September 1984) Regulations 1991. Regulation 6 requires compliance with Schedule 1. In addition the damage stability, requirements in force at that time[5] required compliance with Schedule 3 of the same Regulation. The following summary is given by way of explanation of the effect of these two Schedules on the design of *Lamma IV*.

6. <u>Schedule 1 covers the need for watertight subdivision</u> by defining the maximum floodable length of a compartment. The floodable length at any location along the vessel is described amongst the Definitions in Part 1 Section 1 of CAP.369AM

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[2] Stability Booklet for *Lamma IV* with Lead Ballast, 1998
[3] Instructions for the Survey of Launches and Ferry Vessels (1989)
[4] Instructions for the Survey of Class I and Class II Launches and Ferry Vessels (1995)
[5] Fax from Marine Department dated 1 August 1994 attaching requirements for local ferries for stability and watertight subdivision

Merchant Shipping (Safety) (Passenger Ship Construction and Survey)(Ships Built on or after 1 September 1984) Regulations 1991, as meaning "the maximum length of that portion (*of a ship*) having its centre at a given point in the ship which, at that draught and under such of the assumptions of permeability set forth in Schedule 1 as are applicable in the circumstances, can be flooded without submerging any part of the ship's margin line when the ship has no list". The margin line is defined[6] as "a line drawn at least 76 millimetres below the upper surface of the bulkhead deck at the side of the ship." When considering floodable length, the vessel can only trim in the longitudinal direction, as it has no list by definition, and therefore the only position at which the margin line can immerse is either at the bow or at the stern, which is illustrated by the diagrams contained within the damage stability book[7]. It should be noted that the specified regulatory criteria is that the margin line is not immersed, and no reference is made as to whether the vessel might sink or not. The margin line criteria provides some "margin" over the deck becoming immersed or the vessel sinking, and in this way makes some allowance for the effect of any waves swamping the craft.

7. <u>Schedule 3 covers the Damage Stability requirement</u> (which are non-mandatory according to my understanding of MarDep's comments). The requirement is that the vessel maintains a metacentric height (GM_T) of at least 50 mm and also that the margin line is not immersed. There are also some other requirements concerning interim values during the flooding process, but these would not apply to *Lamma IV.*

8. The metacentric height (GM_T) in Schedule 3 is specified to ensure that the vessel does not loose stability and capsize to one side whilst flooded, and is entirely related to transverse characteristics of the vessel. The criteria of more than 0.050 metres for GM_T is a nominal and quite small value derived empirically from examination of many other ships that have survived when damaged, and includes for the effect of moderate wind and weather and passenger crowding to one side.

9. The immersion of the margin line referenced in Schedule 3 is a different requirement to the immersion of the margin line contained in Schedule 1 which has no list or heel. Schedule 3 covers the situation where the lack of stability when damaged might cause the vessel to heel to one side and immerse the margin line at the deck edge,

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[6] Merchant Shipping (Safety)(Passenger Ship Construction and Survey)(Ships Built on or after 1 September 1984), CAP.369AM
[7] Stability Booklet with relocated ballast, July 21, 2005

even though the margin line is not immersed at the ends as checked under Schedule 1. Because the transverse immersion of the margin line and the value of the GM_T are both issues involved in transverse stability, there is some weak relationship between them, but it is not a direct relationship and for this reason **both requirements must be complied with**. GM_T gives an indication of the energy remaining in the ship to avoid capsize (turning over sideways), whereas immersion of margin line gives an indication of the likelihood of flooding with the vessel upright or at some small angle. Compliance with only one of the requirements would not be a safe assumption because the science behind their derivation is different. By way of an example, a hypothetical ship might have a weight added low down in the hull, and as a consequence the draught would increase and the margin line would get closer to the water. The floodable length would decrease, but the GM_T would increase. However, if the same weight was added high up in the same ship, both the floodable length and the GM_T would decrease, demonstrating that conclusions about one characteristic cannot be deduced from the other.

10. The damage stability book issued in 1998 assumes one-compartment damage in accordance with the practice at the time, but the information in the book assumes a watertight door was fitted at Frame ½. There does not appear to have been a calculation done to assess the result of flooding both the Tank Room and the Steering Gear Compartment, and thus representing the real situation with no watertight door at Frame ½. According to my calculation using the spreadsheet of the flooding model referred to in My Report at paragraphs 36 & 37[8], for the condition known as "Full Load Departure" in the stability book, the length of the two compartments when considered together after the ballast had been added in 1998 would exceed the maximum floodable length for that location. Before 1998 when the ballast was added, it appears to me that the floodable length was not exceeded, and therefore the watertight door could have been omitted without breaching the requirements for floodable length and for damage stability, **but this was not the case after the ballast was added**.

11. The situation remained the same as it was in 1998 after the ballast was moved in 2005 and a new Stability and Damage Stability Booklet[9] were issued by Cheoy Lee and checked by MarDep. The damage stability book only presented information on individual compartments, and the combined Tank Room and Steering Gear

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[8]Flooding Model, Expert Bundle, Item 7
[9]Stability Booklet for *Lamma IV* with relocated Lead Ballast, 2005

Compartment with an opening between them was not presented. In the condition contained in the Stability Book named "Full Load Departure", according to my calculation using the spreadsheet of the flooding model referred to in My Report at paragraphs 36 & 37[10], the floodable length was exceeded and the margin line was immersed.

12. A summary of the floodable length calculation for margin line immersion in accordance with Schedule 1, as given by my spreadsheet for the vessel with a lightship according to the inclining experiment results in 1996, 1998 and 2005 and using the loading of *Lamma IV* as it was believed to be on the night of 1 October 2012 is given in the following Table, **for damage to the Tank Room only**:

		Lightship			Condition based on the deadweight (loading) on 1st October 2012		
Condition	Date	Weight [t]	LCG [m]	KG [m]	Weight [t]	LCG [m]	KG [m]
As-constructed	**1996**	48.74	9.862	3.187	62.67	8.397	3.31
With Ballast	**1998**	63.618	8.626	2.430	77.55	8.522	2.66
Raised Ballast	**2005**	60.36	8.397	2.273	74.29	8.473	2.55

TANK ROOM ONLY

Condition	Date	**Depth to margin line [m]**	
As-constructed	**1996**		
With W/T door		1.212	Satisfactory
No W/T door		0.272	Satisfactory
With Ballast	**1998**		
With W/T door		1.007	Satisfactory
No W/T door		**Immersed by 0.115**	**FAIL**
Raised Ballast	**2005**		
With W/T door		1.046	Satisfactory
No W/T door		**Immersed by 0.042**	**FAIL**

13. A similar investigation of the margin line immersion under Schedule 1 (floodable length) was carried out with both the Engine Room and the Tank room flooded, both

[10]Flooding Model, Expert Bundle, Item 7

with a watertight door at Frame ½ and without, using a lightship according to the inclining experiment results in 1996, 1998 and 2005 and using the loading of *Lamma IV* as it was believed to be on the night of 1 October 2012 is given in the following Table, **for damage to the Tank Room and Engine room**. It is noted that as constructed in 1996 and as finally modified in 2005, the vessel in this condition would have met the floodable length criteria (the margin line was not immersed) IF a watertight door had been fitted to Bhd ½, but that the vessel would sink without the watertight door. There was no requirement for this condition to be checked, but it was relevant to the outcome of the accident. The vessel failed to meet margin line requirements as it was in 1998. It should be noted that these tables do not represent the damage stability requirements, only the floodable length requirements. Dr Peter Cheng reports on his investigation of the damage stability requirements, and I have no reason to disagree with these, but my understanding of MarDep's comments is that damage stability is not mandatory, but floodable length calculations are.

		Lightship			Condition based on the deadweight (loading) on 1st October 2012		
Condition	Date	Weight [t]	LCG [m]	KG [m]	Weight [t]	LCG [m]	KG [m]
As-constructed	1996	48.74	9.862	3.187	62.67	8.397	3.31
With Ballast	1998	63.618	8.626	2.430	77.55	8.522	2.66
Raised Ballast	2005	60.36	8.397	2.273	74.29	8.473	2.55

ENGINE ROOM AND TANK ROOM FLOODED

Condition	Date	**Depth to margin line [m]**	
As-constructed	**1996**		
With W/T door		0.378	Satisfactory
No W/T door		**VESSEL SINKS**	**FAIL**
With Ballast	**1998**		
With W/T door		Margin line immersed	**FAIL**
No W/T door		**VESSEL SINKS**	**FAIL**
Raised Ballast	**2005**		
With W/T door		0.021	Satisfactory
No W/T door		**VESSEL SINKS**	**FAIL**

14. It is noted that the third inclining experiment was conducted on *Lamma IV* in 2005 because of modifications to the vessel, namely that the ballast was raised by ten inches. I note that the vessel weight as measured during this experiment had reduced by 3 tonnes from the 1998 experiment. Probably this was associated with the difficulty of reading the draught marks accurately, owing to the weather or waves on the surface of the water, which is not unusual. I find it more problematical that raising the ballast resulted in a lowering of the centre of gravity of the whole vessel by 157 mm (over six inches). This problem is suggestive of some substantial error at some unknown time, either during the 1998 inclining experiment or during the 2005 inclining experiment. It could also be an error in the software used for one or other calculation, as the software was changed between the two dates.

<u>Understanding of the term "Aft peak"</u>

15. An on-line dictionary defines the aft peak as "the extreme after part of the interior of the hull, especially that part below the water immediately forward of the sternpost." This is in line with my understanding of the term.

16. The origins of the term "aftpeak" most likely originate from the opposite of the term "forepeak" which is an old word related to wooden sailing ships where the foremost part of the deck curved upwards at the forward end to provide additional freeboard at the bow as well as to better support the bowsprit (the approximately horizontal mast running forward from the hull and used to support the foremast). Because the deck was raised up at this point and it was the highest point of the under-deck space it was called a peak space, relating to its height. The aftpeak was most likely an opposing term for the small space at the rear of the hull which had little use because of its small triangular dimensions, but was used to support the rudder. Because of the difficulties of bringing a large amount of timber planking to a finish at the stern of a wooden ship, this was generally considered to be the most vulnerable part of the vessel which usually leaked, and an aft peak bulkhead was often fitted to minimise the flow of water into the vessel.

17. The relevance of the aft peak bulkhead in modern times I understand to be related to the need to provide a space of restricted volume such that in case of leakage of sea water past the propeller shaft or the rudder shafts, then the volume of water that could be admitted to the vessel would be minimised. The propeller shaft and rudder shafts represent penetrations of the watertight hull and rely on mechanical seals to provide watertight integrity, and which can fail. On *Lamma IV* there was no

propeller shaft passing through the bulkhead on Frame ½, but there were two rudder shafts penetrating the hull and contained within the steering gear compartment. The importance of the aft peak bulkhead is covered in SOLAS, and also in Regulation 7 of the CAP.369AM Merchant Shipping (Safety) (Passenger Ship Construction and Survey)(Ships Built on or after 1 September 1984) Regulations 1991. However, Regulation 7 is not referenced in either set of Instructions.

18. I have never previously seen a ship design in which the aft peak bulkhead was located anywhere other than close to the stern of the vessel.

Regulatory Standards and watertight doors

19. The safety standards represented by regulations and the Instructions for the Survey of launches and vessels for guidance represent a minimum acceptable safety standard. There can be no lee-way or flexibility in minimum standards. Consequently most prudent engineers would carefully consider the risk associated with designing to the minimum standard, especially when it was intended to carry a large number of passengers.

20. In particular I note that many craft have been lost owing to aft watertight doors being left open or omitted, and this fact is widely known in the industry. Several examples known to me and covering the past 100 years are the loss of *Lusitania* in 1915 (1198 fatalities), *Empress of Ireland* 1914 (1012 fatalities), loss of *Sedco Helen* in 1970 (9 fatalities), *Express Samina* in 2000 (82 fatalities), *Katmai* in 2011 (7 fatalities), *Rabaul Queen* in 2012 (numbers not known but estimated as over 320), and according to information released by the Italian Parliament, *Costa Concordia* in 2012 (32 fatalities) although the Court of Inquiry in this case has not yet published its Final Report.

21. It is because of the risk associated with watertight doors that the International Regulatory Body, the International Maritime Organisation IMO, specifies strict requirements for watertight doors for sea-going ships, including that they have remote indication and alarms in the wheelhouse, remote operation from the wheelhouse, and be of sliding construction such that they can be closed against a force of incoming water. Hinged doors are not permitted.

22. I am surprised and disappointed that a vessel designed for and operating with over 200 passengers can be accepted with a watertight door removed when it appears that

it was originally designed to have one, whether or not it was required under the regulations when it was built.

Corrosion of Aluminium

23. During investigation of the damage to the hull of *Lamma IV* I noted that the thickness of the hull plating appeared to be thinner than plating that I have been used to in vessels of this size. Approximate measurements with a tape measure suggested that the plating was a little over 4 mm. I assumed initially that the plating may have been stretched as a result of the collision and thus reduced in thickness, but I also examined the inside of the engine room for evidence of the general upkeep of the aluminium structure and whether the thickness of the engine room plating may have suffered a reduction in thickness owing to corrosion. I found that the hull plating in the engine room and tank room were in generally excellent condition, as stated in my initial Report at paragraph 23. I then purposefully looked for the results of the thickness gauging carried out during the survey process as reported in paragraph 25 of My Report.

24. Whilst my opinion of the structural condition of *Lamma IV* in the Engine Room and Tank Room was that it was in excellent condition, I did not look at the whole structure, only isolated parts that were readily accessible.

25. I note that the generally accepted tolerances for marine grade aluminium plating of this size are 0.2mm, for example as given by the Classification Society regulations of Det norske Vertitas[11]

26. I have been involved in the design and manufacture of aluminium craft since 1989, almost all of them using 5083 grade marine aluminium plate with 6061 grade extrusions. I have also assisted with maintenance of various craft and provided expert technical advice on corrosion issues that have affected several aluminium fast ferries and luxury yachts. The great majority of problems with corrosion that I have witnessed have related to the areas around stainless steel materials in way of waterjet inlets, and the remainder have related to galvanic action caused by dis-similar metals on the vessel and/ or on the wharf. In all of these cases the corrosion has been below the waterline external to the craft and involved other materials.

[11] Extract from the Rules for High-Speed and Light Craft of Det norske Veritas ("DnV"), July 2011 (see Appendix IV, Item 21)

27. Aluminium alloy oxidizes extremely rapidly when the surface is scratched or abraded, to form aluminium oxide. Whilst aluminium might generally be considered to be a soft material, in fact aluminium oxide is **one of the hardest substances known to mankind**. It is also called corundum, an extremely abrasive material, and in other crystaline arrangements is known as ruby and also sapphire. When formed on bare aluminium it is extremely thin (about 4 nanometres), but nevertheless it forms a highly effective boundary to corrosion.

28. Because the corrosion properties of marine grade aluminium are so good, a large number of high-speed craft have been built in 5083 marine grade aluminium without being painted, particularly on the interior, and on the outside of catamarans between the hulls. Paint is only generally applied to these craft to provide an identity of the owner. An example of a 2006 design for which I was responsible and which was built in aluminium and which has not been painted is given in Appendix IV Item 22.

29. I doubt whether the reduction in thickness of the side plating from 4.83mm to 4.4 mm could have been caused by corrosion. I also find it difficult to comprehend how this could have happened in the first nine years (1996-2005) and then there was no further significant corrosion over the next six years (2005-2011) as suggested by the thickness gauging reports. However, I note that *Lamma IV* has been operating in tropical areas with high temperatures and high humidity, and it is possible that condensation on the inside surfaces may have been acidic and caused some corrosion. I have been involved in several military vessels operating in the Western Pacific, in conditions of high temperatures and high humidity, and these have not exhibited corrosion of the plating. These craft however have not been operating in areas with atmospheric pollution such as are sometimes experienced in Hong Kong.

30. Classification Society regulations do permit lesser scantlings than the 5.0 mm minimum required by the 1995 Instructions. I understand that the designer has commented that the scantlings would be satisfactory even at 4.4 mm thickness. However I also note that the 1995 Instructions[12] permit scantlings to be set by Classification Societies, but if so then the vessel must remain in Class with that Society.

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[12] Instructions for Survey of Class I and Class II Launches and Ferry Vessels (1995)

Separation of *Sea Smooth* from *Lamma IV*

31. The MarDep radar information provided in Captain Pryke's Supplemental Report suggests that *Sea Smooth* appeared to continue on past *Lamma* IV after the collision for some distance before back-tracking at very high speed[13]. These echoes are, I believe, spurious. They could be caused by the large wave wake wash that was being generated by *Sea Smooth* at that time as previously discussed, owing to the critical speed and depth of water, but more likely it was a function of the radar which I believe attempts to be predictive as to the next location of the echo in order to maintain continuity of tracking individual targets. As such the system does not cope well with sudden changes of course or deceleration such as may happen during a collision. The radar echoes are also historical, in discrete time steps of 3 seconds owing to the antennae rotation, and the radar only indicates the course over the ground. However I am not an expert in radar. Nevertheless I believe that the radar echoes related to *Sea Smooth* between 20:20:17 and about 20:21:00 are spurious. The result of the spurious echoes is that it is easy to conclude that the vessels glanced off each other and continued approximately on the same course as previously.

32. The evidence from the damage on both vessels, and specifically on *Lamma IV*, is that the vessels did not glance off each other, and in fact the upper part of *Sea Smooth* did come to rest within the cabin of *Lamma IV* and did not pass through it, as detailed in my Report and further discussed in My 1st Supplemental Report. I also estimated the relative positions of the two craft in my Report and suggested that *Sea Smooth* probably rotated and extracted itself and thus appeared to anyone within the cabin to back out of *Lamma IV*. I also noted that it was possible that *Sea Smooth* could have been mechanically reversed, but that there was no evidence of this from my inspections.

33. Given the unreliability of the radar track, I therefore looked at the AIS data produced by the ship's GPS system[14]. The GPS location is not as accurate as the radar data for actual location, but I believe it does accurately represent relative changes in location over short time intervals. The location of the two craft as given by the radar for *Lamma IV* and by the GPS for *Sea Smooth* in three-second intervals is given in Appendix IV Item 20. The paths are similar to those predicted by analysis of the structural damage, and the location of the vessels agrees with the description of some of the witnesses. *Sea Smooth* was stationary for at least 15 seconds

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[13]MarDep radar track reports and radar plots

[14]Information and data generated from the AIS of *Sea Smooth*

according to the GPS after the collision, and presumably this is when the crew of *Sea Smooth* were collecting their thoughts and rapidly checking the damage.

34. I also note that in this plot the vessels meet at 40 degrees, as indicated by the cut in the deck of *Lamma IV*. This greater angle than previously indicated is a result of *Lamma IV* turning to Starboard more rapidly than had previously been thought by examination of the radar track. That *Lamma IV* turned rapidly is supported by the translation of witness statements of Cheung Kwok-hong[15], To Nin Chee Angel[16], Wong Yee Yi[17], Chan Kin Yan[18], Lee Kin Fai [19], SzetoLan[20], Wong Tai Wah[21], Tsu Chi Keung[22], Lam Muk Lin[23], Chan KamHo[24], and Tang Ying Kit[25],who comment that they felt the vessel accelerate in the seconds before the collision, although in which direction is not generally stated, and it was dark, so it could have been the vessel turning that was felt. It is also supported by the translation of the witness statement of Tang Ying Kit[26] who was standing on the upper open deck looking aft and commented that he saw the wake change just before the collision. Given that it was dark, the wake must have turned white for it to be visible, and I suggest that this is consistent with what would have been seen if the rudders were put hard over and full power applied.

35. Whilst I accept that it is inaccurate to plot radar tracks and GPS data for two different ships, nevertheless I suggest that this provides the only realistic record of the locations and positions and headings of the two craft at the time of this particular accident, as it fits the damage trail left on both craft and also some of the witness accounts, as well as matching the requirements of the physics of the collision. One conclusion from these diagrams is that *Sea Smooth* probably came away from *Lamma IV* of its own volition, and not by being backed out, although witnesses in the cabin of *Lamma IV* could not know this because of their limited view of the overall situation.

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[15]English Translation of the Statement of Cheung Kwok-hong (*Lamma IV* passenger)
[16]English Translation of the Statement of To Nin Chee Angel (*Lamma IV* passenger)
[17]English Translation of the Statement of Wong Yee Yi (*Lamma IV* passenger)
[18]English Translation of the Statement of Chan Kin Yan (*Lamma IV* passenger)
[19]English Translation of the Statement of Lee Kin Fai (*Lamma IV* passenger)
[20]English Translation of the Statement of SzetoLan (*Lamma IV* passenger)
[21]English Translation of the Statement of Wong Tai Wah (*Lamma IV* passenger)
[22]English Translation of the Statement of Tsu Chi Keung (*Lamma IV* passenger)
[23]English Translation of the Statement of Lam MukLan (*Lamma IV* passenger)
[24]English Translation of the Statement of Chan KamHo (*Lamma IV* passenger)
[25]English Translation of the Statement of Tang Ying Kit (*Lamma IV* passenger)
[26]English Translation of the Statement of Tang Ying Kit (*Lamma IV* passenger)

Expert's Declaration

I, DR NEVILLE ANTHONY ARMSTRONG, DECLARE THAT:

1. I declare and confirm that I have read the Code of Conduct for Expert Witnesses as set out in Appendix D to the Rules of High Court, Cap. 4A and agree to be bound by it. I understand that my duty in providing this written report and giving evidence is to assist the Commission. I confirm that I have complied and will continue to comply with my duty.

2. I know of no conflict of interests of any kind, other than any which I have disclosed in my report.

3. I do not consider that any interest which I have disclosed affects my suitability as an expert witness on any issues on which I have given evidence.

4. I will advise the Commission if, between the date of my report and the hearing of the Commission, there is any change in circumstances which affect my opinion above.

5. I have exercised reasonable care and skill in order to be accurate and complete in preparing this report.

6. I have endeavoured to include in my report those matters, of which I have knowledge or of which I have been made aware, that might adversely affect the validity of my opinion. I have clearly stated any qualifications to my opinion.

7. I have not, without forming an independent view, included or excluded anything which has been suggested to me by others, including my instructing solicitors.

8. I will notify those instructing me immediately and confirm in writing if, for any reason, my existing report requires any correction or qualification.

9. I understand that:

(a) my report will form the evidence to be given under oath or affirmation;

(b) questions may be put to me in writing for the purposes of clarifying my report and that my answers shall be treated as part of my report and covered by my statement of truth;

(c) the Commission may at any stage direct a discussion to take place between the experts for the purpose of identifying and discussing the issues to be investigated under the Terms of Reference, where possible reaching an agreed opinion on those issues and identifying what action, if any, may be taken to resolve any of the outstanding issues between the parties;

(d) the Commission may direct that following a discussion between the experts that a statement should be prepared showing those issues which are agreed, and those issues which are not agreed, together with a summary of the reasons for disagreeing;

(e) I may be required to attend the hearing of the Commission to be cross-examined on my report by Counsel of other party/parties;

(f) I am likely to be the subject of public adverse criticism by the Chairman and Commissioners of the Commission if the Commission concludes that I have not taken reasonable care in trying to meet the standards set out above.

Statement of Truth

I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. I believe that the opinions expressed in this report are honestly held.

Neville A Armstrong

Dr Neville A Armstrong
25 January 2013

APPENDIX III

Documents referred to in this Report

Footnote		Bundle Reference
1.	Letter dated 10 March 1998 from Cheoy Lee to MarDepof ballast to be added to *Lamma IV*	Marine Bundle 3, p.428
2.	Stability Booklet for *Lamma IV* with Lead Ballast, 1998	Police P, Item 28 pp.4917+
3.	Instructions for the Survey of Launches and Ferry Vessels (1989)	Marine Bundle 8, pp.1761+
4.	Instructions for the Survey of Class I and Class II Launches and Ferry Vessels (1995)	Marine Bundle 8, pp.1810+
5.	Fax from Marine Department dated 1 August 1994 attaching requirements for local ferries for stability and watertight subdivision	Marine Bundle 8, Item 17 p.2081
6.	Merchant Shipping (Safety)(Passenger Ship Construction and Survey)(Ships Built on or after 1 September 1984), CAP.369AM	
7.	Stability Booklet with relocated ballast, July 21, 2005	Marine Bundle 4, pp.667+
8.	Flooding Model, Expert Bundle, Item 7	Expert Bundle, Item 7
9.	Stability Booklet for *Lamma IV* with relocated lead Ballast, 2005	Marine Bundle 4, pp.667+
10.	Flooding Model, Expert Bundle, Item 7	Expert Bundle, Item 7
11.	Extract from the Rules for High-Speed and Light Craft of Det norske Veritas ("DnV"), July 2011	Appendix IV, Item 21
12.	Instructions for Survey of Class I and Class II Launches and Ferry Vessels (1995)	Marine Bundle 8, pp.1810+
13.	MarDep radar track reports and radar plots (Supplemental Expert Report of Captain Nigel R. Pryke)	Expert Bundle pp. 310-336, 356-359
14.	Information and data generated from the AIS of *Sea Smooth* (Supplemental Expert Report of Captain Nigel R. Pryke)	Expert Bundle pp.337-355
15.	English Translation of the Statement of Cheung Kwok Hong (*Lamma IV* passenger)	Police Bundle A(I), Item 2a p. 15-4
16.	English Translation of the Statement of To Nin Chee Angel (*Lamma IV* passenger)	Police Bundle A(I), Item 3a p. 24-5
17.	English Translation of the Statement of Wong Yee Yi (*Lamma IV* passenger)	Police Bundle A(I), Item 13c p. 117-9
18.	English Translation of the Statement of Chan Kin Yan (*Lamma IV* passenger)	Police Bundle A(I), Item 23c p. 242-8
19.	English Translation of the Statement of Lee Kin Fai (*Lamma IV* passenger)	Police Bundle A(I), Item 27c p. 280-10
20.	English Translation of the Statement of SzetoLan (*Lamma IV* passenger)	Police Bundle A(I), Item 33b p.328-4
21.	English Translation of the Statement of Wong Tai Wah (*Lamma IV* passenger)	Police Bundle A(II), Item 36a p.352-3
22.	English Translation of the Statement of Tsu Chi Keung (*Lamma IV* passenger)	Police Bundle A(II), Item 39c p.387-7
23.	English Translation of the Statement of Lam MukLan (*Lamma IV* passenger)	Police Bundle A(II), Item 40c p.397-6
24.	English Translation of the Statement of Chan KamHo (*Lamma IV* passenger)	Police Bundle A(II), Item 54a p.492-2
25.	English Translation of the Statement of Tang Ying Kit (*Lamma IV* passenger)	Police Bundle A(II), Item 63a p.598-3
26.	English Translation of the Statement of Tang Ying Kit (*Lamma IV* passenger)	Police Bundle A(II), Item 63a p.598-3

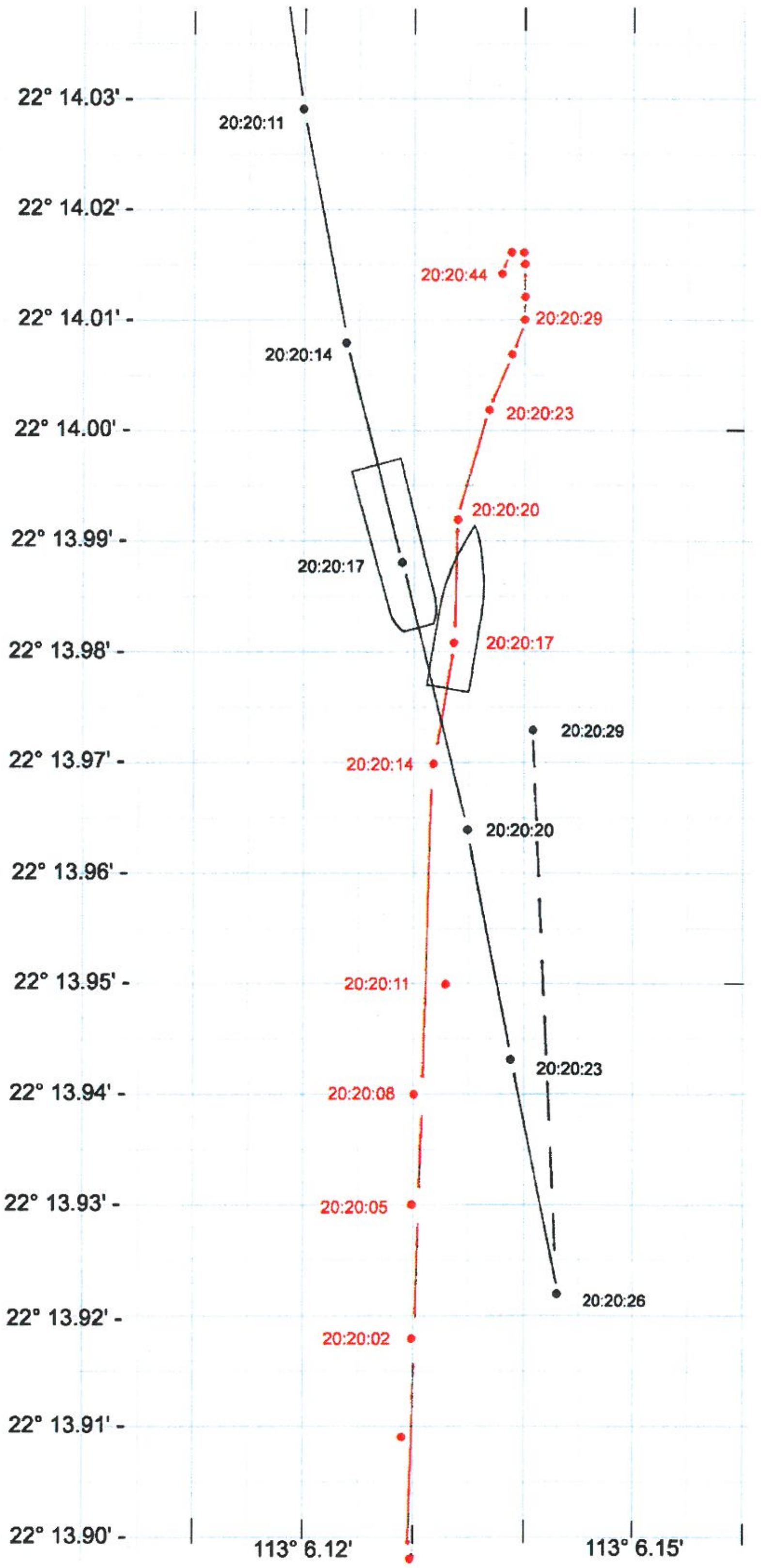
APPENDIX IV

Diagrams and sketches by Dr NEVILLE A ARMSTRONG, and referenced in this Report

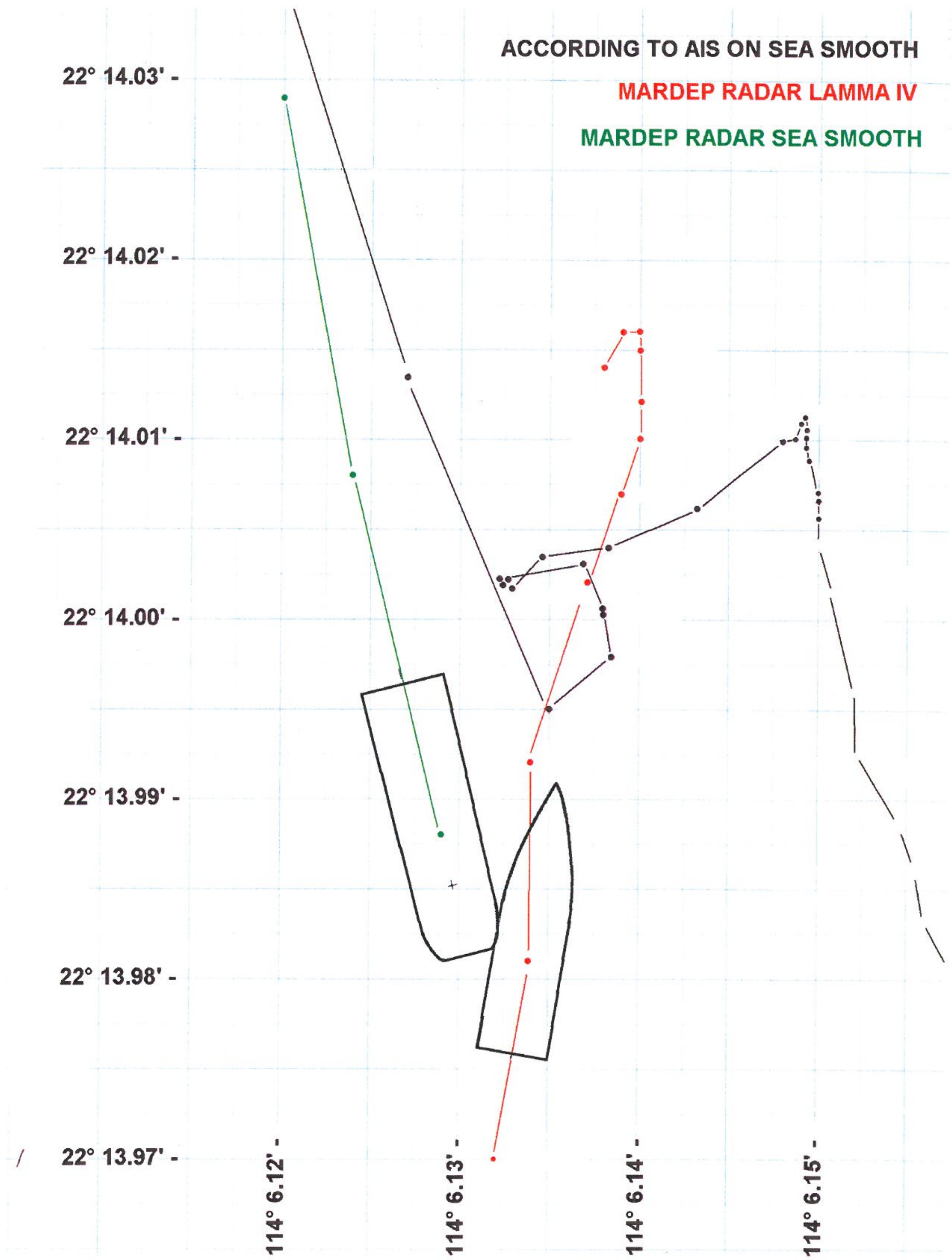
App IV Item	Description	Paragraph in Main Report referencing this Appendix	App IV Page No.
20.	The location of the two craft as given by the radar for *Lamma IV* and by the GPS for *Sea Smooth* in three-second intervals	33	19-29
21.	Extract from the Rules for High-Speed and Light Craft of Det norske Veritas (DnV) July 2011	25	30
22.	*USS Independence*, a 127 metre long all-aluminium vessel, built from the exact same materials as the hull of *Lamma IV*	28	31

Appendix IV Item 20

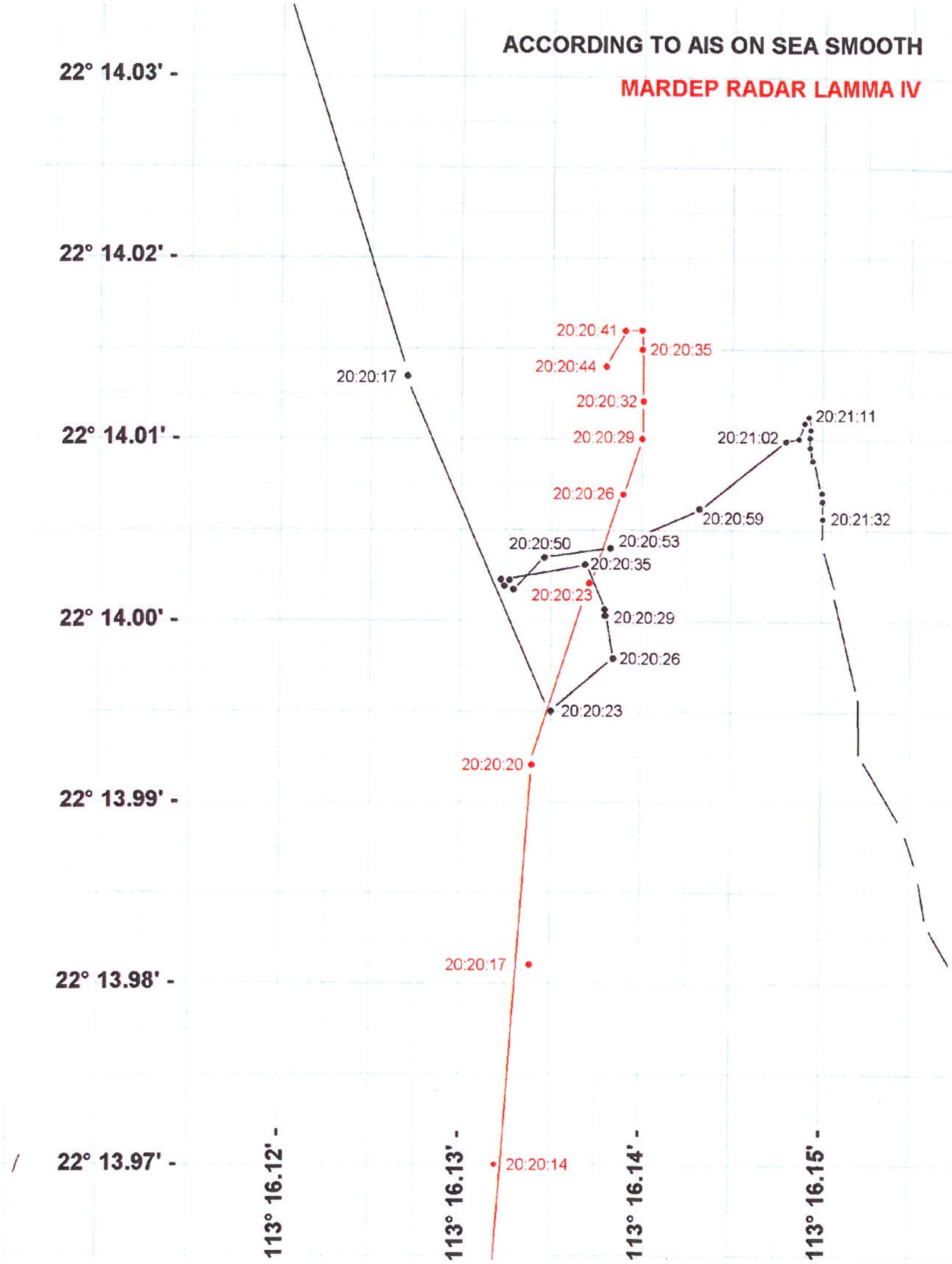
Radar Tracks *for Sea Smooth* and *Lamma IV*



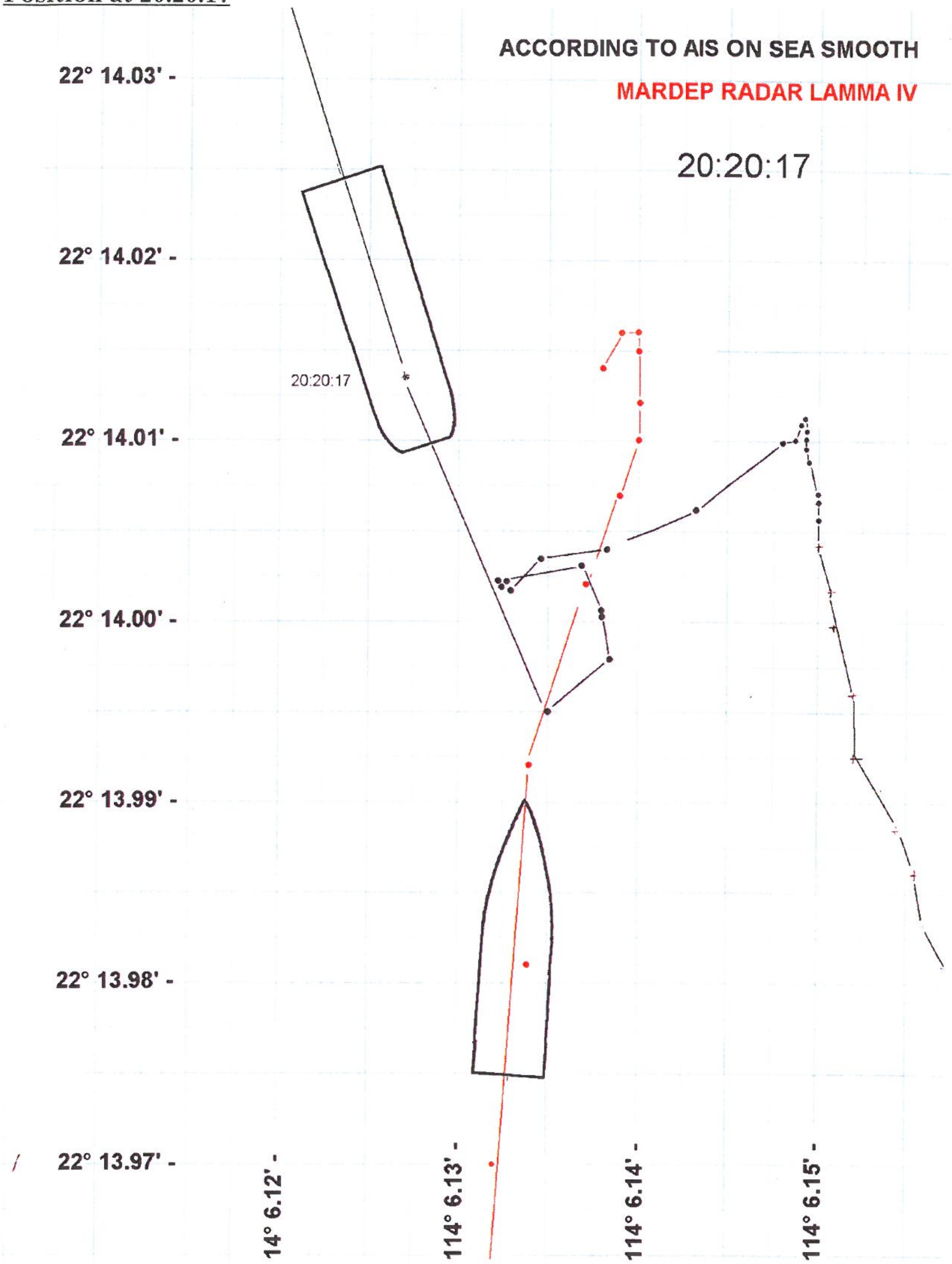
Comparing Radar Track with AIS Track for *Sea Smooth*



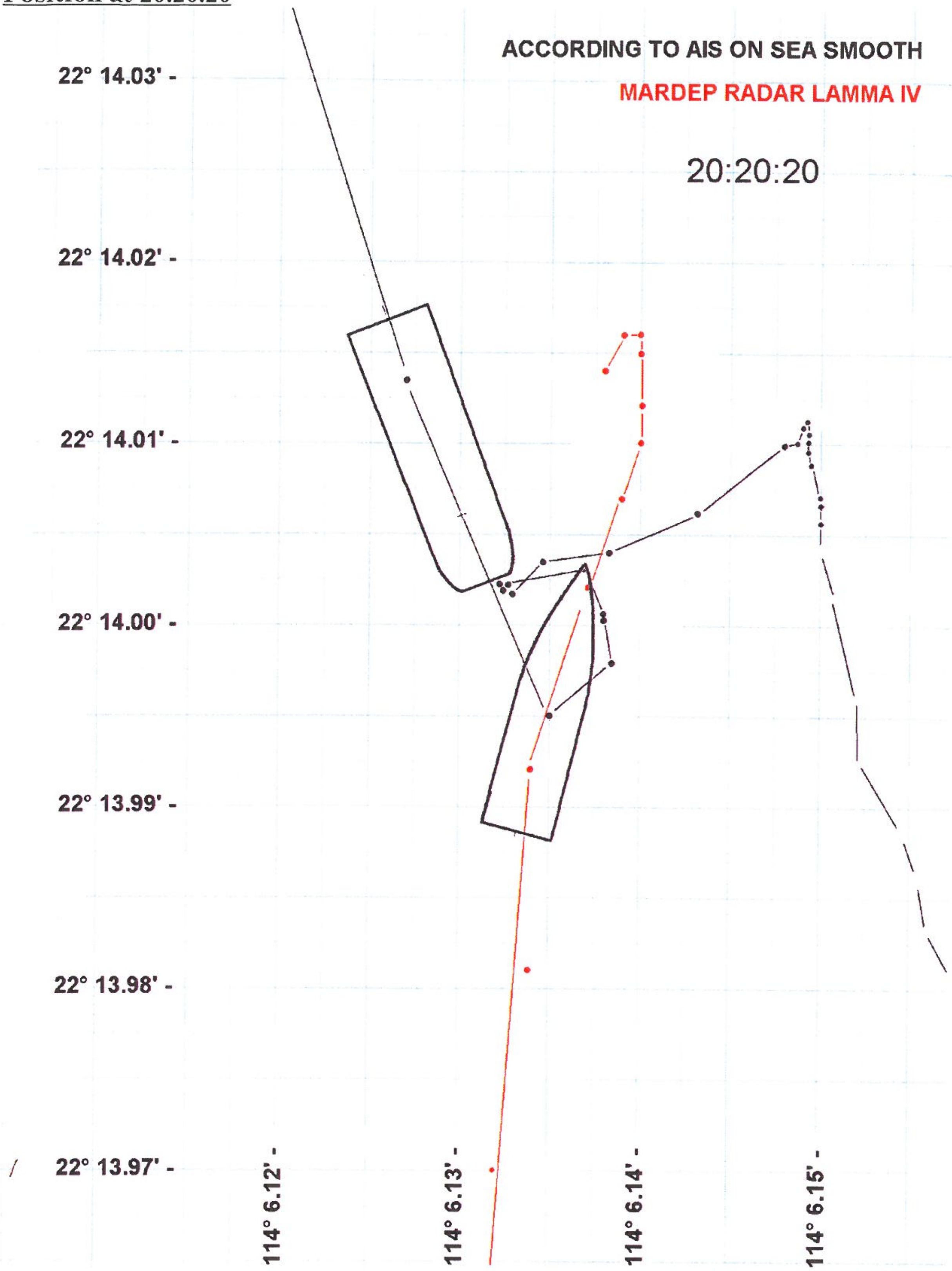
AIS/ GPS for *Sea Smooth* andRadar Track for *Lamma IV*



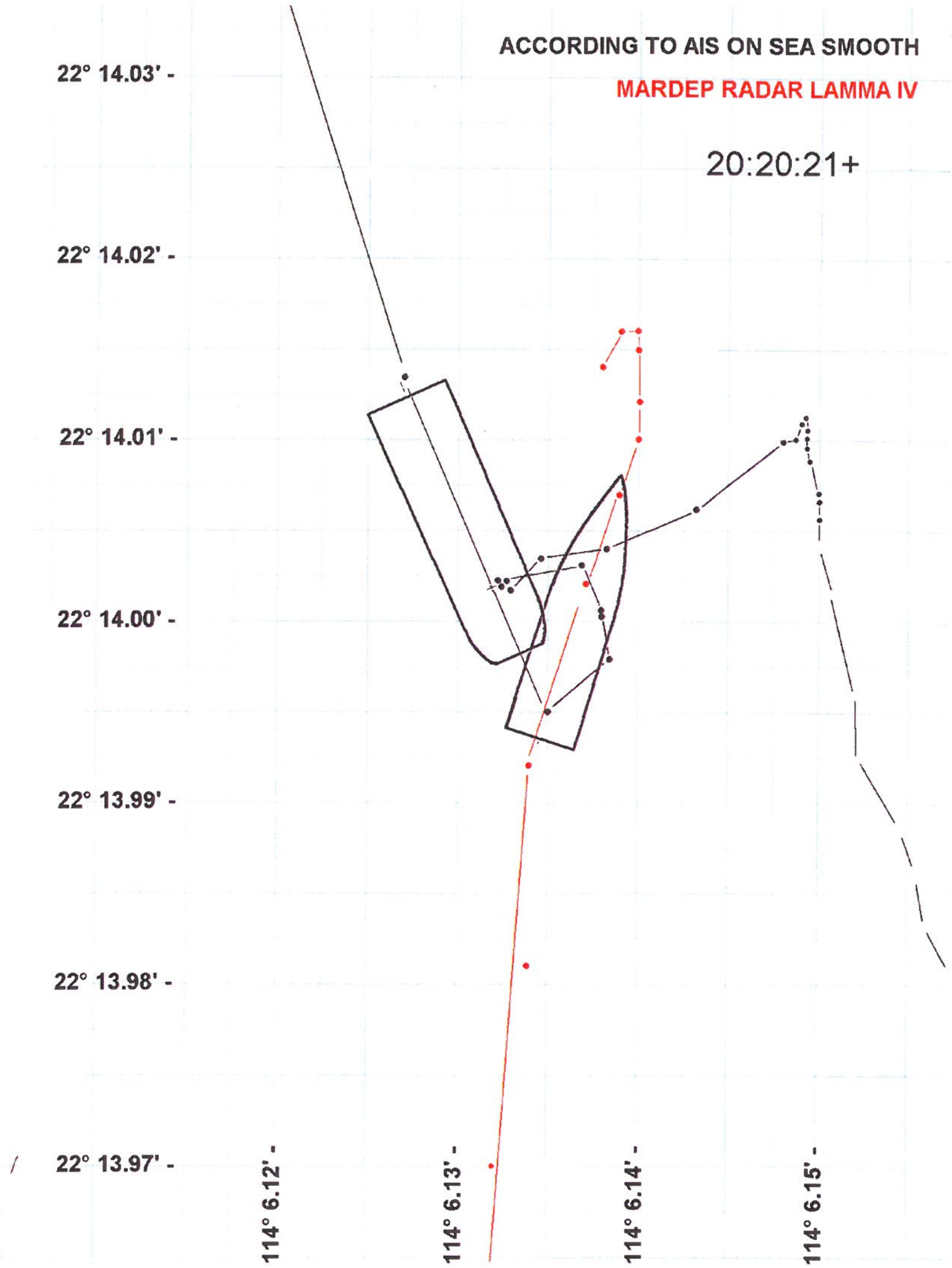
Position at 20:20:17



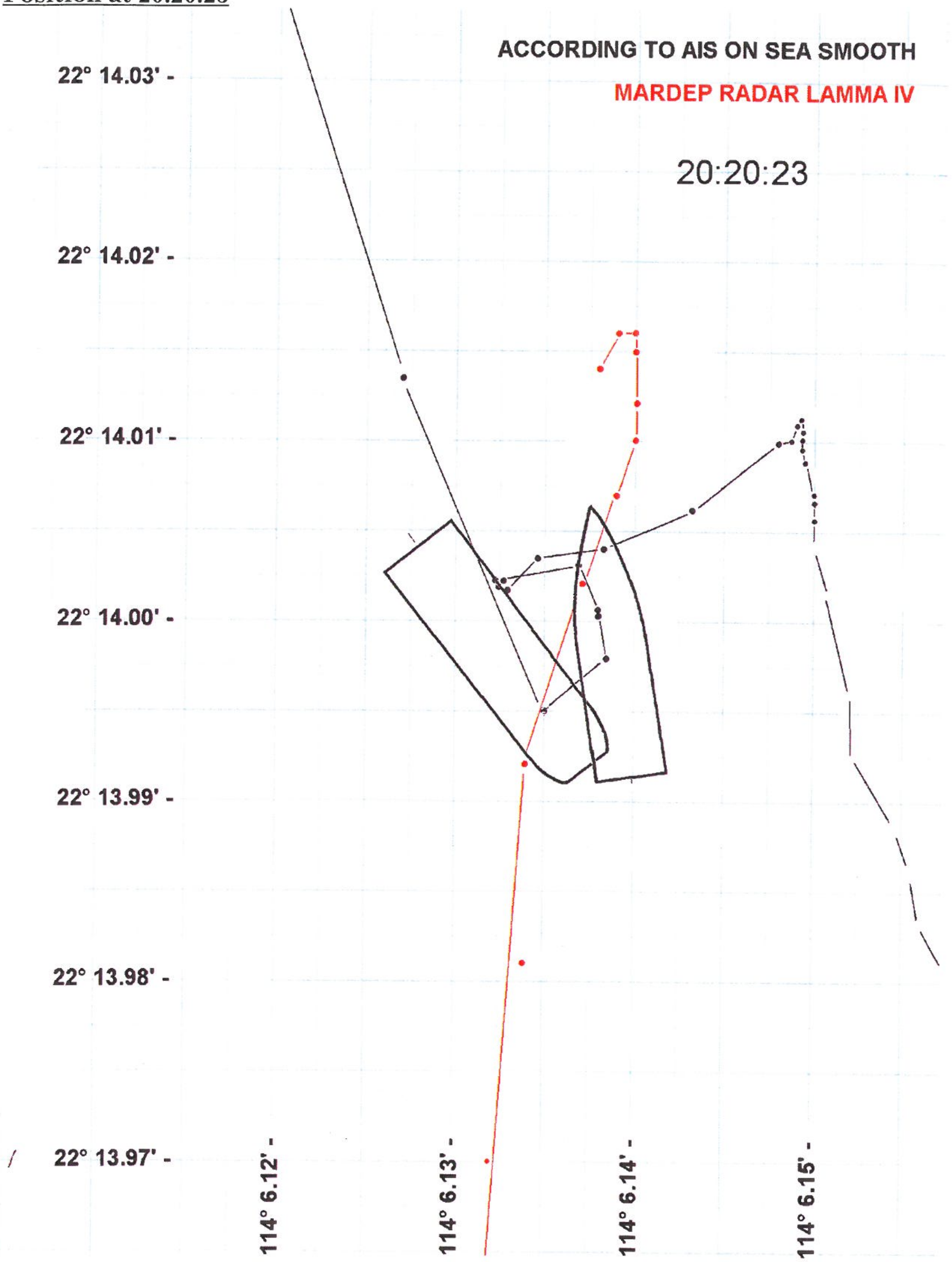
Position at 20:20:20



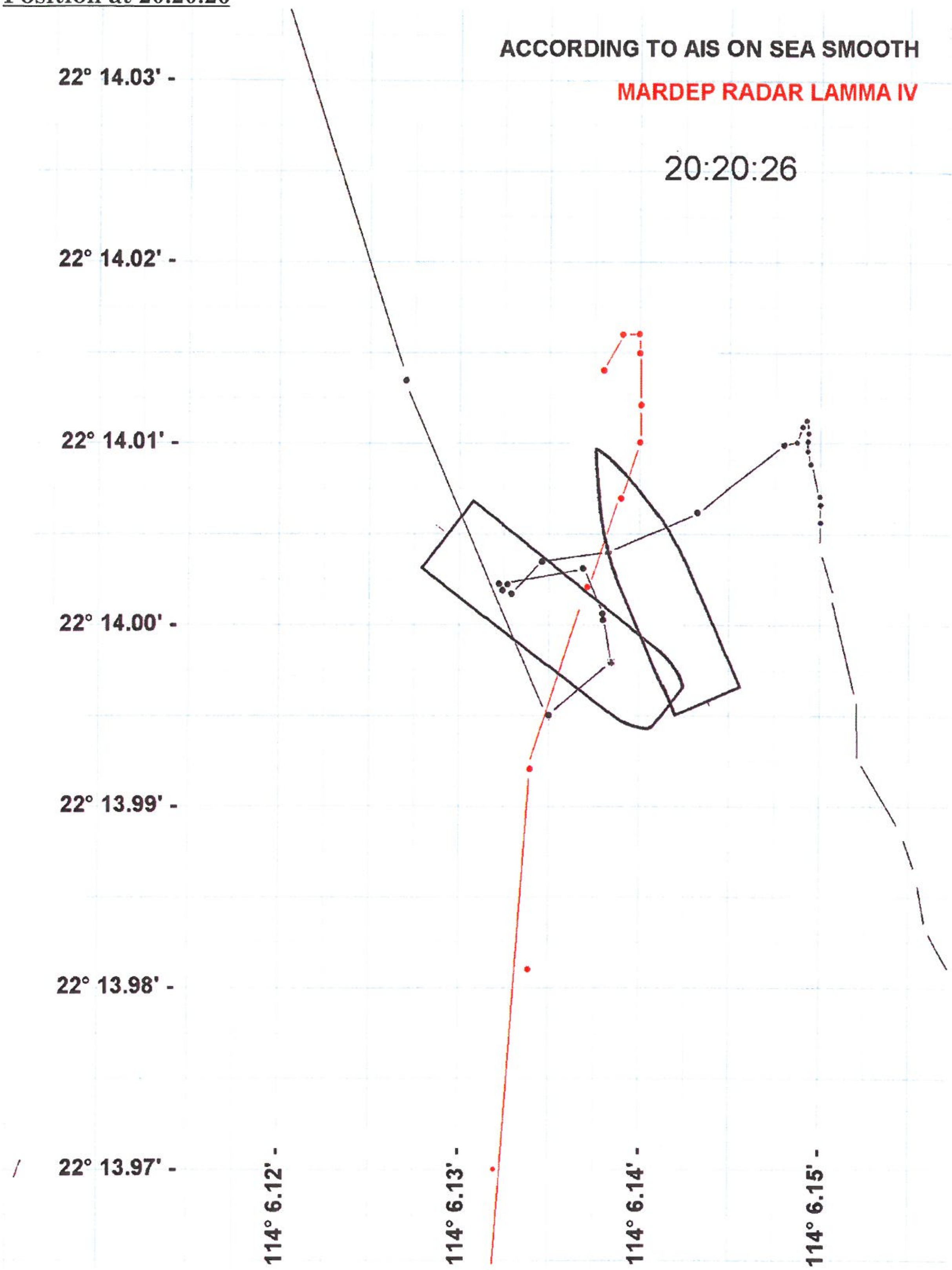
Position at 20:20:21



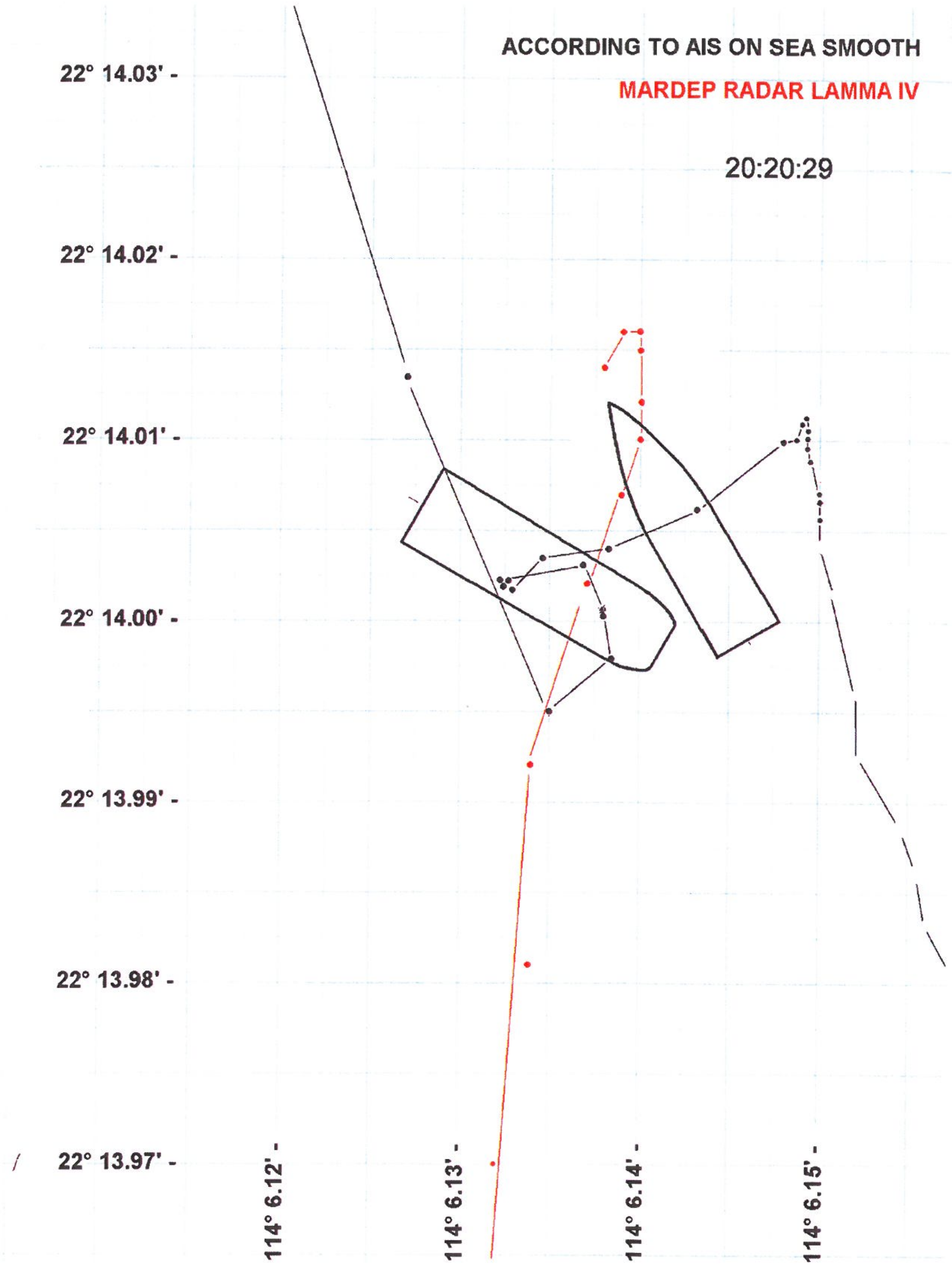
Position at 20:20:23



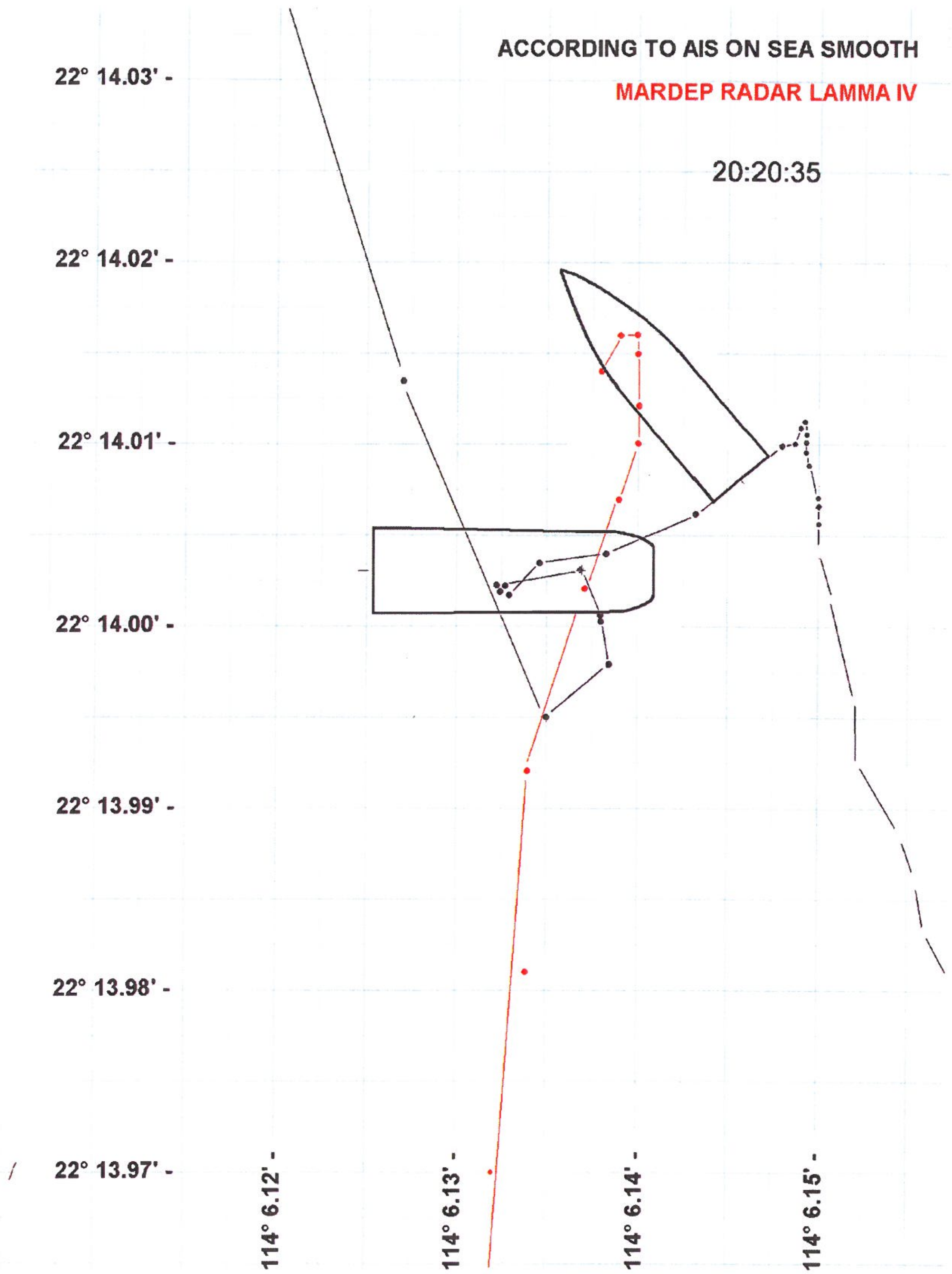
Position at 20:20:26



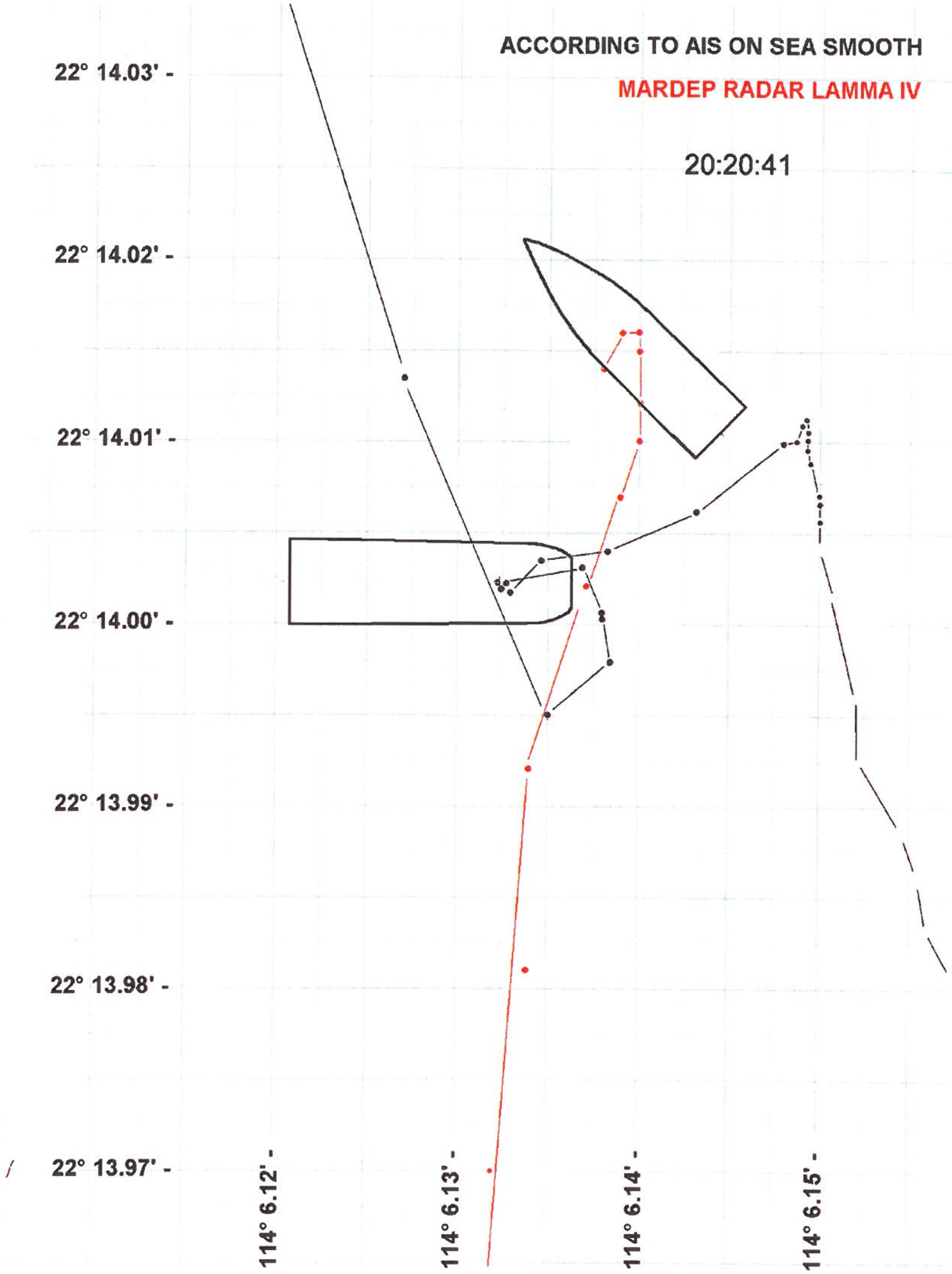
Position at 20:20:29



Position at 20:20:35



Position at 20:20:41



Appendix IV Item 21

Extract from Rules for High-Speed and Light Craft of Det norske Veritas (DnV)

Table A3 Mechanical properties for extruded aluminium alloys

Grade	*Temper*	*Thickness, t (mm)*	*Yield strength $R_{p0.2}$ min. (MPa)*	*Tensile strength Rm min. or range (MPa)*	*Elongation* [1]	
					$A_{50\ mm}$ min. (%)	*A_{5d} min. (%)*
NV-5059	H112	$t \leq 50$	200	330	10	10
NV-5083	0	$t \leq 50$	110	270 to 350	14	12
	H111	$t \leq 50$	165	275	12	10
	H112	$t \leq 50$	110	270	12	10
NV-5086	0	$t \leq 50$	95	240 to 315	14	12
	H111	$t \leq 50$	145	250	12	10
	H112	$t \leq 50$	95	240	12	10
NV-5383	0	$t \leq 50$	145	290	17	17
	H111	$t \leq 50$	145	290	17	17
	H112	$t \leq 50$	190	310	13	13
NV-6005A	T4	$t \leq 50$	90	180	15	13
	T5	$t \leq 50$	215	260	9	8
	T6	$t \leq 10$	215	260	8	6
		$10 < t \leq 50$	200	250	8	6
NV-6060	T4	$t \leq 50$	60	120	16	14
	T5	$t \leq 50$	100	140	8	6
	T6	$t \leq 50$	140	170	8	6
NV-6061	T4	$t \leq 50$	110	180	15	13
	T5	$t \leq 50$	205	240	6	7
	T6	$t \leq 50$	240	260	10	8
NV-6063	T4	$t \leq 50$	65	130	14	12
	T5	$t \leq 50$	110	150	8	7
	T6	$t \leq 50$	170	205	10	9
NV-6082	T4	$t \leq 0$	110	205	14	12
	T5	$t \leq 50$	230	270	8	6
	T6	$t \leq 5$	250	290	6	
		$5 < t \leq 50$	260	310	10	8

1) Elongation in 50 mm applies for thicknesses up to and including 12.5 mm and in 5d for thicknesses over 12.5 mm.

Table A4 Underthickness tolerances for rolled products (mm)

Nominal thickness, t (mm)	*Width of plate (w) (mm)*		
	$w \leq 1500$	*$1500 < w \leq 2000$*	*$2000 < w \leq 3500$*
$3.0 \leq t < 4.0$	0.10	0.15	0.15
$4.0 \leq t < 8.0$	0.20	0.20	0.25
$8.0 \leq t < 12.0$	0.25	0.25	0.25
$12.0 \leq t < 20.0$	0.35	0.40	0.50
$20.0 \leq t < 50.0$	0.45	0.50	0.65

Table A5 Underthickness tolerances for extrusions (mm)

Nominal thickness range, t (mm)	*Open profiles, sections circumscribed by a circle of diameter, d (mm)*			*Closed profiles*
	$d \leq 250$	$250 < d \leq 400$	$d > 400$	
$3.0 \leq t < 6.0$	0.25	0.35	0.40	0.25
$6.0 \leq t < 50.0$	0.30	0.40	0.45	0.30

Appendix IV Item 22

USS Independence. An all-aluminium design built from 5083 marine grade aluminium with 6061 grade stiffeners. Unpainted, except for anti-fouling below the waterline, and non-skid material on the helicopter deck

APPENDIX V

Appendix V – Photo 1. Stern view of *LammaIV* illustrating limit of damage to the after end of the hull and superstructure

Appendix V – Photo 2. *Lamma IV* showing damage from collision bulkhead of *Sea Smooth* which stopped the forward momentum of *Sea Smooth*

Appendix V – Photo 3. Access opening in Bulkhead ½ seen from inside the steering gear compartment, showing corrugated bulkhead above door coaming, and illustrating lack of room to fit a watertight door. This could be overcome by fitting a wider door coaming.

Appendix V – Photo 4. The cut in the port-side deck from directly above.