MARIN

Anchor loads and rate of turn M.S. Planet V

Part II: Rate of turn analysis

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Part II: Rate of turn analysis

Ordered by : Dutch Safety Board

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1 INTRODUCTION

The Dutch Safety Board is investigating the accident of Motor Ship PLANET V on the Western Scheldt on May 26, 2012. The vessel experienced a full black out while overtaking a barge towed by MTS Vantage. The speed through the water at the moment of blackout was approximately 11 knots whereas the speed over ground was approximately 9 knots. After the blackout, the vessel turned to port in the direction of the tow. The crew made an attempt to avoid a collision by use of the port side bow anchor. The anchor winch brake however was not able to stop the running anchor chain. The anchor chain fully ran out and broke out of the chain locker fatally injuring a nearby standing crew-member. Also, the collision with the barge could not be avoided.

In her investigation of the accident, the Safety Board would like to find the answer to the following two questions:

First question: What is the magnitude of the loads on the anchor gear and the vessel when a vessel is stopped by the anchor? What are the main parameters and what loads can be expected for various scenarios?

Second question: What is the cause of the Rate of Turn of the vessel after the black-out and what could have prevented this Rate of Turn?

This document describes the work executed by MARIN to find the answer to the second question. First the accident was analysed in order to create a clear picture of the events that happened, and to establish a clear time line of events. Using bridge simulator software the accident was reconstructed and analysed.

This document can be divided in the following sections:

1. Introduction;
2. Analyses of the available data regarding the accident;
3. Set up of the simulator database;
4. Reconstruction of the sailed track;
5. Conclusions.

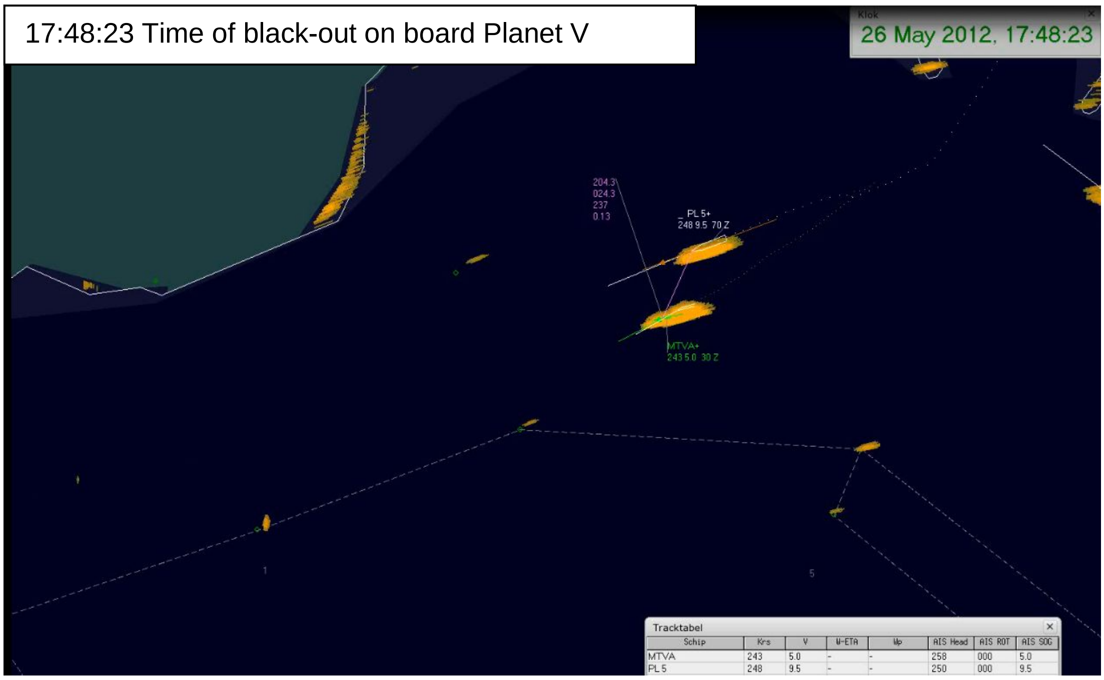
2 ANALYSIS OF THE ACCIDENT

In this section the accident is analysed. The aim of this phase is to get a clear picture of what happened and evenly important in what sequence. The following data was received to analyse and reconstruct the accident:

- Powerpoint presentation
- DVD with recorded radar images and voice recordings of the VTS
- Abstract communications
- AIS data
- Pictures
- Sea trials report

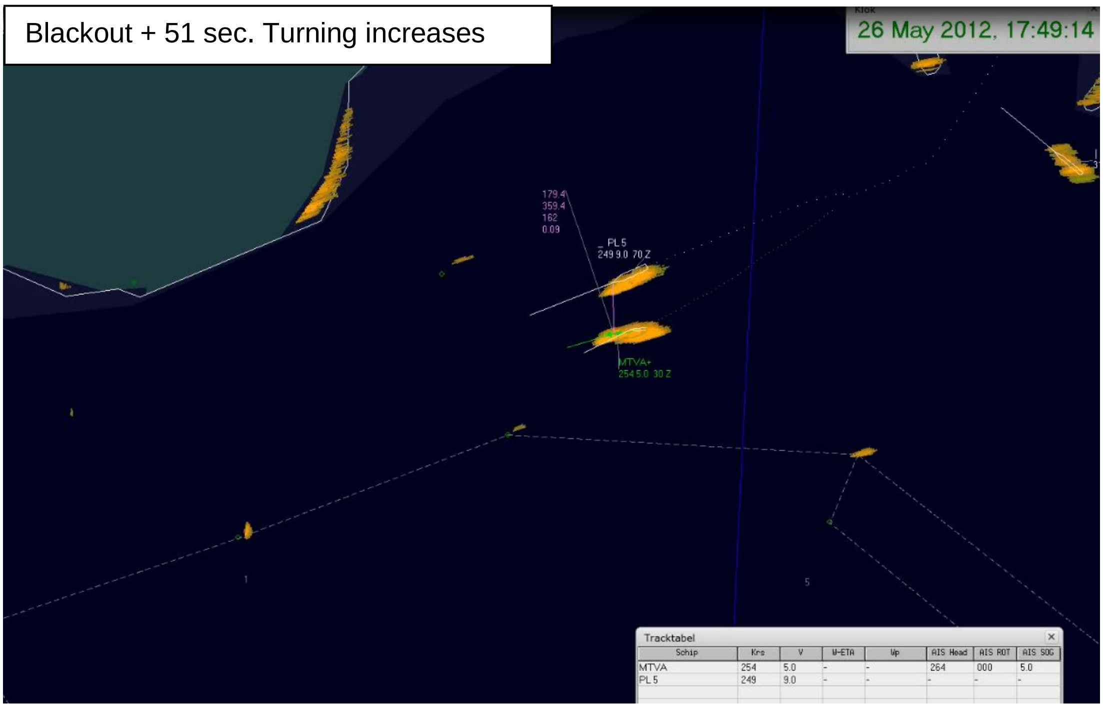
2.1 Summary of events during the accident

In the next figures captures of the VTS radar recordings are shown. In between these graphs tables are included which contain transcriptions of the voice recordings that were made during the accident. This gives a good impression of the events that took place during the accident.



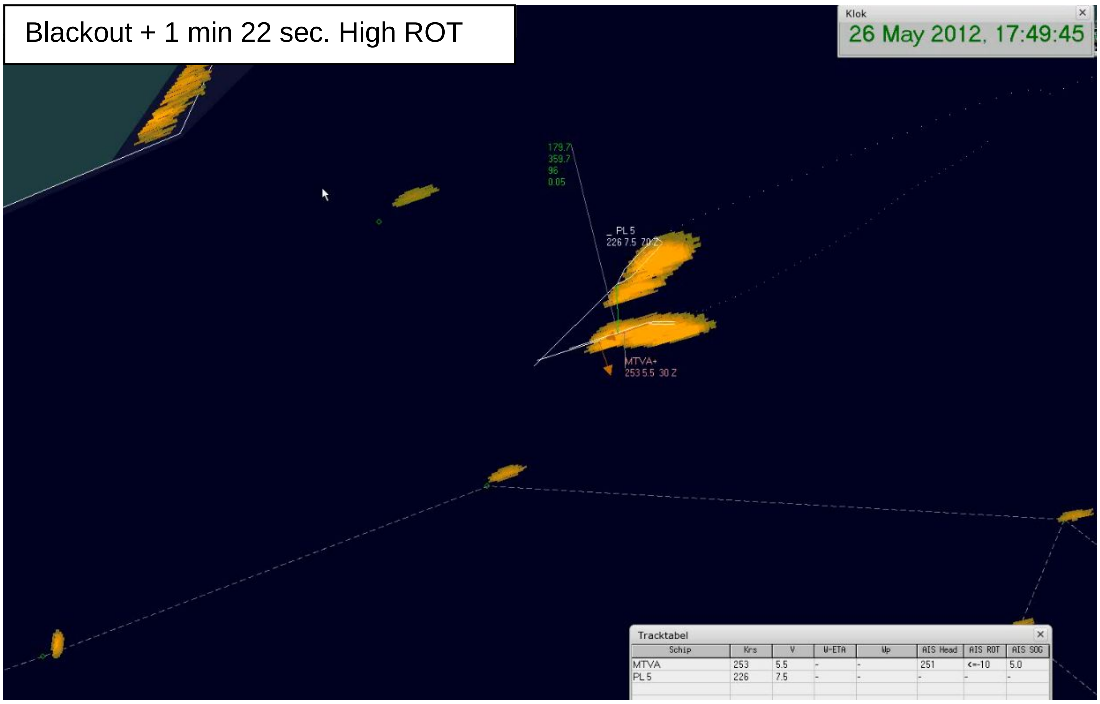
0:09	Planet V		alarmtoon (piep), toenemend volume
0:13	Planet V	kapitein	oh oh oh
0:16	Planet V	kapitein	Clear the anchor
0:25	Planet V		alarmtoon, zeer sterk volume
0:51	Planet V	loods	Mts Vantage, geef eens vol vooruit. Ik heb een black-out.

Blackout + 51 sec. Turning increases

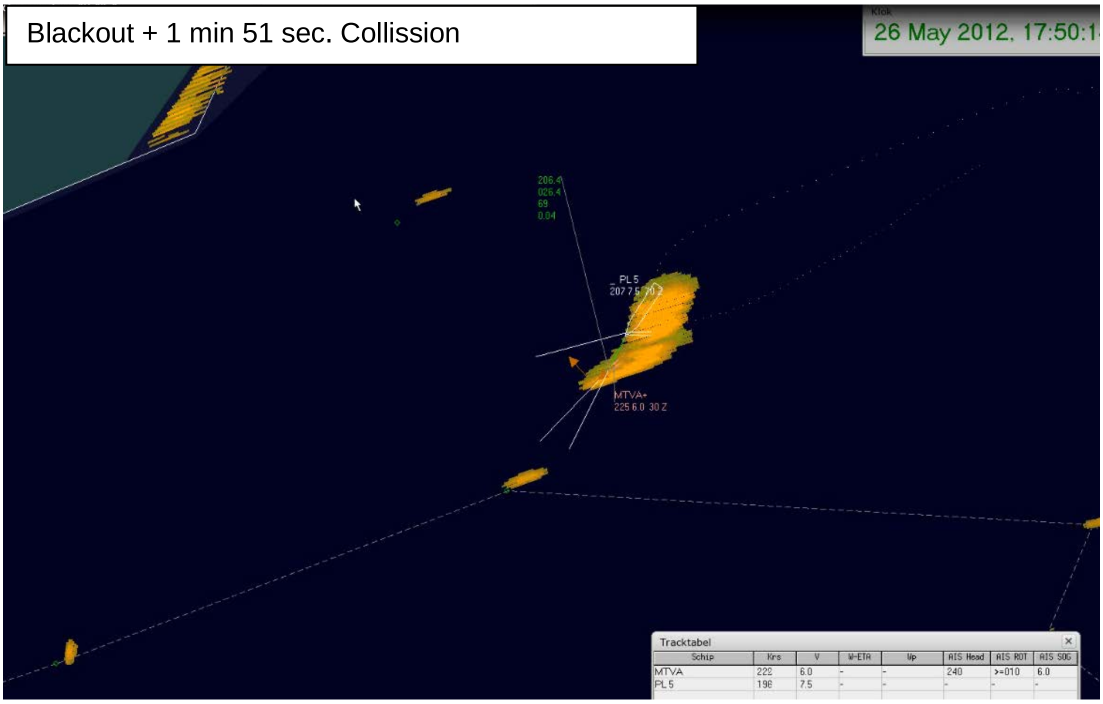


0:56	MTS Vantage	loods	Ja ok.
1:01	Planet V	loods	Centrale Vlissingen, Planet V. Black-out.
1:04	SCC	operator 2	Planet V, centrale Vlissingen. Begrepen.
1:11	Planet V	kapitein	Let go anchor
1:20			Vermoedelijk ruis van uitlopen ankerketting

Blackout + 1 min 22 sec. High ROT



1:28	Planet V	kapitein	…fast…
1:33	Planet V	kapitein	fast…fast
1:41	Planet V		alarmtoon (piep), [elke 10 seconden]
1:51			Aanvaring (ruis)



1:54	Planet V	loods	Centrale Vlissingen, Planet V.
1:54	Planet V	kapitein	where's the anchor?
1:57	SCC	operator 2	Planet V, centrale Vlissingen.
2:00	Planet V	loods	Vlissingen, de Planet V heeft die bak van het sleeptransport geraakt met de black-out. Het bakboord anker hadden we erin gegooid, maar we konden niets meer doen.
2:08	Planet V	kapitein	Keep anchor fast

The time of black-out is recorded in the transcriptions of the voice recordings at 17:48:23 and is based on a supposed audible decrease of rpm's. After analysing the audio recordings MARIN concurs that at this moment the noise decreases, but that it is also difficult to conclude this is caused by a reduction in revolutions of the main engine. Another possibility is that first some auxiliary machinery stops and the actual black-out of the main engine occurs later (after the audible alarms).

2.2 Evaluation of heading during the accident

On board of Planet V data is recorded via the SVDR. The SVDR is the ships voyage data recorder. In the timeframe between the blackout and the collision only data of the first 37 seconds after the blackout was recorded by the SVDR. The following plot shows the development of ships heading and Course over Ground (COG). 17:48:23 is the time the black-out occurred according to the log that was provided by the Dutch Safety Board.

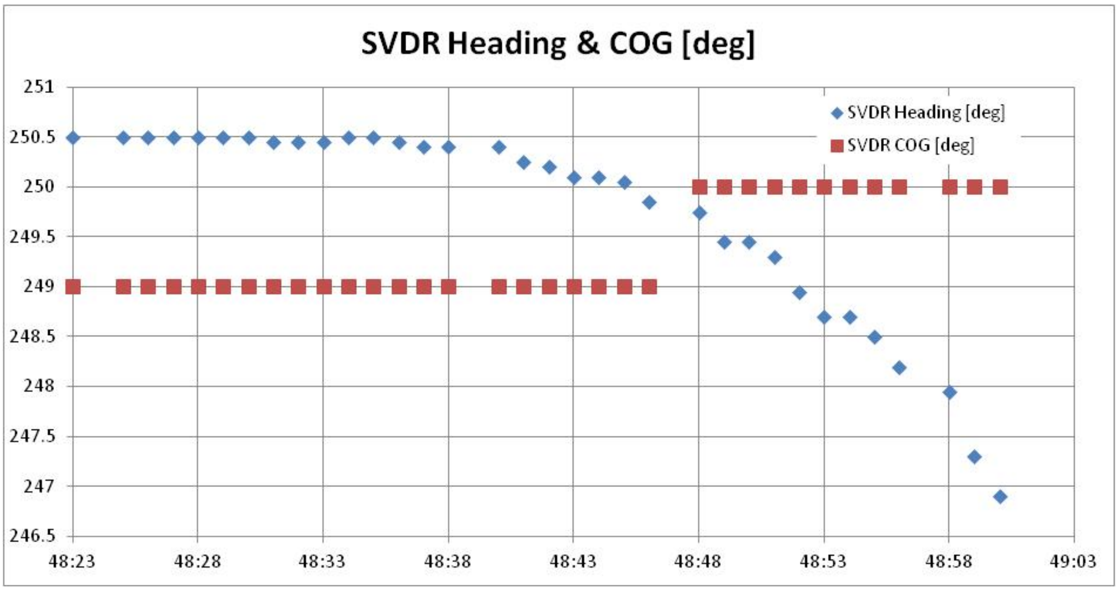


Figure 2-1 Heading and Course over Ground (t=0 is time of black-out)

From these graphs it becomes clear that approximately 14 seconds after the recorded time of black-out the vessel starts to turn to port. The heading data was used to construct the turning rate of the Planet V. This is shown in Figure 2-2.

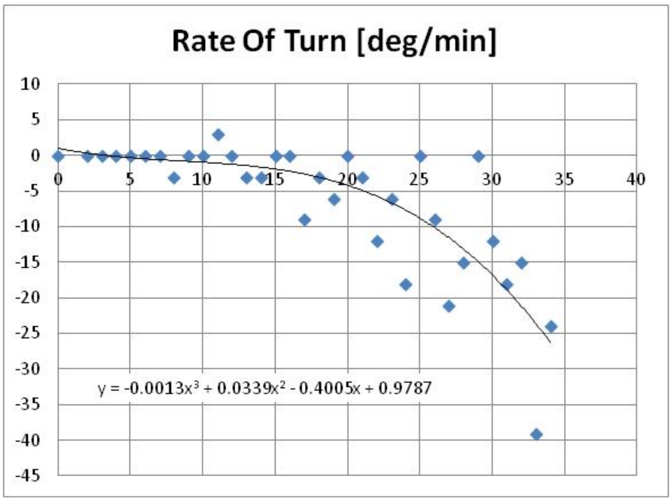


Figure 2-2 Rate of turn (t=0 is time of black-out)

This graph only shows the development of the rate of turn in the first 35 seconds. Since there is no on board data available after 17:49:00 the heading of the vessel was also estimated from the radar pictures (see Table 2-1). This may not be the most accurate method, but the results look very plausible and are confirmed by the picture taken just before the collision.

Table 2-1 Estimated heading of Planet V

Time	Heading [°]
17:48:50	249.5
17:49:00	248
17:49:10	247
17:49:20	242
17:49:30	235
17:49:40	223
17:49:50	214
17:50:00	208
17:50:10	198
17:50:20	190
17:50:30	185

When the headings measured with the SVDR and the estimated headings from the radar picture are joined together, the following figure can be created (see Figure 2-3). The time of black-out, the time the anchor was dropped and the time the collision took place are indicated in this figure.

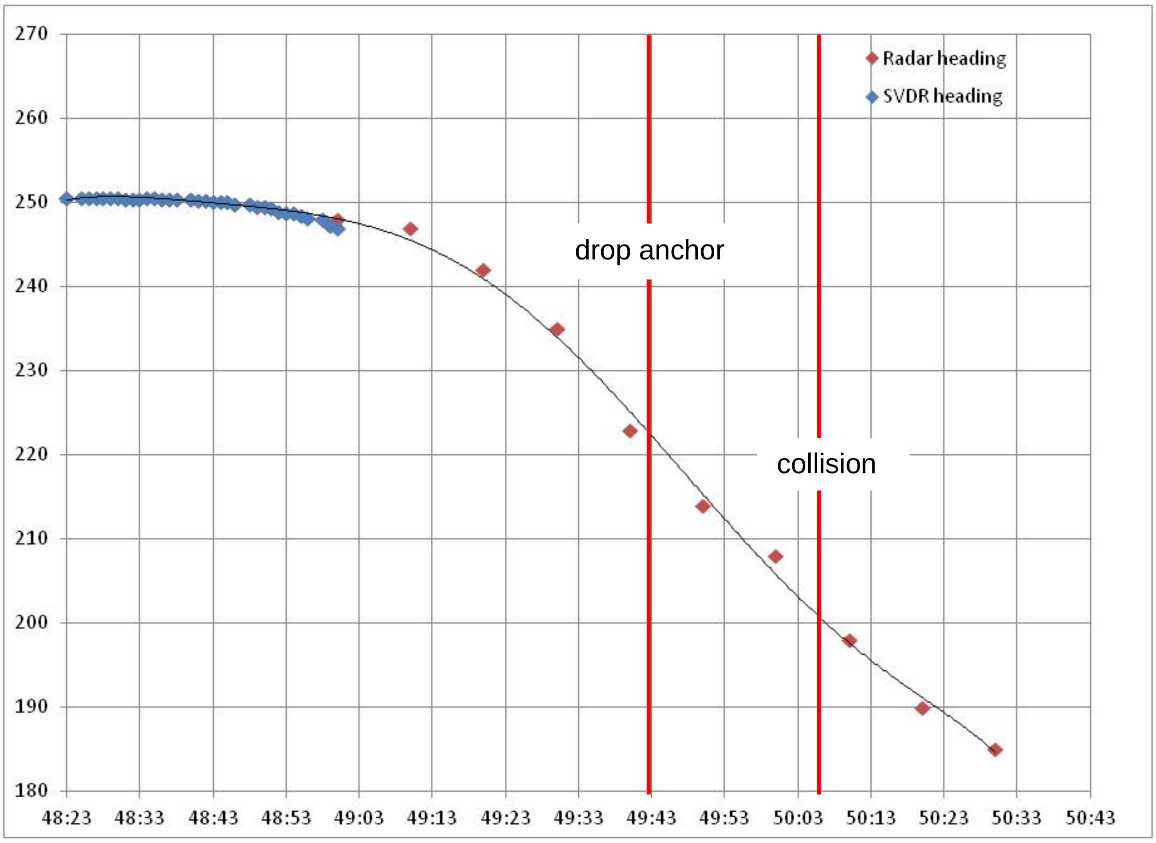


Figure 2-3 Heading Planet V [deg]

From Figure 2-3 the rate of turn could be determined. Table 2-2 shows the development of the rate of turn from the moment of the black-out. The first 30 seconds after the recorded time of black-out the rate of turn remains low, than it increases rapidly, until it reaches its maximum of 57 deg/min at 17:49:43. Than it gradually decreases again.

Table 2-2 Rate of turn

Time	ROT [°/min]
17:48:23	0
17:48:33	0
17:48:43	-4
17:48:53	-8
17:49:03	-15
17:49:13	-28
17:49:23	-37
17:49:33	-50
17:49:43	-57
17:49:53	-57
17:50:03	-50
17:50:13	-40
17:50:23	-34

From pull out trials, executed during the sea trial program, it can be taken that the ship is course stable and therefore high forces/moments are necessary to create a high rate of turn.

2.3 Evaluation of speed during the accident

The following plot shows the development of ships speed (COG), as recorded by the SVDR.

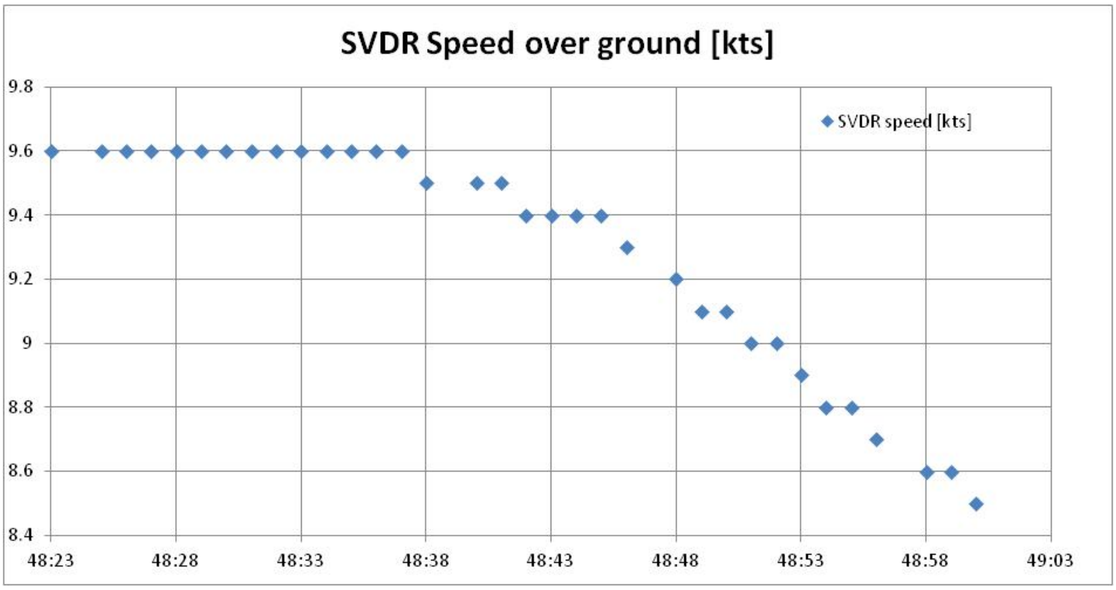


Figure 2-4 Speed over ground in knots (t=0 is time of black-out)

To create a more complete picture of the speed development during the accident, data of the sea trial program was used. Deceleration tests were part of the sea trial program executed with the Planet V (see Appendix A). A deceleration test from half ahead to stop, shows that for a short period the speed remains almost constant. Than after 10-15 seconds it decreases almost linear (from T+15 to T+80) with 0.6 kts/10 sec. Between T+80 and T+200 the deceleration is approximately 0.4 kts/10 sec.

During the sea trials the vessel was in ballast, while during the accident the Planet V was partly loaded. Despite this fact, the speed decrease logged by the SVDR is perfect in line with the data from the sea trials. Therefore the measured data has been extrapolated using the sea trial deceleration curve. When we plot the radar speed in the same figure, it seems to lag behind. This may be expected, since radar speeds always have some delay when a contact changes speed. The radar speed is also influenced by the current. At the beginning of the turn the current is head on, at the end of the turn the current is from abeam. This effect is not accounted for in the extrapolation based on the sea trial data.

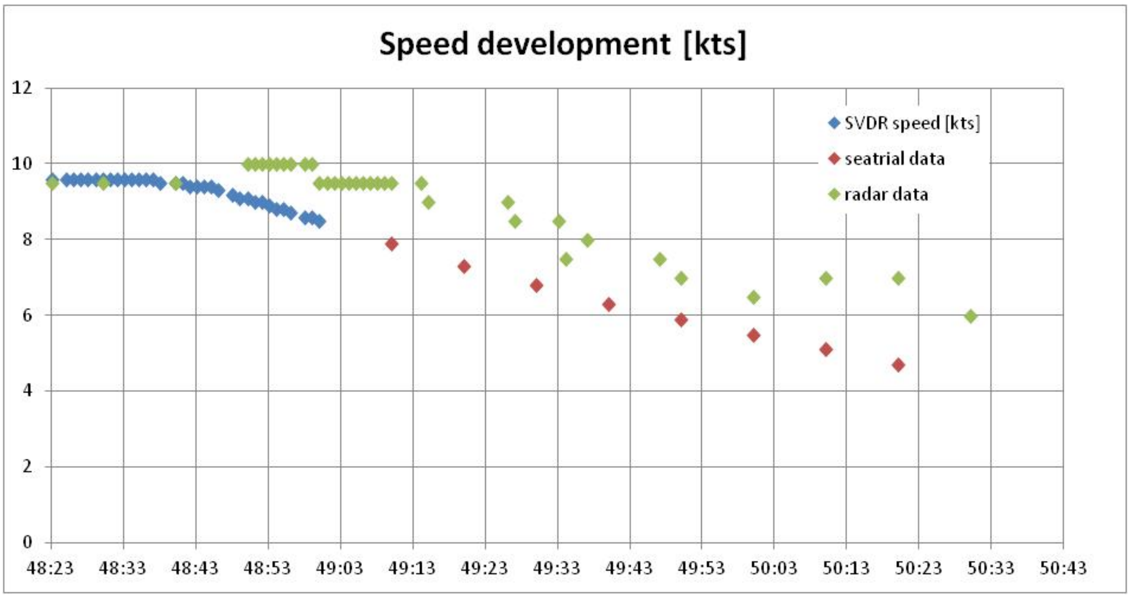


Figure 2-5 **Speed development from different sources**

What can be concluded from Figure 2-5 is that it takes 14 seconds before the Planet V starts to decrease speed. Therefore the time of the black-out given in the communication abstract may be erroneous. Careful study of the SVDR tapes reveal that at 17:48:23 the noise level drops, but it is difficult to assess if the main motor hum decreases in revolutions. It may be that first some auxiliary machinery stops, and that the main engine and shaft revolutions react somewhat later. If we define the black-out as the moment the shaft revolutions start to decrease the most likely time of black-out should be corrected to: 17:48:37.

An overview of the speed and heading development is given in Figure 2-6. The time of black-out, the moment the anchor is dropped and the time of collision are indicated in this figure. On the left axis the heading scale is in degrees, on the right axis the speed scale is in knots.

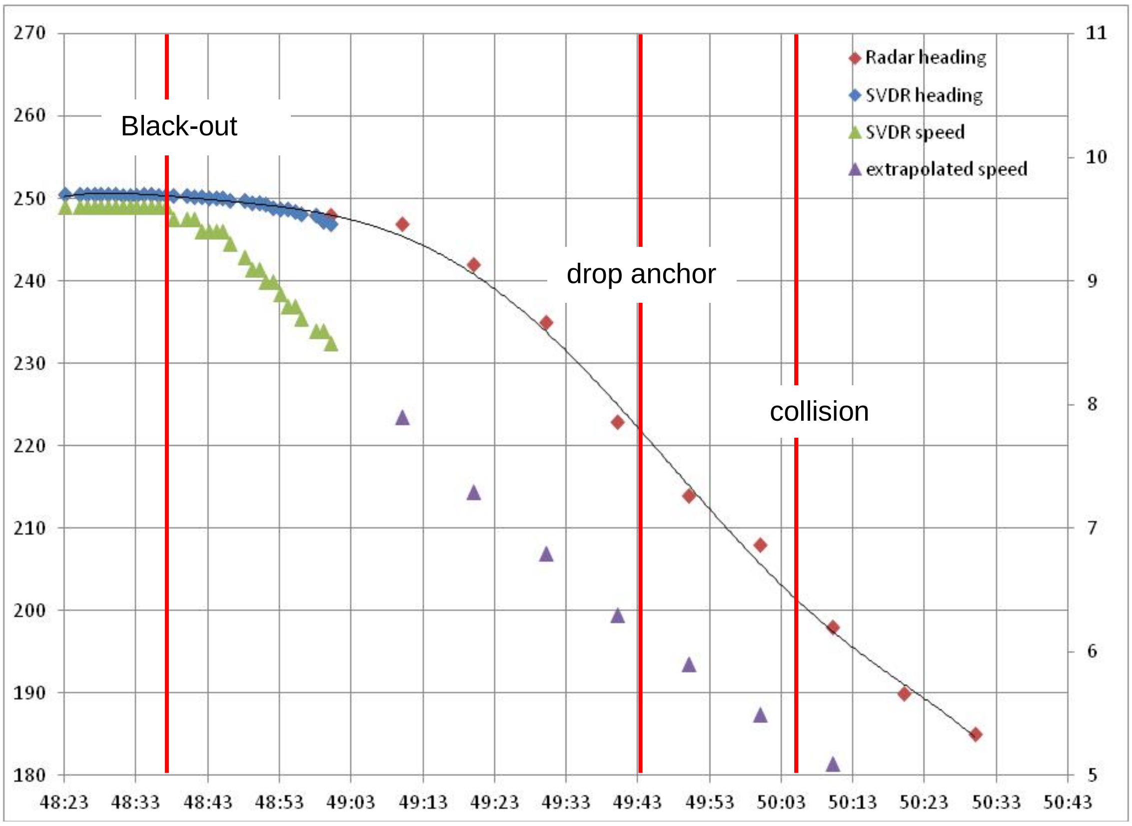


Figure 2-6 Development of heading and speed

2.4 Intermediate results

Based on the study of the events during the accident the following can be concluded:

1. No noticeable speed decrease or course change was recorded by the SDVR or shore radar for the first 14 seconds after the time of black-out was recorded in the communications abstract. The most likely time of the black-out is therefore corrected to 17:48:37.

2. After the black-out (at 17:48:37) the Planet V starts to turn to port. The Rate of Turn reaches a maximum of 57 deg/min at 17:49:43. Since the anchor was dropped at the same time and no increase in rate of turn or a stronger decrease of speed were observed from this point onwards, it can be concluded that the anchor did not contribute significantly to the executed manoeuvre.

   There was simply not enough time (only 25 seconds between the moment the anchor was dropped and the time of collision), to deploy enough chain. Therefore the holding power of the anchor was too low to be of any influence. This is confirmed by the picture taken just before the collision (Figure 2-7). On this picture it can be seen that the anchor chain is pointing almost straight down, meaning it is not pulling sideways or astern, and is therefore not contributing to the rate of turn and is not slowing down the vessel.

Figure 2-7 Picture taken just before the collision

3 SET UP OF THE SIMULATOR DATABASE

This chapter describes the set up of the simulator database that was used to reconstruct the accident in the simulator.

3.1 Simulator database

The simulator database contains all elements necessary to reconstruct the accident. The following elements can be distinguished:

- Lay-out of the area;
- The manoeuvring models of the ships;
- Environmental conditions.

3.2 Lay-out of the area

The accident was reconstructed using the Vlissingen database. A database is available at MARIN which contains the Westerschelde and approach. The area and bathymetry are modelled in great detail.

3.3 Vessels

For the reconstruction of the accident a mathematical model of the Planet V was constructed by scaling an existing model of a similar container carrier to the exact dimensions and draft of the Planet V. The barge was also modelled, but very basically. It was just used to give an impression of the sailed track of the tow. The MTS Vantage was not included, but ship-ship interaction forces that were caused by the combination of tug and tow were included in the model of the barge.

Figure 3-1 MTS Vantage with barge

Table 3-1 gives an overview of the main dimensions of the Planet V.

Table 3-1 Main characteristics of the planet V at time of accident

Ship's type		**CONTAINER Vessel**
Length over all	[m]	116.4
Length between perpendiculars	[m]	107.8
Beam	[m]	19.2
Depth	[m]	-
Draught amid ship's	[m]	6.8
Draught forward	[m]	6.8
Draught after	[m]	6.8
Displacement	[tons]	-
Dead Weight tonnage	[tons]	7,000
Maximum draught	[m]	7.05
Engine type	[-]	Diesel
Power	[kW]	3960/2100
Number of revolutions	[rpm]	134.6
Service speed	[kn]	23.6
Number of propellers	[-]	1
Diameter of propeller	[m]	4.4
Pitch ratio	[-]	Var
Bow Thruster	[kW]	353
Number of rudders	[-]	1

MSCN mathematical models contain the following hydrodynamic effects:

- Effect of Underkeel Clearance on manoeuvring characteristics;
- Bank suction effects;
- Squat;
- Wind coefficients based on wind tunnel tests;
- Mean drift forces and first order motions are computed with DIFFRAC, this model also takes into account shallow water effects;
- Collision and line forces from tugs assisting the vessel (push or pull) and from the fenders and mooring lines.

The model of the Planet V was extended with ship-ship interaction forces. Furthermore the mathematical model was tuned with results of the sea-trials. In section 4.1 this is described in more detail.

3.4 Environmental conditions

The black-out on the Planet V occurred on Saturday May 26th 2012 at 17:48:23 Local time. To make an accurate evaluation of the incident it is important to reconstruct the conditions under which the incident took place. The following data was used:

3.4.1 Current

The black-out took place approximately 30 minutes before HW Vlissingen. The tidal range on May 26th was 3.51 m which is around 1/3 of the maximum tidal range. The current was going to 074 – 2.0 kts. In the Vlissingen database a full tidal cycle (spring tide) of the current is modelled. In this database High water occurs at 15:20. By scaling the magnitude of the current field a ENE going current field with a strength of 2.0 kts was created.

3.4.2 Wind

The wind was coming from the ENE (direction 070) with speeds of 7 to 10 m/s. The simulations were executed with wind of 8 m/s. For wind a uniform field was used. Some gusting was incorporated in the simulations as well.

3.4.3 Waves

The weather at the time of the accident was good and since it took place in fairly sheltered waters, there were only low wind waves. Based on photography at the time of the collision the wave height was estimated 0.2 m.

3.5 Ship-Ship interaction forces

When two Ships are passing each other at close range interaction effects occur. Especially in confined waters the effects may be quite large. With the MARIN tool ROPES the ship-ship interaction forces were calculated for the Planet V case. The results were used to fill a database in the simulator, so the Planet V would experience ship-ship interaction forces when passing the barge in the simulator.

The calculations were made for the case that the Planet V overtakes the tow combination. The tow consists of tug with barge. A sensitivity study showed that the interaction forces on the Planet V were higher for the combination, than for the barge alone. This can be explained by the larger volume of the tow combination.

The interaction forces were calculated for the following case:

- Water depth 20m;
- STW Planet V 11.5 kts
- STW Tow 7 kts
- The barge makes an angle of 10 degrees with respect to the tug
- Both Ships sail a straight and parallel course
- The CPA is 160 m.

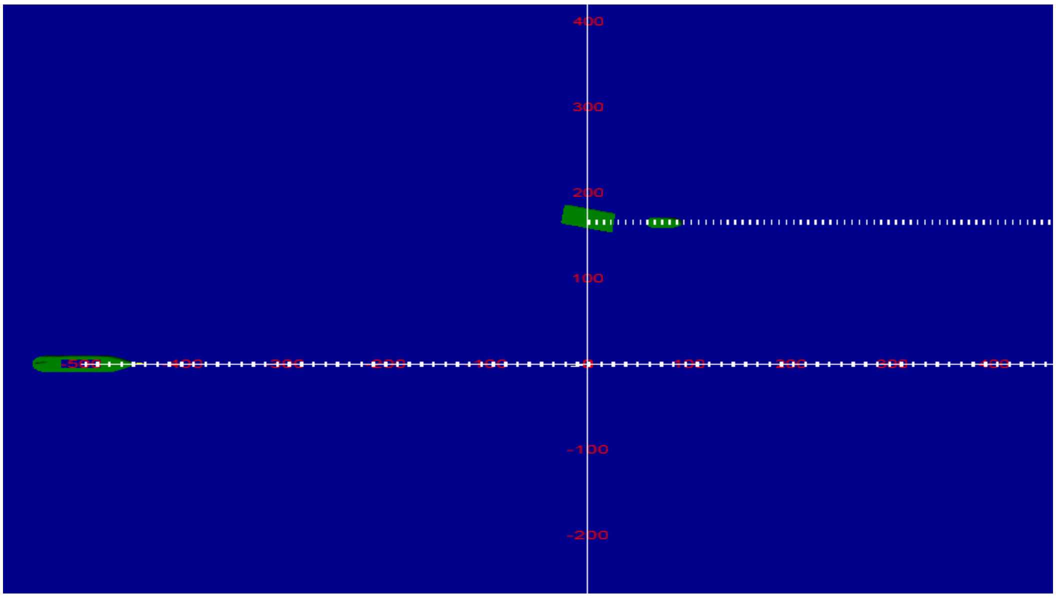


Figure 3-2 base case scenario

Maximum yaw moment

The overtaking creates predominantly a yawing moment. Horizontal forces (Y and Z) are very small and can be ignored. The maximum yaw moment exists when the Planet V is just about to overtake the barge.

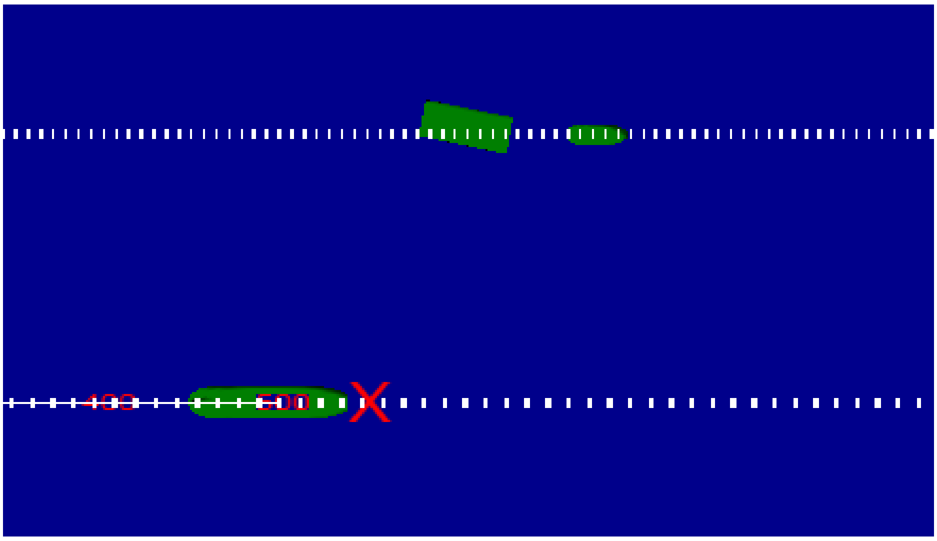


Figure 3-3 Point of maximum yaw moment

The effect of passing distance

Varying the passing distance from 150 to 160 and 170 meters shows that the maximum yaw distance increases when the passing distance decreases. A change of 10 meters in passing distance equals approximately 8 kNm.

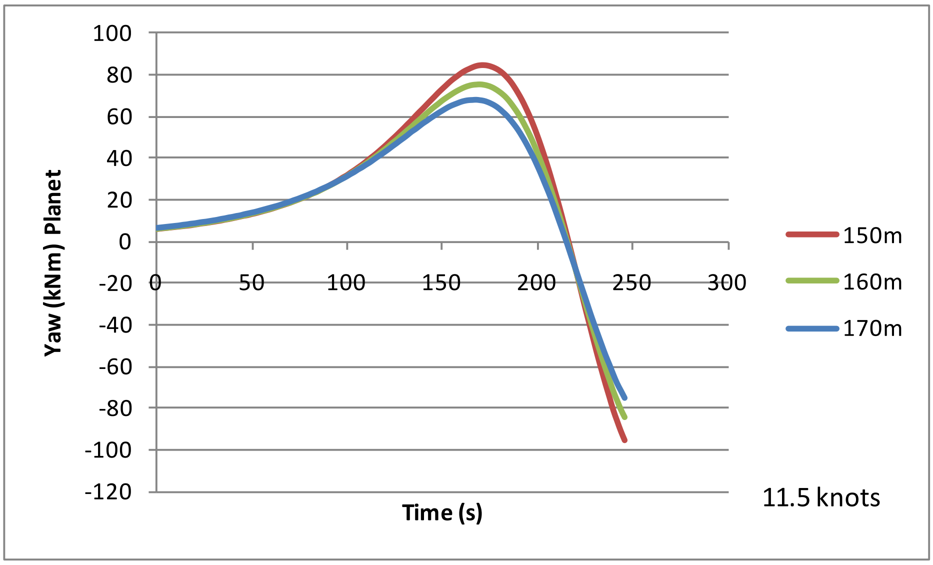


Figure 3-4 The effect of the passing distance

The effect of passing speed

At a passing distance of 160 m the speed of the vessels was varied. Calculations were executed with a speed of the Planet V of 10,5, 11.5 and 12.5 knots and 6, 7 and 8 knots for the tow. Overtaking at higher speeds increases the maximum yaw moment. 1 kts difference contributes to an increase of almost 20 kNm.

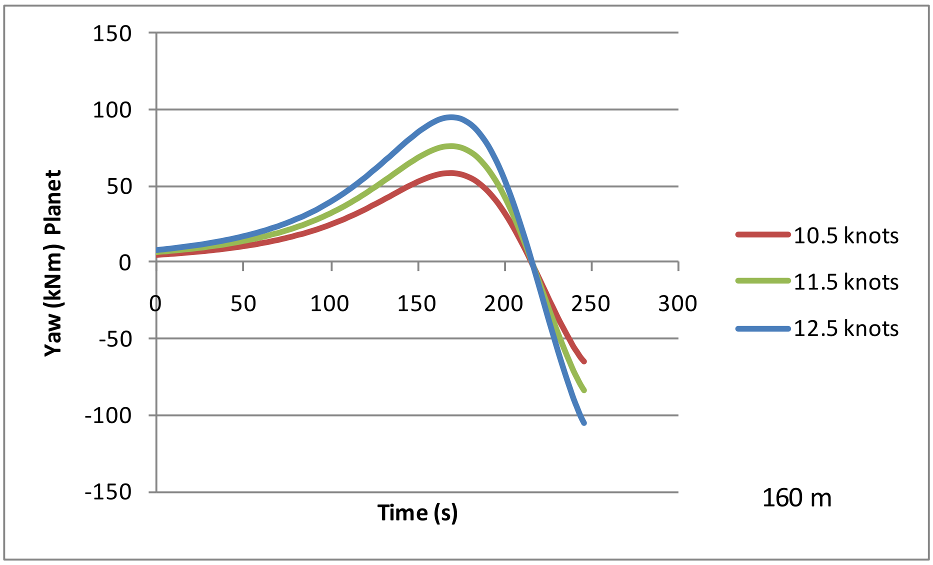


Figure 3-5 **The effect of the overtaking speed**

Tow combination versus barge only

At first calculations were made for a barge shaped hull only. Later the calculations were improved by modelling the effect of the tug. A comparison was made between the yaw moments when passing a barge and passing a tow combination (so with the effect of the tug included). The comparison shows that the tow combination causes much larger yaw moments on the Planet V. This data was further used in the reconstruction simulations.

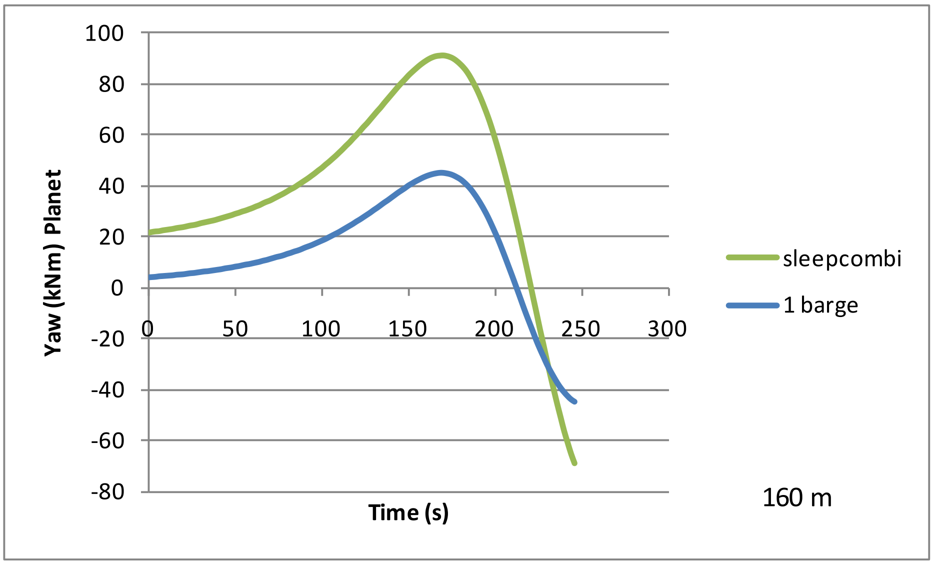


Figure 3-6 **Tow combination versus barge only**

4 RECONSTRUCTION OF THE ACCIDENT

The reconstruction of the accident with the Planet V was divided in three steps:
First a comparison was made between the sea trial data and the mathematical ship model of the Planet V at sea trial draft. The model was tuned to give the same performance on some important ship manoeuvring tests. In this case the deceleration test was the most important.

Secondly the mathematical model was scaled to the draft corresponding with the draft the Planet V had at the time of the accident. Also the wind areas were adjusted to reflect the correct load (two layers of containers).

Finally simulations were carried out with the Planet V to see if the events that happened during the accident could be reconstructed. These simulations included the tow combination and corresponding ship-ship interactions.

4.1 Comparison between sea-trials and mathematical model

Sea trials with the Planet V were executed in May 1994 by the Shipyard. The trials were executed with the Planet V in ballasted condition. During these trials the draft forward was 3.3 m, the draft aft was 5.15 m. A mathematical model of a similar container vessel was scaled to the appropriate dimensions, and to the correct draft. Wind areas, engine parameters etc. were taken from the sea trial report [1]

With this model the deceleration test (see Appendix A) was reproduced. The vessel was brought to a speed of almost 12 kts and when course and speed were steady, the pitch of the propeller was reduced to 0%.

Already in the first runs the deceleration was in line with the sea trial. Only the model seemed more willing to turn to starboard. The mathematical model was adjusted slightly to bring the simulation more in line with the sea trial. The results were very satisfying and a good fit was found. The development of heading, speed and rate of turn is shown in Table 4-1. At T+5’03 the model had turned 31 degrees, covered 762 m and had a speed of 2.1 kts. The same test at sea resulted in a course change of 24 degrees, a distance of 780 m and a final speed of 1.7 kts.

Table 4-1 Reconstruction of deceleration test

	Heading	STW [kts]	ROT
T	179	11.9	0.7 P
T+1’00	179.4	7.0	2.4 S
T+2’00	182.4	4.9	5.2 S
T+3’00	189.5	3.5	9.0 S
T+4’00	199.4	2.7	10.7 S
T+5’03	210.2	2.1	10.5 S

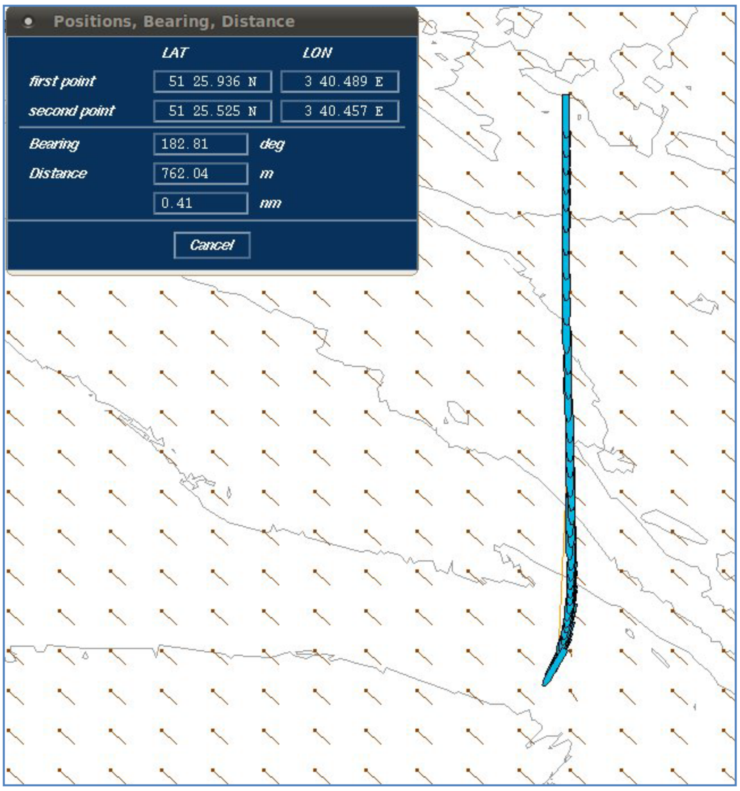


Figure 4-1 Reconstruction of deceleration test

Figure 4-1 shows the track of the deceleration test. In this figure the wind is plotted as vanes. Wind is coming from the NW as during the sea trials. Based on these results it was concluded that the deceleration test with the mathematical model had a very good fit with the Planet V in ballast. To reflect the situation at the time of the incident the draft of the model and the wind areas were adjusted. At the time of the incident the Planet V was loaded with two layers of containers.

4.2 Reconstruction of the accident

With the newly created mathematical model attempts were made to reconstruct the accident, or at least study the sensitivities that could have led to the high rate of turn to port and the collision. The reconstruction starts at 17:48:23, which is the time the black-out starts according to the communications extract.

The Planet V starts in position 51°44.29 N 003°65.79 E, STW 11.5 kts, heading 251°. The bow of the MTS Vantage is positioned at 204° relative to the bow of the Planet V at 237 m. The MTS Vantage has a heading of 258° and a STW of 7 kts. In the simulations we have kept the course of the MTS Vantage constant.

Figure 4-2 shows the current field that was used in the reconstruction. During the incident the current speed was 2 kts going to 070-080°. Note that the figure shows current vanes and not arrows.

The wind was coming from direction 070° (ENE), with a velocity of 7 m/s.

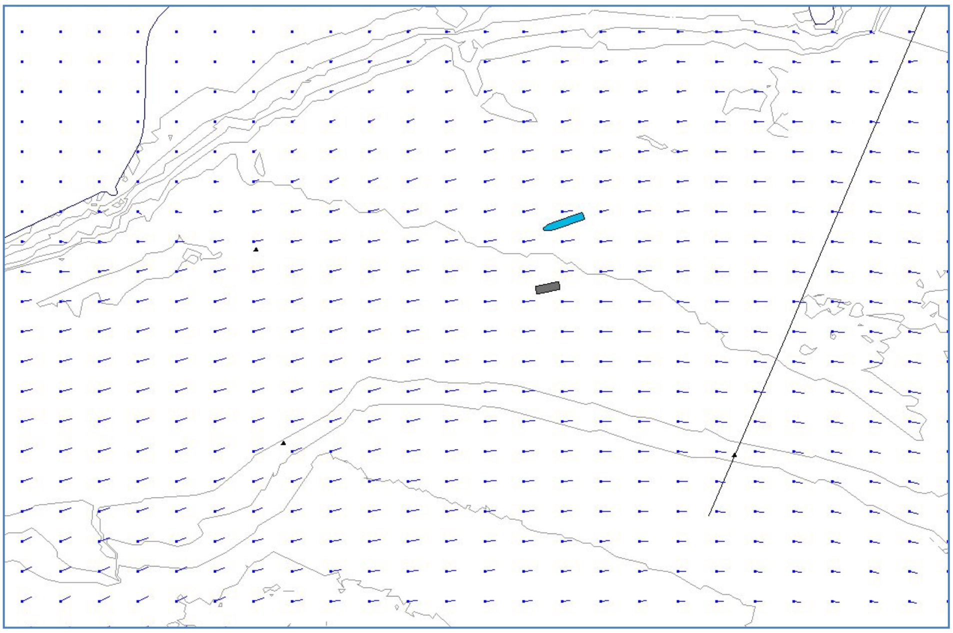


Figure 4-2 Current field used during reconstruction

4.2.1 Run 1, deceleration test with P/D=0

The run looks very similar to the deceleration tests executed for the ballasted vessel. After 3 minutes the Planet V had turned starboard to course 270°. The speed had decreased to 5.4 kts and the ROT was 12.0 Starboard. Ship-ship interaction forces and wind force did not turn the ship to port. The vanes in Figure 4-3 show the wind field.

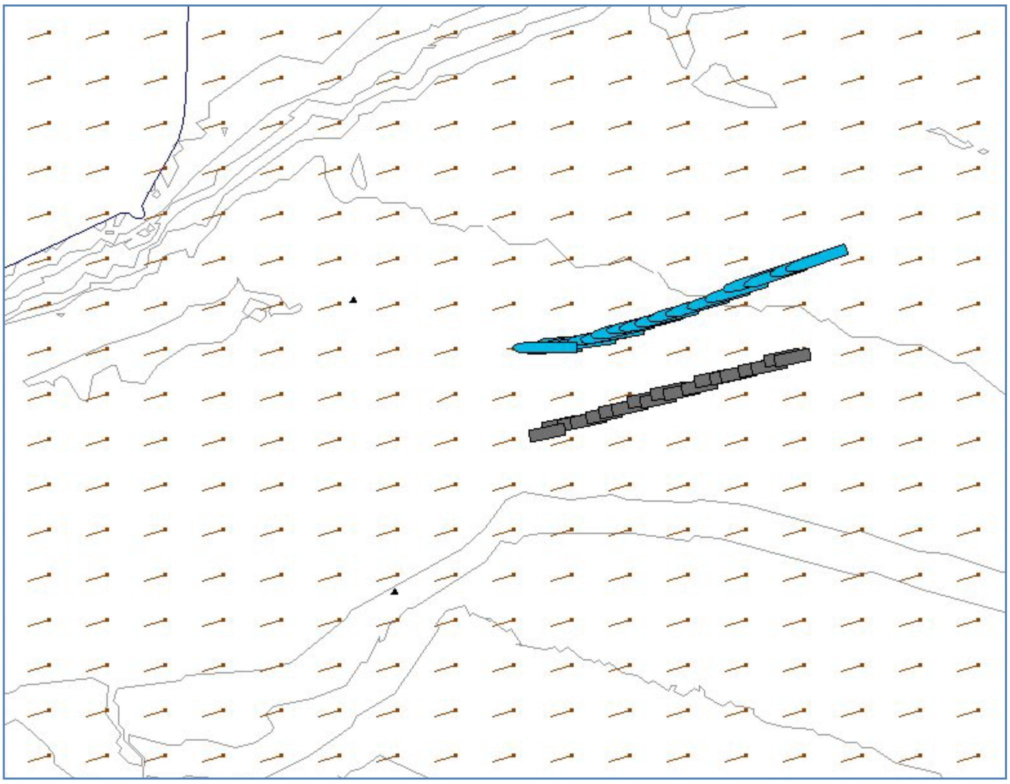


Figure 4-3 Run 1 deceleration test at T+03'00

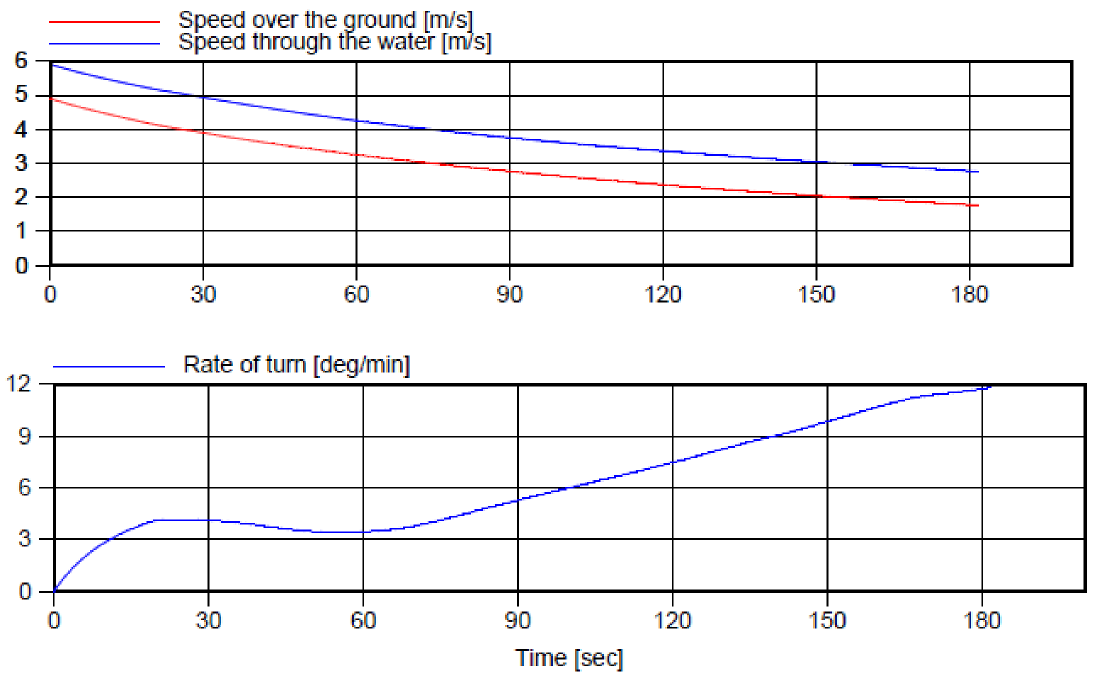


Figure 4-4 Development of speed and rate of turn during run 1

This run shows that the ship-ship interaction forces and the wind from ENE are not strong enough to turn the Planet V to port.

4.2.2 Run 2, deceleration test with full port rudder and P/D=0

Run 1 was repeated, but now full port rudder was used. After two minutes the heading was 247°, STW 7.2 kts and the Rate of Turn 2.9 SB. The rudder had very little effect on the manoeuvre. Although a short built up of the Rate of Turn to port was seen (maximum around 16 deg/min port), this rapidly disappeared and the vessel started to turn to starboard again.

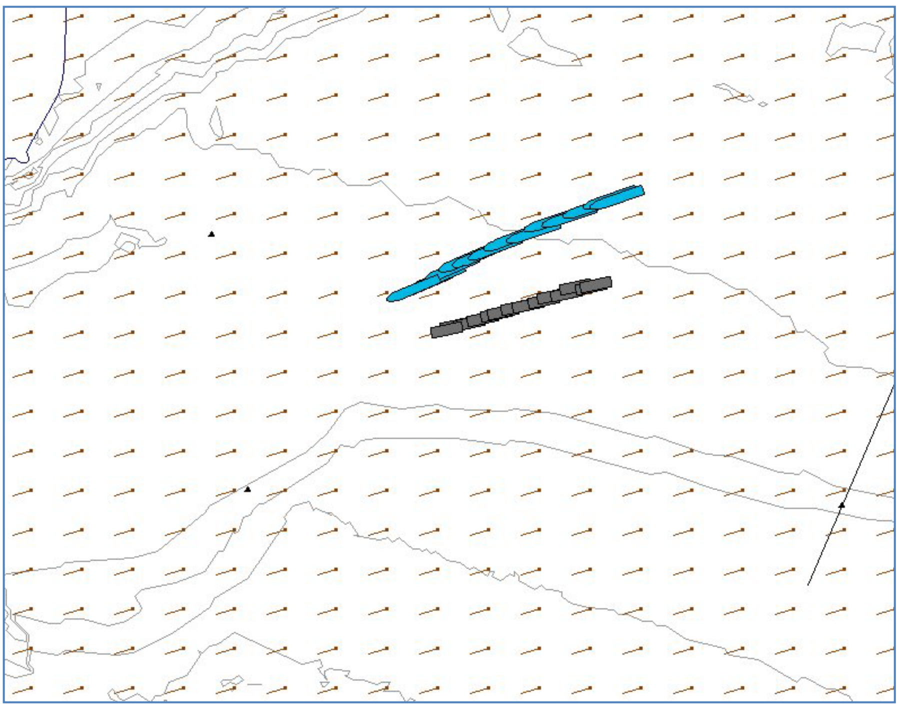


Figure 4-5 Run 2 deceleration test at T+02’00

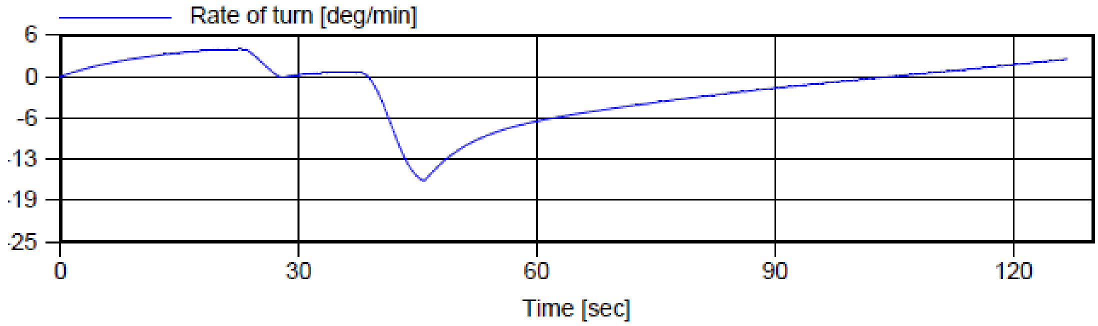


Figure 4-6 Development of rate of turn during run 2

This behaviour can be explained by the fact that the rudder had very little effect once the pitch of the propeller is reduced to zero. The propeller with zero pitch acts as a large plate, that blocks the water inflow to the rudder. Without this water inflow the rudder cannot generate lift and is therefore ineffective.

However, this is not what happened during the black-out. The crew observed that after the black-out the pitch of the propeller remained at 50%. It can also be expected that the propeller shaft does not stop immediately but that this is a more gradual process. The rpm's of the propeller will decrease rapidly but it will take a long time before they reach zero, because the propeller will rotate due to the force of the water pushed against it. This is called wind milling. The propeller will only be stopped completely at a very low speed and the resistance of the engine stops the propeller. Based on these observations it is likely that the rudder would profit from more water inflow and be more effective than observed in run 2.

In chapter 2 it was concluded that the Planet V reached its maximum rate of turn to port before the anchor was dropped. Wind effect and ship-ship interaction forces have been ruled out. It is also very unlikely that the bow thruster had contributed to the turn, since it is very ineffective at high speeds and pictures show no wake at the position of the bow thruster. Therefore it is assumed that a certain rudder angle is responsible for the high rate of turn. To reconstruct the incident we looked at deceleration tests in which the rpm's of the Planet V were reduced in steps to simulate the wind milling effect of the propeller. In the following runs a wind milling propeller in combination with different rudder angles was used. From the SDVR data it was concluded that the actual reduction in speed (and therefore of the RPM's) only occurred 14 seconds after 17:48:23 (the original time of black-out). In the following reconstructions the black-out is initiated at T=00:27, which corresponds to 17:48:37. Likewise T=01:33 correspond to 17:49:43, the time the anchor is dropped and T=01:55 corresponds to 17:50:05, the time the collision occurred. These events are indicated in the graphs used in the following sections.

4.2.3 Run 3, deceleration test with wind milling propeller, rudder 15° port

At T+00'27 the black-out was initiated and propeller revolutions were reduced. Also the rudder was set to port 15 degrees. The Planet V started to rotate to port, with a maximum rate of turn of around 24 deg/min. After two minutes the heading was 223°, STW 8.0 kts and ROT 14.4 deg/min to port. Even with a wind milling propeller and 15 degrees port rudder the model does not turn quick enough. The speed at the end of the run is too high compared to the accident.

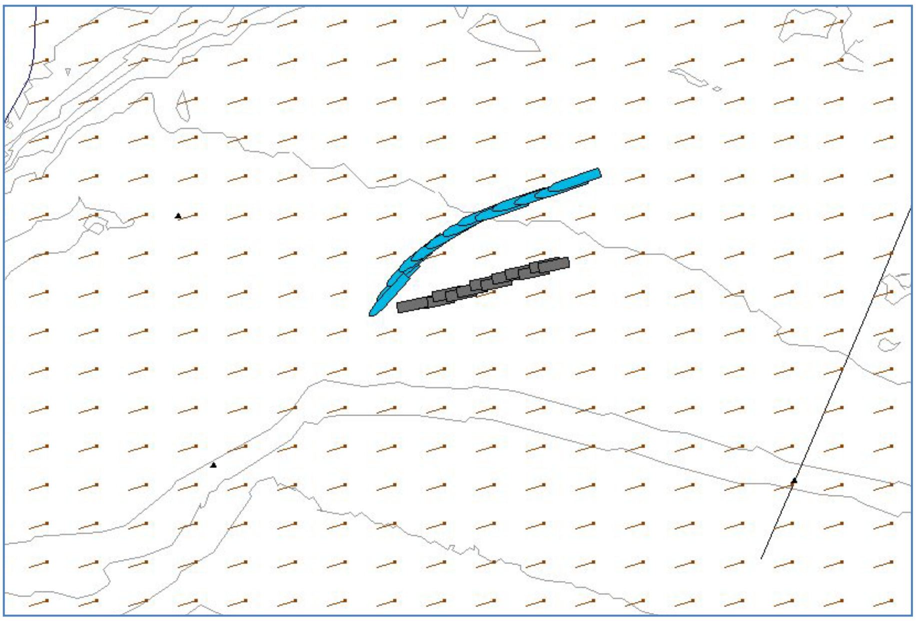


Figure 4-7 Run 3

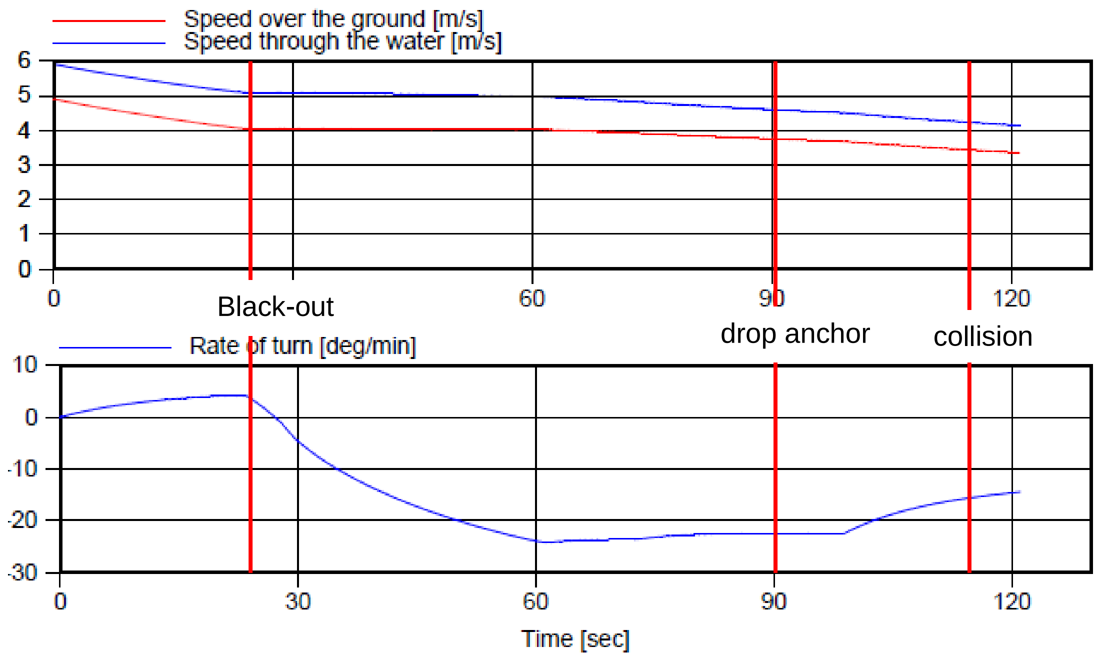


Figure 4-8 Development of speed and rate of turn during run 3

4.2.4 Run 4, deceleration test with wind milling propeller, rudder 30° port

At T+00’27 the black-out was initiated and propeller revolutions were reduced. At the same time the rudder was set to port 30 degrees. The Planet V started to rotate to port, with a maximum rate of turn of around 38 deg/min. The collision occurs at T+01’50, and the speed is also correct. However, the impact angle is not correct because the model did not turn quick enough.

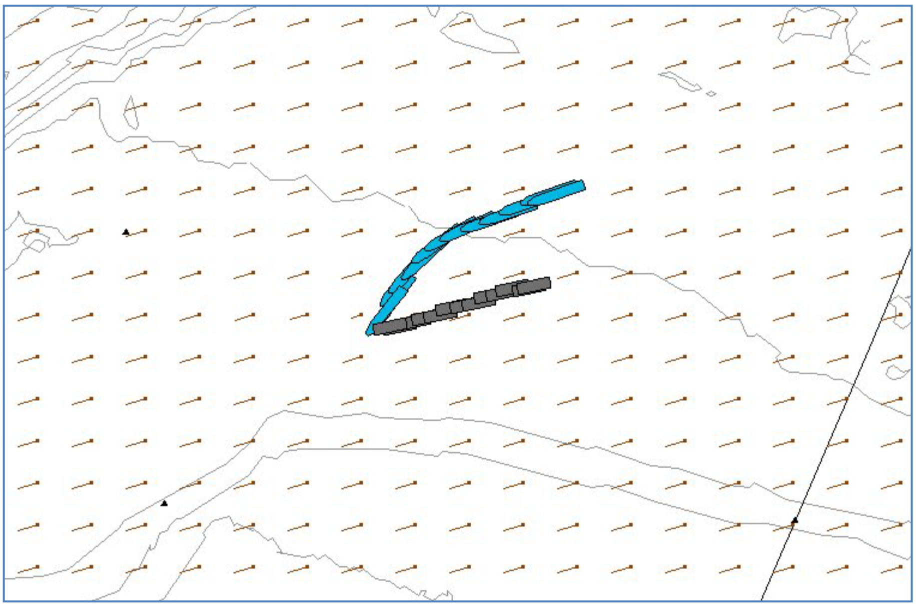


Figure 4-9 Run 4

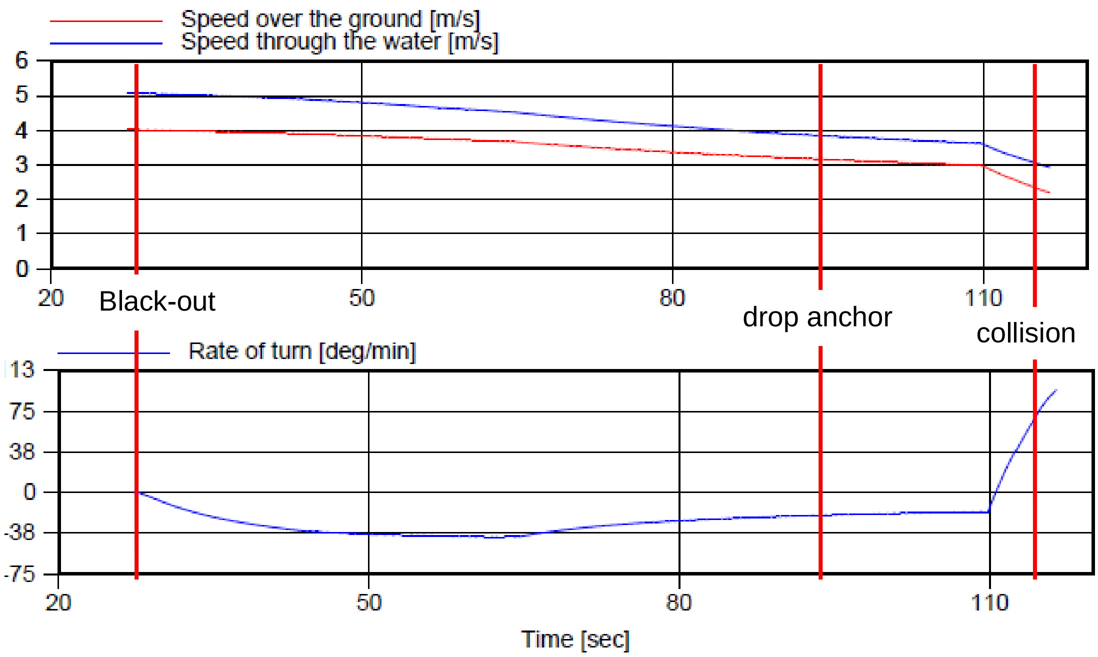


Figure 4-10 Development of speed and rate of turn during run 4.

4.2.5 Run 5, deceleration test with wind milling propeller, rudder 45° port

In this run full port rudder was used. This resulted in a collision at T+1'39, which is a bit too soon. The maximum ROT was around 45 deg/min which comes close to the observed ROT during the accident. It should be noted that the wind milling effect was modelled very roughly and it is outside the scope of this study to model this more accurately. With this mathematical model of the Planet V only a maximum rudder angle to port could have caused the observed rate of turn.

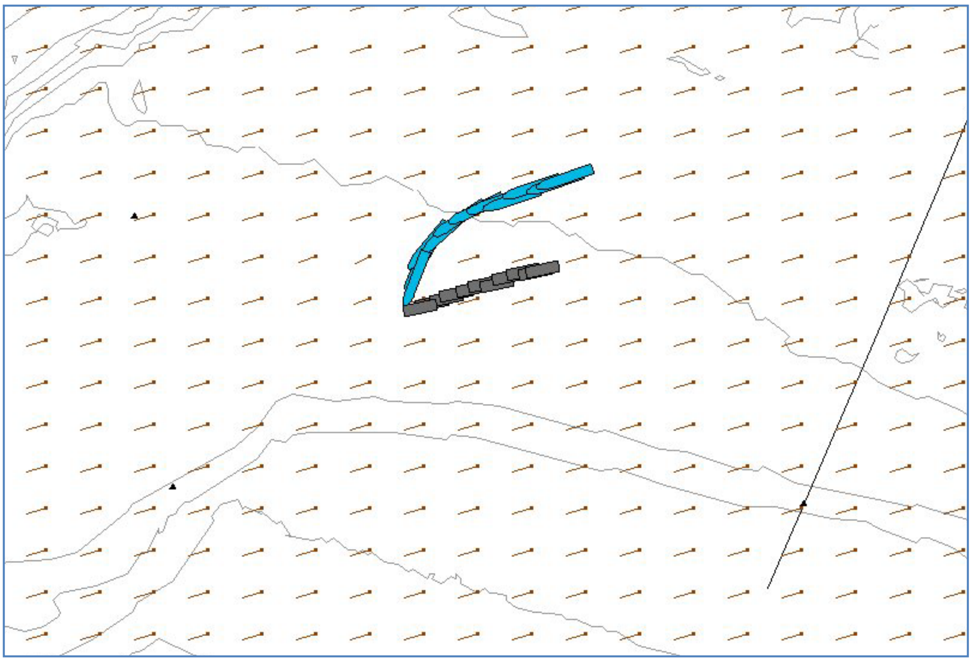
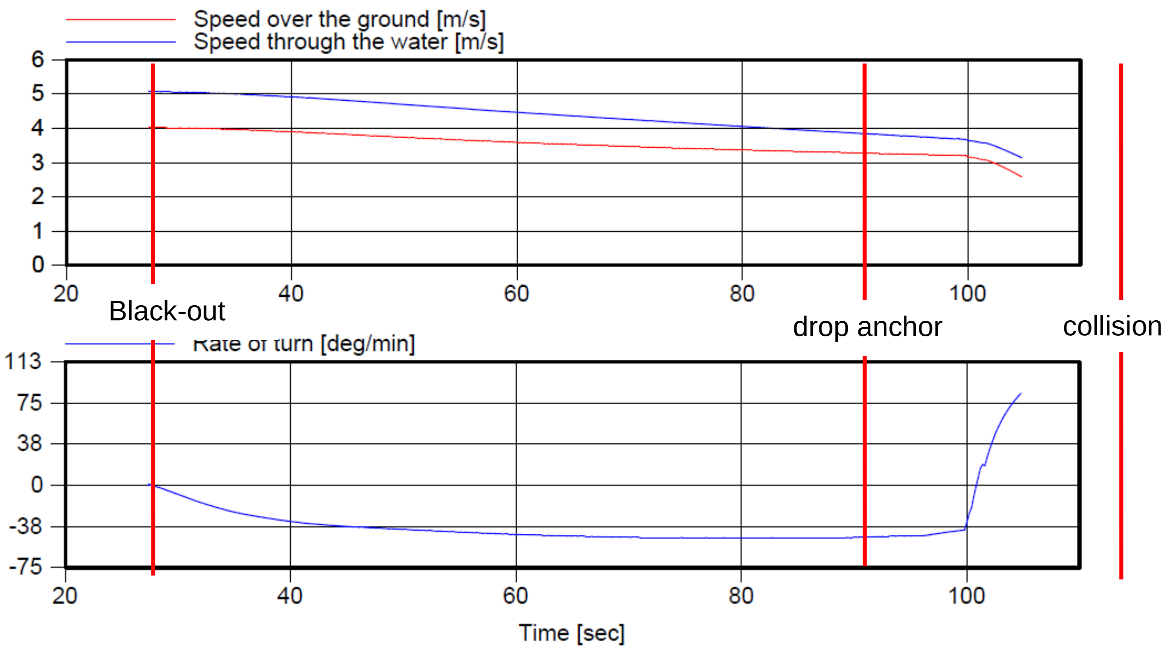


Figure 4-11 Run 5



5 CONCLUSIONS

Based on the analysis and reconstruction of the accident the following was concluded:

1. No noticeable speed decrease or course change was recorded by the SDVR or shore radar for the first 14 seconds after the time of black-out was recorded in the communications abstract. The most likely time of the black-out is therefore corrected to 17:48:37.

2. After the black-out (at 17:48:37) the Planet V starts to turn to port. The Rate of Turn reaches a maximum of 57 deg/min at 17:49:43. Since the anchor was dropped at the same time and no increase in rate of turn or a stronger decrease of speed were observed from this point onwards, it can be concluded that the anchor did not contribute significantly to the executed manoeuvre. There was simply not enough time (only 25 seconds between the moment the anchor was dropped and the time of collision), to deploy enough chain. Therefore the holding power of the anchor was too low to be of any influence.

3. Pull out tests from the sea-trial report confirm that the vessel is course stable and therefore high forces/moments are necessary to create a high rate of turn. The turning moment created by wind and ship-ship interaction forces were too small to be responsible for the observed rate of turn.

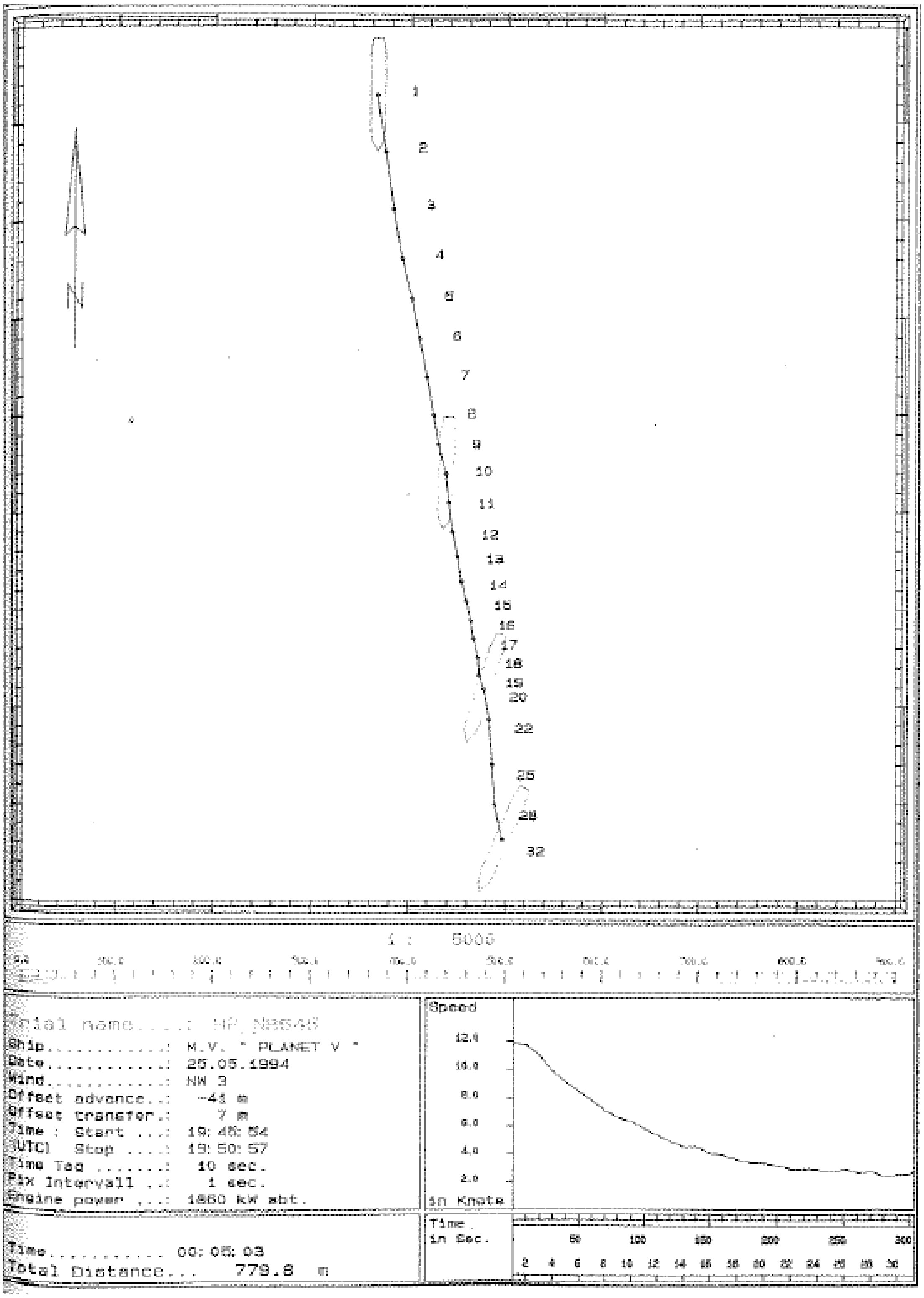
4. The observed rate of turn to port can only be explained by large rudder forces acting on the vessel. Full port rudder in combination with a wind milling propeller (and P/D=50%) are most likely responsible for the high rate of turn. This conclusion is contradictory with statements of the pilot and captain which state that during the incident the rudder indicator read starboard 25 or full starboard rudder. It may be that the indicator and or the auto-pilot were unreliable due to the black-out.

5. The crew stated that the Planet V was sailing on auto-pilot when the black-out occurred. With the black-out also the power supply to the auto pilot was shortly interrupted, which caused it to shut off. When, after a short period, the power supply was restored the crew switched the steering to manual. The communication abstract makes no notice of any course or rudder orders being given between the time of black-out and the collision. It is not clear what happened with the rudder during the accident.

REFERENCES

[1] Manoeuvring Information for M.V. ‘Planet V’, Bremen, June 2nd 1994, Nautisches Buro Bremen

APPENDIX A SEA TRIALS DATA



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1 : 5000
Ship..............: M.V. " PLANET V "
Date..............: 25.05.1994
Wind..............: NW 3
Offset advance..: -41 m
Offset transfer.: 7 m
Time : Start ....: 19:45:54
(UTC) Stop .....: 19:50:57
Time Tag ....: 10 sec.
Fix Intervall ...: 1 sec.
Engine power ....: 1860 kW abt.
Time.............. 00:05:03
Total Distance... 779.8 m
Speed
12.0
10.0
8.0
6.0
4.0
2.0
in Knots
Time
in Sec.
50
100
150
200
250
300