FIUMICINO WATERFRONT

SOGGETTO ESECUTORE E FINANZIATORE

GIUBILEO 2025 PELLEGRINI DI SPERANZA

INTERVENTO N. 146

CITTÀ DI FIUMICINO

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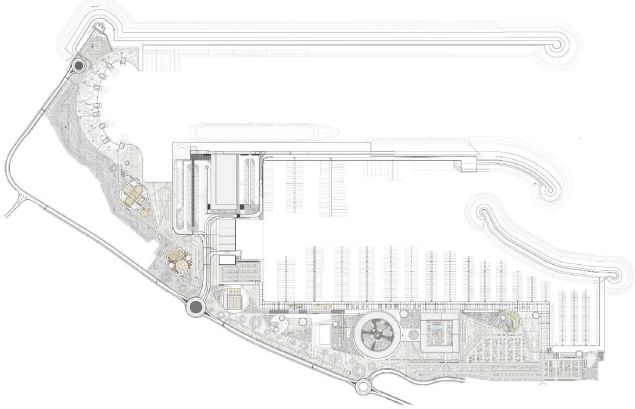
PROGETTO DI FATTIBILITÀ TECNICO ECONOMICA



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RELAZIONI SPECIALISTICHE

NAVIGATION SIMULATION STUDY

COMMESSA	SERVIZIO	LOTTO	OPERA	DISCIPLINA	TIPO	PROG.	REV.	SCALA
P0031150	D	0	OM00	RS	REL	06	00	-

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ABBREVIATIONS AND ACRONYMS

ARPA	Automatic Radar Plotting Aid
Azipod	Azimuthal propulsor
BoD	Basis of Design
BP	Bollard Pull
ECDIS	Electronic Chart Display and Information System
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
°N	Heading respect to the True North
Hs	Significant Wave Height
Kn	Knot
NM	Nautical Mile
OA	Oasis of the Seas
Ps	Port side
SoG	Speed over the Ground
Sbd	Starboard side
Tp	Wave Peak Period
Vc	Current speed
Vw	Wind speed

Consultant	RINA Consulting Spa
Company	Royal Caribbean Cruises Ltd (RCG)
Client	Fiumicino Waterfront

EXECUTIVE SUMMARY

Nell'ambito del Progetto Fiumicino "Isola Sacra", RINA Consulting S.p.A. è stata incaricata di sviluppare una sessione di simulazioni di manovra real-time con l'obbiettivo di verificare il layout delle aree portuali ipotizzato per le manovre delle navi da crociera dirette al terminal passeggeri.

Il layout delle aree portuali è stato inizialmente progettato, accettato e condiviso con la divisione di Marine Port Development di RCG: le aree navigabili sono state definite assumendo come nave di progetto la "Oasis of the Seas", rappresentativa della classe Oasis.

Le attività di simulazione sono state eseguite su software Wartsila NTPro, dove è stato riprodotto il layout portuale di progetto. Il modello della nave classe Oasis è stato ottenuto su concessione da parte di RCG.

La sessione di simulazione si è svolta dal 14 al 16 giugno 2023, presso il centro di simulazione Scenario S.r.l., con sede a Genova. L'attività si è svolta in presenza del Cliente e dal team di simulazione composto da ingegneri RINA e Scenario e dal Pilota John Gatti, ex capo-pilota del corpo piloti di Genova, il quale ha condotto gli esercizi di simulazione governando la nave dal ponte di comando del simulatore. Le risultanze delle manovre eseguite negli esercizi di simulazione sono state discusse e condivise con i Piloti della Capitaneria di Porto di Civitavecchia e Fiumicino.

I risultati della sessione di simulazione condotta hanno dimostrato l'adeguatezza delle aree portuali per le manovre di ingresso e di uscita per le navi di classe Oasis. Le condizioni-meteomarine assunte negli esercizi hanno dimostrato la fattibilità delle manovre con un vento limite fino a 25 nodi da ogni direzione: per quattro direzioni di provenienza principali (210°, 240°, 270° e 330°N) è stata inoltre considerata la presenza di onde fino a 1.5m di altezza significativa e le annesse correnti. In alcuni esercizi sono state testate delle condizioni di avaria parziale (eliche di prora e propulsore di sinistra).

Le manovre sono state tutte concluse con esito positivo.

La visualizzazione delle aree occupate dalla nave modello durante le manovre e le discussioni sulle manovre stesse hanno portato alle seguenti conclusioni:

- ✓ La larghezza del canale di Accesso è da estendersi da 180 m a 200 m a favore di sicurezza, in modo tale da aumentare gli spazi a disposizione per le correzioni di manovre necessarie al mantenimento della rotta lungo questa tratta.
- ✓ Sebbene il layout proposto sia stato verificato con una velocità del vento limite fino a 25 e accettato dalle Parti, con gli interventi di ottimizzazione, è stato concordato che in una fase iniziale, la velocità del vento limite per l'operatività della nave progetto è da ritenersi pari a 20 nodi da ogni direzione. Una volta che i Piloti avranno completato opportune formazioni e sulla base dei feedback che si otterranno sulla fattibilità delle manovre, sarà possibile valutare un incremento dei valori di vento limite e quindi valutare una estensione dell'operatività del terminale.
- ✓ L'inviluppo delle manovre ha mostrato due possibili allargamenti delle forme del bacino di evoluzione:
  - Un allargamento nell'area N-NW compresa tra le boe 3R, 4R e 5R, aumentando gli spazi a disposizione in ingresso al canale di accesso durante le manovre di partenza;
  - Un ulteriore allargamento nell'area E-SE in corrispondenza della boa 3G, che permette di avvantaggiare la poppa in uscita dal canale di accesso per la successiva manovra di evoluzione durante le manovre di arrivo.
- ✓ Inoltre, l'inviluppo delle manovre ha mostrato che è stata mantenuta una distanza minima di almeno 40 m tra lo scafo della nave progetto e la parte interna della diga del molo Traiano portando a pensare una possibile ottimizzazione dell'area all'interno del Bacino Crociere.

Alla luce degli aspetti sopracitati, le parti coinvolte nella sessione concordano sulle ottimizzazioni del layout di progetto (riportato in Figure 6.1e sui ridotti limiti meteomarini identificati, i quali potranno essere soggetti a possibili misure mitigative sulla base dei feedback ricevuti dai Piloti nelle successive fasi di operatività del Terminale.

1 INTRODUCTION

In the framework of Fiumicino "Isola Sacra" Project, RINA Consulting S.p.A. was appointed to carry out a real-time navigation simulation workshop to assess the proposed Project port layout. The vessel considered in the present study is the one representative of the Oasis Class of the Royal Caribbean Cruise Ltd (RCG).

The workshop was performed from the 14 June to the 16 June 2023 at Scenario S.r.l. the Genoa Simulation Centre, in presence of Client and RINA representatives. The Oasis vessel manoeuvres were performed by John Gatti, the former head of Pilots of Genoa Pilot Association

The simulation exercises were executed on Wartsila NTPro software on a Class A Full Mission Bridge Simulator properly representing the mock up bridge furnished with a manoeuvring console with three levers, one for each azipod, with all the electronic instruments available onboard such as Radar/ARPA, Conning, ECDIS and with a visibility of 270 degrees.

Each simulation exercise was performed considering different meteocean conditions expected to occur at the Project location as provided in the meteocean study (Ref. [5]).

Emergency simulation exercises were also carried out assuming partial engine failures, in particular bow thrusters and azipod thrusters' failure.

The document is subdivided in the following sections:

- ✓ Section 2, 3 and 4: Input to the navigation simulation workshop and details on how these input has been modelled for simulation purposes;
- ✓ Sections 5: Organization of the navigation simulation workshop, the related simulation matrix where all the exercises conducted are reported and the outcomes of the exercises;
- ✓ Section 6: Conclusion of the workshop

In Appendix A of this document are reported the simulation exercise sheets in which details of each exercise are inserted, as well as the swept path of the manoeuvre and the main parameters time histories.

In Appendix B of this document details of the simulation system used to carry out the simulation exercises is reported.

1.1 SCOPE OF THE DOCUMENT

The document aim to assess the feasibility Project Port layout through the outcome of the manoeuvres executed with the design vessel (Oasis Class) assessing the adequacy of the water areas.

In light of the above, this document details the navigation simulation exercises carried out and its main findings.

2 LAYOUT DESCRIPTION

2.1 PROPOSED PORT LAYOUT

In the framework of the Fiumicino “Isola Sacra” Project, the Port layout has been defined, shared, and agreed with RCG Marine Port Development. In particular, the construction of two neighbouring Ports is foreseen:

- ✓ The Cruise basin, delimited by the two breakwaters Traiano and Claudio, where the former will extend the existing breakwater and the latter will host the berthing area and the passenger Terminal;
- ✓ The Marina area, where the pleasure craft will be hosted.

The Cruise basin will host the Oasis class vessels (design vessel) and due to the limited water depth surrounding the ports area, dredging works will be performed to realize a navigation route that will connect the port to the open sea and that will allow such vessel to be reach the berthing area.

The navigation route can be split in four main navigation areas. These are respectively:

- ✓ Access Channel;
- ✓ Turning Basin;
- ✓ South Channel;
- ✓ Cruise Basin.

In Figure 2.1, areas characterised by the same depth are shown in the same colour. Specifically, the Access Channel, the Turning Basin and the South Channel are shown in dark red (12.0m depth), while the Cruise Basin area in yellow (11.5m depth). In violet, it is highlighted the dredged area of the Marina (4.5m depth), the last is not relevant for the purpose of this document since this area is not used by the cruise vessels.

The bathymetry outside the dredged area is based on the bathymetry data collected within the Project in June 2022 (Ref. [6]).

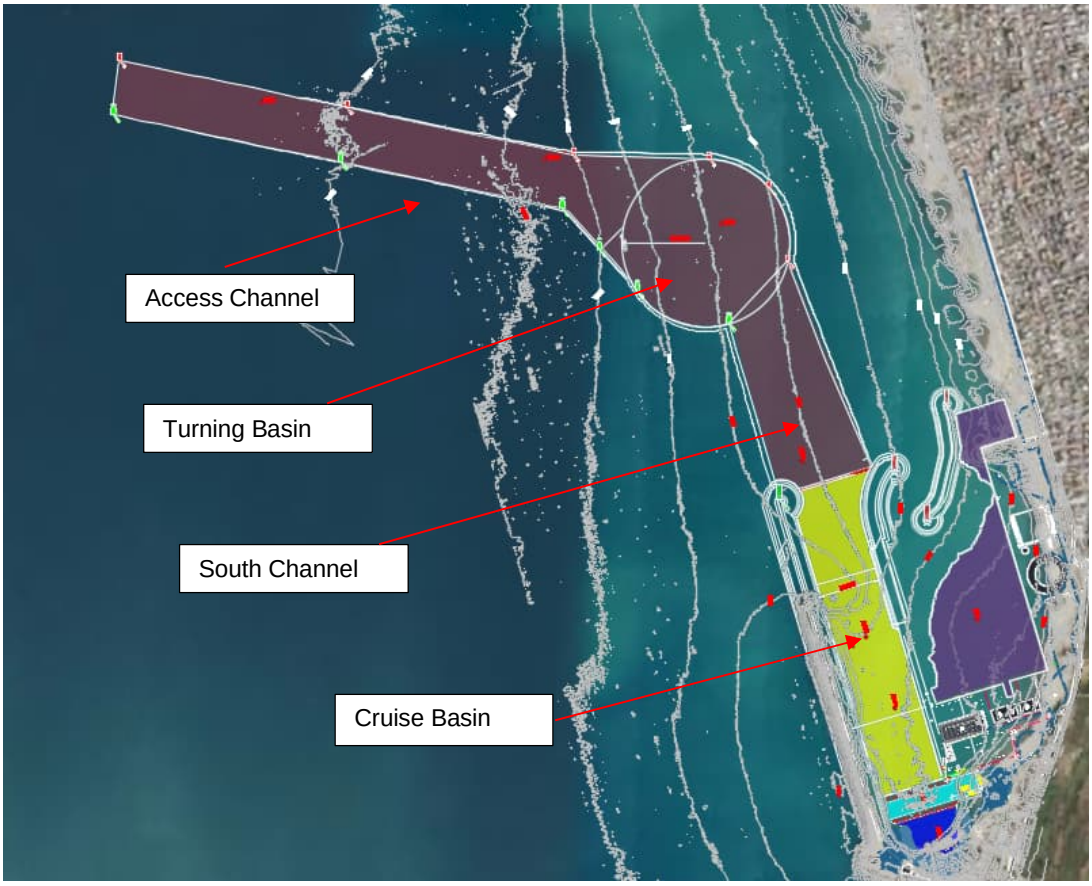


Figure 2.1: Example of arrival maneuvers

Additional details are given in following Sections, from 2.1.1 to 2.1.5.

2.1.1 ACCESS CHANNEL

The access channel is characterised by the following geometry:

- ✓ Direction 102/282°N
- ✓ Length about 1380 m (0,75 NM);
- ✓ Width about 180 m;
- ✓ Dredged depth -12,0m below mean sea level
- ✓ Channel slope 1/3

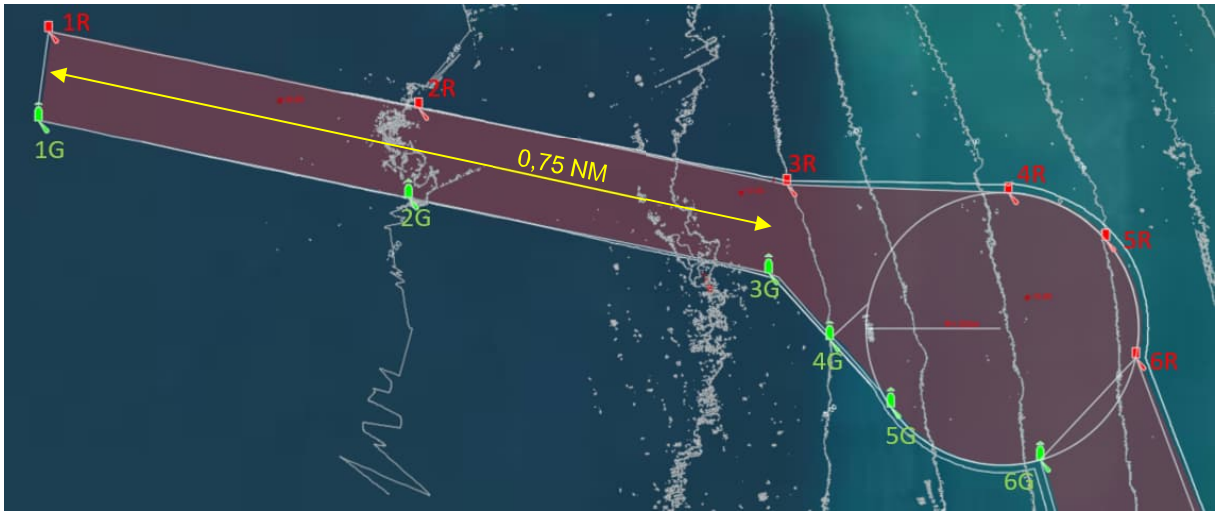


Figure 2.2: Access Channel

2.1.2 TURNING BASIN

The Turning Basin is located approx. 600m outside from the breakwater. It has a diameter of 500m (1.4 times the design vessel length - Figure 2.2). The dredged depth in the Turning Basin is kept -12.0m below mean sea level.

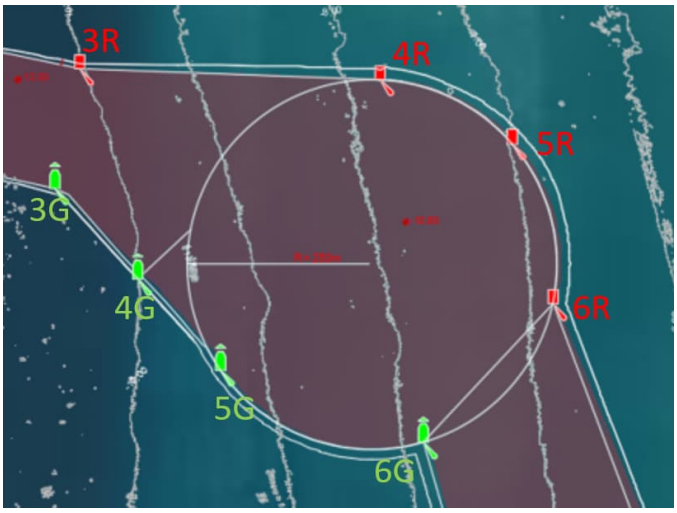


Figure 2.3: Turning Basin

2.1.3 SOUTH CHANNEL

The South Channel connects the Turning Basin to the Cruise Basin. This is characterized by:

- ✓ Direction 160/340 °N
- ✓ Length approx. 600 m (0,324 NM);
- ✓ Variable width between 230 and 270 m;
- ✓ Dredged depth -12,0m below m.s.l.

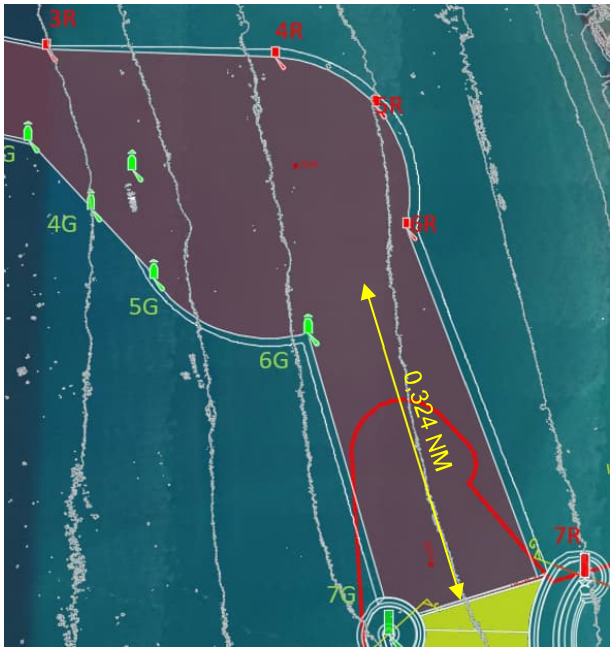


Figure 2.4: South Channel

2.1.4 CRUISE BASIN

The Cruise basin area shows different characteristics:

- ✓ Width — approx. 180m at narrowest point
- ✓ Dredged depth — -11,5 m.s.l (yellow area in Figure 2.5);
- ✓ Berth orientation — 163/343 °N

Figure 2.5: Cruise Basin Area (Yellow)

2.1.5 AIDS TO NAVIGATION

The dredged area is defined by a series of 12 buoys (to mark the main navigational areas (Access channel, Turning basin, South channel and entrance at the Cruise basin). Four lights shall be placed at the end of the breakwaters.

These are proposed to generate redundancy in the number. The buoy system is suggested as the area is not affected by large tide, allowing a good precision in the marking of the different areas.

The definition is based on IALA definition with red buoy on the port side and green buoys on the starboard side entering the port.

The aids to navigation will be defined in their specifications by the Authorities but it is expected that they will be also visible in the electronic nautical chart.

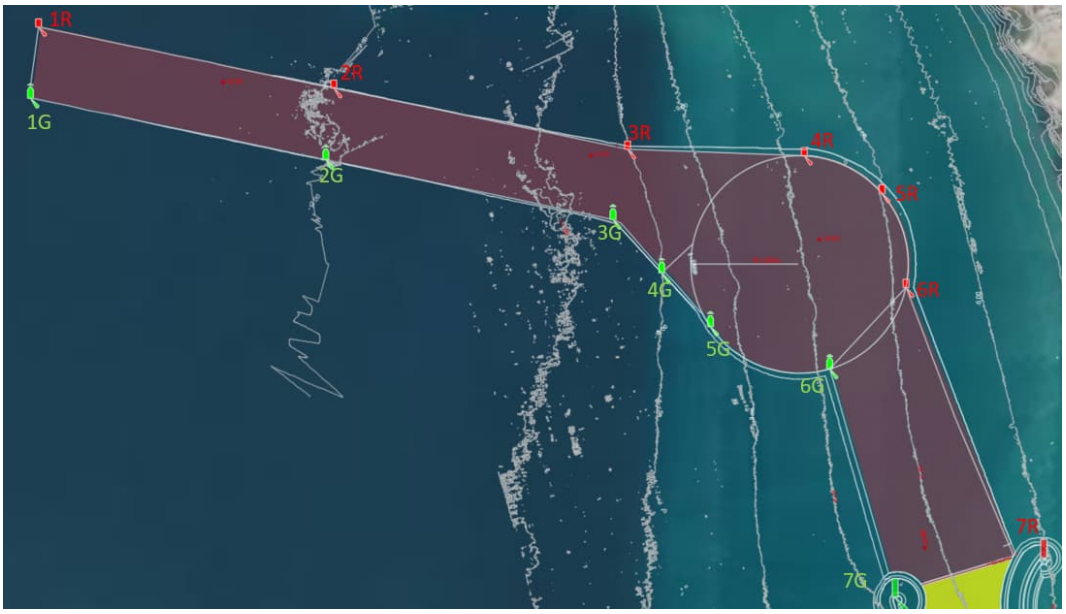


Figure 2.6: Position and ID of buoys along the navigation route

2.2 LAYOUT MODEL

The simulation session was carried out on a 3D model of the Project based on the characteristics described in sections 2.1 to 2.5 and accordingly to the Project details.

The georeferenced design layout of the port was insert in the ship simulator. The elevation of the structures was taken from the provided design section to return a 3D model allowing a 3D view of the future port.

Figure 2.7 shows the layout view from the ship bridge.

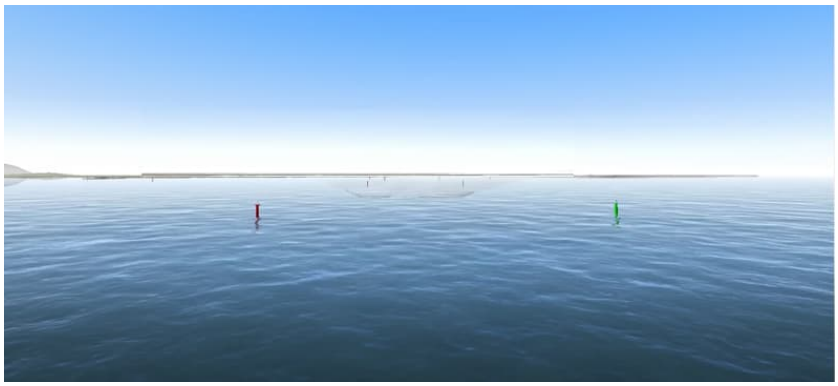


Figure 2.7: Model of the Access channel

3 DESIGN VESSEL

3.1 OASIS OF THE SEAS

Among the RCG Cruise vessel fleet, the Oasis of the Seas has been chosen as the design vessel for the navigation simulation assessment. Such a vessel is also representative of the biggest class of cruise vessels that have been built nowadays.

Main characteristics of the Oasis of the Seas are summarized in Table 3.1 based on the available information (Ref. [3]).

Table 3.1: Oasis of the Seas main characteristics (from RCG Pilot card)

Main parameters	Title
Length OA [m]	362
Length PP [m]	330
Beam (moulded) [m]	47
Draft (summer) [m]	9.3
Displacement (summer) [t]	104,000
Keel to mast height [m]	81.2
Propulsion type	Azimuth
Propulsion power [kW]	60,000 (3 x 20,000 Azipods)
Bow thrusters [kW]	4 x 5,500

Figure 3.1: Oasis of the Seas (from google)

3.2 OASIS VESSEL MODEL

3.2.1 Overview of the available vessel models

Oasis vessel model, as all Wartsila “restricted” models, is commissioned, tested and validated from the ship owner and once approved this cannot be edited (e.g., the draft cannot be updated). Information about the vessel model was shared with RCG which granted the access and use for the navigation simulation workshop.

The available characteristics of the design vessel model are summarized in Table 3.2 of such Oasis class vessel model:

Table 3.2: Oasis of the Seas main model characteristics (from Wartsila Library)

Main parameters	Title
Ref. no	TR-S-NT-DB-OM469
Thrusters power [kW]	Diesel Electric, 3 x 21,053
Thrusters, bow/stern [kW]	4 x 5,500
Propeller	3 azipod
Speed [kn]	24
Displacement [t]	97,728
Dimensions (L X B X T) [m]	362 x 47 x 8.76
Loading condition	Half pax and fuel, T=8.8m

According to the information reported in Table 3.2, there are some differences between the characteristics of the Oasis vessel and the available mathematical model:

- ✓ The model azipod thrusters’ power (21MW) is approximately equal to the one of the real vessel (20MW), which means approx. 5% difference.
- ✓ The model loading condition (8.8 m) is similar to the one of the real vessel (9.3m), approx. 5% difference.

Based on the available information, technical checks were conducted on the Oasis class vessel model, and these are discussed in section 3.2.2

3.2.2 Comparison between the real vessel and the model vessel

From the available Wheelhouse poster characteristics for the Oasis model it was possible to check some of the propulsion characteristics of the vessels and compare these with the real Pilot Card of the Oasis that was provided by RCG.

The comparison was conducted on the following manoeuvring aspects:

- ✓ Propulsive power: the max power per azipod for the vessel model is 21,053 kW and max power per bow thruster is 5,500 kW as reported in the Oasis Pilot card. Additionally, max azipod angle range in navigation mode is ±35-deg as per Oasis Pilot card.
- ✓ Manoeuvring mode: the max power per azipod for the vessel model when used in manoeuvring mode is 10,000 kW, as reported in the Oasis Pilot card. Additionally, max azipod angle range in manoeuvring mode is “all around” as per Oasis Pilot card.
- ✓ Astern mode: when using the azipod in standard configuration (Figure 5.3) in astern mode, max power per azipod is reduced to 10,000 kW, as reported in the Oasis Pilot card.

4 METOCEAN CONDITIONS

The metocean conditions considered in the ship simulation exercises were taken from the outcome of the metocean study carried out by RINA Consulting and detailed in Ref. [5]. These are reported in the following paragraphs.

4.1 METOCEAN STUDY

4.1.1 Wind

Wind regime has been extracted from the ECMWF-ERA 5 database, on the basis of the data collected by the three different stations located at Civitavecchia, Anzio and Ponza. Technical checks have been conducted as well as a data validation procedure as reported in Ref. [5]

The characteristic values are reported in Table 4.1, in which the 10 minutes averaged wind speed are divided in ranges of wind speed and incoming direction and the correspondent probability of occurrence is reported.

Table 4.1: Annual distribution of probability of occurrence of wind speed vs incoming direction

Dir [N]	Wind speed (kn) - Annual 12.25°E 41.75°N											
	5	10	15	20	25	30	35	40	45	50	>50	TOT.
0	4.42	1.67	1.37	1.11	0.59	0.19	0.02	*	*			9.36
30	4.93	2.35	1.51	0.77	0.22	0.05	*					9.83
60	4.85	1.05	0.18	0.02	0.01	*						6.12
90	4.12	0.88	0.29	0.10	0.03	*	*					5.42
120	3.92	2.07	1.48	0.96	0.42	0.09	0.01	*				8.97
150	3.64	3.06	2.50	1.47	0.61	0.13	0.03	*	*	*		11.43
180	3.40	2.48	1.07	0.45	0.16	0.07	0.02	*				7.64
210	3.53	2.25	0.89	0.38	0.15	0.05	0.02	*				7.27
240	3.72	2.62	1.17	0.80	0.47	0.16	0.04	*				8.98
270	4.27	3.04	1.20	0.45	0.23	0.10	0.02	*	*			9.31
300	4.75	2.37	1.10	0.30	0.08	0.03	0.01	*				8.64
330	4.52	1.56	0.65	0.21	0.06	0.02	*	*	*			7.03
TOT.	50.08	25.41	13.41	7.00	3.02	0.89	0.16	0.01	*	*		100.00

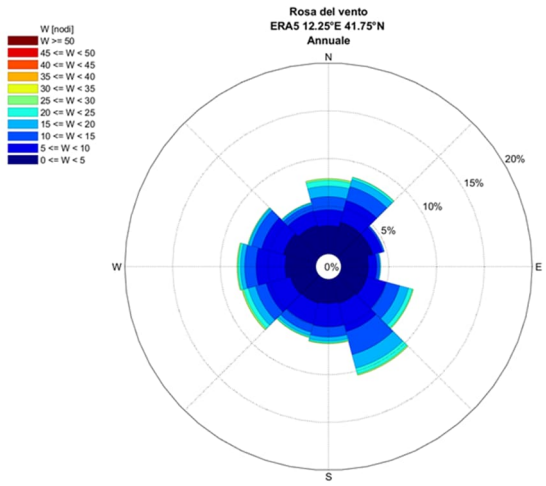


Figure 4.1: Annual wind rose

Considering the data reported in Figure 4.1, wind regimes is almost equally distributed from the incoming sectors analyzed. Considering the above, it was agreed with Pilot to consider as a minimum four wind directions (the worse for the maneuver) from 180 deg to 0 deg, mainly from SW sector.

Additionally, wind blowing from N-NE sectors were analyzed in the exercise, to provide overall feedback for what concerns the most relevant wind directions.

4.1.1.1 Wind operability limits

In the metocean Study (Ref. [5]) it is reported a section related to the number of days exceeding wind threshold values. This shows that:

- ✓ The mean annual probability of exceeding 20 knots of wind is equal to 49,1 days; increasing this threshold to 25 and 30 knots, the probability of exceeding drops to 18,2 days and 4,9 days each year respectively.
- ✓ In the summer season, June, July, August, September, the mean annual probability of exceeding 30 knots of wind speed is very limited. Less than 1 day each month the wind speed exceeds 20 knots.

Table 4.2: Number of days exceeding wind threshold values

	Number of days of wind overpassing threshold values												
	Annual	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
W > 20 nodi	49.1	6.5	6.1	5.7	4.1	1.8	1.0	0.8	0.9	2.2	4.7	7.3	8.1
W > 25 nodi	18.2	2.9	2.6	2.5	0.8	0.5	0.2	0.1	0.2	0.4	1.3	3.0	3.8
W > 30 nodi	4.9	0.9	0.7	0.6	0.1	0.1	0.0	0.1	0.0	0.1	0.3	0.8	1.2

In light of the above, a wind speed up to a maximum of 25 knots will be considered for the navigation simulation assessment.

4.1.2 Waves

Nearshore waves data were derived from the metocean study Ref. [5]. According to the data provided, the outcomes of the metocean study highlighted that most of the waves are coming from 210 ° - 300 ° N (about 88% of total events). The higher waves registered are in the class Hs= 3.5 - 4 m associated to a probability of occurrence of less than 0.18% of total events, while almost 98% of the events are characterized by a Hs equal or lower than 2.5 m.

Table 4.3: Annual frequency occurrence of Hs vs Incoming direction at turning basin– Depth -12,5m

Dir [N]	Hs (m) - Annuale Turning Basin									
	0.5	1	1.5	2	2.5	3	3.5	4	>4.5	TOT.
0	0.02									0.02
30										
60	0.05									0.05
90	*									*
120	0.05									0.05
150	0.24									0.24
180	5.88	2.29	0.30	*	*					8.47
210	13.46	9.46	3.93	1.39	0.50	0.27	0.15	0.01		29.17
240	6.44	4.40	3.07	1.63	0.65	0.34	0.19	0.10		16.82
270	10.53	9.10	3.41	1.21	0.47	0.18	0.20	0.07		25.18
300	10.46	4.92	1.41	0.15	0.03	0.02				16.98
330	1.38	1.52	0.11							3.02
TOT.	48.51	31.70	12.23	4.38	1.66	0.81	0.55	0.18	0.00	100.00

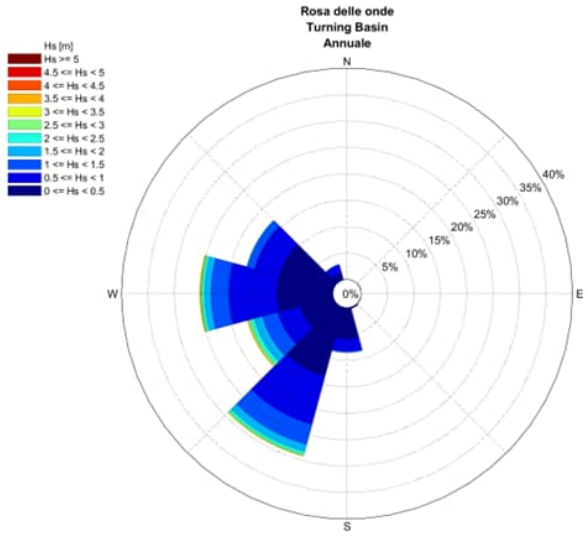


Figure 4.2: Annual wave rose

4.1.2.1 Waves operability limits

Considering the annual statistics, the frequency of occurrent of events higher Hs higher than 1,5m is below 7,57% of total events.

Probability of exceedance of several thresholds are reported in Table 4.4:

Table 4.4: Annual frequency of exceedance (%) of Hs, events above threshold

Reference period	Waves exceedence frequency (m)(%)							
	0.5	1	1.5	2	2.5	3	3.5	4
Annual	51.49	19.80	7.57	3.19	1.53	0.72	0.18	0.00

Reference period	Waves exceedence frequency (m)(%)							
	0.5	1	1.5	2	2.5	3	3.5	4
January	67.42	34.60	12.98	6.24	3.49	1.56	0.32	0.00
Feburary	68.68	31.21	12.26	4.93	2.16	1.09	0.12	0.00
March	65.86	31.26	12.04	5.00	1.72	0.78	0.08	0.00
April	55.19	18.67	6.44	1.25	0.31	0.06	0.00	0.00
May	52.02	15.22	4.65	1.34	0.67	0.43	0.00	0.00
June	39.28	5.39	0.78	0.00	0.00	0.00	0.00	0.00
July	37.72	8.98	1.77	0.59	0.19	0.00	0.00	0.00
August	27.63	5.67	1.72	0.81	0.05	0.00	0.00	0.00
September	40.89	13.97	3.86	1.14	0.28	0.00	0.00	0.00
October	52.07	16.59	5.46	2.98	1.56	0.78	0.46	0.00
November	60.72	31.69	16.17	6.78	3.19	1.17	0.36	0.00
December	51.69	25.05	13.01	7.28	4.73	2.77	0.75	0.00

For the purpose of the navigation simulation assessment, it was decided to set initially the operability limit to 1,5 m of wave height.

4.1.3 Wind and waves driven currents

According to the metocean Study (Ref. [5]), the main currents occurring at Project site are wind and waves driven. Since that measurements at the Project site or in the surrounding areas are not available, it has been agreed to conduct dedicated numerical simulations (Delft3D) to assess the speed and directions of prevailing currents, considering the updated bathymetry comprehensive of the foreseen dredged areas.

In the simulations, the currents were generated assuming four main representative conditions accordingly to the studies summarized in section 4.1.1 and 4.1.2:

- ✓ Waves with Hs=2,5m, Tp=10s, aligned wind speed of 30 knots, main direction 210°N;
- ✓ Waves with Hs=2,5m, Tp=10s, aligned wind speed of 30 knots, main direction 240 °N;
- ✓ Waves with Hs=2,5m, Tp=10s, aligned wind speed of 30 knots, main direction 270 °N;
- ✓ Waves with Hs=2,5m, Tp=10s, aligned wind speed of 30 knots, main direction 330 °N.

Results for each simulation are shown from Figure 4.3 to Figure 4.6. These show the effect of Traiano breakwater and dredged areas on the flow. The flow is separated into different streams, one heading towards North and the other one generating headings at the entrance of the Marina. Results show average current speed between 0,5 and 1 kn (along the entire water column)..The cruise basin is instead characterized by negligible current.

From the above simulation, nine representative points of interest from the Access channel to the Cruise Basin (shown from Figure 4.3 to Figure 4.6) located in the center of the dredged areas, were extracted from the current simulations and assumed representative of each area.

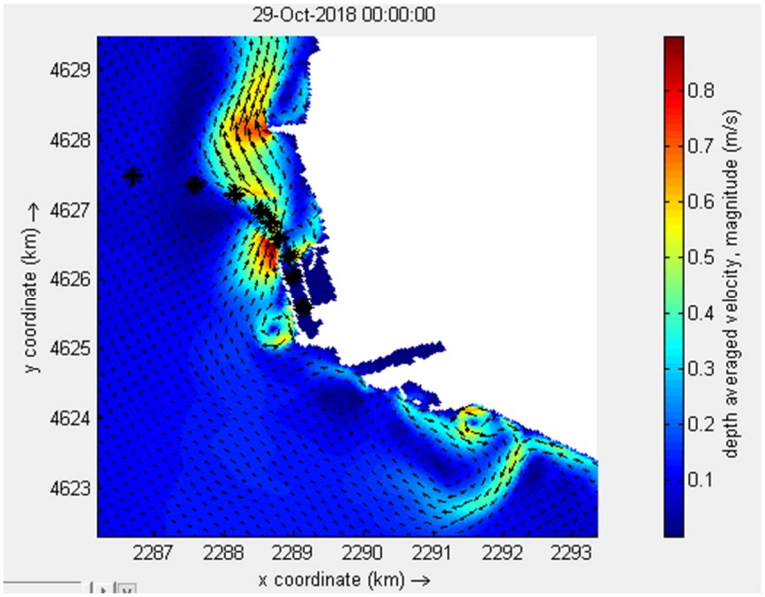


Figure 4.3: Current generated by wind and waves from 210°N

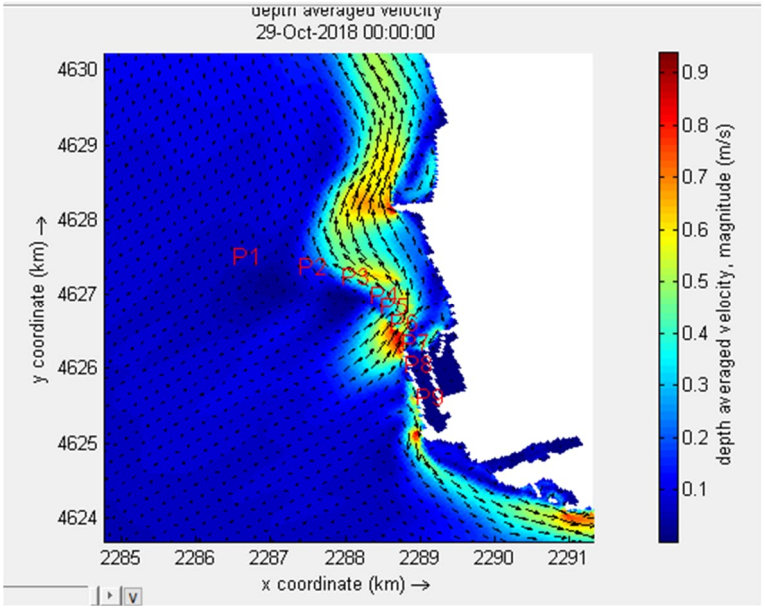


Figure 4.4: Current generated by wind and waves from 240°N

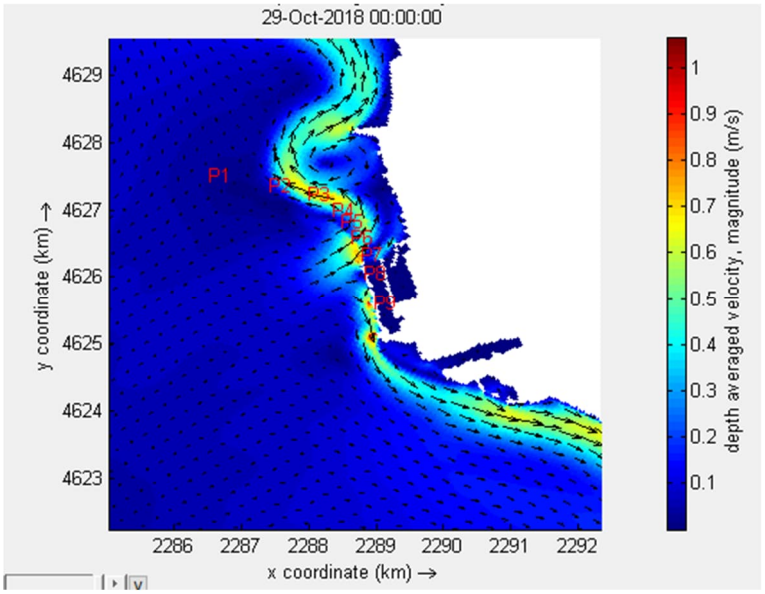


Figure 4.5: Current generated by wind and waves from 270°N

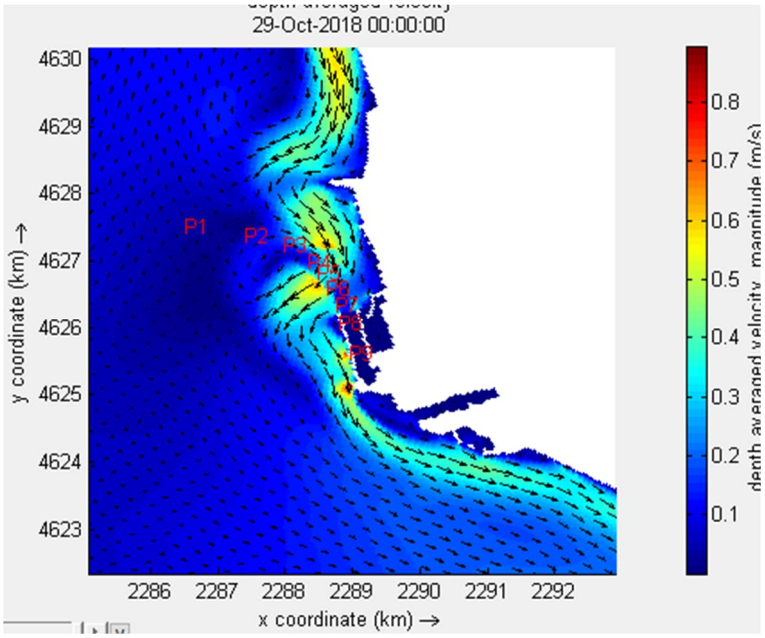


Figure 4.6: Current generated by wind and waves from 330°N

4.2 MODELLED METOCEAN CONDITIONS

4.2.1 Wind modelling

The wind was generally modelled in each exercise as a two-wind component:

- ✓ A constant value for the duration of the entire simulation
- ✓ Gusting events that will occur every pre-defined time step, increasing temporarily the constant value (as reported in the exercises summary.

Such wind modelling is usually adopted in navigation simulations represent a more realistic wind nature during the exercise. In the exercise where gusting event were considered, the temporary increase of the wind speed was set up to 30% reaching a value of 32 knots.

4.2.2 Waves modelling

It is a usual practice, when performing simulation navigation session, to model the waves through an irregular wave sea state defined by a JONSWAP spectrum, for which within the simulator environment the representative Hs can be set.

For the purpose of this navigation simulation assessment, it was adopted a more conservative approach and waves have been modelled as regular sinusoidal waves characterized by Hs between 1 and 1.5 m. With this approach, it was also possible to set the associated waves period T=Tp between 6 and 8 seconds.

From the meteocean study (Ref. [5]), it is considered acceptable to introduce a single wave characteristic within the full modelled area except for the cruise basin, where it is not expected that significant waves will occur (Ref. [7]). The wave considered is therefore the one computed at the Turning Basin.

4.2.3 Current modelling

In the ship simulation, the current has been set as local conditions, applied in user-made zones and for which different environmental conditions were set. These zones are defined as “condition zones”:

While wind and waves have been applied as global conditions (except for the Cruise basin in which waves were neglected) since they are not expected to vary along the navigation area of interest, the numerical simulations performed to investigate the current spreading shown that the navigation area is characterized by different current directions and speeds in a way that it is not possible to set a global current valid for all the area.

To take into account the variability in current speed and direction, the data extracted from the nine points of interest (two to three points per each area, reported in red dots in Figure 4.7) were evaluated and one representative current speed and direction for each of the three zones has been defined.

The three zones, one for each main area i.e. Access channel, Turning basin and South channel, are reported in Figure 4.7. In each zone, the current speed and direction was considered constant.

Accordingly, to the numerical current study, the current was considered negligible in the Cruise Basin.

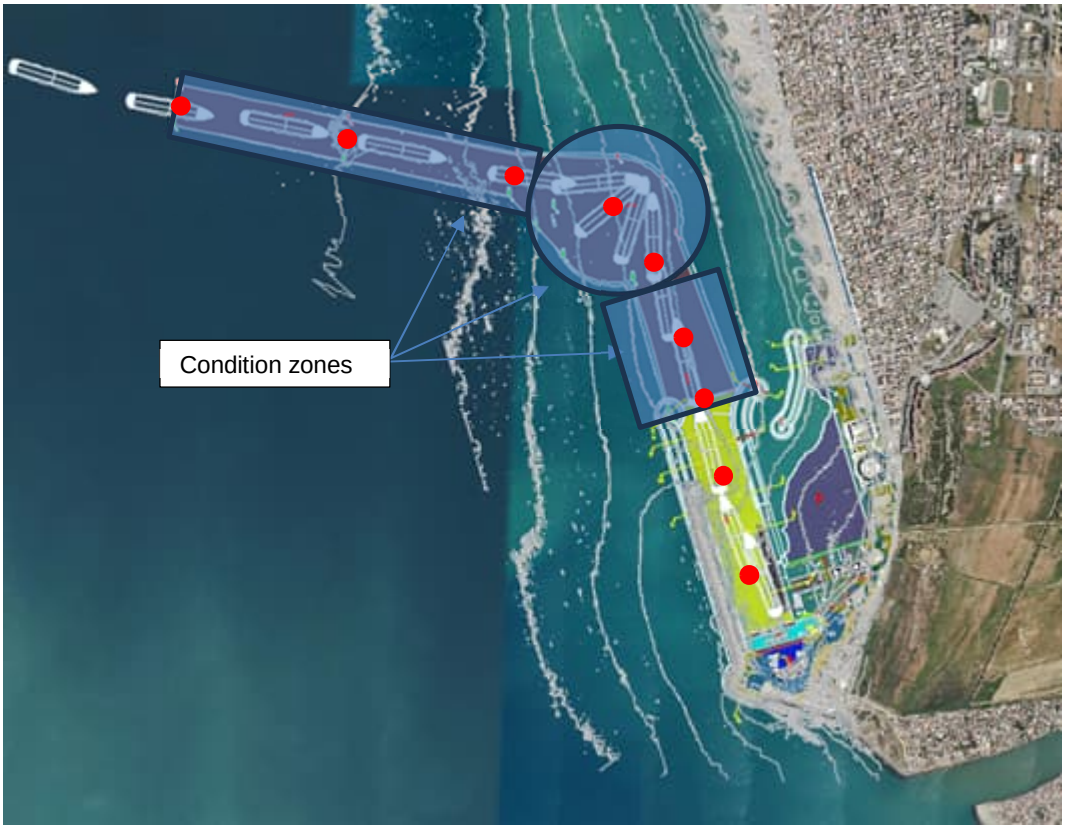


Figure 4.7: Condition zones

5 NAVIGATION SIMULATION WORKSHOP

5.1 WORKSHOP STRUCTURE AND ORGANIZATION

The workshop was arranged during week 24, from 14-16th June 2023, for a total of 3 (three) days, at the Simulator facility located in Genoa.

The overall list of attendees of the workshop is here below reported:

- ✓ Galliano Di Marco — Fiumicino Waterfront
- ✓ John Gatti — Pilot, RINA
- ✓ Alessandro Odasso — Project Director, RINA
- ✓ Marino Balzarini, — General Project Manager, RINA
- ✓ Roberta Riva, — Project Manager, RINA
- ✓ Marco D'Odorico — Marine engineer and naval architect, RINA
- ✓ Davide Paolobello — Marine engineer and naval architect, RINA
- ✓ Andrea Rossi — Marine engineer and naval architect, RINA

During the workshop, three different online meetings were held to discuss the findings of the simulations with representatives of Fiumicino Coast Guard.

- ✓ Giuseppe Strano — Head of Rome maritime Port Division
- ✓ Michele Scotto Lavina — Head of Fiumicino and Civitavecchia Pilots Association

5.1.1 Navigation simulation session

The navigation simulation session started with an introduction meeting explaining the input used in the simulation session.

The simulation session carried on with different exercises performed in a real time simulation by the Pilot from the simulator bridge (characteristics of the simulator bridge are reported in Appendix B). The rationale of the maneuver was shared by RCG Marine Port Development.

Each arrival exercise was initialized a few ship lengths before the entrance to the Access channel. Then, the design vessel will swing in the Turning Basin to proceed astern in the Cruise Basin, as the vessel will berth starboard side alongside Molo Claudio Berth. The exercise was considered closed once the vessel was positioned close and adjacent to the berth and/or it was under control.

The departure exercises were initialized close to the berthing area, with the vessel parallel to the berth line: the manoeuvring of the vessel was performed without swing as the vessel was already bow out.

Additional details regarding the ad-hoc strategy adopted by the Pilot in each of the exercises conducted is reported in the exercises sheet in Appendix A of the present document.

A debriefing was held at the end of the exercises to collect the outcome of each one of them. An additional meeting with the Coast Guard was held at the end of each day. The outcomes of the debriefing sessions were used as input for the following exercises and for optimizations of the layout.

5.2 SIMULATION MATRIX AND RESULTS

A summary of the rationale and of the main outcomes behind the foreseen simulation exercises is reported below.

- ✓ Exercises 1 aimed to gain confidence with the vessel model, hence the feasibility of approaching the Cruise Terminal at relatively mild wind speed was investigated.
- ✓ Exercises 2 aimed to investigate the feasibility of the maneuvering strategy with a wind gusting speed of 25 knots. The exercise showed the feasibility of carrying out the maneuvers. This wind speed was then investigated also for the other exercises. The vessel kept the bow on the north of the turning circle before moving astern.

- ✓ Exercises 3, 4, 5, 6 aimed to investigate the main meteocean conditions at the site. These exercises showed the maneuvering strategy that was followed to enter to the port: the vessel generally kept a speed over the ground of approximately 6 knots in the Access channel; the vessel was lead at the center of the basin and swing with the help of the bow thrusters, either clockwise or anticlockwise depending on the prevailing metocean conditions. When the vessel was proceeding astern after the swinging maneuver, the main issue identified was adjust the ship heading to keep a minimum distance from Traiano inner breakwater. These exercises demonstrated that the proposed port layout and the designed water areas available for the Oasis class vessel maneuvers were adequate for the arrival maneuvers in the tested conditions;
- ✓ Exercise 7 aimed to investigate the feasibility of the departure maneuvers in the worst-case scenario detected by the Simulation Team as wind, waves and current coming from the W and pushing the vessel against the Claudio breakwater while leaving the berthing area. The exercise showed the adequacy of the proposed port layout;

The previous exercise showed marginality of safety in the access channel. It was suggested to increase the channel width to 200m. Further optimization was discussed with the Client, Pilot and Coast Guard representatives. It was decided to conduct additional exercises in the proposed Port layout prior to make any modifications.

- ✓ Exercise 8 aimed to investigate the feasibility of the arrival maneuvers when in presence of 25 knots of wind speed coming from SE to account for wind blowing from landside. The exercise was conducted successfully.
- ✓ Exercise 9 aimed to further investigate a departure maneuver in presence of wind coming from E-NE, to further extend the comprehension of wind speed influence from landside. The exercise highlighted the need to keep the vessel stern position as high as possible to avoid grounding in Buoy 3G. The exercise was conducted successfully.
- ✓ Exercise 10 aimed to investigate the feasibility of the maneuver in case of failure. The presence of wind, waves and current was considered, although the wind speed, the significant wave height and the current speed were slightly decreased when compared to the values adopted in exercises from 3 to 7. The loss of power from a set of generators was simulated with consequent failure of bow thruster 1 and 3 (remaining available bow thrust power was 50%). The failure was planned to occur in the final part of the Access channel and the Pilot was notified of the failure only during the maneuver and 2 minutes after its occurrence. Despite this failure, the maneuver was conducted successfully.

After exercise 10, the proposed layout was updated with the suggested variation and tested in exercise 11.

- ✓ Exercise 11 aimed to investigate an alternative case of failure, again in the presence of wind, waves and current. The partial loss of power was tested with the failure of the portside azipod. The failure was planned to occur in the last quarter of the Access channel. The pilot was notified of the failure 1 minute after the failure occurred. Despite this failure, the maneuver was conducted successfully. The vessel remains within the dredged area and it was possible to continue the maneuver with the remaining power. Nonetheless, the area between buoy 3G and buoy 4G added after previous discussion on the layout, was used to control the ship drifting towards the south area of the turning basin.

The departure was repeated with the initial proposed layout.

- ✓ Exercise 12 aimed to complete the evaluations simulating a departure maneuver in 25 knots of wind from S. The exercise confirmed the critical point of the departure maneuver that can be spotted at the entrance of the Access channel, due to the needing of a continuous control of the vessel bow and stern to be handled in confined areas. This suggested to widen the channel area close to the turning circle.

On the base of considerations above, the simulation matrix is introduced in Table 5.1.

The outcomes of the exercises have been arranged in arrival and departure maneuvers and these are detailed in Sections 5.2.1 and 5.2.2 respectively.

Table 5.1: Simulation Matrix

Exercise no.	Manoeuvre:	Layout	Wind		Waves			Current		Notes/Outcomes
			Direction from [° N]	Speed [kn]	Direction from [°N]	Hs [m]	Tp [s]	Direction to [°N]	Speed [kn]	
1	Arrival	Standard Layout (Channel width = 180m)	0	10	N/A	N/A	N/A	N/A	N/A	Familiarization exercise. Manoeuvre conducted successfully; wind speed is relatively mild.
2	Arrival	Standard Layout (Channel width = 180m)	0	25	N/A	N/A	N/A	N/A	N/A	Manoeuvre conducted successfully. Wind speed is challenging but the manoeuvre remained feasible
3	Arrival	Standard Layout (Channel width = 180m)	210	25	210	1.5	8	Access Channel: 345 Turning basin: 330 South Channel: 30	Between 0,5 and 1 kn	Manoeuvre conducted successfully. Wind and waves from 210° (S-SW) pushed the vessel against the N-NE edge of the basin when entering within the Turning basin. The manoeuvre is challenging, extra space when entering the turning basin is advisable.
4	Arrival	Standard Layout (Channel width = 180m)	240	25	240	1,5	8	Access Channel: 330 Turning basin: 330	Between 0,5 and 1 kn	Manoeuvre conducted successful. Compared to exercise n.3, the main direction of wind and waves is less demanding for the turning manoeuvres, although recommendations for extra space for the manoeuvres to be considered.

Exercise no.	Manoeuvre:	Layout	Wind		Waves			Current		Notes/Outcomes
			Direction from [° N]	Speed [kn]	Direction from [°N]	Hs [m]	Tp [s]	Direction to [°N]	Speed [kn]	
								South Channel: 30		
5	Arrival	Standard Layout (Channel width = 180m)	270	25	270	1,5	8	Access Channel: 315 Turning basin: 315 South Channel 225	Between 0,5 and 1 kn	Manoeuvre conducted successfully. Wind and waves from 270° (W) acts on vessel stern quarters along the Access channel hence bow thrusters and pods levers to be continuously adjusted to keep the vessel inside the dredged area. The same applied when the vessel is in the South Channel to keep the vessel route when proceeding astern corrections are needed. Extra space for the Access channel width is advisable
6	Arrival	Standard Layout (Channel width = 180m)	330	25	330	1,5	8	Access Channel: 100 Turning basin: 180 South Channel 225v	0,5 kn	Manoeuvre conducted successfully. Wind and waves from 330° (NE-N) push the vessel in the south edge of Access channel and turning circle. Adjustment on azipods and bow thrusters' levels are required to keep the route. Extra space for the Access channel width is advisable.

Exercise no.	Manoeuvre:	Layout	Wind		Waves			Current		Notes/Outcomes
			Direction from [° N]	Speed [kn]	Direction from [°N]	Hs [m]	Tp [s]	Direction to [°N]	Speed [kn]	
7	Departure	Standard Layout (Channel width = 180m)	270	25	270	1,5	8	Access Channel: 315 Turning basin: 315 South Channel 225	Between 0,5 and 1 kn	Departure in worst condition Manoeuvre conducted successfully. The effect of wind and waves from 270° (W) that push the vessel against Traiano breakwater, is to be counteracted. A correct planning of the manoeuvres for passing the South channel and Turning basin to enter the Access channel is needed.
8	Arrival	Standard Layout (Channel width = 180m)	120	25	N/A	N/A	N/A	N/A	N/A	Manoeuvre conducted successfully. Wind from 120° (E-SE) is pushing the vessel toward the turning basin NW edge.
9	Departure	Standard Layout (Channel width = 180m)	30	25	N/A	N/A	N/A	N/A	N/A	Manoeuvre conducted successfully. Wind from 30° (N-NE) is pushing the vessel toward buoy 3G when the vessel egressed the Access channel.
10	Arrival (Emergency)	Standard Layout (Channel width = 180m)	240	20	240	1	6	Access Channel: 330 Turning basin:	0,3	Failure of n.1 and n.3 bow thrusters. Manoeuvre conducted successfully. The loss of power of bow thrusters is counterbalanced by the azipod power and their capability to operate.

Exercise no.	Manoeuvre:	Layout	Wind		Waves			Current		Notes/Outcomes
			Direction from [° N]	Speed [kn]	Direction from [°N]	Hs [m]	Tp [s]	Direction to [°N]	Speed [kn]	
								330 South Channel N/A		
11	Arrival (Emergency)	Optimized layout (Channel width = 200m and local enlargments of the Turning basin)	210	20	210	1	6	Access Channel: 0 Turning basin: 0 South Channel 30	0,3	Loss of Portside Azimuth Pod Manoeuvre conducted successfully in optimized layout. The remaining available power for controlling the vessel stern at the Turning basin entrance was used to faster reach the turning basin centre and bringing forward the swinging manoeuvre. The loss of one azipod is counterbalanced by the bow thruster's full power and the central and starboard azipod capability to operate all-around.
12	Departure	Scenario A (Channel width = 180m)	180	25	N/A	N/A	N/A	N/A	N/A	Manoeuvre conducted successfully. Wind from 180° (S) is pushing the vessel toward the turning basin NW edge.

The simulation matrix was prepared taking into account the following considerations:

- ✓ Wind and waves directions should be considered "from". Current directions should be considered "toward";

5.2.1 Arrival maneuvers

The arrival exercises, namely 1,2,3,4,5,6,8,10 and 11 demonstrated that the vessel could be handled in the proposed Port layout in presence of a wind speed up to 25 knots from each direction, collinear waves with Hs up to 1.5m and Tp of 8s and associated currents.

The following considerations were deducted from the exercises conducted, with respect to the navigation along the Access channel:

- ✓ The SoG at the channel entrance was kept around 6 knots and the time required for the vessel to proceed along the Access channel was approx. 7-9 minutes, depending on the prevalent metocean conditions. When in proximity of the Turning Basin, the SoG was gradually reduced to 3-4 knots;
- ✓ The average configuration of the Azipods during the navigation along the access channel was kept mainly as follows:
  - Starboard pod either at ±90° or 0°, sometimes a specific angle to correct the heading of the vessel was needed;
  - Central pod with an angle of 0° or 180°, to provide power as needed;
  - Portside pod either at ±90°, or at specific angle to correct the heading of the vessel when needed;
- ✓ The use of the azipods has been adeguate to safely handle the vessel in combination with the bow thrusters which have been used to adjust the vessel heading when required and especially when in presence of beam wind and waves. The worst wind directions experienced were found to be from NE and SW, although a significant drift angle has been also experienced in presence of stern quartering waves coming from W, that in such condition reached a value of 8-9°;
- ✓ The minimum distance kept between the vessel sides and the buoys delimiting the last section of the channel, prior to entering within the turning basin, was approximately 40 m (Buoy 3R) and 30 m (Buoy 3G);
- ✓ The exercises highlighted that when in presence of a wind speed of 25 knots, the safety margin for route corrections is minimum due to the limited width of the channel and the length of the Oasis class vessels: in particular, when drift angles increase, the channel width occupancy increases.

The diameter of the “turning basin” has been found sufficient to perform the key maneuver for all the exercises conducted. This study found the following strategy to be successful for the layout:

- ✓ Based on prevalent wind and waves directions, it is advisable that the stern is located windward during evolution. In deciding whether to evolve clockwise rather than counterclockwise, it is suggested to take into account the high power of the thrusters compared to that offered by the azipods;
- ✓ The vessel stern generally tends to drop to the south edge of the channel while entering the “Turning basin” (Buoy 3G). This is particularly true in presence of metocean conditions coming from NE and NW sectors: the strategy adopted in the exercise was to bring the vessel toward the center of the basin at almost zero forward speed and to perform the swinging maneuver either at starboard or at port side, depending on the prevailing metocean conditions.

Furthermore, it was noticed that the minimum distance that was kept between the vessel bow and stern with the Cruise Basin edges was between 20 and 30 meters.

The rate of turn of the vessel during the swinging maneuver was found to be within 35°/min depending on the prevalent metocean conditions. The only case in which such value was exceeded was during one of the emergency exercises. The bow thrusters’ performances, especially at almost zero SoG, were found to be higher than expected, leading to transverse ship speed at bow and stern up to more than 7 knots in absolute value.

The exercises shown that the shape and dimensions of the South Channel were adequate to conduct the vessel astern in all the tested metocean conditions with a wind speed up to 25 knots: the envelope of the maneuvers shown that the trajectory of the vessel has been maintained always along the channel midline.

When approaching the entrance of the Cruise basin, attention shall be paid to the passage of the vessel between the breakwater ends. During the maneuver, the vessel needs to increase the clearance between the vessel starboard side and the first part of Claudio breakwater, prior to reaching the berthing area.

The envelope of all arrival swept path is reported in Figure 5.1. The simulation session found the maneuvering areas adequate for the arrival of the design vessel, although two modifications, related to the turning basin

intersection with the Access channel, were discussed and agreed with Pilot and Coast Guard, with the purpose to increase the area available for swinging. These modifications led to the definition of the optimized layout, as defined in Section 6.

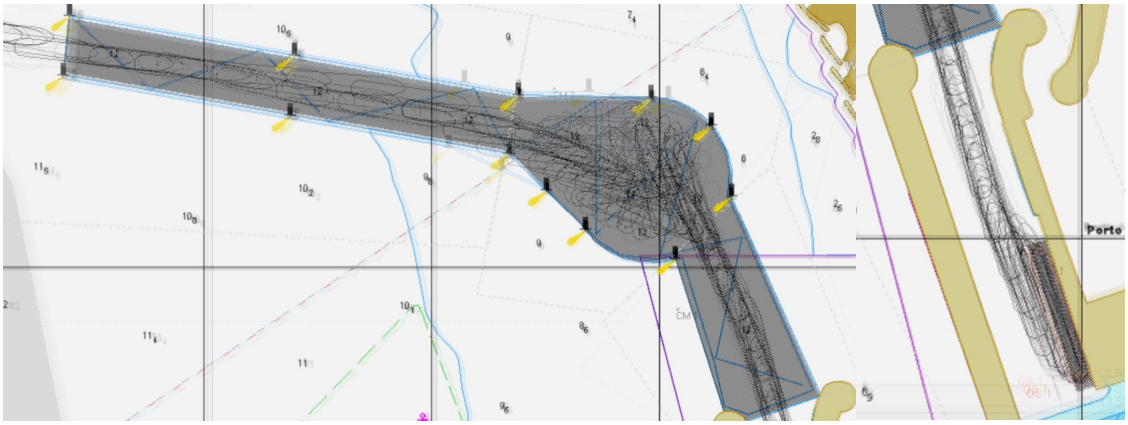


Figure 5.1: Envelope of arrival swept paths, outside (left hand side) inside (right hand side) the Cruise Basin areas

5.2.2 Departure maneuvers

The vessel departure exercises, based on the metocean conditions tested in exercises 7, 9 and 12, showed the feasibility of the maneuvers needed to bring the vessel from the Cruise basin to the open sea with a wind speed up to 25 knots.

Observation from the Simulation Team are reported below for the first part of the departure maneuver, from the berthing area to the breakwaters tip (Cruise basin):

- ✓ The bow thrusters were used to adjust the vessel heading while the vessel was in the South Channel. The Pilot underlined that, especially when in presence of wind up to 25 knots from W, the handling of the vessel in the Cruise Basin was challenging.
- ✓ The vessel SoG at the South Channel entrance was kept approx.4 knots.

When transiting along the South channel and in way of approaching the Turning basin, two major point of attention shall be considered when planning the maneuvering strategy:

- ✓ Avoid possible interference between the vessel stern and the southern west buoy delimiting the South Channel exit (buoy 6G). In light of that, the vessel shall be kept as much as necessary with the bow heading to the east side of the South channel.
- ✓ Avoid possible interference between the vessel stern and the southern west buoy delimiting the Access channel entrance (buoy 3G). In light of that the vessel shall be kept as much as practicable in the norther part of the basin and already in line with the Access channel entrance.
- ✓ Avoid being towards the NW edge of the turning basin, prior to entering the Access channel, in the presence of wind blowing from S/SE.

The vessel speed shall be controlled while passing through the north side of the basin and the vessel: ideally around 4 knots to maximize the effect of the bow thrusters.

Bow thrusters were used to adjust the vessel heading and align it with the Access channel heading.

Once the vessel entered the access channel, no major issues were identified. Bow thrusters power use was below 75 % of the maximum available and mainly used to correct the heading based on prevalent wind direction. An extra margin of power can therefore be available in case required.

The envelope of departure swept path is reported in Figure 5.2.

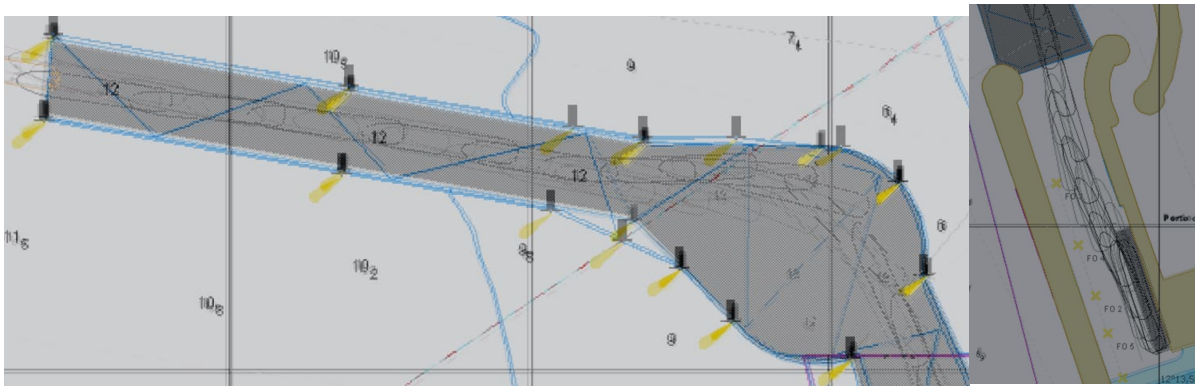


Figure 5.2: Envelope of departure swept paths, details of the navigation areas

5.3 EXERCISE SHEETS DETAILS AND CHARTS

In addition to the main outcomes reported for each exercise in Table 5.1 and Sections 5.2.1 and 5.2.2, in Appendix A are shown the simulation exercise sheets in which the following information are reported:

- ✓ Exercise number and general description;
- ✓ Vessel model used and associated loading condition;
- ✓ Type of maneuver (arrival, departure);
- ✓ Metocean conditions (global and local through condition zones);
- ✓ Key aspects of the exercise related to the maneuvering strategy and Pilot's feedback;

At the end of each exercise sheet, two main figures are reported:

- ✓ The swept path of each exercise showing the vessel shape every minute
- ✓ Graphs reporting the time histories of the vessel key parameters:
  - RPM of the engines and azipods;
  - Speed over ground (SoG);
  - Azipods angle;
  - Bow thruster power
  - Turning rate
  - Trasverse speed at vessel bow, centre and stern;
  - Azipods telegraph order;
  - Azipods propeller longitudinal force;
  - Azipods propeller transversal force.

In Figure 5.3 it is reported the standard configuration of azipods of the vessel model at the simulation start. The convention of the angle of each azipod respect to the 0 deg position is also reported for ease of reference.

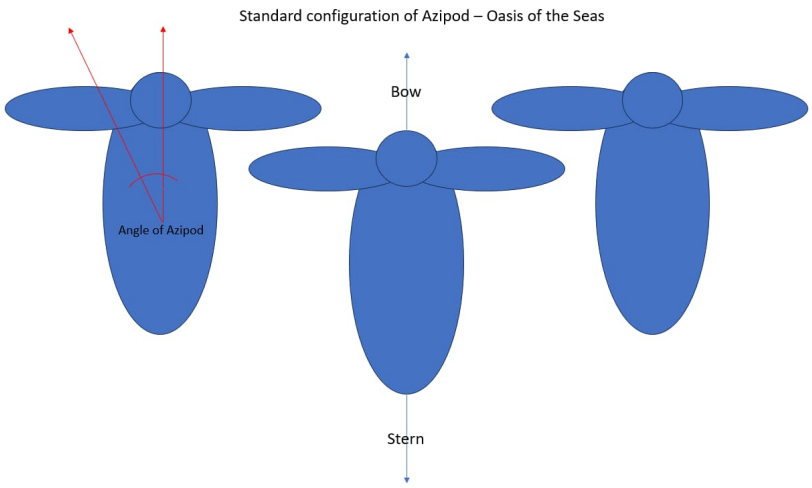


Figure 5.3: Oasis vessel model azipod standard configuration (from Warstila)

6 CONCLUSIONS

In the framework of Fiumicino "Isola Sacra" Project, RINA Consulting S.p.A. was appointed to carry out a real-time navigation simulation workshop to evaluate the proposed Project port layout.

The navigation simulations workshop was conducted at Genoa simulator facility, in presence of the RINA personnel, engineers and Pilot and Client's representatives. Fiumicino Coast Guard Pilots also attended the workshop via online meetings.

The navigation simulations workshop demonstrated the adequacy of the Project Port layout (Section 2) for the arrival and departure manoeuvres conducted with the Oasis class vessel model in a wind speed condition up to 25 knots from every direction.

A discussion with the local Coast Guard was carried out during and at the endo of the simulation session and the outcomes of the maneuvers were shared in the debriefing. The visualization of the swept paths and the presentation of the exercises held by the Pilot that performed the maneuvers of the exercises led to improvements that shall be considered as a basis for future studies. These considerations are briefly reported below

- ✓ The Access channel width to be considered shall be 180m as a minimum and based on the feedback of Pilot and Coast Guard, possibly further increased up to 200m based on the feedbacks gathered from exercises n.5 and n.7. Such considerations arise from the fact the Oasis class vessel length is approx. 360m and even with a minimum drift angle, the transversal space occupied by the vessel may increase significantly. In case of any undesired event, the space to correct the vessel heading is limited.
- ✓ Although the layout was verified by up to 25 knots of wind speed and found acceptable with the suggested improvement, an initial phase of familiarization with the navigation areas is advisable: in this initial phase the, limiting wind speed may be identified in 20 knots from each direction. Pilots training shall be performed to gain knowledge and confidence in the prior to increasing the above-mentioned wind speed limit.
- ✓ The swept path of the exercises shows that the northern buoys 3R, 4R and 5R are not interfering with the execution of the arrival maneuver, although a local enlargement shall be considered to increase the safety margin for departure maneuvers. Similarly, the south area connecting the Access channel and the turning basin, in proximity of the buoy 3G, to increase the available water area for stern handling for arrival maneuvers.

Based on the outcomes above, the optimized layout reported in Figure 6.1 has been developed and tested (exercise n.11) demonstrating the benefit gathered from the Access channel width extension up to 200 m and to the local enlargements at the Turning basin Edge in proximity of buoy 3G and buoy 3R, 4R and 5R, to smooth the sharp intersection between the Access Channel and the Turning Basin.

All the other characteristics, including the dredged depth, were kept equivalent to the one of the standard layout and described in Section 2.

Additionally, on the basis on the swept path of the exercises, an optimization of dredging works in the south-western part of the basin can be conducted since a part of this area was not occupied by the vessel during the execution of the exercises.

From the swept path of the exercises, it was also possible to observe that a distance of at least 40 m has been always kept between the vessel port side and the inner part of Traiano breakwater, as also reported in Figure 6.2 suggesting further optimization.

Indeed, the limiting metocean conditions reported above represent a first evaluation that will be subjected to dedicated Coast Guard regulations. Ad-hoc training shall be arranged for Pilots that will operate in Fiumicino Port to familiarize them with the route and standardize the maneuvering strategy depending on the prevalent metocean conditions.

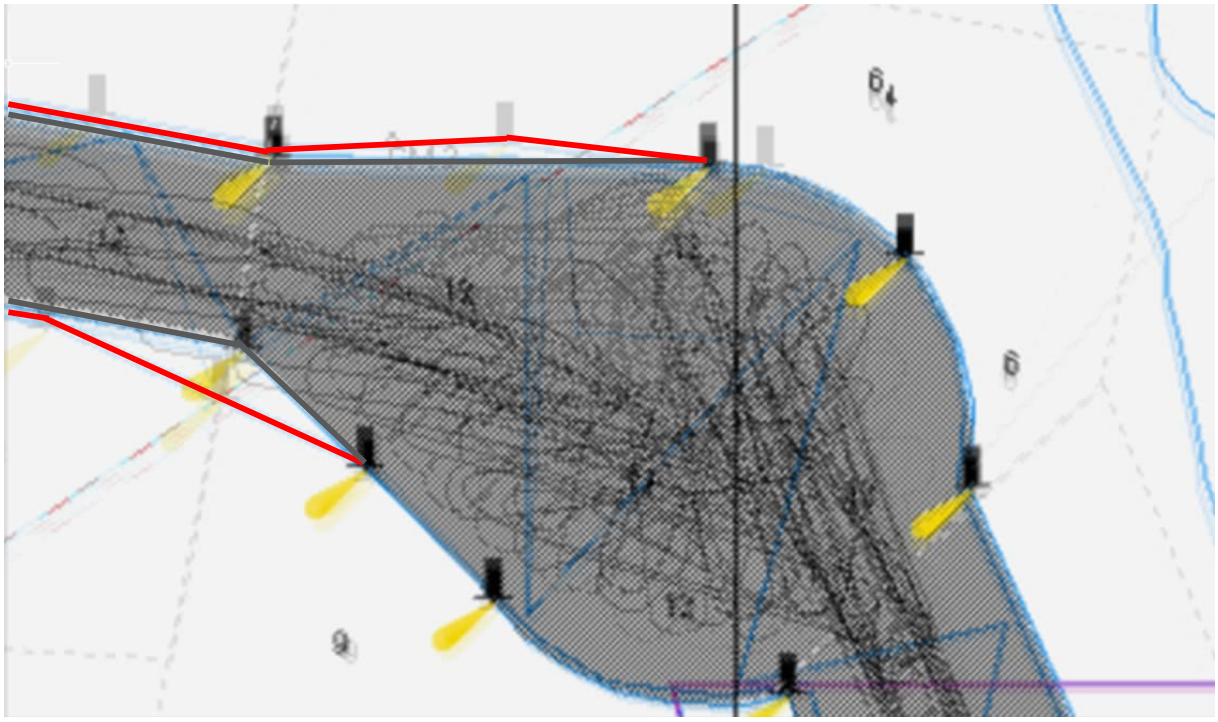


Figure 6.1: Standard layout (grey) vs Optimized layout (white and blue), in red the local enlargements at the turning basin and Access channel

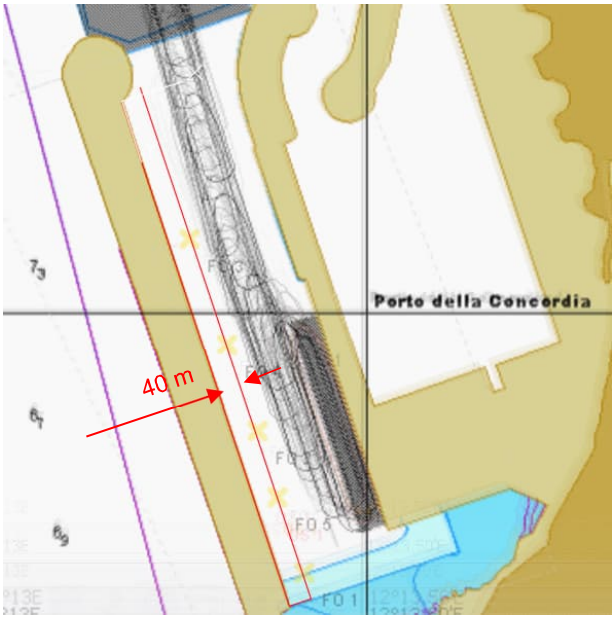


Figure 6.2: Detail of the swept path, distance from Traiano inner breakwater

REFERENCES

[1] P0031150-2-1-01-M13, Planimetria Area Dragaggio - Tav. 1/2, 03/05/2022

[2] P0031150-2-1-01-M13, Planimetria Area Dragaggio - Tav. 2/2, 03/05/2022

[3] Oasis of the Seas, Pilot Card

[4] P0031150-2-A09 – Vessel Data and Access from Genoa Simulator, 30/05/2023

[5] P0031150-2-H01 Rev. 00 – Studio Meteomarino - 10/2022

[6] P0031150-D-1-MP01-RI-PLA-03_00, Bathimetric Survey

[7] P0031150-2-H02-Rev00– Studio di agitazione interna al Porto - 10/2022

Appendix A:
Exercise Sheets for each maneuver

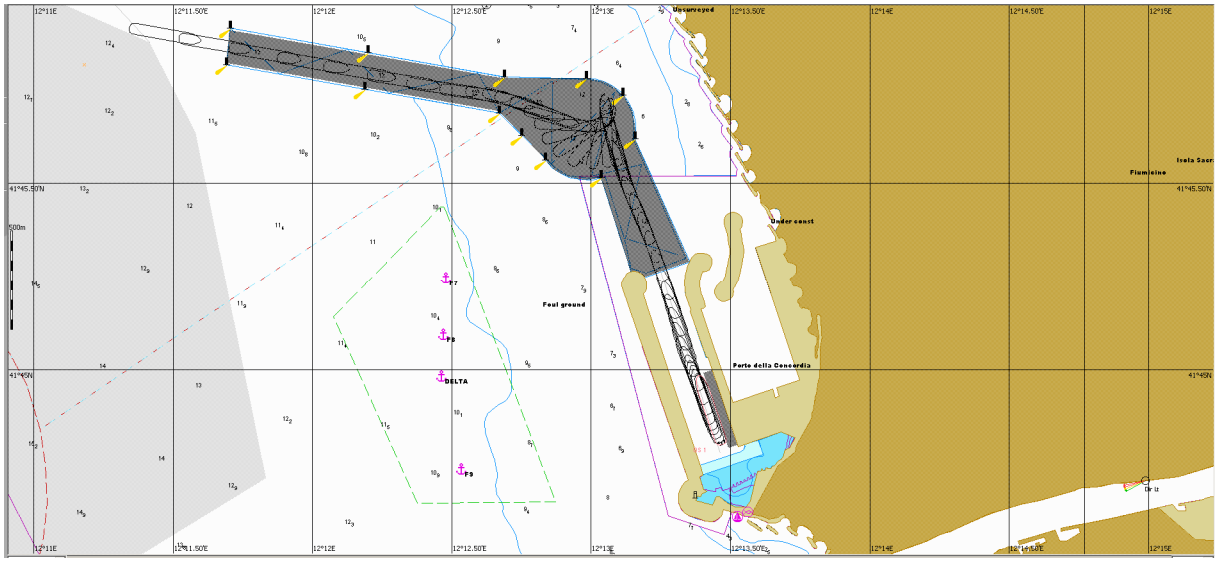
APPENDIX A: EXERCISE SHEETS

EXERCISE 1: FAMILIARIZATION - ARRIVAL

Date	14/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	1	Exercise name	Familiarization	
Description of the exercise		Wind 10 kn **N**		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 0° (N)	Vw	10 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (Turning basin)	Wind	Dir: 0° (N)	Vw	10 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (South channel)	Wind	Dir: 0° (N)	Vw	10 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir:	Vc	

Notes:

The manoeuvre has been initialized approximately 1.5 ship length outside the Access channel.
The vessel proceeded in the Access channel with a SoG of approximately 8 knots using the all the three pods at xx% of total power, then the speed was progressively reduced to approx.1 knot at the Turning basin entrance.
The midship vessel drift speed along the channel was approx. 0.2 knots.
Within the turning basin, the effect of the wind was used in combination with the bow thruster and azipods to perform the turning manoeuvre portside: the bow thrusters were used at 50% of total power, in combination with the azipods in the following configuration.
The maximum rate of turn reached during the manoeuvre was approx. -23 °/min.
The minimum distance between the vessel and the turning basin edge was approx. 50m.
The turning manoeuvre started approx. after 15 minutes from the simulation start and lasted for approx. 3-4 minutes.
During the turning manoeuvre, the Pilot noticed that the bow thrusters are very powerful.
Once swinged, the vessel was conducted backwards with a SoG between 2 and 4 knots. At the entrance in the Cruise basin area, the minimum distance between the vessel sides and the breakwater Traiano was approx. 60m.
The vessel was the controlled in the berthing area using both the azipods and the bow thrusters.
In conclusion, the manoeuvre was conducted successfully with no issue to be underlined. The overall manoeuvre lasted for approx. 42 minutes.



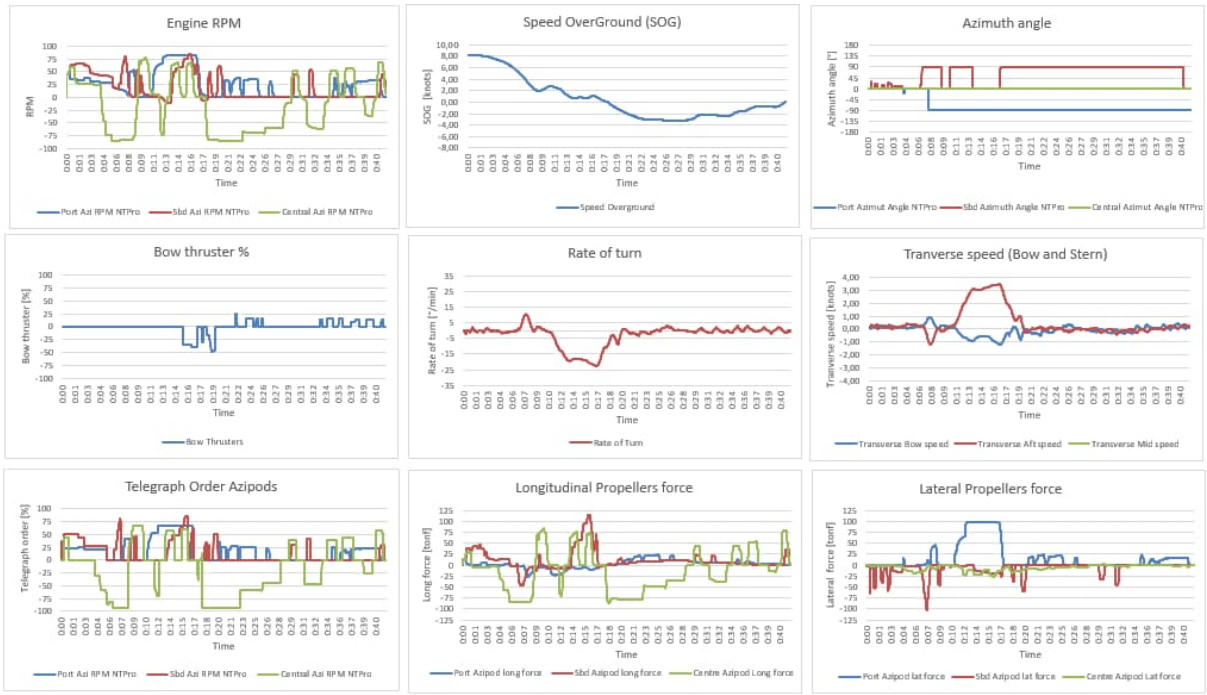


Figure 6.3: Exercise 1 swepth path and time histories of main parameters of the Oasis vessel model

EXERCISE 2: WIND VARIABILITY TEST (N) - ARRIVAL

Date	14/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	2	Exercise name	Wind N	
Description of the exercise		Wind 25 kn **N**		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 0° (N)	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (Turning basin)	Wind	Dir: 0° (N)	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (South channel)	Wind	Dir: 0° (N)	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir:	Vc	

Notes:

The feasibility of the key maneuvers to reach the Cruise terminal in presence of a mean wind speed of 25 knots and gusting events was investigated.
From the start of the manoeuvre, the effect of the wind was clearly visible: the vessel proceeded in the Access channel with a SoG of approximately 8 knots using two pods at 80-100% of the total power and the bow thrusters were used to counteract the wind effect.
Differently from the previous Exercise, it was needed to keep a higher SoG during the navigation along the Access Channel to maintain the route stability also since during the manoeuvre the midship vessel speed along the channel was approx. 6 knot: considering that, at the turning basin entrance the vessel SoG was approx.4 knot.
Within the turning basin, the main target was to proceed ahead toward the centre of the basin enabling the stern to rotate and overpass the Access channel edge: the effect of the wind was used in combination with the bow thruster and azipods to perform the turning manoeuvre portside. the bow thrusters were used at 80% of total power, in combination with the azipods. The maximum rate of turn reached during the manoeuvre was approx. -30 °/min.
According to the Pilot, the manoeuvre could have a different strategy controlling better the vessel speed in the turning circle.
The turning manoeuvre started approx. after 10-11 minutes from the simulation start and lasted for approx. 3-4 minutes.
Once swinged, the vessel was conducted backwards with a SoG between 2 and 4 knots. At the entrance in the Cruise basin area, the minimum clearance between the vessel sides and the breakwater Traiano was approx. 40m.
The vessel was the controlled in the berthing area using both the azipods and the bow thrusters.
In conclusion, the manoeuvre was conducted successfully. It is still to be noticed the great performance of the bow thrusters. The overall manoeuvres lasted for approx. 38 minutes.

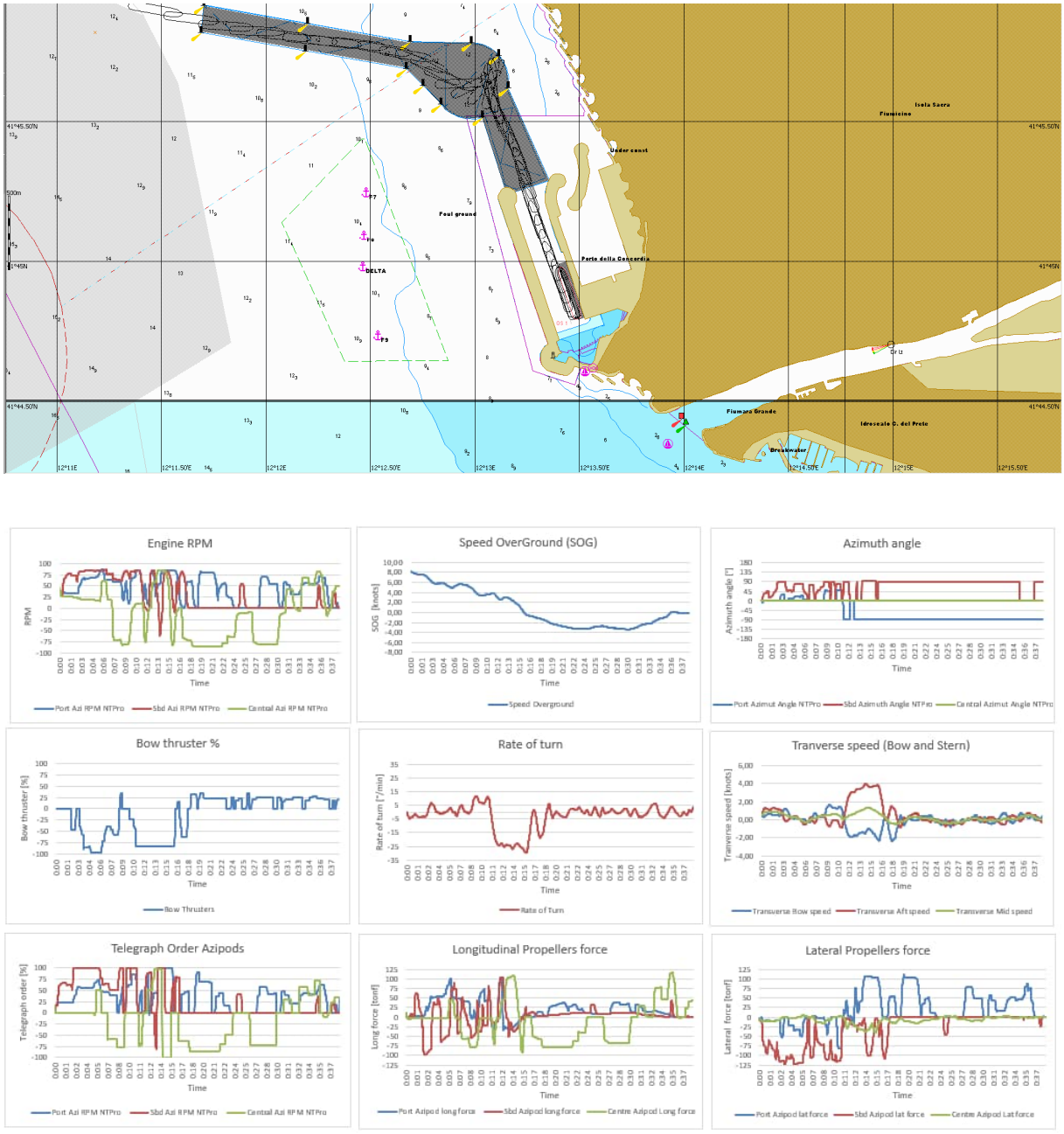


Figure 6.4: Exercise 2 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 3: Wind Waves and Current (S-SW) - Arrival

Date	14/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	3	Exercise name	Wind Waves and Current S-SW	
Description of the exercise		Wind Waves and Current S-SW		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 210°	Vw	25 kn
	Wave	Dir: 210°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:345°	Vc	1 kn
Environmental conditions (Turning basin)	Wind	Dir: 210°	Vw	25 kn
	Wave	Dir: 210°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:330°	Vc	1 kn
Environmental conditions (South channel)	Wind	Dir: 210°	Vw	25 kn
	Wave	Dir: 210°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir: 30°	Vc	0.5 kn

Notes:

The starting point of the simulations was set at approx. 3-4 ships lengths from the entrance of the Access Channel.
Differently from the previous Exercise, the SoG during the navigation along the Access Channel was maintained at approx. 6 knots to improve the vessel control. Bow thrusters were extensively adopted to counteract the effect of wind and waves, also considering their lower efficiency at the above-mentioned SoG.
When approaching the turning basin, the SoG was reduced progressively to 2 knots.
The vessel proceeded ahead toward the centre of the basin at slow speed to keep the vessel in the centre of the basin for the swinging manoeuvre the bow thruster and the azimuth thrusters were used to swing. During this phase, the central pod was not responding properly, due to a hardware problem, hence the vessel was pushed toward the north side of the basin: however, even in this condition, the Pilot was able to handle the vessel and using the combination of bow thrusters and azipods, to complete the swinging manoeuvre in one of the narrowest parts of the basin.
Once that the vessel stern was aligned with the south channel, the vessel proceeded with an astern speed between 2 and 4 knots.
According to the Pilot, the feasibility of the manoeuvre could be considered marginal due to the strong wind and the failure that occurred in strong wind conditions. The layout was anyway considered acceptable due to the occurrence of the double jeopardy.

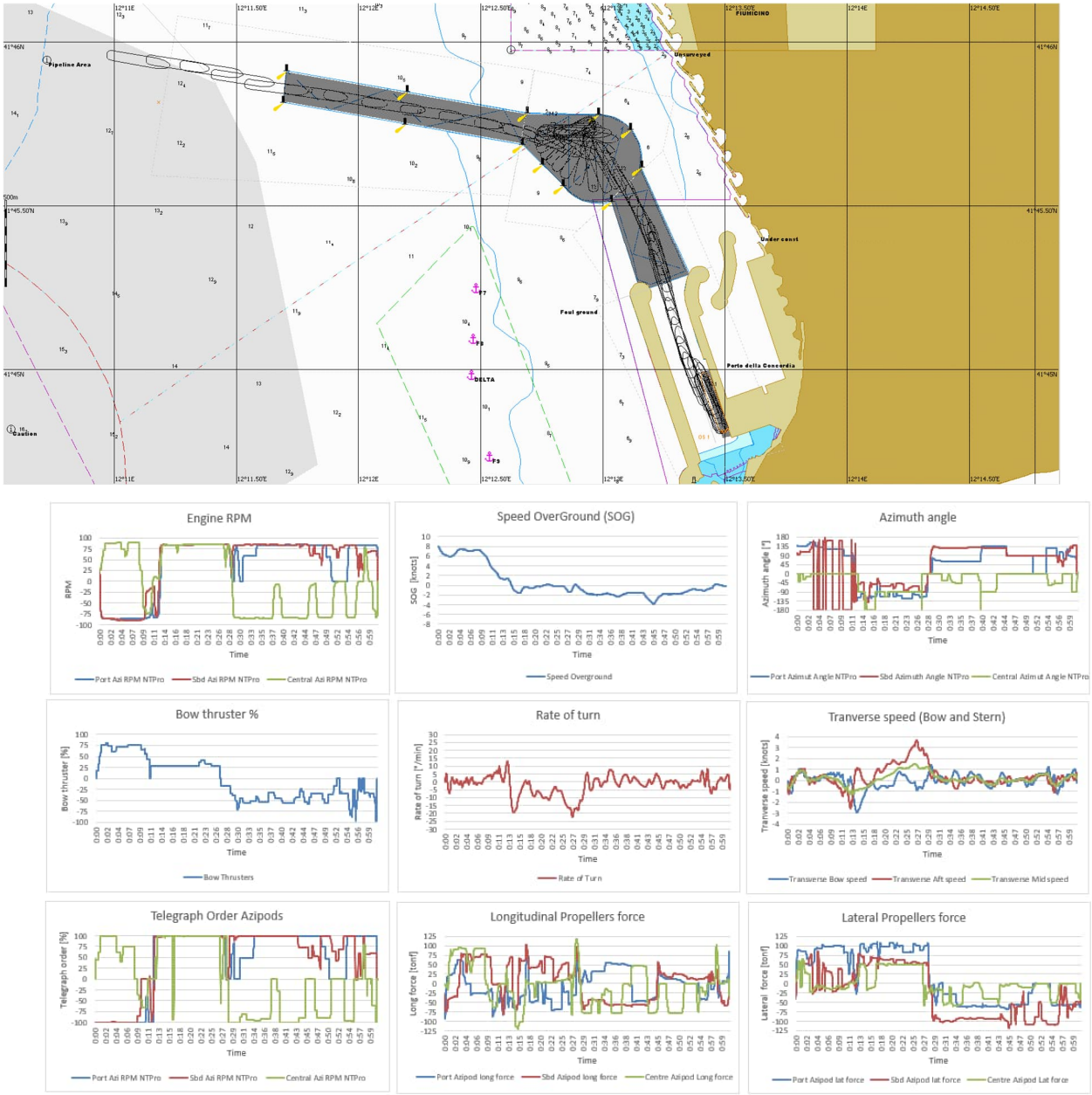


Figure 6.5: Exercise 3 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 4: Wind Waves and Current (SW-W) - Arrival

Date	14/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	4	Exercise name	Wind Waves and Current SW-W	
Description of the exercise		Wind, waves and current SW-W		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 240°	Vw	25 kn
	Wave	Dir: 240°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:330°	Vc	1 kn
Environmental conditions (Turning basin)	Wind	Dir: 240°	Vw	25 kn
	Wave	Dir: 240°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:330°	Vc	1 kn
Environmental conditions (South channel)	Wind	Dir: 240°	Vw	25 kn
	Wave	Dir: 240°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir: 30°	Vc	0.5 kn

Notes:

The starting point of the simulations was set at approx. 3-4 ships lengths from the entrance of the Access channel to improve the position of the vessel and its heading when approaching it because of the southwest wind and waves combined actions. The vessel speed was initially set approx. at 8 knots.
Differently from the previous Exercise 3, the metocean conditions are acting from stern quarters to stern in the access channel, making easier to keep the route.
When approaching the turning basin, the main target was to proceed ahead toward the centre of the basin at slower speed to keep the vessel in the centre of the basin for the swinging manoeuvre, that was conducted successfully. The minimum distance between the vessel bow and the edge of the turning basin was approx. 45m. The maximum rate of turn was approx. 35 deg/min.
When proceeding astern in the South channel, the vessel is subjected to a current speed heading toward N-NE, hence correction to the route is needed to keep it in line with the centre of the Cruise basin entrance, between breakwaters. The minimum distance between vessel sbd side and Traiano breakwater tip was approx. 45m.
Once the vessel entered within the Cruise basin, it was safely conducted at the berthing area keeping a distance between the sbd side and the breakwater of approx.70m.
The manoeuvre was conducted successfully.

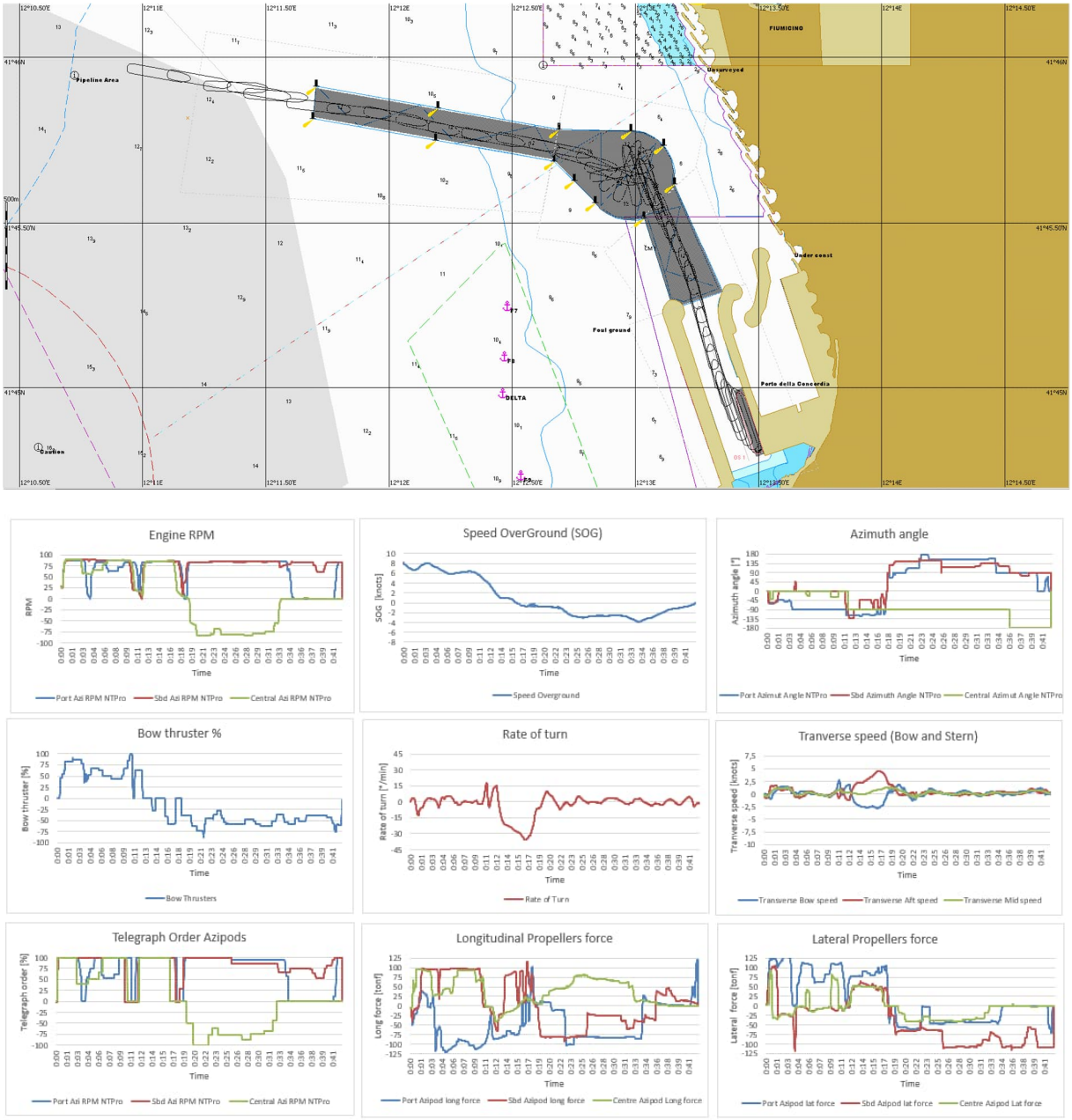


Figure 6.6: Exercise 4 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 5: Wind Waves and Current (W) - Arrival

Date	15/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	5	Exercise name	Wind Waves and Current W	
Description of the exercise		Wind, waves and current W		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 270°	Vw	25 kn
	Wave	Dir: 270°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:315°	Vc	1 kn
Environmental conditions (Turning basin)	Wind	Dir: 270°	Vw	25 kn
	Wave	Dir: 270°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:315°	Vc	1 kn
Environmental conditions (South channel)	Wind	Dir: 270°	Vw	25 kn
	Wave	Dir: 270°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir: 225°	Vc	0.5 kn

Notes:

In this maneuver, the feasibility of the vessel arrival in prevalent metocean conditions coming from W was investigated.
The starting point of the simulations was set at approx. 2 ships length to improve the position of the vessel and its heading when approaching the access channel because of southwest wind and waves. The vessel speed was initially set at 8 knots.
The metocean conditions were acting from the south in the Access channel, pushing the vessel on the northern area of the channel: the bow thrusters were kept active to keep the route since that the lateral vessel speed reached 1 knot on several occasions.
When approaching the turning basin, the Pilot brought the bow to the southern part of the turning circle prior to reach the centre of the basin taking advantage of the meteocean conditions prevalent direction for the swinging manoeuvre, although there's the influence of current heading towards NE-N and then the constant support of bow thrusters and azipods was needed. The minimum distance between the vessel stern and the north edge of the turning basin was approx. 30m. The maximum rate of turn was approx. 28 deg/min.
When proceeding astern in the South channel, the vessel was subject to a current heading toward S-SW to consider effect of recirculating currents. The bow thrusters were used to keep the vessel at the channel centre also at the entrance of the Cruise basin: the minimum distance between vessel side and breakwater end was approx. 75m.
Once the vessel entered within the Cruise basin, it was safely conducted at the berth keeping a distance between to the southern breakwater of approx.30m.
The manoeuvre was conducted successfully.

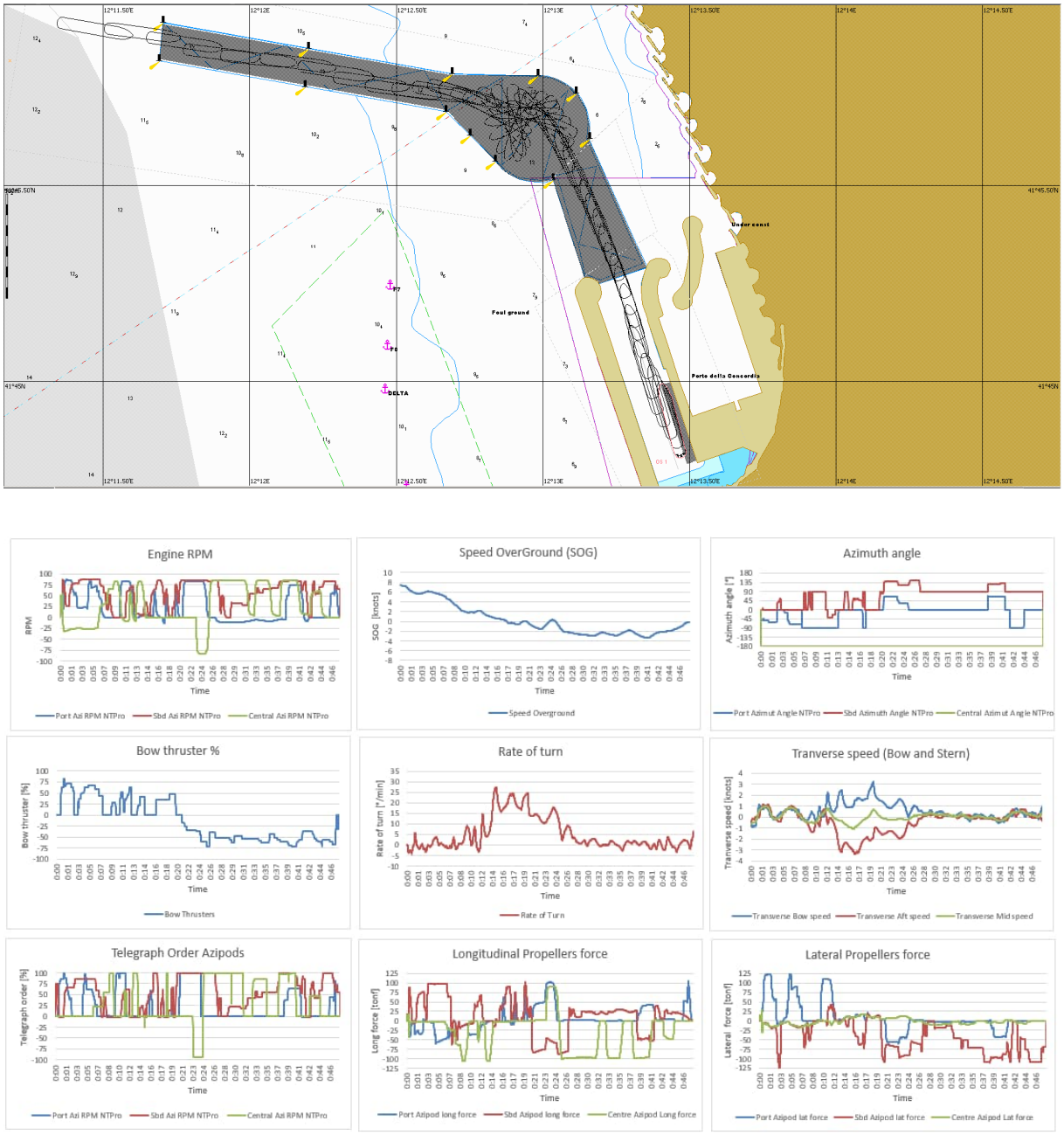


Figure 6.7: Exercise 5 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 6: Wind Waves and Current (NW-N) - Arrival

Date	15/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	6	Exercise name	Wind Waves and Current NW-N	
Description of the exercise		Wind, waves and current NW-N		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 330°	Vw	25 kn
	Wave	Dir: 330°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:100°	Vc	0.5 kn
Environmental conditions (Turning basin)	Wind	Dir: 330°	Vw	25 kn
	Wave	Dir: 330°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:180°	Vc	0.5 kn
Environmental conditions (South channel)	Wind	Dir: 330°	Vw	25 kn
	Wave	Dir: 330°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir: 225°	Vc	0.5 kn

Notes:

In this maneuver, the feasibility of the vessel arrival in prevalent metocean conditions coming from NE-N was investigated. The starting point of the simulations was set at approx. 2 ships length to improve the position of the vessel and its heading when approaching the access channel because of southwest wind and waves. The vessel speed was initially set at 8 knots. The metocean conditions were pushing the vessel along the channel south edge in the Access channel: the bow thrusters were used on half power to keep the vessel in the channel.
When approaching the turning basin, the Pilot headed toward the centre of the basin, reaching a position with the vessel headed easterly at zero speed. Then both the bow thrusters and the pod were used for the swinging manoeuvre. The minimum distance between the vessel stern and the south edge of the turning basin was approx.40m. The maximum rate of turn was approx. 30 deg/min.
When proceeding astern in the South channel until reaching the berthing area, the bow thrusters were used extensively (around 15-20 minutes at 50-75%) to keep the vessel in the centre of the channel and in the middle of the entrance of the Cruise basin. The minimum clearance between the vessel and the breakwater was approx. 75m.
Entering the Cruise Basin, the vessel kept a clearance of approx.30m to the breakwater. In the Cruise Basin the same was about 20m.
The manoeuvre was conducted successfully.

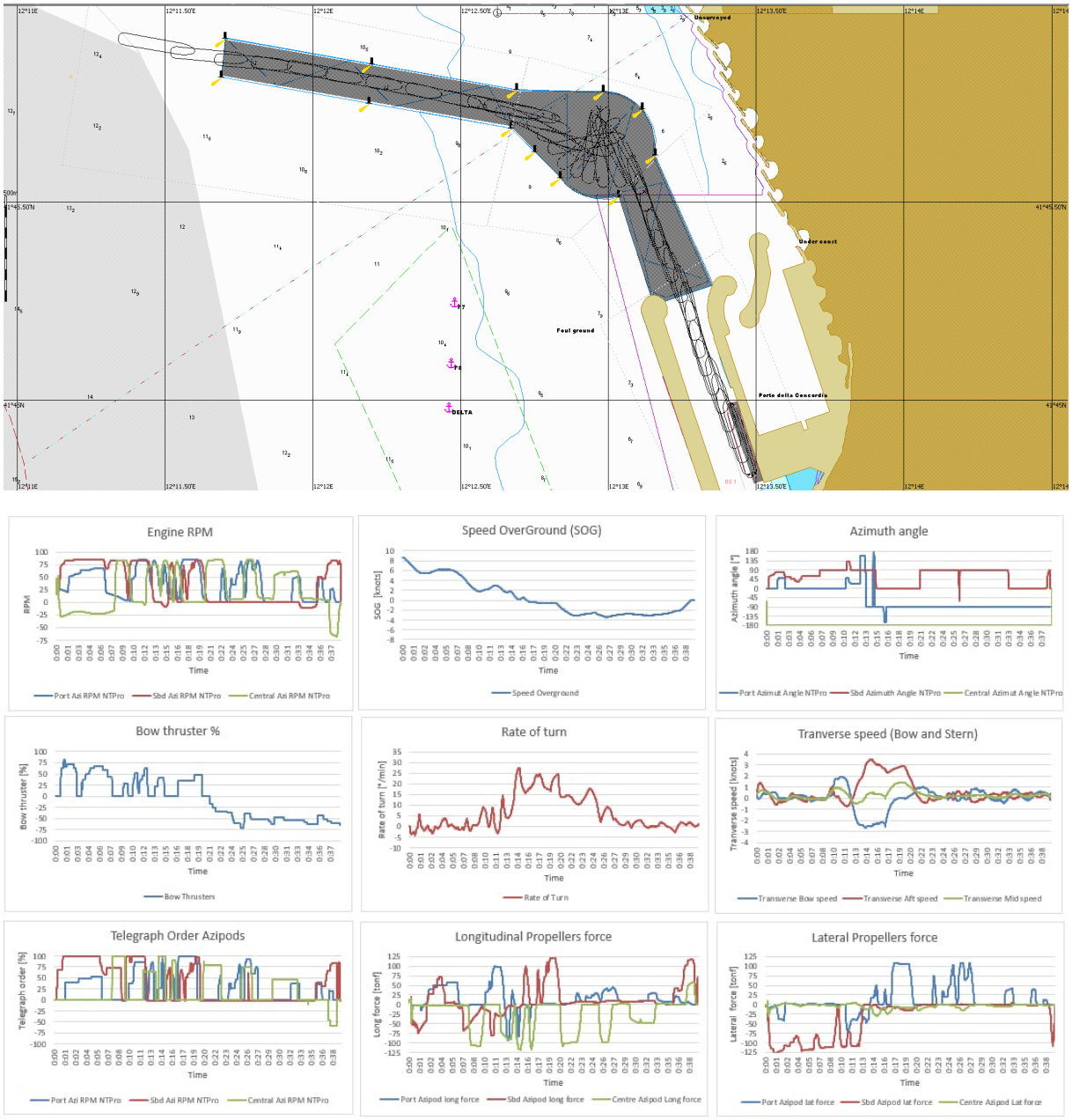


Figure 6.8: Exercise 6 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 7: Wind Waves and Current (W) - Departure

Date	15/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	7	Exercise name	Wind Waves and Current W	
Description of the exercise		Wind, waves and current W		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☐
		Departure		☒
Environmental conditions (Access channel)	Wind	Dir: 270°	Vw	25 kn
	Wave	Dir: 270°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:315°	Vc	1 kn
Environmental conditions (Turning basin)	Wind	Dir: 270°	Vw	25 kn
	Wave	Dir: 270°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:315°	Vc	1 kn
Environmental conditions (South channel)	Wind	Dir: 270°	Vw	25 kn
	Wave	Dir: 270°	Hs and type	1.5 m
			Tp	8 s
	Current	Dir.:225°	Vc	0.5 kn

Notes:

This is the first departure manoeuvre that was conducted, assuming one of the worst metocean conditions agreed with Pilot.
The azipods and the bow thrusters were used to counteract the wind effect since the beginning of the manoeuvre. Both the bow thrusters and pods were extensively used to keep the vessel in the northern side of the basin.
The vessel overpassed the breakwaters tip with a minimum side distance of 60m. No major issue was encountered in the navigation path along the South channel.
In the turning basin, the vessel was kept at the channel north side prior to head the bow in the direction of the access channel to avoid collision with Buoy 3G and the vessel stern may occur.
This exercise highlighted potential optimizations of the north edges of the basin; a local enlargement at the N-NW edge of the basin allows the vessel to move further towards this area, so that when entering within the Access channel, the clearance between the vessel stern and buoy 3G increases.

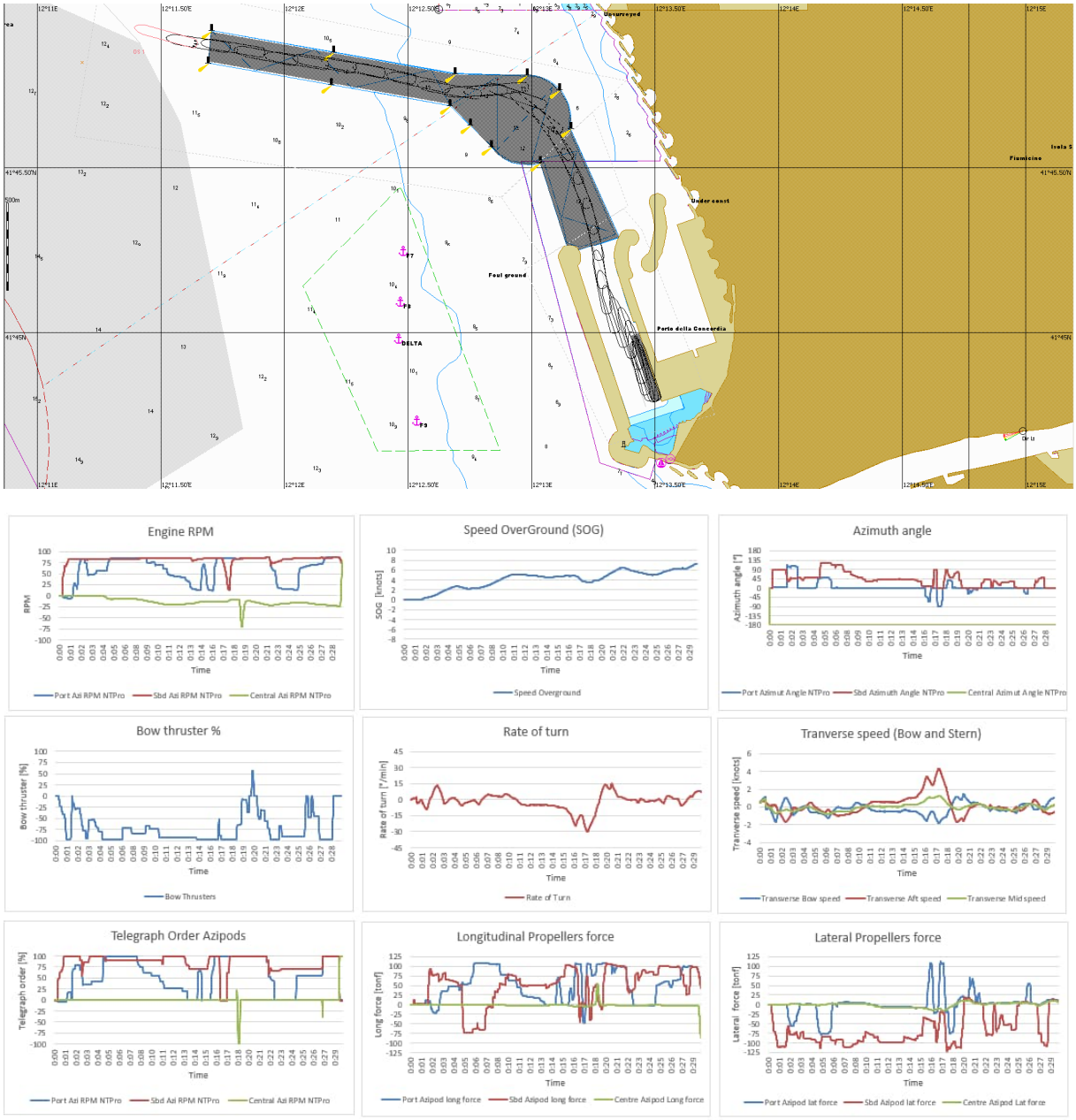


Figure 6.9: Exercise 7 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 8: Wind Variability Test (E-SE) - Arrival

Date	15/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	8	Exercise name	Wind E-SE	
Description of the exercise		Wind SE		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 120°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.: °	Vc	
Environmental conditions (Turning basin)	Wind	Dir: 120°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (South channel)	Wind	Dir: 120°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	

Notes:

In this exercise it was decided to investigate the arrival manoeuvre with wind condition from the shore side.
The vessel speed was set to 8 knots at the beginning of the exercise.
The use of bow thruster was required in combination with the azipods to egress the Access channel, where only the port and sbd pods were used, with less than 50% of bow thruster power to adjust the heading.
The manoeuvring strategy followed was proceed at slow speed approaching the turning basin, aim toward the centre of the turning circle before proceeding with the swinging manoeuvre.
The Pilot reported an unforeseen increase of the vessel ahead speed during the manoeuvre, that brought the vessel closer to the northern edge of the basin: the minimum distance between the vessel bow and the channel edge was 10m. Although this event, the swinging manoeuvre was conducted successfully.
The navigation in the South channel was conducted with an astern speed between 2 and 3 knots using the central pod.
The manoeuvre was conducted successfully

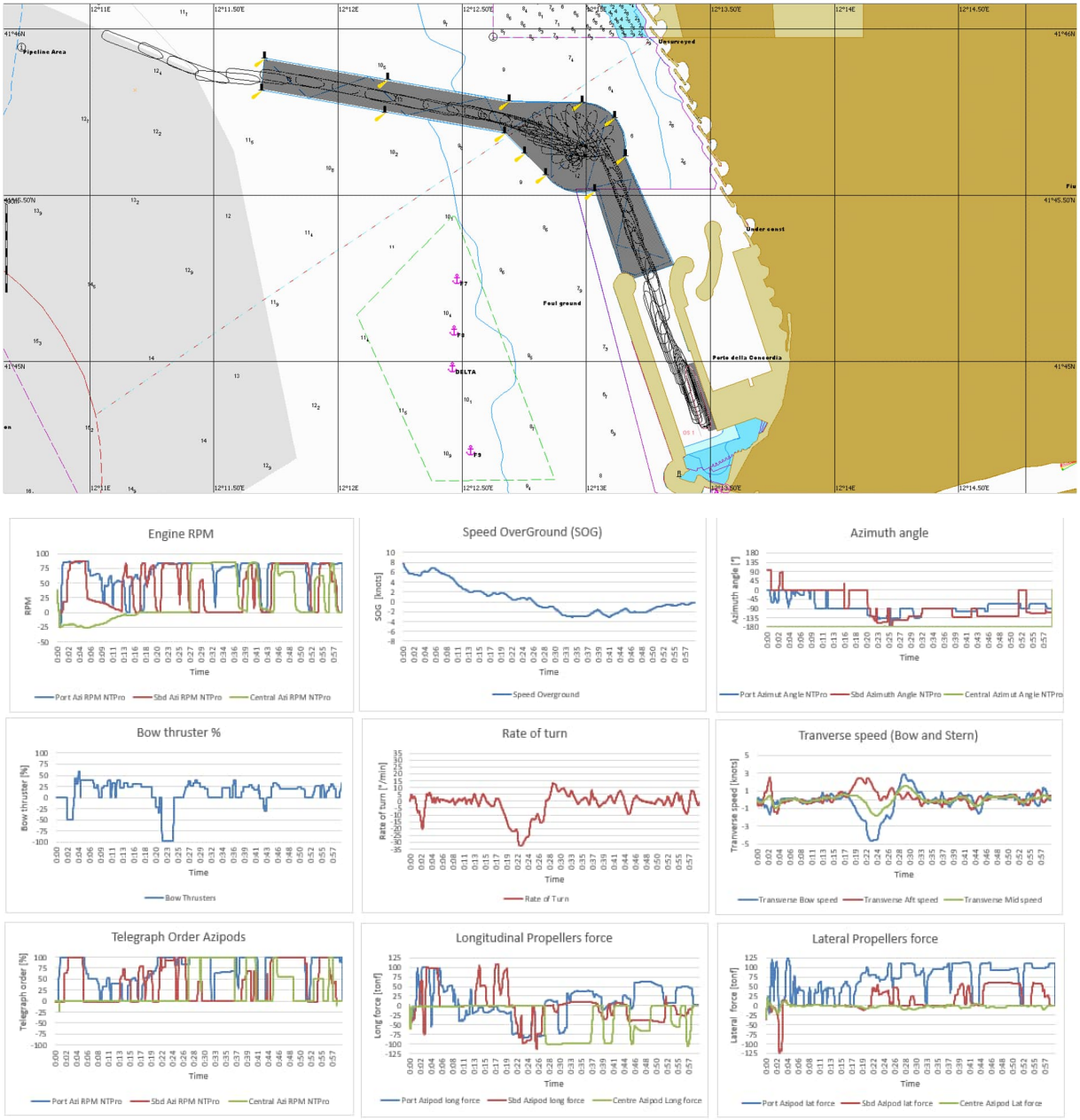


Figure 6.10: Exercise 8 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 9: Wind Variability Test (N-NE) - Departure

Date	16/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	9	Exercise name	Wind N-NE	
Description of the exercise		Wind N-NE		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☐
		Departure		☒
Environmental conditions (Access channel)	Wind	Dir: 30°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (Turning basin)	Wind	Dir: 30°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (South channel)	Wind	Dir: 30°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	

Notes:

In this departure manoeuvre the wind was assumed coming from N-NE.
A set of buoys have been deployed parallel to the Traiano breakwater to further reduce the space available for the vessel manoeuvres within the Cruise Basin. The vessel outside the Cruise Basin were executed with a minimal use of the bow thrusters. The minimum clearance between the buoys line and the vessel was approx. 42m and a minimum of 23m between the vessel sbd side and the Claudio Breakwater. The vessel kept the middle of the Cruise Basin.
The Pilot headed to the northern buoy within the turning basin to take advantage of the wind to move toward the Access channel with the vessel heading almost parallel to it. The pilot focused in controlling the vessel stern to avoid any interference with the last south buoy of the access channel (buoy 3G).
The clearance kept between the vessel and the last north buoy of the Access channel while entering it was approx. 50m.
The manoeuvre was performed successfully.

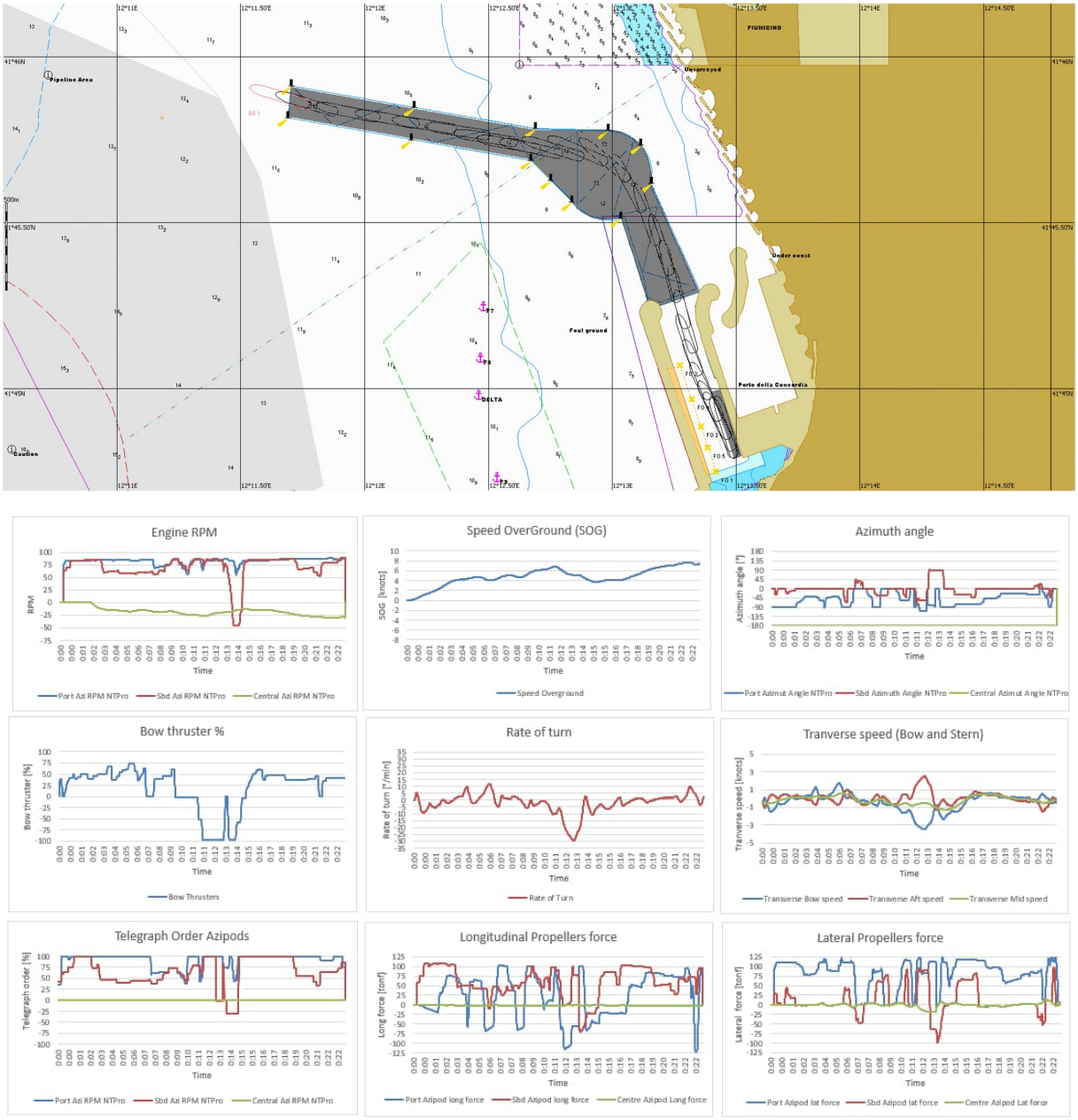


Figure 6.11: Exercise 9 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 10: Wind Waves and Current (SW-W) – Arrival – Emergency bow thrusters

Date	16/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	10	Exercise name	Wind Waves and Current SW-W – Emergency bow	
Description of the exercise		Wind, waves and current SW-W - Emergency		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 240°	Vw	20 kn
	Wave	Dir: 240°	Hs and type	1 m
			Tp	6 s
	Current	Dir.:330°	Vc	0.3 kn
Environmental conditions (Turning basin)	Wind	Dir: 240°	Vw	20 kn
	Wave	Dir: 240°	Hs and type	1 m
			Tp	6 s
	Current	Dir.:330°	Vc	0.3 kn
Environmental conditions (South channel)	Wind	Dir: 240°	Vw	20 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir:	Vc	

Notes:

First emergency maneuver analyzed. To not consider double jeopardy, the metocean conditions were considered less demanding when compared to the ones of previous exercises 3,4,5,6 and 7.
The vessel entered within the channel at 6 knots of speed.
The failure of bow thruster n.1 and 3 occurred at minute 12:07:30 (generator failure) and it was announced to the Pilot after 2 minutes (12:09:30).
The maximum rate of turn during the swinging maneuver was approx. 31-32 deg/min.
The minimum clearance between the vessel stern and the edge of the basin during the swinging maneuver was approx.25m.
The initial use of bow thrusters was approx. 25-30% and after the failure it increased to 50-60%, however the use of the all the azipods counterbalanced the loss of power of the 1st and 3rd thrusters.
The vessel was able to berth alongside.

Figure 6.12: Exercise 10 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 11: Wind Waves and Current (S-SW) – Arrival – Emergency Azipod

Date	16/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	11	Exercise name	Wind Waves and Current S-SW – Emergency - azipod	
Description of the exercise		Wind Waves and Current S-SW – Emergency - Azi		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☒
		Departure		☐
Environmental conditions (Access channel)	Wind	Dir: 210°	Vw	20 kn
	Wave	Dir: 210°	Hs and type	1 m
			Tp	6 s
	Current	Dir.:345°	Vc	0.3 kn
Environmental conditions (Turning basin)	Wind	Dir: 210°	Vw	20 kn
	Wave	Dir: 210°	Hs and type	1 m
			Tp	6 s
	Current	Dir.:345°	Vc	0.3 kn
Environmental conditions (South channel)	Wind	Dir: 210°	Vw	20 kn
	Wave	Dir: 210°	Hs and type	1 m
			Tp	6 s
	Current	Dir: 30°	Vc	0.3 kn

Notes:

Second emergency maneuver analyzed. To not consider double jeopardy, the metocean conditions were considered less demanding when compared to the ones of previous exercises 3,4,5,6 and 7.
The vessel proceeded along the Access Channel and when approaching the Turning Basin, at minute 12:10:30 the failure of the port side azipod was notified to the Pilot, after approximately 1 minute the failure occurred.
The turning maneuver was executed with the full assistance of the bow thruster (100% power for around 1 minute) and associated pods power, leading to a maximum rate of turn close to 45 deg/min.
The astern maneuvers were executed controlling the astern speed with the central and sbd azipod and controlling the heading of the vessel with the bow thrusters.
The vessel entered the Cruise Basin using the sbd side azipod to adjust the vessel's stern position.
Considering an extensive use of bow thrusters and central/sbd azipods, the maneuver was conducted successfully.

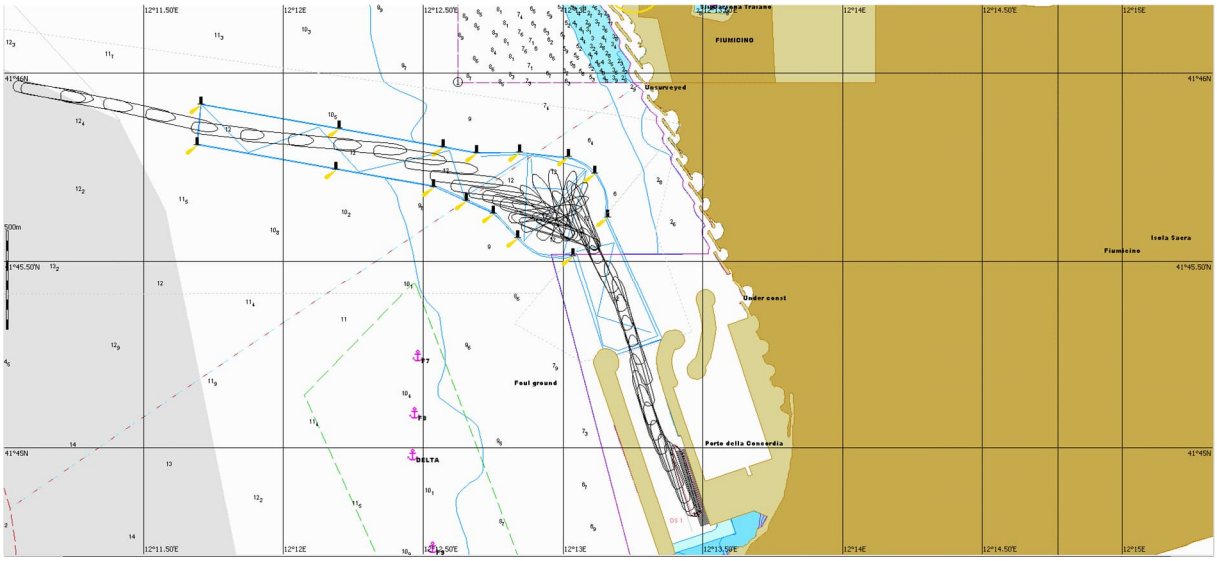


Figure 6.13: Exercise 11 swept path and time histories of main parameters of the Oasis vessel model

EXERCISE 12: Wind Variability Test (S) - Departure

Date	16/06/2023	Project	P0031150 – Isola Sacra Cruise Terminal Project	
Start time		End time		
Exercise n.	12	Exercise name	Wind Variability Test S	
Description of the exercise		Wind Variability Test S		
Pilot		John Gatti		
Design vessel	Type	Oasis of the Seas (Max LOA=362m, T=8.8m)		☒
Conditions	Location	Cruise Terminal – Isola Sacra Fiumicino		
	Manoeuvre	Arrival		☐
		Departure		☒
Environmental conditions (Access channel)	Wind	Dir: 180°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (Turning basin)	Wind	Dir: 180°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	
Environmental conditions (South channel)	Wind	Dir: 180°	Vw	25 kn
	Wave	Dir:	Hs and type	
			Tp	
	Current	Dir.:	Vc	

Notes:

An additional departure manoeuvre with wind from S was performed.
The manoeuvre was conducted successfully.

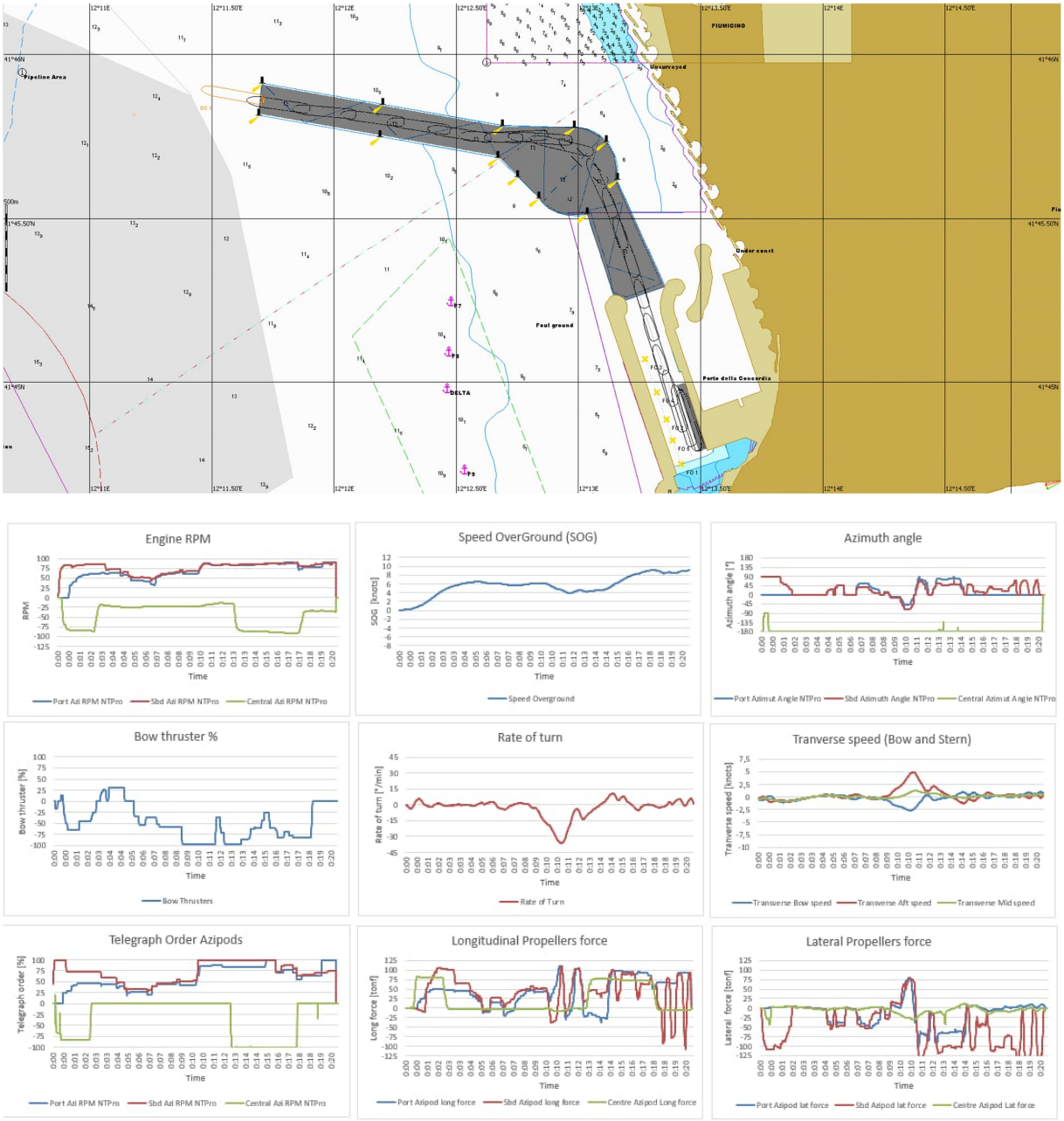


Figure 6.14: Exercise 12 swept path and time histories of main parameters of the Oasis vessel model

Appendix B:
Simulation System

APPENDIX B: SIMULATION SYSTEM

The Navigation Simulation study was performed by means Wartsila NTPRO 5,000, software suite used for both the definition of the basic scenario as well as the development of the maneuvers. These commercial tools have been developed by Wartsila (formerly TRANSAS) and enable simulator training and certification of Officers, Captains and Pilots on all types of vessels as well as port assessment studies.

NTPRO 5000 (namely the mathematical model) simulates integration of ship/channel hydrodynamic effects and operational procedures so that simulators can be used not only for traditional maritime training, but also for R&D applications as an effective port /channel /terminal design tool.

The simulation System, mainly used for manoeuvrability studies for port design, maritime engineering development, accident analysis and risk assessment require very detailed and comprehensive results, and therefore calculation methods are refined for the following factors:

- ✓ Hull resistance;
- ✓ Shallow water effects including bank effect;
- ✓ Squat effect;
- ✓ Ship to ship interaction;
- ✓ Induced waves;
- ✓ Planning hull;
- ✓ Propulsion systems;
- ✓ Mooring lines and fender systems;
- ✓ Anchoring systems;
- ✓ Steering and thrusters control systems
- ✓ Tugs;
- ✓ Faults and malfunctions;
- ✓ Recording and replay.

The Simulation Model - Mathematical Model

The heart of the system is the mathematical model, able to compute in real time the ship dynamic behaviour in accordance with the captain or pilot commands on the ship steering and heading devices, taking into account the actions of the sea waves, of the current and of the wind, or the effects of particular conditions as for instance shallow and restricted water, crowded water as well as the actions of tugs, fenders and mooring lines in the final phase of the approach manoeuvre.

The mathematical model is able to treat the mechanical and hydrodynamic effects on the ship of several operative, marine and meteorological condition, as listed in the following:

In the following, the general algorithms used in the Mathematical Model are listed:

- ✓ 6-DoF ship motion equation;
- ✓ Hull hydrodynamic model;
- ✓ Stability and flotation model;
- ✓ Air cushion model;
- ✓ Heel tank model;
- ✓ Ballast tank model;
- ✓ Hull aerodynamic model;
- ✓ Main engine model;
- ✓ Propulsive algorithm agents model;
- ✓ Active steering devices model;
- ✓ Rudder model;

- ✓ Engine model;
- ✓ Model of environmental effects (wind, waves, current);
- ✓ Model of shallow water effect;
- ✓ Model of 6-DoF pitch, additional wave resistance and drifting effect;
- ✓ Wave roll/pitch model;
- ✓ Wind-generated and swell wave model;
- ✓ Model of the distributed current effect;
- ✓ Model of hydrodynamic interaction with other ships (tugboats, barges) and geographical peculiarities of the area;
- ✓ Model of mechanical interaction with other ships (tugboats, barges) and mooring walls;
- ✓ Anchor model;
- ✓ Model of multi-functional autopilot;
- ✓ SMM incorporates the following model types: displacement ships, semi-glider ship, catamaran ships, tugs, barges, helicopters and aircrafts;
- ✓ Models are based on the actual prototypes and are adjusted from the data of sea and tank tests (if available).
- ✓ Furthermore, the following real effects are modelled:
- ✓ Shallow water effect on the hydrodynamic properties of the hull, propulsive agents/propeller and helms;
- ✓ Shallow water effect on changing the propulsive quality;
- ✓ Squat effect;
- ✓ Hydrodynamic interaction with other ships (tugboats, barges) and geographical peculiarities of the area (uneven seabed, shoal, mooring wall);
- ✓ Hydrodynamic interaction between the ship and waterway boundaries (walls, inclined bottom, channels, underwater banks);
- ✓ Ship collision with a ship (tugboat, barge);
- ✓ Ship bump with mooring walls and aids to navigation;
- ✓ Grounding;
- ✓ Soft grounding effect.

The Simulation Model – Bridge- Software And Hardware

The bridge of the simulator system is reported in Figure 6.15.

Figure 6.15: Simulator bridge at the Simulator center in Genoa, Italy

The main software and hardware components are summarized below

- ✓ Bridge - Software
  - Conning Software (1 pcs)
  - Navi Sailor 4000 ECDIS Software (2 pcs)
  - Navi Planner 4000 (planning tools) Software (2 pcs) *
  - RADAR/ARPA Software (2 pcs) *
  - Interactive Bridge Information Display Module (1 pcs)
  - Visualization channel (9 pcs)
- ✓ Bridge – Hardware: Maneuvering Console
  - Mini Azipod MA-LH kit
  - Mini Azipod MA-RH kit
  - Third-Mini Azipod
  - Steering Shaft
  - Steering Wheel
  - IBID display
  - Mini Telegraph kit
- ✓ Bridge – Hardware: 3D Scenario
  - Monitor LCD 50 inches (9 pcs) for 270° degrees of vision

INITIALS: DPA04/ANDRO/RRI03