

Drift Analysis Report for MAIB

BMT Maritime Si	mulation & Training Systems
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1. Introduction

1.1. Problem Definition

BMT has investigated the estimated track that persons in the water took during the incident of the 24th of November 2021 in the Dover Straits. BMT have answered the question *"what is the track that persons in the water might have taken during the incident or explain why that cannot be achieved."*

At around 0200 on the 24/11/21 the incident started and at approximately 1300, a fishing vessel reported bodies in the water. BMT will ascertain if the trajectory from the incident location to the final reported scene could have occurred and if not, suggestions will be made to explain the trajectory.

1.2. SARIS

The BMT Search and Rescue Information System (SARIS) an advanced PC based SAR planning system focusing on the complex tasks required for Search Area Determination (SAD) and Search Area Coverage (SAC). For the purposes of this report, we will focus on the SAD element. SARIS uses a database of modelled characteristics along with current and wind databases to predict the trajectory of a missing target.

1.3. Report Methodology

BMT will perform the following steps:

- 1. Requirements Analysis
- 2. Data Collation and Preparation
- 3. Model Preparation and Execution
- 4. Findings and Conclusion

* N.B. All times in this report will refer to UTC.



2. Requirements Analysis

2.1. Incident Duration

	Position	Time	Comment
Start	51° 09.0454'N	0221	A position was sent via WhatsApp from a mobile device thought to be the
	001° 45.5683'E	0221	last reported position of the vessel.
End	51° 05.58'N	1350	A French fishing vessel reported to the French authorities that they had
	001° 43.41'E	1258	come across one or more bodies in the water.

2.2. Incident Target

At some time between 0200 and sunrise (0724) the dinghy foundered, and the persons entered the water.

BMT have attempted to model if the trajectory from the incident location to the final reported scene could have occurred and if not, make suggestions to explain. Multiple targets phases would have needed to be used starting in raft, person into water (alive) then in water (deceased). SARIS cannot model a target that morphs between phases and so BMT have modelled multiple targets. These targets have been run and their behaviour analysed for a pattern.

For the purposes of drift modelling, BMT has chosen the following targets:

- Marine Life Rafts, 15-25 Man Deep Ballast Pockets, With Canopy, Unknown Load
- Person In Water, Unknown State

BMT believe other factors (e.g., metocean data) to be more important as the individual characteristic will be overshadowed by the environmental data. For the purposes of trajectory modelling, the selection of target, although important, will only add some variability into the base trajectory. BMT feel that a composite model that encompasses properties of multiple of the search target would have sufficed but feel detailing multiple options to be worthwhile for clarification.

3. Current Only Simulations

To build up a picture of the issues of drift modelling, BMT had decided to initially produce some plots of the variability of current data alone, without the addition of wind. This would give us a picture of the variability of the current models which the final simulations would rely on.

3.1. Available current data

3.1.1. Forecast Data

The current data BMT chose for the simulations was sourced from the Copernicus Marine Service. "Atlantic -European North West Shelf - Ocean Physics Analysis and Forecast" (see URL below) was chosen. This data is referred to as Wave1.

https://data.marine.copernicus.eu/product/NORTHWESTSHELF_ANALYSIS_FORECAST_PHY_004_013/descripti on



3.1.2. Comparison Data

For comparison three existing available current sources were used. The POL CS3 and CS20 tidal models used by the UK Coastguard for many years and the Jersey tidal model. These models are only to provide comparison and to illustrate the typical variability of current models, they are not the primary modelling current data source.

3.2. Simulations

To investigate the quality and variability of the current data, several current only models were run. Each was run from 0221 to 1300 using the four current models (i.e., CS3, CS20, Jersey and Wave1).

For the purposes of drift modelling, BMT has chosen the following target: Various, Current Only Target. This does not take wind into account or use divergence.



Figure 1: Current Only Trajectory Modelling

3.3. Explanation of variability

These four models demonstrate a great deal of variability. The three tidal models are considerably further away from the End position. Note that the turning time of the models vary significantly. The time they turn results in how far the target will drift south (and towards the End point). As the models continue over time, the error of distance from End will increase.



Name	Colour	Comment	Distance from End	Turning time
CS3		POL CS3 Tidal	6.59 km	0706
CS20		POL CS20 Tidal	7.36 km	0706
Wave1		Copernicus Forecast	3.56 km	0626
Jersey		Jersey Tidal	6.99 km	0656
		Table 1: Current O	nly Variability	

ble 1: Current Only Variability

Although we will revisit this topic later in the report, we must remember that all the models are simply that, models. They provide a varying level of approximation of reality and are products of scientist's mathematical models. We do not know how accurate each model is or areas in which prediction could be better or worse. Mathematical forecast models have improved much over the years but is still trying to model a complex world.

4. **Full Simulations**

These simulations used the current data and the addition of wind data.

Available wind data 4.1.

4.1.1. Forecast Data

The wind data BMT chose for the simulations was sourced from the Copernicus Marine Service. The Global Ocean Hourly Sea Surface Wind and Stress from Scatterometer and Model (see URL below) was chosen. This data is referred to as Wind1.

https://data.marine.copernicus.eu/product/WIND_GLO_PHY_L4_NRT_012_004/description

4.1.2. Actual Data

The MAIB were able to source the actual environmental data from the Sandettie Observations (ESandetti.xlsx).

N.B. This source would not be available at the time of an incident, hence could and would not be used operationally.

https://www.metoffice.gov.uk/weather/specialist-forecasts/coast-and-sea/observations/162304

Simulations 4.2.

Twelve simulations were conducted once for each chosen target.

- Marine Life Rafts, 15-25 Man Deep Ballast Pockets, With Canopy, Unknown Load
- Person In Water, Unknown State

For each of the simulations we ran the simulations with 3 wind alternatives:

- Forecast data (wind1)
- Sandettie Observations employing Wind Driven Current (WDC)
- Sandettie Observations without Wind Driven Current (No WDC)





Figure 2: Raft (left) and PIW (right) Simulations



Current	Wind	Colour	PIW	Raft
CS 3	Wind1 (Forecast)		P3F	R3F
CS 3	WDC		P3W	R3W
CS 3	No WDC		P3N	R3N
CS 2 0	Wind1 (Forecast)		P2F	R2F
CS 2 0	WDC		P2W	R2W
CS 2 0	No WDC		P2N	R2N
Wave1 (Forecast)	Wind1 (Forecast)		PFF	RFF
Wave1 (Forecast)	WDC		PFW	RFW
Wave1 (Forecast)	No WDC		PFN	RFN
Jersey	Wind1 (Forecast)		PJF	RJF
Jersey	WDC		PJW	RJW
Jersey	No WDC		PJN	RJN

Table 2: Runs, Colours and Nomenclature

N.B. Object naming for Table 2 is a three-digit expression with P or R (**P**IW or **R**aft), 3, 2, F or J (CS**3**, CS**2**0, Wave1 (Forecast) and Jersey) and F, W or N (Forecast, **W**DC or **N**o WDC)

Each simulation was run with the varying current and wind options. The trajectory data was captured as KML output (for use in Google Earth). The output can be seen in Figure 2: Raft (left) and PIW (right) Simulations.

4.2.1. Wind Driven Current

In the initial releases of SARIS the primary current sources were tidal based current databases. Wind interacts with the current and adds an additional component called Wind Driven Current (WDC). As current forecast models have largely replaced tidal databases, they include multiple components including tidal, residual and WDC.

4.3. Simulation Results

BMT then looked at each simulation and calculated the distance from the location. This can be seen in Table 3.

Current	Wind	Colour	Raft Distance (km)	PIW Distance (km)
CS3	Wind1		8.9	7.6
CS3	WDC		3.5	1.0
CS3	No WDC		2.8	4.5
CS20	Wind1		9.7	8.5
CS20	WDC		3.8	1.6
CS20	No WDC		2.8	6.9
Wave1	Wind1		4.5	4.0
Wave1	WDC		5.2	4.2
Wave1	No WDC		0.5	1.7
Jersey	Wind1		9.0	7.7
Jersey	WDC		4.3	2.2
Jersey	No WDC		3.1	4.9

Table 3: Simulation Variability



4.3.1. General Observations

In Figure 2: Raft (left) and PIW (right) Simulations, we see a general trend where the use of forecast wind fails to reach the End position whilst the inclusion of real wind gives the best results. The significant runs with real wind are closest to the End position as seen in Figure 3 whilst the use of forecast wind can be seen in Figure 4. If we compare the models of Raft and PIW, we see very similar trajectories (which can be seen in Figure 5).



Figure 3: Trend Modelling using Real Wind



Figure 4: Trend Modelling using Forecast Wind





Figure 5: Raft and PIW Modelling side by side

If the simulations are ranked by distance to the End position, the use of the actual wind fares better than the forecast wind which can be seen in Table 4, Table 5 and Table 6 (which combines the ranks). This is echoed with the use of the particle modelling (ranked High, Mid, Low as located within the probability bands and Fail for not found). With the actual wind the highest density of particles congregate on the End position (see Figure 6 & Figure 7).



Raft Rank	Current	Wind	Colour	Raft Distance (km)	Contour
1	Wave1	No WDC		0.57	High
2	CS3	No WDC		2.86	High
3	CS20	No WDC		2.89	High
4	Jersey	No WDC		3.16	Mid
5	CS3	WDC		3.53	Mid
6	CS20	WDC		3.87	Mid
7	Jersey	WDC		4.36	Low
8	Wave1	Wind1		4.59	Low
9	Wave1	WDC		5.28	Low
10	CS3	Wind1		8.92	Fail
11	Jersey	Wind1		9.02	Fail
12	CS20	Wind1		9.74	Fail

Table 4: Raft Simulation Ranking

PIW Rank	Current	Wind	Colour	PIW Distance (km)	Contour
1	CS3	WDC		1	High
2	CS20	WDC		1.6	High
3	Wave1	No WDC		1.7	High
4	Jersey	WDC		2.2	High
5	Wave1	Wind1		4	Low
6	Wave1	WDC		4.2	Mid
7	CS3	No WDC		4.5	Low
8	Jersey	No WDC		4.9	Mid
9	CS20	No WDC		6.9	Low
10	CS3	Wind1		7.6	Low
11	Jersey	Wind1		7.7	Low
12	CS20	Wind1		8.5	Low

Table 5: PIW Simulation Ranking

Rank	Current	Wind	Colour	Raft Distance (km)	PIW Distance (km)
1	Wave1	No WDC		0.57	1.7
2	CS3	WDC		3.53	1
3	CS20	WDC		3.87	1.6
4	CS3	No WDC		2.86	4.5
5	Jersey	WDC		4.36	2.2
6	Jersey	No WDC		3.16	4.9
7	CS20	No WDC		2.89	6.9
8	Wave1	Wind1		4.59	4
9	Wave1	WDC		5.28	4.2
10	CS3	Wind1		8.92	7.6
11	Jersey	Wind1		9.02	7.7
12	CS20	Wind1		9.74	8.5

Table 6: Combined Simulation Ranking

N.B. The grey rows are the simulations viewed as invalid (see Page 13 Use of WDC).





Figure 6: Raft - Wave1 with real wind (no WDC)



Figure 7: PIW - CS3 with real wind (WDC)



4.4. Explanation of variability

If we take two simulations starting from the same location but use different forecast models, we could have a difference as shown in Figure 8. They travel along the same path but at some point, Models A and B differ taking the simulations on very different paths. Once on different paths finding the "right" solution then becomes increasingly difficult.



Figure 8: Forecast Differences

With the addition of wind, the already established variability of the current databases is magnified by the different wind in use. As the simulations progress the errors (i.e., variation from the actual trajectory) are compounded and magnified.



5. Findings

To answer the question "what is the track that persons in the water might have taken during the incident or explain why that cannot be achieved." We can clearly say that the track taking the vessel from 0221 to 1300 could be calculated, but clearly only in hindsight. Initial runs with the forecast wind were close, but only with the addition of the Sandettie Observations could we "find" the missing target. BMT independently verified more forecast wind for the current year against actual Sandettie Observations and again the forecast varied considerably.

5.1. Use of WDC

Although 3 of the best 4 results with a Raft were produced without the use of WDC, these simulations should not have been performed. As the CS3, CS20 and Jersey are all tidal databases the simulations should have been run with the addition of WDC as tidal current does not include a wind driven component. We can therefore discount the runs (from this report) incorrectly applying WDC, making the use of forecast current with real wind a clear best solution. For completion, the use of the forecast current would not have used WDC (as the forecast data would have wind driven effect included)

Rank	Current	Wind	Colour	Raft Distance (km)	Contour
1	Wave1	NoWDC		0.57	High
2	CS3	NoWDC		2.86	High
3	CS20	NoWDC		2.89	High
4	Jersey	NoWDC		3.16	Mid
5	CS3	WDC		3.53	Mid
6	CS20	WDC		3.87	Mid
7	Jersey	WDC		4.36	Low
9	Wave1	WDC		5.28	Low

Table 8: Incorrect application of WDC

5.2. Inherent limitations of simulations

In the world of weather forecasts, we all know that on any given Monday in the UK the forecast for the weekend is likely to be wrong. As we get closer to the weekend, the forecast has a greater chance of being right but again it is still only a forecast. The question then is why in the drift modelling arena are we expecting 100% certainty? Why could a simulation not pinpoint the location of missing people after 11 hours? We must ask the question of how likely in this scenario would you find the people. If it is 100% of the time, then we have an issue here. More likely is that most of the time people may not be found in these circumstances.

5.3. Real vs Forecast

The real wind data proved to be more accurate in matching to the End position. Unfortunately, in a real SAR incident real data is not available and even with current & wind sensors only for the present time. To predict their movements into the future we need to use forecast data.

The MCA would have had operational forecast current & wind provided to them by their data provider. BMT decided that we did not need to use that data, as the same outcome would have likely occurred. It is doubtful that a forecast will replicate real time and hence finding the targets using that data still would not have happened.



5.4. Length of simulation

The scenario we are investigating is a very long time in modelling terms. As the errors (i.e., variation from the actual trajectory) compound on every step of the simulation, after approximately 11 hours (0221 - 1300) the errors would have been quite large.

6. Conclusion

To conclude, the trajectory to take the persons from start to end location can be achieved. The problem is that this could not have happened during the incident because the simulation that most accurately predicted the actual movement required data that was not available until after the event. Many of the simulated runs would have predicted a location where the final target was not found. This is due to the inherent variability of modelled forecast data and the length of the scenario. Larger durations produce larger search areas and with the variability of forecast data larger errors.





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