REPORT on the distance between two vessels using MARDEP radar data

PREPARED BY

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

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Introduction

This analysis was carried out to assist the Commission of Inquiry, as requested during evidence being given on Day 35 of the hearing, 19th January 2013, pages 105~106.

Background data

The analysis is based on the positions of *Lamma IV* and *Sea Smooth* for the three minutes (approximately) immediately prior to the collision, based on the latitude and longitude of the relevant reflections as tracked by the Hong Kong marine radar and as processed by the Marine Department. These locations are reproduced in Appendix A.

The earth is not a true sphere; rather it is flattened at the poles into a shape which mathematicians call an oblique spheroid, or oblique ellipsoid. The exact shape of the surface at sea level changes with the tides, but for all intents and purposes over a distance of less than 100 nautical miles the effect of tides can be ignored as it changes distances by only millimetres. There are several models of the shape of the earth, but the most widely used and accurate one is WGS84 , formulated in 1984 by NASA. This earth model is the basis for satellite navigation and also for the US military use of GPS. It is also used for commercial GPS systems, and the model is stated to have an accuracy of less than 1 millimetre anywhere on the earth's surface.

Using the WGS84 model and the Vincenty formula for oblate spheroids it is a relatively simple task to calculate the distance between two locations given by their latitude and longitude on the surface of the earth at sea level.

An Excel spreadsheet is available from the Australian Government Geoscience Department at http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-techniques/calculation-methods.html which permits different earth models to be selected, including WGS84, and this was used to calculate the distance between *Sea Smooth* and *Lamma IV* based on the radar locations of each craft at known intervals of time.

Results

The distance apart at various times is given in Table 1 in metres and in nautical miles. The results are also given in graphical form in Figure 1.

Local Time [hr:min:sec]	Distance apart (metres)	Distance apart (n.miles)
20:17:35	3030.17	1.636
20:17:38	2978.68	1.608
20:17:41	2925.47	1.580
20:17:44	2870.42	1.550
20:17:47	2812.84	1.519
20:17:50	2755.54	1.488
20:17:53	2700.36	1.458
20:17:56	2645.05	1.428
20:17:59	2592.98	1.400
20:18:02	2537.81	1.370
20:18:05	2481.58	1.340
20:18:08	2424.30	1.309
20:18:11	2368.38	1.279
20:18:14	2314.61	1.250
20:18:17	2259.01	1.220
20:18:20	2221.94	1.200
20:18:23	2184.71	1.180
20:18:26	2138.76	1.155
20:18:29	2079.64	1.123
20:18:32	2018.52	1.090
20:18:35	1958.05	1.057
20:18:38	1896.94	1.024
20:18:41	1843.33	0.995
20:18:44	1789.73	0.966
20:18:47	1728.96	0.934
20:18:50	1668.57	0.901
20:18:53	1614.62	0.872
20:18:56	1559.39	0.842
20:18:59	1507.46	0.814
20:19:02	1454.26	0.785
20:19:05	1409.86	0.761
20:19:08	1358.13	0.733
20:19:11	1302.74	0.703
20:19:14	1237.39	0.668
20:19:17	1174.07	0.634
20:19:20	1127.25	0.609
20:19:23	1073.11	0.579
20:19:26	1004.87	0.543
20:19:29	938.27	0.507
20:19:32	893.29	0.482
20:19:35	821.19	0.443
20:19:38	769.67	0.416
20:19:41	719.18	0.388
20:19:44	658.30	0.355
20:19:47	598.64	0.323
20:19:50	539.18	0.291
20:19:53	496.63	0.268
20:19:56	450.43	0.243
20:19:59	396.25	0.214
20:20:02	338.85	0.183
20:20:05	269.80	0.146
20:20:08	206.07	0.111
20:20:11	147.50	0.080
20:20:14	71.47	0.039
20:20:17	15.51	0.008

Table 1: Results

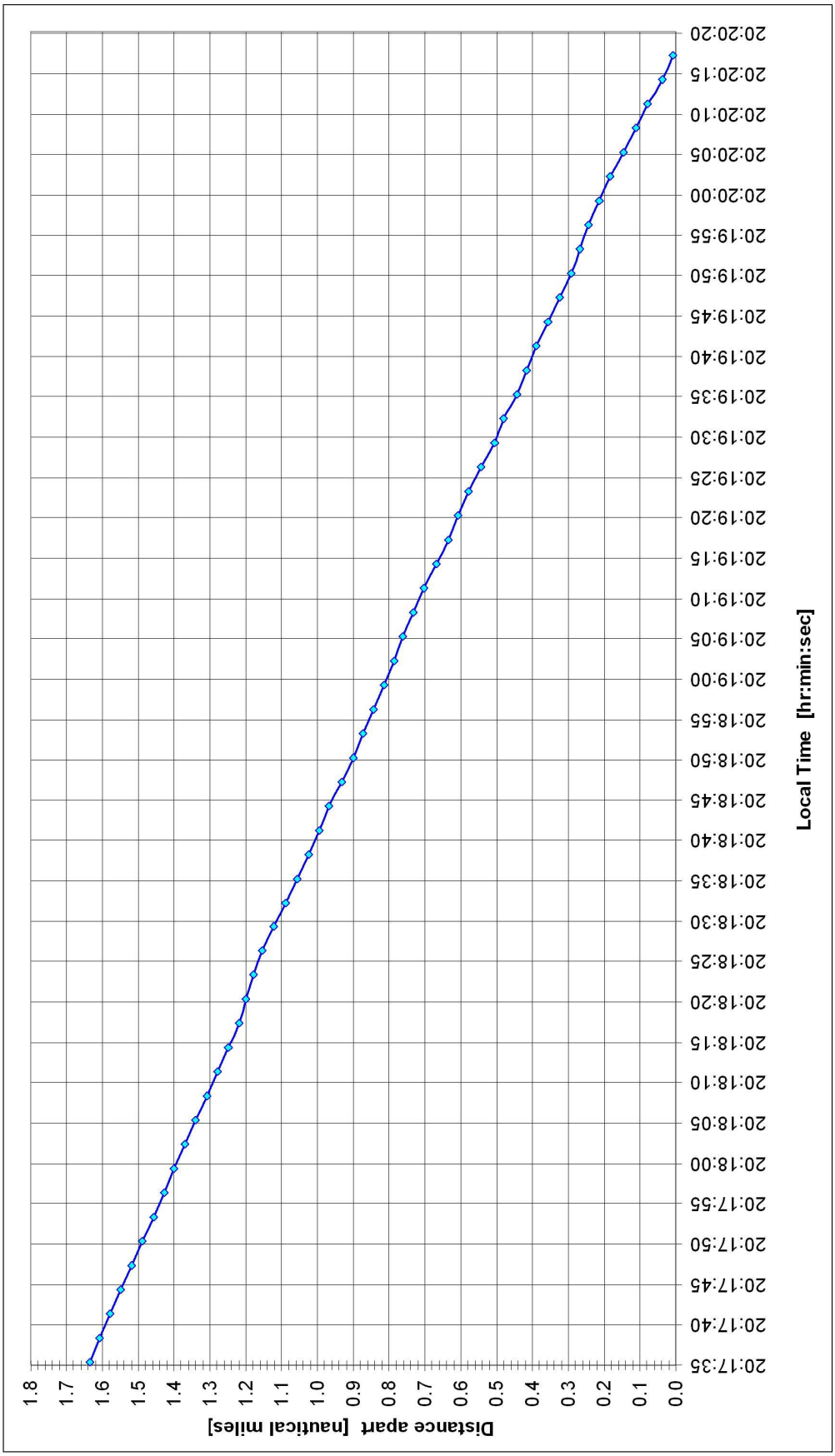

Figure 1: Distance between the two vessels for 3 minutes before the collision

Comment on Accuracy. The calculation of the distance apart of the two craft are based on a highly-accurate model of the earth and are correct to about seven decimal places (although only two are given in Table 1). Any apparent inaccuracies can only be put down to the exact latitude and longitude of the vessel echoes as given by the radar locations provided by Mardep. The radar positions are presented to three decimal places of seconds of arc, which is equivalent to a distance of about 1.85 metres, but I do not know where this apparently exact point is meant to be on each vessel. One might presume that it is calculated as the geometrical centre of various echoes from the signals from the various radar antennae in the Hong Kong system, all of which are reflecting off different surfaces of a vessel at a different time. In this case the output is entirely dependent on the software controlling the multiple inputs, and the accuracy of this software is unknown to me.

Radar only sees edges and facing surfaces, and generally cannot see anything behind them, so one radar is unlikely to "see" the whole vessel and thus locate the centre of the craft. Consequentially I could deduce that the accuracy of the reflection from <u>one radar</u> would be about half the length of the vessel, or about 10-15 metres in this case.

As the Hong Kong radar system has multiple radar antennae, the accuracy must be somewhere between 2 metres and 10 metres.

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6 March 2013