Simulation-Based Evaluation and Recommended Guidelines for the VLCS *Ovation of the Seas*

Proposed Operations in Southeast Alaskan Pilotage Waters, 2019

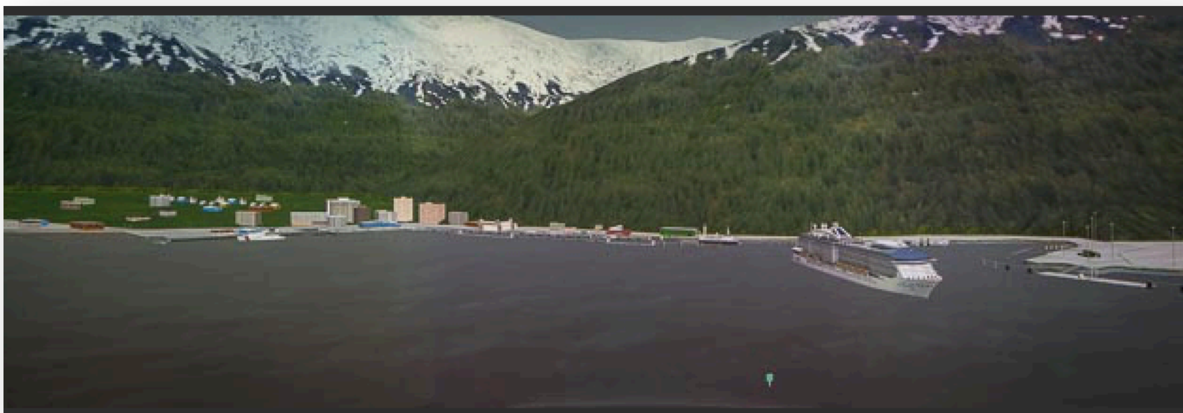


Figure 1: Ovation of the Seas Simulation Model at Ketchikan

Prepared by the Southeast Alaska Pilots Association

Based on Simulations Conducted at Alaska Vocational Technical College (AVTEC), Seward, Alaska December 3-7, 2018

Report Version 1.3
Prepared: 3/6/2019

Editors:
Capt. Barry Olver, SEAPA Pilots
Mr. George B. Burkley, Maritime Pilots Institute

Table of Contents

Table of Figures

Change Sheet

All edits to this document made after Version 3.4 are noted in the change sheet log below:

Change	Page	Edited by

Disclaimer

The research and findings in this report reflect the cooperative work product of the SOUTHEAST ALASKA PILOTS' ASSOCIATION (SEAPA) and ROYAL CARIBBEAN INTERNATIONAL (RCI). This report, and the safe operational guidelines recommended herein are founded on simulation-based research. The results and findings are based on data accumulated in the process of that research as well as the use of the best available technology and the good faith effort of the participants. The use and application of these safe operational guidelines do not relieve the prudent mariner of the obligation to exercise safe navigational practices and do not hold SEAPA or RCI liable. This report is intended for further consideration by SEAPA and RCI to enact the recommendations contained herein.

Acknowledgements

Many thanks are due to a great many people for their efforts expended in the course of this project. First and foremost, the SEAPA Members, Officers and Board of Directors who committed significant personal funds, personal time and effort in this pursuit of due diligence. Our RCI Partners for providing the simulation model and the tremendous collaboration with Captains Henrik Loy, and Preston Carnahan before, during and following the simulations. *Anthem of the Seas'* Captain Henrik Sorenson, Staff Captain Jethro Barry as well as all the officers and crew. Mr. George Burkley of the Maritime Pilots Institute, for taking-on the monumental task of forging a nonwriter pilot's ideas into this report. SEAPA's Captain Jill Russell for taking on the task of administrator for this project, her many hours of preparation, advice and expertise in the field of simulation, and for keeping us all on task during the week of simulation work. The simulation facility AVTEC, in Seward Alaska, for providing a highly professional and excellent facility and support. The SEAPA VLCS (v2) Committee Members -Captains Hans Antonsen, Tomi Marsh, Levi Benedict and Norbert Chaudhary for their significant efforts during the course of this last year. SEAPA Pilots Captains Jeff Baken, Rich Preston, Steve Axelson, Frank Didier, Scott Jones and Kathy Flury for their participation in the simulations. Captain Bob Winter, fellow SEAPA pilot guided the observation trip aboard the *Anthem of the Seas* as part of the simulation model data collection effort. Amak Towing master's, Captain Lonnie Adams, and Captain Mike Korsmo. CLAA agent, Mr. Rick Erickson. USCG COTP Juneau, Captain Steve White, BMP members of the Alaska Marine Board, in particular Mr. Charles Ward and Captain David Artz (AMP), for their interest and strong support.

Introduction

This study is the second in the series of joint simulation-based studies to apprise cruise companies and SEAPA of operational limits and to create safe operating guidelines for VLCS (Very Large Cruise Ships) operating in Southeast Alaska waters. The first study, completed in December of 2017, studied the Norwegian Cruise Lines (NCL) vessel *Norwegian Bliss.* The Norwegian Bliss report may be found on Southeast Alaska Pilots' website.[1] In 2019, SEAPA membership chartered a second VLCS (v2) committee to conduct two additional studies for the Royal Caribbean International (RCI), "Ovation of the Seas", and Princess Cruises "Royal Princess" due to these vessels' pending deployment to Southeast Alaska. This report addresses the findings of these collaborative studies conducted by SEAPA and Royal Caribbean International, for our collective work for the *Ovation of the Seas,* recognizing the separate roles with common goals in the effort to "protect life and property, and the marine environment"[2], in an economically achievable manner.

The primary goal of this simulation-based risk assessment, and corresponding simulation evaluations, was to identify the environmental and operational parameters at which undesirable incidents began to happen, defined by the SEAPA VLCS (v2) Committee as the <u>Edge Of the Comfort Zone</u> (**EOCZ**). The standard of care used by the Committee as a basis for these recommended guidelines was if a simulation maneuver could be reliably completed by an average Marine Pilot, on an average day, while achieving consistent, above average results. Evaluation scenarios were designed to address the challenging operating maritime environment in Southeast Alaska, including restricted channels, fjords, and bays with unpredictable ice concentrations (from glacial calving); as well as, high winds, large tidal ranges, and strong tidal currents. The Committee utilized a framework closely based on the previous study work for Norwegian Bliss for identifying and evaluating the level of risk for simulated evolutions. The base framework involved: 1) the professional judgment of a senior mariner; 2) the measurement of operating performance according to predetermined risk criteria; 3) a separate, individual debrief interview of the master; 4) a separate individual debrief of the pilot (to assess their perceptions of risk); and 5) correlation, comparison, and resolution of the previous four measures by the Committee as a whole.

Various industry stakeholders observed the simulation efforts during the course of the two studies including (2) Amak Towing Company tug masters, The Captain of the Port (COTP) for US Coast Guard Sector Juneau, Cruise Lines Agencies of Alaska (CLAA), Southwest Alaska Pilots Association (SWAPA), Alaska Marine Pilots (AMP), Hawaii Pilots, The Marine Pilot Coordinator (MPC) for the Alaska Board of Marine Pilots. The stakeholders once again responded favorably to the collaborative efforts of the Committee.

[1] https://www.seapa.com/
[2] AS 08.62.157

Summary

To initiate this study for the *Ovation of the Seas*, the SEAPA committee engaged in thorough data-gathering for the vessel which included a review of previous port studies provided by Royal Caribbean International, as well as interviews of RCI Masters. An observation trip in April of 2018 during a 7-day voyage aboard sister ship *Anthem of the Seas* to collect data to vet the simulation model, followed by 4 days of full-mission simulation conducted at AVTEC in Seward, Alaska, for the various Southeastern Alaska ports and waterways to be visited in the 2019 itinerary.

Simulations were conducted during the week of December 3-7, 2018, by a team made up of nine members of the Southeast Alaska Pilots Association (SEAPA) in partnership with two representatives from Royal Caribbean International, including Captain Henrik Loy (*Ovation of the Seas* Master) and Captain Preston Carnahan (Director | Marine Port Development). The project team completed twenty-nine simulation runs covering six geographic pilotage areas (as well as one which is not on the itinerary for 2019, Ketchikan area), simulating the most unfavorable and frequent wind and current conditions. The objectives of the simulations were to identify pilotage navigation scenarios which presented challenges for safe operations of the *Ovation of the Seas*.

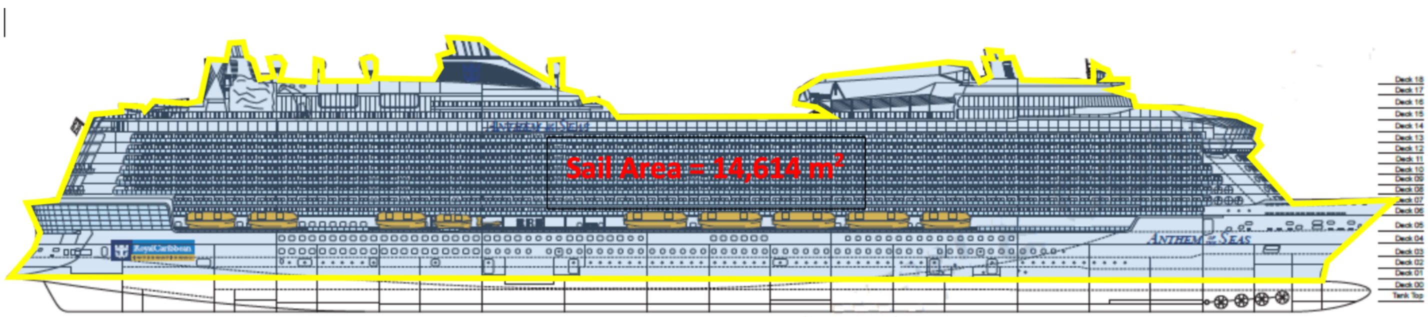
Overall the simulations produced serious challenges in wind and current conditions common to the SEAPA pilotage area. The pilots reported that the *Ovation of the Seas* model was found to be appropriately powered for maneuvering in most conditions encountered in Southeast Alaska waters. Simulations identified a significant swept path track in strong cross winds and currents particularly in the Gastineau Channel/Juneau Area, Tongass Narrows/Ketchikan Area, and in ice conditions simulated at Endicott Arm Bar and Tracy Arm's 'S' Turns. The recommendations in the study agreed to between SEAPA and RCI intentionally favor the conservative side of study findings in determination of operating parameters to ensure safe operations of the *Ovation of the Seas* in Southeast Alaska waters.

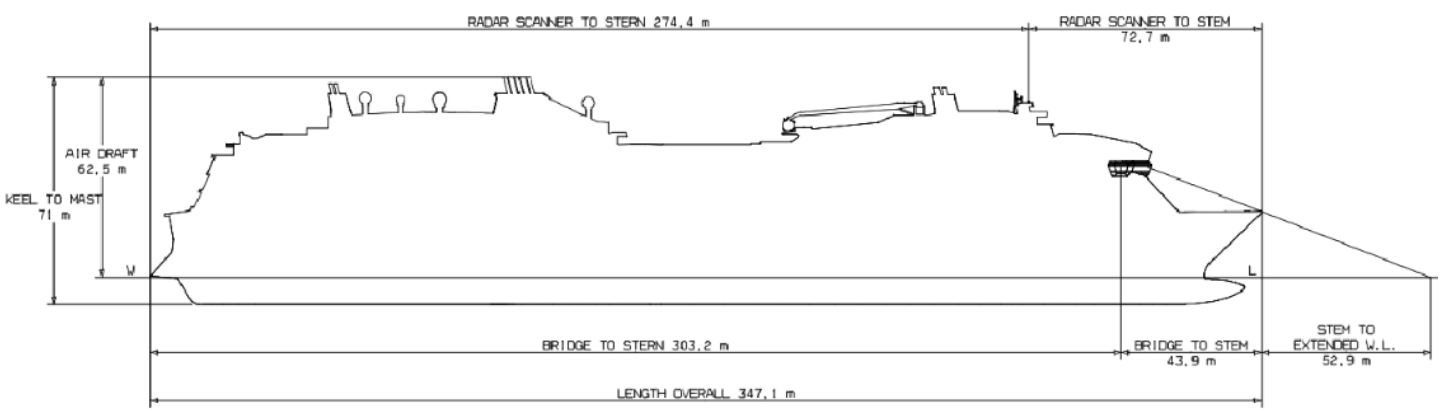
Figure 2: Ovation of the Seas sister ship "Anthem of the Seas" @ Port Liberty

Principal Dimensions - Mega Ship – *Ovation of the Seas*

The *Ovation of the Seas* is a very large passenger vessel of 168,666 Gross Tons, with a length of 1138.5' (347m), maximum structural beam at the bridge wings of 160.4' (48.9m), max (funnel) air draft of 198.4' (60.5m), and summer-load draft of 28.8' (8.8m). The "North Star" observation pod increases the maximum air draft to 312' (95m), and extreme breadth to 206.4' (62.9m) at the extreme limits of operation. She is outfitted with Azipod® propulsion consisting of two 20.5MW ABB azipods with inboard turning propellers, as well as (4) Bow tunnel thrusters listed as 4 X 4694hp +10% (3500KW each). Lateral windage, also known as "sail area" for this vessel is 14,614 square meters. Passenger maximum is 5011, with 1551 crew for a maximum LSA total of 6562. This vessel will be the largest vessel to date to engage in the Alaskan passenger ship trade.

Figure 3: Ovation of the Seas – Lateral Windage





Findings

The following findings are based upon simulations of transits and maneuvers in the areas of Juneau, Skagway, Endicott Arm/Tracy Arm, Sitka, Icy Strait Point, and Ketchikan.[3]

Findings: From the 29 runs conducted in simulation are:

1. *Ovation of the Seas* exhibits the typical challenging slow speed handling characteristics of VLCS class mega ships requiring close attention to handling and judicious use of propulsion (thrusters and azipods).
2. The vessel exhibits significant swept path due to a large sail area and characteristic nature of azipods pulling the stern through the water to steer.
3. *Ovation of the Seas* acts like a heavy ship – slow to accelerate and maintains her momentum once moving.
4. Minimum steering speed is listed as 2 knots on the pilot card for the vessel, but less than 6 knots speed provides poor steerage. 6 knots or greater provides good steerage.
5. Bow Thrusters:
    a. Listed on the pilot card as losing effect at 8 Knots but were found to be effective at harbor speeds of 7-8 Kts during simulation.[4]
    b. During simulation an effective technique to reduce swept path on a straight track was to utilize 20% thruster into the external force (wind/current) and counter the resulting rotation with opposing helm order (thus putting both BTs and Pods thrusting into the wind/current).
    c. Bow thrusters will increase ship's speed (20% BT for ~ 1 minute increased speed from 7.0 to 7.2 knots).
6. Azipods:
    a. Significant RPM are required to effectively get her moving – 60 RPM, and likewise 60 RPM with both pods at 180^{o} to check her way.
    b. The '60/120' orientation with azipods is found to maximumize turning effect in maneuvering.
    c. Due to concerns given the extreme aft location of azipods increasing risk for damage when conning in ice; it has been discussed having the pilot maintain the conn and either maneuvering in 'aziman' with azipod verbal commands or directing the vessel's course to steer while the Master manipulates the pods.

Findings: Use of Tugs

A study was concurrently conducted by SEAPA pilots, with input from experienced tug operators, to evaluate the use of tractor tugs to mitigate risk to ports particularly for VLCS class vessels. The report recommends a minimum of two 70-ton bollard pull (BP) tractor tugs be deployed to the ports of Ketchikan, Juneau and Skagway. Tugs of this capability are not available in the region with only one tractor tug in region estimated to have a 55-60 ton BP rating. All other tugs in region are conventional propulsion (with corresponding limitations in capability to assist) with a maximum estimated rating of 33-ton BP. Both Masters (Anthem of

[3] Due to simulation capabilities, ice transit simulations were conducted in Tracy Arm substitute for transit areas of Endicott Arm
[4] Note from observation trip, Master's comment, thrusters lose much of their effectiveness above 2 knots speed.

the Seas and Ovation of the Seas) made a point of noting that a tug will be required when running/retrieving stern lines with a 25 knot or greater offshore wind in order to prevent entanglement of lines in propellers.

Findings: Known Limitations of Simulation

The SEAPA Pilots recognize that simulation is an excellent tool for general studies and is valuable for informing the decision process. SEAPA also recognizes that simulations, both this current PMI effort and the efforts conducted by others in the port studies prepared by Royal Caribbean International, have inherent limitations in the reliance on mathematical models and assumptions that may be incongruent with actual wind, currents, ship behavior and other intangible factors experienced in actual operations.

The SEAPA Pilots extend their thanks for the participation and support from RCI in the conduct of this important research. The study team agreed it was a privilege to be able to participate in these simulations, and that this process is an essential part of fostering the safety of navigation and the protection of the environment, people and property of the State of Alaska.

Figure 4: Anthem of the Seas and Norwegian Gem at Nassau, Bahamas

Simulation Debrief Notes – Navigation and Controllability

1. The vessel has pod drive and bow-thruster power capable to maintain positive control of the vessel given a theoretical maximum of 30 to 32 knots of wind on her beam. Simulation study results showed the model capable of managing winds to 40 knots for departure (Skagway).
2. Bow thrusters (BTs): The bow thrusters are effective up to 10-12 kts[5] and can be used effectively to minimize swept path with the following techniques.
    a. (20/20/20) used at 6-8 kts: 20% BT in direction of turn, used in conjunction with 20° rudder, maintain a 20° ROT. Note, the BTs were used effectively during simulation as the only means of turning, when it was desired to keep the stern on track
    b. Another technique for minimizing swept path while maintaining a straight track: BTs powered at 20% into the wind/current and counter the resultant with opposing rudder (thus putting both the BT's and the pods thrusting into the wind/current)
3. Azipods. 60 RPMs and above is an effective power setting for increasing speed and also for decreasing speed with both pods at 180°.[6] The OVS acts like a heavy ship; she's slow to accelerate and slow to decelerate (thus the use of > or = 60 RPMs, as noted above)
    a. An efficient technique for changing course, when accelerating at > 60 RPMs, is to give moderate rudder commands (10-15°), wait for the ROT to build up, and then give a heading to the helmsman.[7]
    b. The 60/120 pod configuration is considered most effective for turning the vessel, while maneuvering
    c. The Ovation's azipods are mounted very far aft, thus increasing the danger of ingesting ice or mooring lines.[8]
4. Ice. For conning in ice areas, we discussed that the pilot would keep the conn and either give azipod commands or indicate the course to steer to the master, who will manipulate the pods. The master was advised that both pods inboard is a safe configuration for maneuvering in ice.
5. Speed.
    a. Greater than 6 kts provides good steerage while 6 kts or less provides poor steerage.
    b. 10 kts or less through the water is safe operational speed for shifting from Open Sea to Aziman Mode.
    c. Appropriate arrival speeds (calm environmentals): 1 nm is 5 kts, 1 ship length 3 kts or less, 50 m is 1 kt or less
    d. 3.0 nm advance notice required to slow from 15 to 7 kts
    e. With both pods inboard 90° and zero RPM the ship will slow at 1 kt per 0.1 nm
    f. At 10 kts most drift angles decrease to ~ 3 degrees (and remain small through higher speeds)
    g. Slowing from 12 to 5 kts proves difficult while maintaining steering, (especially with a following wind/current). Therefore, at 10 kts (through the water) the common solution is to put both pods inboard at zero RPMs (which slows the ship at 1 kt / 0.1 nm).

---

[5] Master of *Anthem of the Seas* observation in regard to BTs (paraphrased here) 'offer effect to 7kts, but no great effect above 2 kts', and sufficient power to manage 35 knots of wind.

[6] Master of *Anthem of the Seas* observation stern is heavy, 40-50 RPM required for effective maneuvering

[7] Often a helmsman will use extreme rudder angles to reach a new heading thus providing more thrust to the side and less thrust ahead for speed buildup

[8] Master of *Anthem of the Seas* observation: Pods aft are 'like maneuvering with an outboard engine', makes for a massive sweep when turning (large swept path).

6. The stern seeks the wind, especially with sternway. Observation trip note from master that balcony angled section aft really acts as a wind scoop particularly at apparent wind angles of 45^{o} and 135^{o} and strongly impart strong influence on the handling of the ship.
7. Steering gear motors are electric, rather than hydraulic, thus azipod rotation rate builds up slowly (is not immediate) and reaches a maximum rate of 7.5^{o}/second.
8. When propeller RPM are set at zero, the propellers will freewheel thus there is no slowing effect of 'stopped' propellers.
9. The master advised that many tie-ups require stern breast lines to be run from the offshore side of the ship thus, with 25 kts of offshore wind, the master commonly asks for a tug to push the ship alongside while letting go lines (eliminating the need for pod use while the lines are in the water).[9]
10. SEAPA's azipod command terminology was forwarded to RCCL for consideration. During simulation testing, the SEAPA azipod command terminology was used effectively with both RCCL masters (who also pointed out the similarities between the SEAPA terminology and the terminology being taught in the ABB azipod course).

Observation Trip Notes - based upon observed data and discussion with the Master

1. Speed is the only real solution to reducing swept path.
2. Engine/thruster combinations as related to wind 1 big/1 small + 2BTs for < 25kts wind, 2 big/1small + 3 or 4BTs for > 25kts wind.
3. BT #4 (farthest aft) less effective than the others (farther from the stem).
4. Sandy Hook Pilot suggested Rate of Turn (ROT) as preferred method of turning – felt there is more consistent control with Quartermasters performing better with this method.
5. Captain offered that the ship would take a lot of power to get her moving in a desired direction, but offered that when power was taken off – she would settle quickly.
6. Pods aft are 'like maneuvering with an outboard engine', makes for a massive sweep when turning (large swept path).
7. 25kts of wind (on the beam) pretty much limits ROT to 10^{o} per minute (due to heeling). Can build up to 20^{o} ROT as long as you back off in increments as well. 18kts Speed can turn at 10-15^{o} ROT.
8. May be critical to work in Aziman mode in ice due to extreme aft and outboard location of pods
9. Captain commented that you really can't turn too early, and again she settles very quickly.

[9] This advice was 'mirrored' by the *Anthem of the Seas* master noting: 'Pods so far aft require care with mooring lines, must stop pods to pass stern lines.'

Recommendations

Given the outcome of the simulations and review of reports conducted by Royal Caribbean International of other port areas, the following recommendations are offered by SEAPA:

1. The Operational Guidelines attached (figure 5.) are recommended for the 2019 season, subject to adjustment based on experience and the on-scene decisions of the pilot and master.
2. SEAPA and RCI agree to meet for a post-season de-brief session to discuss and process guideline adjustments, based on the operational experience with this class of vessel.
3. Recommend against any entry at Tracy arm.
4. Closely observe operational capabilities – in particular Bow Thruster ability to counteract forces- due to unresolved discrepancy between simulator model performance and observed vessel/master determinations.

Figure 5: Anthem of the Seas, Bow View from the dock at Nassau, Bahamas

SEAPA Operational Guidelines for 2019 Season

Figure 6: Operational Guidelines - 2019

Royal Caribbean International and Southeast Alaska Pilots Association
---General Guidelines for Royal Caribbean International Vessels---

"What we can do without compromising safety."

General Considerations	
	The Master and Pilot will jointly assess the current, wind speed & direction, visibility, navigational hazards (e.g., channel limitations, density of ice, anchored vessels) to agree on an abort point or to proceed. For port calls where the winds are forecast to exceed 45 knots for any time during the port call, the Master and Pilot will jointly address the port capabilities to include at a minimum: berth limitations (e.g., bollard strength, number & arrangement of bollards); ship's mooring limitations (e.g., max number of lines, line strength); port resources (e.g., tug availability and horsepower) in consideration of port cancellation.

	AREA	WIND	CURRENT
Ice Areas	Yakutat Bay / Disenchantment Bay (Hubbard Glacier)	For evolutions where actual or forecast winds are 30 knots or greater, the Master and Pilot will jointly assess the current, wind direction, visibility, waterway limitations (including size & density of ice, marine mammals, etc.), and the presence of other vessels to agree on an abort point or to proceed.	
	Glacier Bay		
	Endicott Arm	For evolutions where actual or forecast winds are 15 knots or greater, the Master and Pilot will jointly assess the current, wind direction, visibility, waterway limitations (including size & density of ice, marine mammals, etc.), and the presence of other vessels to agree on an abort point or to proceed.	
	Tracy Arm	ADVISE AGAINST ANY ENTRY INTO TRACY ARM	
Juneau Area	Juneau AS Stbd Side-to Docking	30 Knots	1 Knot of current in same direction as wind
		35 Knots	Minimal current
	Juneau AS Stbd Side-to Undocking	30 Knots	1 Knot of current in same direction as wind
		35 Knots	Minimal current
Skagway Ar[ea]	Skagway RRA Docking	35 Knots	N/A
	Skagway RRA Undocking	40 Knots	N/A
Sitka Area	Sitka - Arrival OSD	30 Knots	1 Knot of current in same direction as wind
	Sitka - Departure OSD	30 Knots	1 Knot of current in same direction as wind
ISP Area	Icy Strait Point - Arrival	25 Knots	1 Knot of current in same direction as wind
	Icy Strait Point - Departure	25 Knots	1 Knot of current in same direction as wind
Ketchikan Area	Tongass Narrows East Channel (California and Idaho Rocks)	Southerly through Westerly winds in excess of 25 Knots	1 Knot of current in same direction as wind
		Winds in excess of 30 Knots from any direction	
	Tongass Narrows Ketchikan Harbor to Lewis Reef (Airport / Drydock Area)	Southerly through Westerly winds in excess of 25 Knots	1 Knot of current in same direction as wind
		Winds in excess of 30 Knots from any direction	
	Ketchikan Berth 4 Docking	Winds in excess of 25 Knots from any direction	1 Knot of current in same direction as wind
	Ketchikan Berth 4 Undocking	Winds in excess of 25 Knots from any direction	1 Knot of current in same direction as wind

Ketchikan is not scheduled for the 2019 season (Limits set on very limited simulation run data)

* Aft tug necessary to 'pin' ship at berth during let go for offshore winds (to prevent lines in propellors)

Simulation Run Log

Figure 7: Simulation Run Log

OVATION OF THE SEAS SCENARIOS RUN RECORD - DEC 3-7, 2018

RUN NUMBER					INITIAL CONDITIONS	
Run-LOC-dir-Day#.Total#	LOC	Run?	WATERWAY/PORT	MANEUVER/DIRECTION	WIND	CURRENT
2-JNU-arr-1.2	JNU	▯	Gastineau Ch / Alaska Steam	Inbound	SE 20 KTS	none
3-JNU-arr-1.3	JNU	▯	Gastineau Ch / Alaska Steam	Inbound	SE 30 KTS	none
4-JNU-arr-1.4	JNU	▯	Gastineau Ch / Alaska Steam	Inbound	SE 30 KTS	Fl, 1kt
28-JNU-arr-1.28	JNU	▯	**Gastineau Ch / Alaska Steam**	**Inbound**	**SE 45**	**Fl, 1kt**
5-JNU-arr-1.5	JNU	▯	Gastineau Ch / Alaska Steam	Inbound	NE 25 KTS	E, 1kt
8-JNU-dep-1.8	JNU	▯	Alaska Steam / Gastineau Ch	Undocking / Transit	NE 35 KTS	E, 1kt
9-JNU-dep-1.9	JNU	▯	Alaska Steam / Gastineau Ch	Undocking / Transit	NE 35 KTS	E, 1kt
29-JNU-arr-3.29	JNU	▯	**JNU / Gastineau Ch**	**Inbound**	**SE 35 KTS**	**Fl, 1.5**
30-JNU-dep-3.30	JNU	▯	**JNU / Gastineau Ch**	**Outbound**	**NW 35 KTS**	**E, 1.5kt**
31-JNU-dep-4.31	JNU	▯	**JNU / Gastineau Ch**	**Inbound**	**SE 30 KTS**	**Fl, 1kt**
10-SKG-arr-2.10	SKG	▯	Taiya Inlet / RRA	Inbound	SE 45 KTS	F, 0.5
11-SKG-arr-2.11	SKG	▯	Taiya Inlet / RRA	Inbound	SE 35 KTS	E, 0.5kt
12-SKG-arr-2.12	SKG	▯	Taiya Inlet / RRA	Inbound	SW 25 KTS	none
13-SKG-arr-2.13	SKG	▯	Taiya Inlet / RRA	Inbound	NE 25 KTS	E, 0.5kt
14-SKG-dep-2.14	SKG	▯	RRA / Taiya Inlet	Undocking / Transit	SE 45 KTS	F, 0.5
15-SKG-dep-2.15	SKG	▯	RRA / Taiya Inlet	Undocking / Transit	N 45 KTS	E, 1kt
16-SKG-dep-2.16	SKG	▯	RRA / Taiya Inlet	Undocking / Transit	SW 45 KTS	Fl, 1kt
17-SKG-dep-2.17	SKG	▯	RRA / Taiya Inlet	Inbound	SE 45 KTS	none
22-SIT-arr-3.22	SIT	▯	Sitka Sound / Old Sitka Dock	Inbound	SW 35 KTS	Fl,2 kt
23-SIT-dep-3.23	SIT	▯	Old Sitka Dock / Sitka Sound	Undocking / Transit	NE 35 KTS	E, 1.5kt
24-ISP-arr-3.24	ISP	▯	Icy Strait / Icy Strait Point Dock	Inbound	SW 25 KTS	E, 1kt
25-ISP-dep-3.25	ISP	▯	Icy Strait Point Dock / Icy Strait	Undocking	N 25 KTS	Fl, 1kt
31-TA-ib-3.31	**TA**	▯	**Tracy Arm Bar**	**Inbound**	**none**	**E, 4kt**
18-END-ib-3.18	END	▯	Endicott Arm Bar	Inbound	none	E, 4kt
19-END-ob-3.19	END	▯	Endicott Arm Bar	Outbound	none	E, 4kt
20-TA-s1-3.20	TA	▯	Tracy Arm S Turns	Outbound	SW 30 KTS	none
21-TA-s2-3.21	TA	▯	Tracy Arm S Turns	Outbound	SW 30 KTS	none
26-KTN-arr-4.26	KTN	▯	East Channel / Berth _ / Transit	IB / Docking / OB	SE 25 KTS	Fl, 1kt
32-KTN-dep-4.32	**KTN**	▯	**KTN / Tongass Ch North**	**Outbound**	**SE 25 KTS**	**Fl, 1kt**
Total Simulations:		**29**			**1 - NO GO**	9
					2 - EOCZ	6
					3 - OK	8
					4 - GOOD	6

Note for Simulation Run Log Ratings: Ratings 3 & 4 are operationally manageable risk, 2 is at or beyond the upper limit of risk, and 1 is unacceptable risk. Edge of Comfort Zone (EOCZ is rating 2) is defined as: 'the environmental and operational parameters at which undesirable incidents began to happen'.

Simulation Criteria

#	Item	Standard
1	Ketchikan – Mt Point to Saxman	12 knots by Southeast Alaska Vessel Waterway Guide (VWG)
2	Ketchikan – Saxman to Channel Island	7 knots by CFR reference
3	Ketchikan - Harbor	5 knots by Tongass Waterway Guide and VWG
4	Juneau – Dupont to Sheep Creek	14 knots - VWG
5	Juneau – Sheep Creek to Juneau Isle	10 knots - VWG
6	Juneau – Juneau Isle to Rock Dump	7 knots - VWG
7	Juneau - Harbor	5 knots - VWG
8	Maximum drift angle passing through California and Idaho Rocks	7 degrees
9	Thrusters use for vessel control during channel transits (vessel not maneuvering near berth areas)	Thruster use not a common practice for channel transit
10	Tug use	Evaluated in concurrent study

Pilot Card: Ovation of the Seas[10]

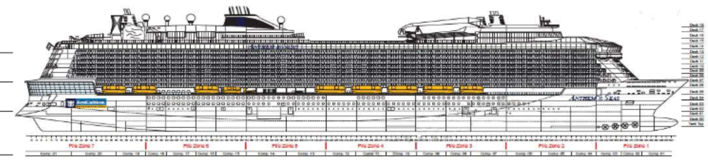
Figure 8: Pilot Card, Ovation of the Seas

Drafts

Fwd : ________

Mid : ________

Aft : ________



No Pax : ________

No Crew : ________

Year Built: 2016
Call Sign: C6BX9
IMO Number: 9697753
MMSI Number: 311000397
Official Number: 7000799
Class: DNV 1A1, Passenger Ship

Ovation Of The Seas - Pilot card

RoyalCaribbean INTERNATIONAL

Port of Register
Nassau, Bahamas

Ship's Particulars	
Gross Tonnage:	168.666 GRT
Net Tonnage:	154,078 NRT
Displacement:	78,250 tonnes
Draught (Min) :	8.1 m. / 26'7"
Draft Max:	8.8 m. / 28'10"
Length Overall:	347.10m/1138.8ft
Length P/P:	320.2m / 1050.5ft
Moulded Breadth on WL:	41.4m. / 135.1 ft
Ext. Breadth (Bridge Wings):	48.9m / 160.3 ft
Max Air Draft @ 8.10 m :	62.9m / 206.4 ft
Max Air Draft @ 8.10 m :	58.2m / 190.9 ft (Retracted Funnels)
Max Air Draft (North Star) :	95.0 m / 311.8 ft
Bridge to Bow:	43.9m. / 144 ft
Bridge to Stern:	303.2m. / 994.9 ft
Anchors:	2 x 14 Shackles(2*385) 17.25MT

Maneuvering Speeds	
RPM	**Speed**
145	**23.4**
102	**16.7**
59	**9.6**
15	**4.9**
0	**2.5**

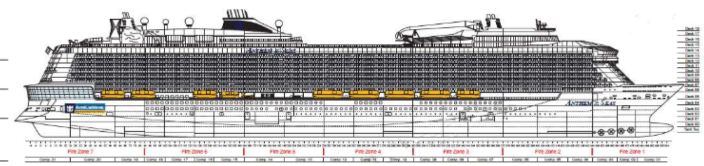
Machinery Characteristic	
PROPULSION: Two 360-degree, fixed pitch Pods, inwards turning	
Max Azipod Angle / Power:	35º (Cruise Mode), 2 X 20 MW
Max Azipod Angle / Power:	360º (Maneuvering Mode), 2 X 10 MW
Pod Turning Rate :	2.5 °/ Sec Normal
Pod Turning Rate :	5.0 °/ Sec Fast mode
Bow Thrusters:	4 x 3500 kW / 4 x 4694hp + 10%
Type of Engines:	Wartsila Diesel Electric
Main Engines:	2 X 14 MW, 2 X 18MW
Total propulsion power:	41,000 kW / 54,982hp
Propulsion machinery:	Two 20.5 MW, ABB Azipod
Max Spd for Thrusters:	8 kts
Max Speed:	23.4 knots - Stopping Distance 0.92 Cables
Stabilizers:	2 , Extend 6.2 Meters
Frontal Wind Area:	1,780 sq.m. / 19,159 sq. ft
Lateral Wind Area:	14,614 sq.m. / 157, 304 sq. ft

Drafts

Fwd : ________

Mid : ________

Aft : ________



No Pax : ________

No Crew : ________

Year Built: 2016
Call Sign: C6BX9
IMO Number: 9697753
MMSI Number: 311000397
Official Number: 7000799
Class: DNV 1A1, Passenger Ship

Ovation Of The Seas - Pilot card

RoyalCaribbean INTERNATIONAL

Port of Register
Nassau, Bahamas

Ship's Particulars	
Gross Tonnage:	168.666 GRT
Net Tonnage:	154,078 NRT
Displacement:	78,250 tonnes
Draught (Min) :	8.1 m. / 26'7"
Draft Max:	8.8 m. / 28'10"
Length Overall:	347.10m/1138.8ft
Length P/P:	321.1m / 1050.5ft
Moulded Breadth on WL:	41.4m. / 135.1 ft
Ext. Breadth (Bridge Wings):	48.9m / 160.3 ft
Max Air Draft @ 8.10 m :	62.9m / 206.4 ft
Max Air Draft @ 8.10 m :	58.2m / 190.9 ft (Retracted Funnels)
Max Air Draft (North Star) :	95.0 m / 311.8 ft
Bridge to Bow:	43.9m. / 144 ft
Bridge to Stern:	303.2m. / 994.9 ft
Anchors:	2 x 14 Shackles(2*385) 17.25MT

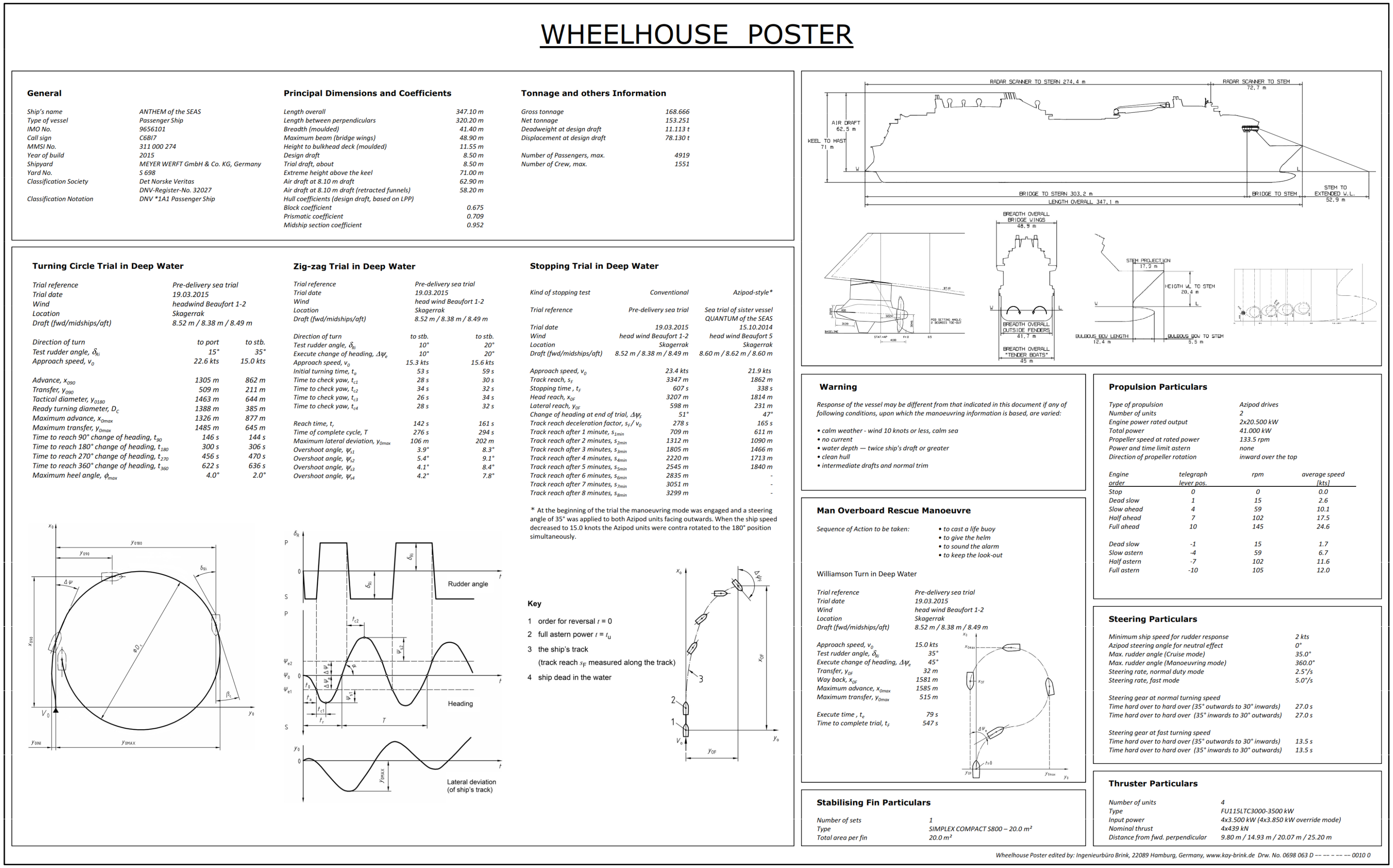
Maneuvering Speeds	
RPM	**Speed**
133	**23.4**
77	**13.5**
56	**9.9**
28	**4.9**
0	**0.0**

Machinery Characteristic	
PROPULSION: Two 360-degree, fixed pitch Pods, inwards turning	
Max Azipod Angle / Power:	35º (Cruise Mode), 2 X 20 MW
Max Azipod Angle / Power:	360º (Maneuvering Mode), 2 X 10 MW
Pod Turning Rate :	2.5 °/ Sec Normal
Pod Turning Rate :	5.0 °/ Sec Fast mode
Bow Thrusters:	4 x 3500 kW / 4 x 4694hp + 10%
Type of Engines:	Wartsila Diesel Electric
Main Engines:	2 X 14 MW, 2 X 18MW
Total propulsion power:	41,000 kW / 54,982hp
Propulsion machinery:	Two 20.5 MW, ABB Azipod
Max Spd for Thrusters:	8 kts
Max Speed:	23.4 knots - Stopping Distance 0.92 Cables
Stabilizers:	2 , Extend 6.2 Meters
Frontal Wind Area:	1,780 sq.m. / 19,159 sq. ft
Lateral Wind Area:	14,614 sq.m. / 157, 304 sq. ft

[10] Pilot Card Data Provided by Royal Caribbean International

Wheelhouse Poster, Ovation of the Seas

Figure 9: Wheelhouse Poster, Ovation of the Seas



WHEELHOUSE POSTER

General

Ship's name	ANTHEM of the SEAS
Type of vessel	Passenger Ship
IMO No.	9656101
Call sign	C6BI7
MMSI No.	311 000 274
Year of build	2015
Shipyard	MEYER WERFT GmbH & Co. KG, Germany
Yard No.	S 698
Classification Society	Det Norske Veritas
	DNV-Register-No. 32027
Classification Notation	DNV *1A1 Passenger Ship

Principal Dimensions and Coefficients

Length overall	347.10 m
Length between perpendiculars	320.20 m
Breadth (moulded)	41.40 m
Maximum beam (bridge wings)	48.90 m
Height to bulkhead deck (moulded)	11.55 m
Design draft	8.50 m
Trial draft, about	8.50 m
Extreme height above the keel	71.00 m
Air draft at 8.10 m draft	62.90 m
Air draft at 8.10 m draft (retracted funnels)	58.20 m
Hull coefficients (design draft, based on LPP)	
Block coefficient	0.675
Prismatic coefficient	0.709
Midship section coefficient	0.952

Tonnage and others Information

Gross tonnage	168.666
Net tonnage	153.251
Deadweight at design draft	11.113 t
Displacement at design draft	78.130 t
Number of Passengers, max.	4919
Number of Crew, max.	1551

Turning Circle Trial in Deep Water

Trial reference	Pre-delivery sea trial
Trial date	19.03.2015
Wind	headwind Beaufort 1-2
Location	Skagerrak
Draft (fwd/midships/aft)	8.52 m / 8.38 m / 8.49 m

Direction of turn	to port	to stb.
Test rudder angle, δ_{Ri}	15°	35°
Approach speed, v_0	22.6 kts	15.0 kts
Advance, x_{090}	1305 m	862 m
Transfer, y_{090}	509 m	211 m
Tactical diameter, y_{0180}	1463 m	644 m
Ready turning diameter, D_C	1388 m	385 m
Maximum advance, x_{0max}	1326 m	877 m
Maximum transfer, y_{0max}	1485 m	645 m
Time to reach 90° change of heading, t_{90}	146 s	144 s
Time to reach 180° change of heading, t_{180}	300 s	306 s
Time to reach 270° change of heading, t_{270}	456 s	470 s
Time to reach 360° change of heading, t_{360}	622 s	636 s
Maximum heel angle, ϕ_{max}	4.0°	2.0°

Zig-zag Trial in Deep Water

Trial reference	Pre-delivery sea trial
Trial date	19.03.2015
Wind	head wind Beaufort 1-2
Location	Skagerrak
Draft (fwd/midships/aft)	8.52 m / 8.38 m / 8.49 m

Direction of turn	to stb.	to stb.
Test rudder angle, δ_{Ri}	10°	20°
Execute change of heading, $\Delta\psi_e$	10°	20°
Approach speed, v_0	15.3 kts	15.6 kts
Initial turning time, t_a	53 s	59 s
Time to check yaw, t_{c1}	28 s	30 s
Time to check yaw, t_{c2}	34 s	32 s
Time to check yaw, t_{c3}	26 s	34 s
Time to check yaw, t_{c4}	28 s	32 s
Reach time, t_r	142 s	161 s
Time of complete cycle, T	276 s	294 s
Maximum lateral deviation, y_{0max}	106 m	202 m
Overshoot angle, ψ_{s1}	3.9°	8.3°
Overshoot angle, ψ_{s2}	5.4°	9.1°
Overshoot angle, ψ_{s3}	4.1°	8.4°
Overshoot angle, ψ_{s4}	4.2°	7.8°

Stopping Trial in Deep Water

Kind of stopping test	Conventional	Azipod-style*
Trial reference	Pre-delivery sea trial	Sea trial of sister vessel QUANTUM of the SEAS
Trial date	19.03.2015	15.10.2014
Wind	head wind Beaufort 1-2	head wind Beaufort 5
Location	Skagerrak	Skagerrak
Draft (fwd/midships/aft)	8.52 m / 8.38 m / 8.49 m	8.60 m / 8.62 m / 8.60 m
Approach speed, v_0	23.4 kts	21.9 kts
Track reach, s_F	3347 m	1862 m
Stopping time , t_F	607 s	338 s
Head reach, x_{0F}	3207 m	1814 m
Lateral reach, y_{0F}	598 m	231 m
Change of heading at end of trial, $\Delta\psi_F$	51°	47°
Track reach deceleration factor, s_F/v_0	278 s	165 s
Track reach after 1 minute, s_{1min}	709 m	611 m
Track reach after 2 minutes, s_{2min}	1312 m	1090 m
Track reach after 3 minutes, s_{3min}	1805 m	1466 m
Track reach after 4 minutes, s_{4min}	2220 m	1713 m
Track reach after 5 minutes, s_{5min}	2545 m	1840 m
Track reach after 6 minutes, s_{6min}	2835 m	-
Track reach after 7 minutes, s_{7min}	3051 m	-
Track reach after 8 minutes, s_{8min}	3299 m	-

* At the beginning of the trial the manoeuvring mode was engaged and a steering angle of 35° was applied to both Azipod units facing outwards. When the ship speed decreased to 15.0 knots the Azipod units were contra rotated to the 180° position simultaneously.

Key

1 order for reversal $t = 0$
2 full astern power $t = t_u$
3 the ship's track (track reach s_F measured along the track)
4 ship dead in the water

Warning

Response of the vessel may be different from that indicated in this document if any of following conditions, upon which the manoeuvring information is based, are varied:

- calm weather - wind 10 knots or less, calm sea
- no current
- water depth — twice ship's draft or greater
- clean hull
- intermediate drafts and normal trim

Propulsion Particulars

Type of propulsion	Azipod drives
Number of units	2
Engine power rated output	2x20.500 kW
Total power	41.000 kW
Propeller speed at rated power	133.5 rpm
Power and time limit astern	none
Direction of propeller rotation	inward over the top

Engine order	telegraph lever pos.	rpm	average speed [kts]
Stop	0	0	0.0
Dead slow	1	15	2.6
Slow ahead	4	59	10.1
Half ahead	7	102	17.5
Full ahead	10	145	24.6
Dead slow	-1	15	1.7
Slow astern	-4	59	6.7
Half astern	-7	102	11.6
Full astern	-10	105	12.0

Man Overboard Rescue Manoeuvre

Sequence of Action to be taken:

- to cast a life buoy
- to give the helm
- to sound the alarm
- to keep the look-out

Williamson Turn in Deep Water

Trial reference	Pre-delivery sea trial
Trial date	19.03.2015
Wind	head wind Beaufort 1-2
Location	Skagerrak
Draft (fwd/midships/aft)	8.52 m / 8.38 m / 8.49 m
Approach speed, v_0	15.0 kts
Test rudder angle, δ_{Ri}	35°
Execute change of heading, $\Delta\psi_e$	45°
Transfer, y_{0F}	32 m
Way back, x_{0F}	1581 m
Maximum advance, x_{0max}	1585 m
Maximum transfer, y_{0max}	515 m
Execute time , t_e	79 s
Time to complete trial, t_F	547 s

Steering Particulars

Minimum ship speed for rudder response	2 kts
Azipod steering angle for neutral effect	0°
Max. rudder angle (Cruise mode)	35.0°
Max. rudder angle (Manoeuvring mode)	360.0°
Steering rate, normal duty mode	2.5°/s
Steering rate, fast mode	5.0°/s
Steering gear at normal turning speed	
Time hard over to hard over (35° outwards to 30° inwards)	27.0 s
Time hard over to hard over (35° inwards to 30° outwards)	27.0 s
Steering gear at fast turning speed	
Time hard over to hard over (35° outwards to 30° inwards)	13.5 s
Time hard over to hard over (35° inwards to 30° outwards)	13.5 s

Stabilising Fin Particulars

Number of sets	1
Type	SIMPLEX COMPACT S800 – 20.0 m²
Total area per fin	20.0 m²

Thruster Particulars

Number of units	4
Type	FU115LTC3000-3500 kW
Input power	4x3.500 kW (4x3.850 kW override mode)
Nominal thrust	4x439 kN
Distance from fwd. perpendicular	9.80 m / 14.93 m / 20.07 m / 25.20 m

Wheelhouse Poster edited by: Ingenieurbüro Brink, 22089 Hamburg, Germany, www.kay-brink.de Drw. No. 0698 063 D –– –– – –– –– 0010 0

Figure 10 Anthem of the Seas at Nassau

End of Report