Simulator-Based Evaluation

And

Recommended Guidelines

For the

VLCS Norwegian Bliss in Southeast Alaska, 2018

A Cooperative Study
By
The Southeast Alaska Pilots' Association
And
Norwegian Cruise Line

Pacific Maritime Institute, Seattle, WA
December 11-15, 2017

Version 1

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Contents

Change Sheet

All edits to this document made after Version 1 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 NORWEGIAN CRUISE LINE (NCL). This report, and the safe operational guidelines recommended herein, are founded on simulation-based research and 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 NCL liable. This report is intended for further consideration by SEAPA and NCL to enact the recommendations contained herein.

Executive Summary

The purpose of this joint study is to apprise SEAPA and NCL of operational limitations and resultant safe operational guidelines for the *Norwegian Bliss* class of vessel. SEAPA and NCL jointly formed the cooperative Very Large Cruise Ship Committee (the "Committee") to address the deployment of the *Norwegian Bliss* (1,094 feet LOA and 168,028 GT) to Southeast Alaska in 2018. This effort was chartered in anticipation of future deployments of additional very large cruise ships (VLCSs), to Southeast Alaska, in the coming years.

The Committee engaged in thorough data-gathering, including a week-long observer trip on a sister-ship; development and vetting of a hydrodynamic model of the *Norwegian Bliss*; and a week of full-mission ship simulation in various Southeast Alaska ports and waterways. Simulations were conducted at the Pacific Maritime Institute (PMI), in Seattle, WA, December 11-15, 2017.

No pre-determined guidelines or limitations existed at the start of this cooperative study. The intent was to engage in a holistic approach by assessing the body of knowledge of previous studies, and incorporating experiential data and professional experience to identify the parameters where undesirable events begin to happen; as well as, to address the measures for correcting, or eliminating root-causes and their potential consequences. Integrity of purpose was the foundation of the collaboration between SEAPA and NCL; recognizing common goals and separate roles, in an effort to, *"protect life and property and the marine environment"* (State.of.Alaska, 2017), in an economically achievable manner.

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 most unfavorable and frequent wind and current conditions were tested in seven critical areas (based on the 2018 itinerary of the *Norwegian Bliss*): Tongass Narrows East Channel (from Spire Island Reef to north of California- and Idaho Rocks), Ketchikan's Berth 3, North Tongass Narrows (from Berth 3 to north of the airport/dry dock area), Tracy Arm Bar, the 'S' Turns in Tracy Arm, Juneau's AJD berth, and Skagway's RRA berth.

On the final day of testing, the Committee and PMI hosted an open house for industry stakeholders. One of the evaluation simulation scenarios and the associated risk-assessment process was demonstrated; followed by a round-table discussion and review of the process, a preliminary draft of guidelines for the *Norwegian Bliss*, and a facilitated dialog which included stakeholder questions, concerns, and suggested areas for follow-up. Stakeholders attending the Open House included: the USCG COTP for Juneau, the USCG COTP for Seattle, the USCG Deputy Sector Commander for LA / Long Beach, the Executive Director of the Marine Exchange of Alaska, multiple cruise companies, the American Pilots' Association, and West Coast Pilot groups. The stakeholders responded favorably to the collaborative efforts of the Committee, as evidenced by the process and the open dialogue.

The Committee clarified that the draft guidelines were intended only for the *Norwegian Bliss* for the start-of-the-cruise-season, and declared its intention to actively monitor and revise the proposed guidelines, as appropriate. Furthermore, the Committee intends to apply feedback from the actual

maneuvering characteristics of the *Norwegian Bliss* to more completely tune the hydrodynamic model, if warranted.

Additional items highlighted at the Open House, for future followup, were the increased need for real-time environmental data (e.g., wind and current speed and direction) and risk assessment with regards to port infastructure and resource availability.

The Committee members from SEAPA expressed their desire that the collaborative process, expressed in this study with NCL, be applied with other cruise lines for additional evaluation of anticipated VLCS deployments and possible training opportunities.

Recommended Guidelines

The primary goal of this risk assessment, and corresponding simulation evaluations, was to identify the environmental and operational parameters at which undesirable incidents began to happen. The general standard of care, by which the Committee based these recommended guidelines, was if a simulation maneuver could be reliably completed by an average mariner, on an average day, while achieving consistent, above average results.

The VLCS *Norwegian Bliss* was found to be appropriately powered for maneuvering in most conditions encountered in Southeast Alaska. Simulations identified a significant swept path outline, in strong crossing winds and currents, in Tongass Narrows East Channel, Tongass Narrows in the vicinity of the airport and dry dock, and in ice conditions at Tracy Arm's Bar and 'S' Turns. Scenarios in upper-limit winds demonstrated maneuvering reserve margins (e.g. rudder and/or bow thruster reserves) and vessel speed limits, as prescribed in Southeast Alaska's Voluntary Waterway Guide (VWG), which had to be exceeded in order to keep vessel swept path within the margins of safety.

The following season-start recommended guidelines were identified through experience in the simulations:

Norwegian Cruise Lines and Southeast Alaska Pilots		
VLCS Committee Recommended 2018 Guidelines for VLCS Norwegian Bliss		
"What We Can Do Without Compromising Safety"		
AREA	GENERAL GUIDELINES	
	WIND	CURRENT
Tongass Narrows East Channel (California and Idaho Rocks)	20 Knots	1 Knot of current in same direction as wind
Ketchikan Berth 3 Docking	25 Knots	1 Knot of current in same direction as wind
Ketchikan Berth 3 Undocking	25 Knots	1 Knot of current in same direction as wind
Tongass Narrows Ketchikan Harbor to Lewis Reef (Airport / Drydock Area)	25 Knots	1 Knot of current in same direction as wind
Tracy Arm	ADVISE AGAINST ANY ENTRY INTO TRACY ARM BY A VESSEL OF THIS SIZE	
Juneau AJD Docking, utilizing a 3000 HP tug	SE / NW 25 Knots	1 Knot of current in same direction as wind
	SE / NW 30 Knots	No current
Juneau AJD Undocking, utilizing a 3000 HP tug	NW 25 Knots	1 Knot of current in same direction as wind
	NW 30 Knots	No current
Skagway Railroad Aft Docking	30 Knots	N/A
Skagway Railroad Aft Undocking	35 Knots	N/A

Table 1. VLCS Norwegian Bliss Guidelines

The Committee agreed that these guidelines will be flexible; and subject to future adjustment based on experience and the on-scene decisions of the pilot and master. Additionally, the Committee agreed 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.

Recommendations

Tracy Arm. The Committee recommendation that the *Norwegian Bliss* not schedule, or transit, Tracy Arm is in keeping with the current Wilderness Best Practices Management Agreement (U.S.Forest.Service, 2017) which allows for visits to Endicott Arm when safety limits operations elsewhere. Accordingly, this study's conclusion, that it is unsafe for the *Norwegian Bliss* to operate in Tracy Arm under any conditions, is consistent with the agreement that the ship operate in Endicott Arm for 2018.

Alternative Route for Tongass Narrows East Channel. When environmental conditions limit transit in Tongass Narrows East Channel (Table 1), the Committee recommends an alternative approach to Ketchikan, by transiting Tongass Narrows from the north. Pilots may be boarded at the Guard Island pilot station.

Alternative Approach to Ketchikan's Berth 3. When environmental conditions, and on-scene determinations by the master and pilot limit transit east of Tongass Narrows Buoy 4A, while approaching Ketchikan's Berth 3 from the south; the Committee recommends transiting west of Buoy 4A.

The Process

Background

A VLCS is informally defined as a cruise ship greater than, or equal to, 120,000 Gross Tons; or greater than, or equal to, 1000 feet (305 meters) length overall (LOA) (Image 1). Currently two vessels meeting this definition: the *Celebrity Solstice* at 1,041 feet / 121,878 GT and the *Explorer of the Seas* at 1,021 feet / 138,194 GT, have been deployed to Southeast Alaska for the summer cruise season. Experience with these two ships, in addition to NCL's and other cruise companies' announced plans to deploy increasingly larger VLCSs to Southeast Alaska (beginning in 2018), prompted the formation of the VLCS Committee. The Committee was chartered to:

Image 1. VLCS size comparison

- Develop a simulation protocol to systemically assess the operating characteristics of VLCSs;
- Develop and evaluate safe operational guidelines for the *Norwegian Bliss*; and

- Document the project framework and standards for future VLCS simulation evaluations and potential pilot training on VLCSs.

The Committee was comprised of representatives from NCL and SEAPA representing a combined 254 years of sea-going experience, including 164 years of Alaska experience; 40 years master's experience and 93 years of pilotage experience.

Goals

The primary goal of this joint, industry-pilot study was, through the sharing of observations and experience, combined with simulation protocol, to establish safe operational guidelines for the deployment of the latest generation of VLCSs to Southeast Alaska. The focus was to identify the operational parameters where undesirable events begin to happen through:

- Leading Indicators,
- Trigger Points, and
- Edge of the Comfort Zone (EOCZ) Markers.

These parameters were intended to indicate where the level of safety became marginally unacceptable (not at points of operational failure).

Additional goals included establishment of the framework and standards for future VLCS risk assessment and resources for pilot training.

Scope

The scope of the joint study was focused on the deployment of the *Norwegian Bliss* to Southeast Alaska in 2018. The process for this joint collaboration and study protocol was envisioned as a model for future evaluations (as noted above); however, the cooperation between NCL and SEAPA, as it pertains to the evaluation of the *Norwegian Bliss* (and representative sister ships), was the sole focus of this study.

Process and Resources – General

In pursuit of the project goals, elements of the process framework were designed to create a program to systemically, via full-mission ship simulation, test and evaluate ship behaviors, operating risks, and limitations for the safe deployment of the *Norwegian Bliss* to Southeast Alaska for the planned 2018 itinerary. Specific elements of this framework included:

- Research by pilot members of the Committee, of previous studies of large ship risk (not solely cruise ships), in order to develop a proven protocol and to avail of previous studies' strong and weak points. Many of the examined studies included problematic concerns with the accuracy of simulated ship models, limited or myopic views on risk assessment, and the lack of resolution for differing perceptions of risk. These concerns were addressed in this process through a variety of means.
- Sharing and examination of vessel-specific design specifications and operating information, such as the sister-ship *Norwegian Joy's* Maneuvering Booklet and the operating tables for the sister-ship *Norwegian Escape*.

- Detailed observation and evaluation of a sister vessel's (*Norwegian Escape*) actual operating behaviors, through dispatch of SEAPA pilots, in close coordination with the onboard ship's master and officers. Two SEAPA pilots embarked on a one-week voyage onboard the *Norwegian Escape* during which they observed and recorded all dockings and un-dockings; as well as, several ship maneuvers conducted specifically for the project.
- During the observer trip (noted above) and throughout the 2017 summer cruise season, informal interviews were conducted with cruise industry officers with experience on similar vessels of the class.
- NCL and SEAPA engaged in joint sponsorship to have a *Norwegian Bliss* visual and hydrodynamic model built for simulation (Image 2). Given that the ship is presently in sea trials, and there did not exist a specific model for this ship, it was deemed important to develop the best tool possible for the full-mission simulation. The model was developed using the sister-ship's observed maneuvering data, officer feedback, maneuvering booklets, and the *Norwegian Bliss* construction specifics.

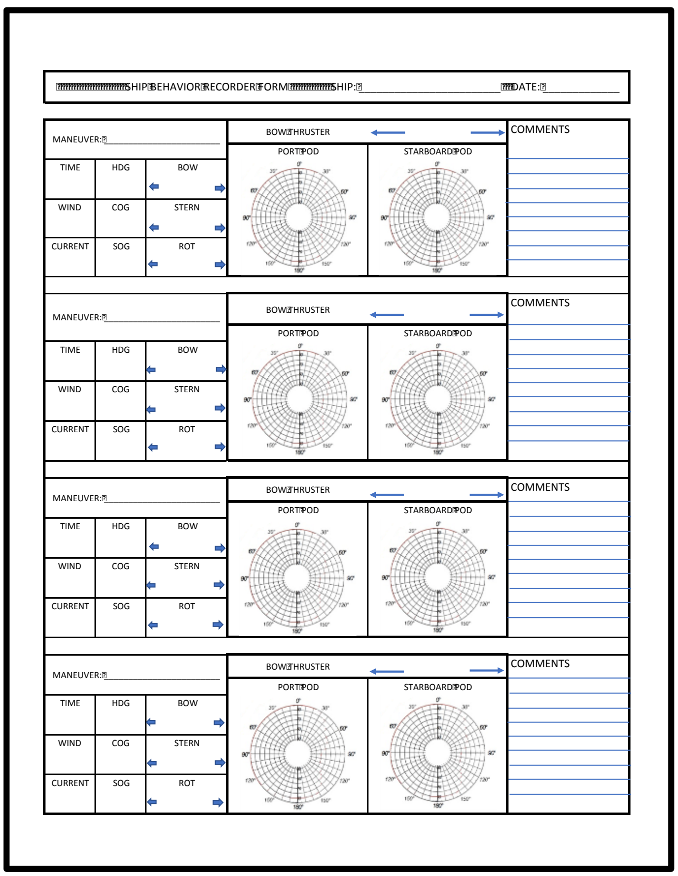
Image 2. VLCS Norwegian Bliss model and Tracy Arm / Endicott Arm databases developed for this study

- A new Holkham Bay (Tracy Arm and Endicott Arm) database was developed as another necessary tool for the simulation evaluation (Image 2).
- The Committee engaged the Pacific Maritime Institute (PMI), as a well-regarded third-party (i.e. not industry- or pilot-affiliated) maritime, full-mission ship simulator facility, to develop the ship model and to conduct the simulation evaluations in Southeast Alaska waterway databases.
- Although this project was largely self-administering, the Committee engaged the services of Mr. George Burkley, the Executive Director of the Maritime Pilots Institute, as a well-regarded, third-party, independent, maritime risk assessment subject matter expert, to act as a reviewer and advisor on the process and report.

Process and Resources – Observer Trip

As noted above, two SEAPA pilots embarked on the *Norwegian Escape* for a seven-day observation trip (Image 3). In preparation for that trip, and the subsequent ship simulation, the Committee developed, tested and refined the data-gathering objectives and process. The Committee developed several versions of a form for capturing maneuvering inputs and ship behavior while onboard (not on duty) various Azipod cruise ships during the 2017 summer cruise season (Figure 1).

Image 3. Norwegian Escape departing Miami



SHIP BEHAVIOR RECORDER FORM SHIP: ____________________ DATE: ____________

MANEUVER: ____________________
TIME | HDG | BOW
WIND | COG | STERN
CURRENT | SOG | ROT
BOW THRUSTER
PORT POD | STARBOARD POD
COMMENTS

MANEUVER: ____________________
TIME | HDG | BOW
WIND | COG | STERN
CURRENT | SOG | ROT
BOW THRUSTER
PORT POD | STARBOARD POD
COMMENTS

MANEUVER: ____________________
TIME | HDG | BOW
WIND | COG | STERN
CURRENT | SOG | ROT
BOW THRUSTER
PORT POD | STARBOARD POD
COMMENTS

MANEUVER: ____________________
TIME | HDG | BOW
WIND | COG | STERN
CURRENT | SOG | ROT
BOW THRUSTER
PORT POD | STARBOARD POD
COMMENTS

Figure 1. Ship Behavior Recorder Form

In conjunction with this effort, the Committee experimented with video and data capture via a GoPro® camera and SEAiq® navigation applications. GoPro® videos captured status panel readouts of maneuvering configurations (azipod and bow thruster use), vessel movement, and environmental conditions (Image 4). The SEAiq® data capture was important for recording vessel movements (entire maneuvering evolutions were recorded); as well as, drift angle and swept path (Image 5).

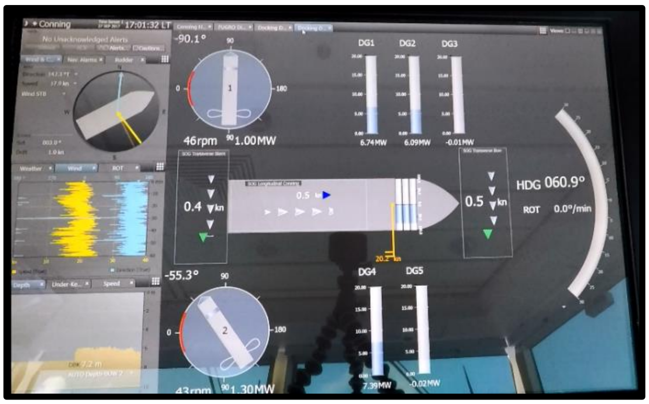


Image 4. GoPro video capture of status panel

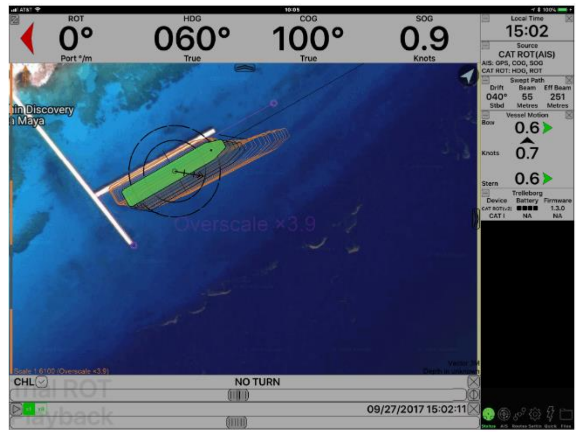


Image 5. SEAiq data capture.

Experience demonstrated that all three means of gathering data proved useful; however, the data gathered on GoPro® and SEAiq® proved especially valuable for later comparison, review, and compilation of information into spreadsheet format (Figure 2).

Miami Turning Basin: Slow and Turn to Stbd (9.30.17) Arr Miami
Aziman Mode, Var Pod Angles & RPMs
Environmentals: Wind & Current-negligible

Time	ROT° P/S	Speeds (kts)	PODS (angles)	RPMS	BT (%) P/S	Remarks
00m (0553)	0°	6.0	0° to I/B 90°	15 RPM	0%	Begin slow down, call Aziman, BPs I/B 90°
01m	0°	5.1	BPs I/B 90°	15-25 RPM	0%	RPMs incr. to 25 RPMs
02m	0°	4.2	BPs I/B 90°	25-44 RPM	0%	RPMs incr. to 44 RPMs
03m	0°	3.4	BPs I/B 90°	44-58 RPM	0%	RPMs incr. to 58 RPMs
04m	0°	2.4	BPs I/B 90°	58 RPM	0%	Increased RPMs, with BPs I/B 90°, assisting slow down.
05m	0°	1.8	BPs I/B 90°	58 RPM	0%	
05m30s	N/A	N/A	Pods Rotating	RPMs Chg'g	N/A	End of slow down, beginning of rotation. Pods rotated to: PP O/B 60°, SP I/B 120°. RPMs changed to: PP 33 RPMs, SP 58 RPMs.
06m	15° Stbd	Bow: 1.1 Stbd 1.2 Ahd Stern: 1.7 Port	PP O/B 60° SP I/B 120°	PP 33 RPM, SP 58 RPM	50% Stbd	Rate of turn increasing.
07m	24° Stbd	Bow: 1.8 Stbd 0.6 Ahd Stern: 2.5 Port	PP O/B 60° SP I/B 120°	PP 33 RPM, SP 58 RPM	50% Stbd	Rate of turn increasing.
08m	26° Stbd	Bow: 2.1 Stbd 0.3 Astern Stern: 2.6 Port	PP O/B 60° SP I/B 120°	PP 33 RPM, SP 58 RPM	50% Stbd	End of turn, pods configured to approach berth.

(Azipod abbreviations: BP = both pods, I/B = inboard, O/B = outboard, PP = port pod, SP = starboard pod.)

Figure 2. Norwegian Escape turning maneuvering data.

Upon completion of the observer trip, the videos and voyage recordings were used to develop correlations between the ship control inputs, environmental forces, and resultant ship behaviors. This information was then combined with Maneuvering Booklet information and proved valuable for the development, adjustment, and validation of the hydrodynamic model of the *Norwegian Bliss*.

Process and Resources - Risk Assessment Methodology

Risk was addressed within the context of hazard frequency of occurrence, magnitude of consequence, and root-cause correction or elimination. A multi-stage process was developed to identify, correlate, and validate risk identification and magnitude. For this study, the proposed 2018 itinerary for the *Norwegian Bliss* was examined by pilot members of the Committee to identify ten areas of higher risk probability and consequence. These areas were then prioritized through a combination of ranking and successive iterative actions to refine the list to fit within the resources (most specifically simulator time) available.

This study was not designed as a "port-study" per se, but rather a study of one-specific VLCS (the *Norwegian Bliss*) in areas of heightened concern, based on the ship's 2018 itinerary. The areas finalized for simulation with the *Norwegian Bliss* model were:

- Revillagigedo Channel to East Channel through California and Idaho Rocks,
- Arrival and departure at the Ketchikan Berth 3,
- Tongass Narrows from Ketchikan Harbor through the airport and dry dock area,
- Arrival and departure at the Alaska-Juneau dock (AJD),
- Tracy Arm Bar,
- Tracy Arm S-Turns, and
- Arrival at Skagway's Railroad Aft (RRA) dock.

Several other areas and/or evolutions (e.g., un-dockings vs. dockings, northbound vs. southbound transits, etc.) were considered and their omission from the testing is not intended to invalidate concerns for those evolutions. The Committee had to make priority choices within the resources available for testing. One example, of an area of significant risk that did not make the list for simulation at this time, is Snow Passage.

The Committee developed a framework for identifying and evaluating the level of risk for simulated evolutions in the areas listed above. 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.

Data recording forms, video capture, and SEAiq® recording techniques were refined to support the identification and documentation of the risk observed in the simulated evolutions. Examples of these forms and screen shots are provided below in the section of this report addressing Simulation Methodology.

In addition to the preparatory work noted above, the Committee developed and compiled extensive wind and current fields (based on the pilots' proprietary local knowledge) for application to the simulation scenarios (Image 6).

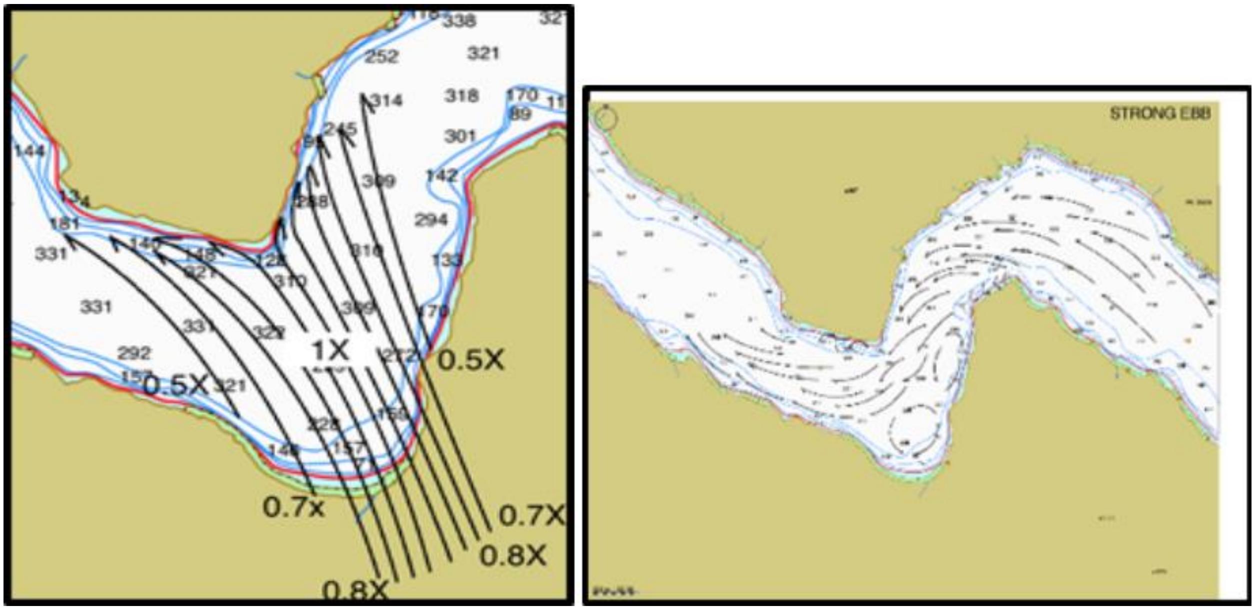


Image 6. Representative Excerpt of Wind and Ebb Current, Tracy Arm 'S' Turns

Prior to simulation evaluation, four days of simulator work was conducted by members of the Committee as follows:

- Two days of simulation to vet the accurate behavior of the *Norwegian Bliss* hydrodynamic ship model, specifically using the metrics recorded from the week of sister ship observation in addition to the input from other sources, as previously noted.
- Two days of simulation to vet the environmental fields developed for the critical operating areas.
- One day of pre-simulation meeting, by the full Committee, to review and adjust the simulation format, evaluation processes, scenarios, environmental inputs, and risk assessment criteria.

Process and Resources - Simulation Methodology

Consistent with the professional norms for studies of this extent, full-mission ship simulation was used as a substantive tool for the evaluation and risk assessment process. During the week of December 11-15, 2017, thirty-four simulations were performed by participating SEAPA pilots, two NCL masters, and bridge support personnel (composed of SEAPA pilots, trainees, and licensed volunteers). Commonly practiced maneuvers were conducted in a conservative fashion, to a typical standard of care, with the pilot conning the vessel to, or from, the berth and the master performing the docking or undocking. Several docking and undocking maneuvers were performed by pilots. [Alaska Marine Pilot Regulations state that, *"the pilot shall be on duty, at the conn, piloting the vessel at all times when the vessel is in transit or maneuvering in compulsory pilotage waters."* (State.of.Alaska, 2017)] Three SEAPA pilots and two NCL Masters conducted the simulations with one SEAPA pilot rotating out mid-week and another joining to give a fresh perspective on the process.

The objectives of the simulation were to:

- Utilize professional judgment and experience of subject matter experts, masters and pilots, to assess operating risk and identify the parameters where undesirable incidents begin to occur;
- Measure operating performance, against specific risk criteria, to identify and correlate the EOCZ and corresponding trigger points;
- Assess through pilot and master interviews, perceptions of risk, comfort levels, etc. immediately on completion of each simulation;
- Via the Committee as a whole, coordinate and review the information from the above processes, addressing correlation (both strong and weak) as it existed; and
- Provide the VLCS Committee and Independent Advisor, with the necessary information and data to comprehensively review, correlate, and validate the risk assessments and the subsequent recommended guidelines.

The scenarios were designed to be realistic, while testing the limits of environmental conditions that realistically occur. There were no “designed to fail” objectives. The exercises were specifically designed to assess the operating characteristics and limitations of the *Norwegian Bliss* when subjected to strong environmental conditions. With the focus on the navigational limitations, there was very little scripting of distractors that occur in real life (e.g. traffic, onboard emergencies, etc.). For the very few simulations that did include factors such as traffic, it was readily apparent that many transits were a “one-distraction” situation. These issues were reservered for subsequent training evaluation.

Realism in the simulations was important. The pilot and master were expected to practice good BRM/MPX; however, this study and the simulations were not intended to be assessments of the performance or training for the pilots and masters; therefore, no records of individual master or pilot performance were maintained.

It was expected that the participating pilots and masters would experience some learning with the subsequent simulations (as occurs in real life). That behavior was not only expected, but welcomed, as a tangible outcome of this effort. Inherent in the process was that participants would share their experiences and best practices, and this was factored into the end goals of tangible outcomes.

Implicit in the nature of these efforts was that, as experience was gained in the simulation process, the simulation start location(s), simulation environmental conditions, etc. would be adjusted for the sake of efficiency and effectiveness, but not to compromise the goals and objectives.

It is a well-recognized fact in the maritime training community that, for some people, the artificialities of the simulator and/or the simulations can be distracting or marginalize the experience. Masters and pilots are not expected to have the same familiarity with the simulator bridge as they would on an actual ship. The equipment is often generic and the terminology may not be familiar. The mariner’s perspectives are often limited to that available by the simulator (e.g. center-view, etc.). The bridge personnel may not have worked together previously. The form, format, and location of available maneuvering and navigation information is often generic and different, and there is no tactile "feel" of the ship beneath your feet and the environmental conditions projected on to the screens.

To address these concerns, initial scenarios were designed to allow for the participants to gain simulator familiarization; simulation (un)realities were kept simple, with no edge-of-comfort-zone environmental conditions or traffic, etc. Additionally, simulation time was allocated to allow participants to become familiar with their roles, the roles of the other "bridge team" personnel, and the expectations of the Committee.

Each simulation was preceded by a Master-Pilot Exchange (MPx) (Image 7) to verbally define the expectations of the participants and the roles they would be filling, the geographical area of the simulation, an overview of a basic "voyage plan", and the forecast environmental conditions. The MPx included (at a minimum) identification of planned speed changes, anticipated traffic, exchange of conn (as applicable), and maneuvering status changes.

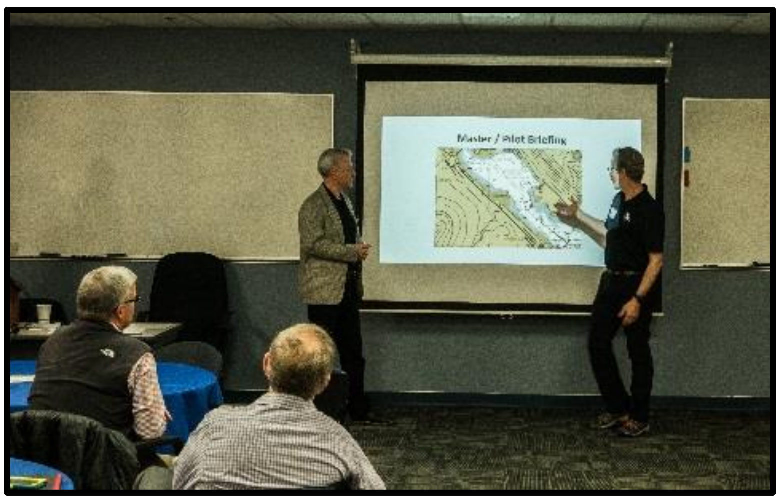


Image 7. Master - Pilot Exchange

Tools, Techniques, and Data Sources. The Committee used jointly-developed tools and techniques (agreed upon prior to simulation) to collect data and assess risks and corresponding EOCZ, trigger points, etc. during simulation. Tools and techniques used to measure and record risk included:

- **Maneuvering Risk:** A senior pilot member of the Committee, present on the bridge, applied his professional judgment by recording observations on: vessel control, intention vs. execution (based on voyage planning during the master/pilot briefing), stress levels, task difficulty, and safety margins (Figure 3).

OBSERVER RECORD - MANEUVERS & TRANSITS				Run #:_________
SIMULATION SCENARIO:	Exercise: Juneau Docking AJD			
SCENARIO CONDITIONS:	WIND	CURRENT	TRAFFIC	OTHER
	ROCK DUMP TO LAWSON CK	TURN IN JUNEAU HBR	MANEUVER TO BERTH	
INTENTION V. EXECUTION				
PLAN EXECUTION/CPA'S?	1 2 3 4 NOT CLOSE CLOSE	1 2 3 4 NOT CLOSE CLOSE	1 2 3 4 NOT CLOSE CLOSE	1 2 3 4 NOT CLOSE CLOSE
VESSEL CONTROL				
UNINTENDED VESSEL MOVEMENT	1 2 3 4 MARGINAL OK	1 2 3 4 MARGINAL OK	1 2 3 4 MARGINAL OK	1 2 3 4 MARGINAL OK
STRESS LEVELS				
BODY LANGUAGE, COMMUNICATIONS - CLEAR, CONCISE, CONSISTENT?	1 2 3 4 HIGH LOW	1 2 3 4 HIGH LOW	1 2 3 4 HIGH LOW	1 2 3 4 HIGH LOW
TASK DIFFICULTY				
ALLOW EXP/INEXP/MATE/TRAINEE?	1 2 3 4 HARD EASY	1 2 3 4 HARD EASY	1 2 3 4 HARD EASY	1 2 3 4 HARD EASY
SAFETY MARGIN				
SPEED, RPM'S, RUDDER RESERVE?	1 2 3 4 LOW HIGH	1 2 3 4 LOW HIGH	1 2 3 4 LOW HIGH	1 2 3 4 LOW HIGH
OVERALL				
DO AGAIN/DIFFERENT?	1 2 3 4 NO GO ACCEPTABLE	1 2 3 4 NO GO ACCEPTABLE	1 2 3 4 NO GO ACCEPTABLE	1 2 3 4 NO GO ACCEPTABLE
VLCS OBSERVER COMMENTS (ALL COMMENTS OF A 1 OR 4 REQUIRE COMMENT - USE REVERSE FOR ADDITIONAL COMMENTS):				
				VLCS Scenario Observer Form 12.2017

Figure 3. Observer Record Form

- **Navigation Risk:** A second Committee member, working in coordination with the simulator operator in the control room, referenced PMI's Transas simulator and a SEAiq® Portable Pilot Unit (PPU) to conduct risk assessment by comparing simulation results with pre-determined risk assessment limits of: RPMs, azipod use, bow thruster and tug use, ship's speed, drift angles, rates of turn, approach angles to/from the berth, CPAs to fixed and floating hazards, and swept path (Figure 4).

RISK ASSESSMENT RECORD				Run #:________
SIMULATION SCENARIO:	Exercise: Juneau Docking AJD			
SCENARIO CONDITIONS:	WIND	CURRENT	TRAFFIC	OTHER

	POWER RESERVE - CONTROL INPUTS: AMOUNT / FREQUENCY / DURATION			
1. MANEUVERING RISK	ROCK DUMP TO LAWSON CK	TURN IN JUNEAU HBR	MANEUVER TO/FM BERTH	OVERALL
Internal — A. Azipod RPMs:				
RPM/% in Reserve	RPMs > 60 > 2 MIN	RPMs >60 > 5 MIN	RPMs > 60 >5 MIN	RPMs >80
B. Azipod Mode/Orientations:				
Xfer to Aziman/Pod Use				
C. Bow Thruster/Tug Use:				
Amount in Reserve	B/T > 50% >5 Min	B/T > 80% >10 Min	B/T > 80% >15 Min	B/T >80% >50% of Time
	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
MANEUVERING RISK SCORING:	HIGH LOW	HIGH LOW	HIGH LOW	HIGH LOW

	NAVIGATION MARGINS - SPEED / DISTANCE / ASPECT IN RELATION TO HAZARDS			
2. NAVIGATION RISK	ROCK DUMP TO LAWSON CK	TURN IN JUNEAU HBR	MANEUVER TO/FM BERTH	OVERALL
External — A. Speed Through the Water:				
VWG/HBR Rules	> 8 KTS (EOCZ)	> 6 KTS	SOG >5 KTS @ 2 SL	
B. Crab Angle:				
	> 6°			
C. Approach Angle to Berth:				
	n/a	n/a	> 20°	
D. Rate of Turn (Speed of Bow and Stern):				
	> 20o	< 20o	n/a	
E. CPA to Fixed Hazards:				
	EOCZ 10m <100m	EOCZ <30m Lawson CK	EOCZ <20m LB2A / <30m CT	
F. CPA to Floating Hazards (e.g. Buoys):				
	< 30 m	< 20m LB2A	< 20 m to F/V's	
	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
NAVIGATION RISK SCORING:	HIGH LOW	HIGH LOW	HIGH LOW	HIGH LOW

VLCS OBSERVER COMMENTS (ALL RATINGS OF 1 OR 4 REQUIRE COMMENT - USE REVERSE FOR ADDITIONAL COMMENTS):

VLCS RISK ASSESSMENT FORM 12.2017

Figure 4. Risk Assessment Record

- **Human Factors Risk**: After simulation, a third Committee member conducted separate, individual de-briefings of the master and pilot to collect their individual perceptions of: intention vs. execution, safety reserves, comfort levels, and vessel control (Figure 5).

VLCS PILOT / MASTER DE-BRIEF FORM (circle one)				Run #:_________
SIMULATION SCENARIO:	Exercise: Juneau Docking AJD			
SCENARIO CONDITIONS:	WIND	CURRENT	TRAFFIC	OTHER
	ROCK DUMP TO LAWSON CK	TURN IN JUNEAU HBR	MANEUVER TO BERTH	
1. On a scale of 1 to 4, with 1 being not close to plan and 4 being as planned (WHOLE NUMBERS ONLY), was the maneuver executed as planned?				
INTENTION V. EXECUTION				
TRACK DEVIATION / SPEEDS / SPEED CHANGES	1 2 3 4 NOT CLOSE ↔ CLOSE	1 2 3 4 NOT CLOSE ↔ CLOSE	1 2 3 4 NOT CLOSE ↔ CLOSE	1 2 3 4 NOT CLOSE ↔ CLOSE
2. On a scale of 1 to 4 with 1 being no safety reserve and 4 being high safety reserve, how would you rate the amount of safety reserve throughout the maneuver? Did you retain a safe margin of power? Did you ever use full power?				
SAFETY RESERVE				
RUDDER, ENGINE, B/T, TUG USE	1 2 3 4 LOW ↔ HIGH	1 2 3 4 LOW ↔ HIGH	1 2 3 4 LOW ↔ HIGH	1 2 3 4 LOW ↔ HIGH
3. How comfortable was this maneuver? Was CPA to hazards/tfc acceptable? Would you feel comfortable with any of the following performing this maneuver: Senior - Experienced?, Mid-Level? Junior?				
COMFORT LEVELS				
CRAB ANGLE, SWEPTH PATH, CPA TO FIXED/FLOATING OBJECTS	1 2 3 4 LOW ↔ HIGH	1 2 3 4 LOW ↔ HIGH	1 2 3 4 LOW ↔ HIGH	1 2 3 4 LOW ↔ HIGH
4. On a scale of 1 to 4 with 1 being marginal control and 4 being acceptable control, how would you rate the vessel control during this maneuver? Was the drift angle excessive? Was the ship's speed excessive? Bow and Stern speed? Swing Control? Why?				
VESSEL CONTROL				
UNINTENDED EXTREME VESSEL MOVEMENT?	1 2 3 4 MARGINAL ↔ OK	1 2 3 4 MARGINAL ↔ OK	1 2 3 4 MARGINAL ↔ OK	1 2 3 4 MARGINAL ↔ OK
5. On a scale of 1 to 4 with 1 being unsafe and 4 being very safe, overall would you perform this maneuver in real life? What would you have done different?				
OVERALL				
WOULD YOU DO IT AGAIN/DIFFERENT?	1 2 3 4 UNSAFE ↔ SAFE	1 2 3 4 UNSAFE ↔ SAFE	1 2 3 4 UNSAFE ↔ SAFE	1 2 3 4 UNSAFE ↔ SAFE
DE-BRIEFER COMMENTS (ALL COMMENTS OF A 1 OR 4 REQUIRE COMMENT - USE REVERSE FOR ADDITIONAL COMMENTS):				
				VLCS DE-BRIEF FORM 12.2017

Figure 5. Pilot / Master De-brief Form

- **VLCS Committee Overall Risk:** A fourth Committee member functioned as the overall manager for the simulations. The Manager coordinated with all participants regarding their roles and responsibilities and to confirm performance and worked closely with the Simulator Operator to ensure that all required actions, scenario inputs/conditions, and elements of the Simulation Run Matrix were accomplished, as intended. In addition, the Manager monitored, adjusted as necessary, and updated the daily schedule. At the conclusion of each simulation, the risk assessment forms were collected, reviewed for correlation, and disparities were noted for the Committee to review and de-conflict into a summary of risk assessment; resulting in an overall risk assessment (Figure 6).

VLCS SUMMARY RISK ASSESSMENT FORM				RUN #:__________
SIMULATION SCENARIO:	Exercise: Juneau Docking AJD			RUN NR: __________
SCENARIO CONDITIONS:	WIND	CURRENT	TRAFFIC	OTHER
AREAS:	ROCK DUMP TO LAWSON CK	TURN IN JUNEAU HBR	MANEUVER TO BERTH	OVERALL
OBSERVER RATINGS				
INTENTION V. EXECUTION	1 2 3 4 (NOT CLOSE – CLOSE)	1 2 3 4 (NOT CLOSE – CLOSE)	1 2 3 4 (NOT CLOSE – CLOSE)	1 2 3 4 (NOT CLOSE – CLOSE)
VESSEL CONTROL	1 2 3 4 (MARGINAL – OK)	1 2 3 4 (MARGINAL – OK)	1 2 3 4 (MARGINAL – OK)	1 2 3 4 (MARGINAL – OK)
STRESS LEVELS	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)
TASK DIFFICULTY	1 2 3 4 (HARD – EASY)	1 2 3 4 (HARD – EASY)	1 2 3 4 (HARD – EASY)	1 2 3 4 (HARD – EASY)
SAFETY MARGIN	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)
OVERALL	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)
RISK ASSESSOR RATINGS				
MANEUVERING RISK	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)
NAVIGATION RISK	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)	1 2 3 4 (HIGH – LOW)
OVERALL	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)
DE-BRIEFER RATINGS				
INTENTION V. EXECUTION	1 2 3 4 (NOT CLOSE – CLOSE)	1 2 3 4 (NOT CLOSE – CLOSE)	1 2 3 4 (NOT CLOSE – CLOSE)	1 2 3 4 (NOT CLOSE – CLOSE)
SAFETY RESERVE	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)
COMFORT LEVELS	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)	1 2 3 4 (LOW – HIGH)
VESSEL CONTROL	1 2 3 4 (MARGINAL – OK)	1 2 3 4 (MARGINAL – OK)	1 2 3 4 (MARGINAL – OK)	1 2 3 4 (MARGINAL – OK)
OVERALL	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)
VLCS COMMITTEE RISK ASSESSMENT				
OVERALL	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)	1 2 3 4 (NO GO – ACCEPTABLE)
VLCS COMMITTEE COMMENTS (USE REVERSE FOR ADDITIONAL COMMENTS):				

VLCS Summary Risk Assessment Form 12.13.2017

Figure 6. Summary Risk Assessment Form

- **Video Recording:** A GoPro® camera recorded status panel readouts of: local- and simulator time, azipod angles and RPMs, heading, rate-of-turn, Doppler log data, and relative wind (Image 8).

Image 8. Photographic capture of a Status Panel

- **Scenario Recording:** The SEAiq® piloting software, on an iPad PPU, was used to record each scenario. SEAiq® provided the ability to record rate of turn, heading, course over ground, speed over ground, cross track error, local time, vessel motion, and rudder angle; while offering swept path (effective beam) and CPAs (to hazards) for measurement. The SEAiq® recordings allowed for playback of simulations for later reference (Image 9).

Image 9. Screenshot of data collection with SEAiq

- **PMI Transas Simulator Data Recording.** PMI's simulator operator saved data from each scenario in Excel format. Data recorded included: time, azipod (rudder) angles, azipod thrust (in percentage and RPMs), bow thruster thrust, course, heading, speed over ground, speed through the water, wind direction and speed, and current direction and speed (Figure 7).

Run Number:	**2-A-6-12**														
Area:	Ketchikan6_PMI														
Exercise:	03+04 Ketchikan East Channel SW														
Ship:	Norweigan Bliss														
Date:	12-Dec-18														
Run Start	9:46														
Run Finish	10:09														
	Port Azipod Angle	**Stbd Azipod Angle**	**Port Azipod Thrust**	**Stbd Azipod Thrust**	**Port Azipod RPM**	**Starboard Azipod RPM**	**Bow thruster Thrust**	**Ship's Course**	**Ship's Heading**	**SOG**	**STW**	**True wind**	**True wind speed**	**Current direction**	**Current speed**
Units	**(degrees)**	**(degrees)**	**(%)**	**(%)**	**RPMs**	**RPMs**	**(%)**	**(degrees)**	**(degrees)**	**(knots)**	**(knots)**	**(degrees)**	**(knots)**	**(degrees)**	**(knots)**
Simulator Time:															
12:20:07	7	7	50	50	73	73	0	-49.3	310.7	10.9	10.9	200	30	0	0

Figure 7. Transas Simulator Recorded Data.

- **PMI Transas Simulator Screenshots.** The simulator operator also saved screenshots of critical areas of interest (Image 10).

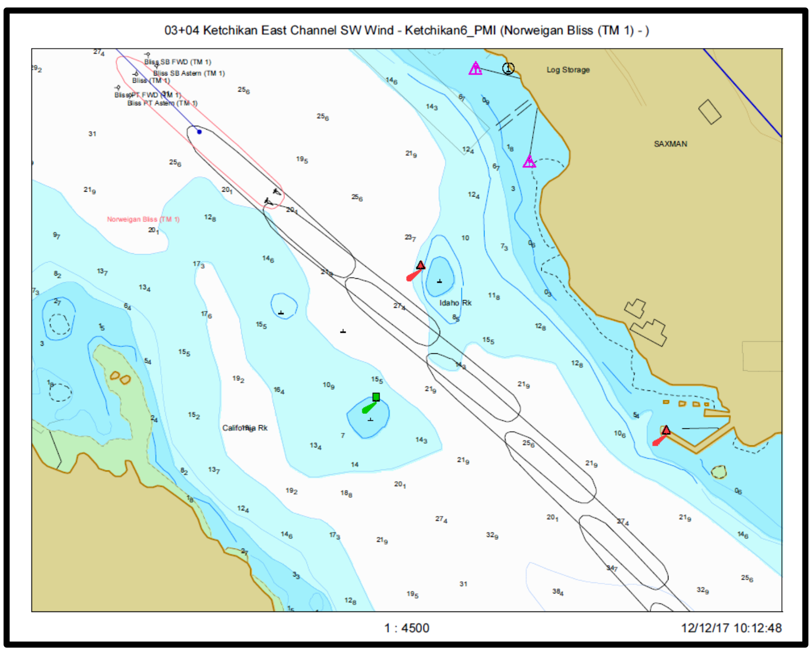


Image 10. California and Idaho Rocks

- **Data Analysis.** The tools listed above, in conjunction with PMI's Transas simulator data recordings, allowed for further analysis to confirm observations and correlations between the tools and data sources.

  For example, in the scenario illustrated below, as the ship approached Juneau's AJD Berth (Image 11) in 30 knots of SE winds with maximum flood current (from the SE), the bow thruster was used at greater than 80% power (up to 100%), for greater than 70% of the time for the final approach (Figure 8).

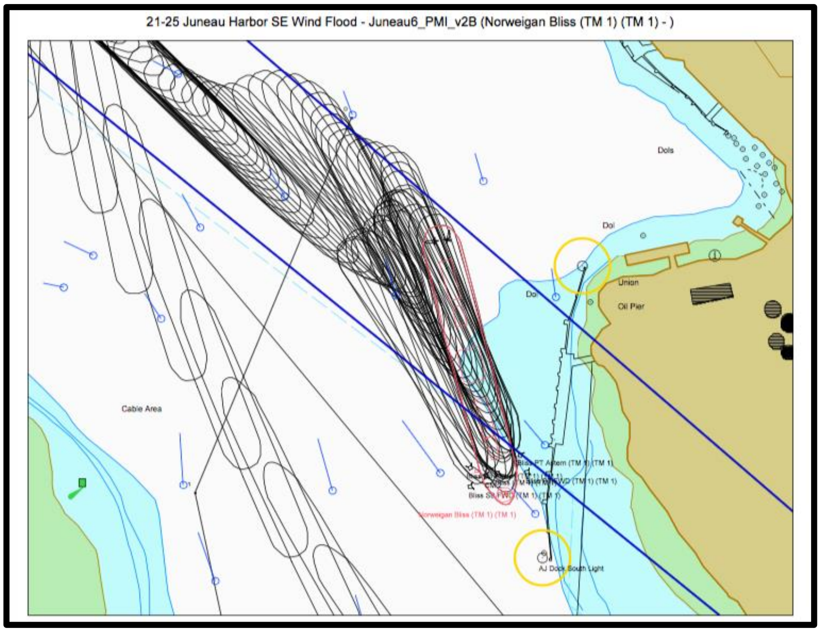


Image 11. Approach to Juneau's AJD Berth

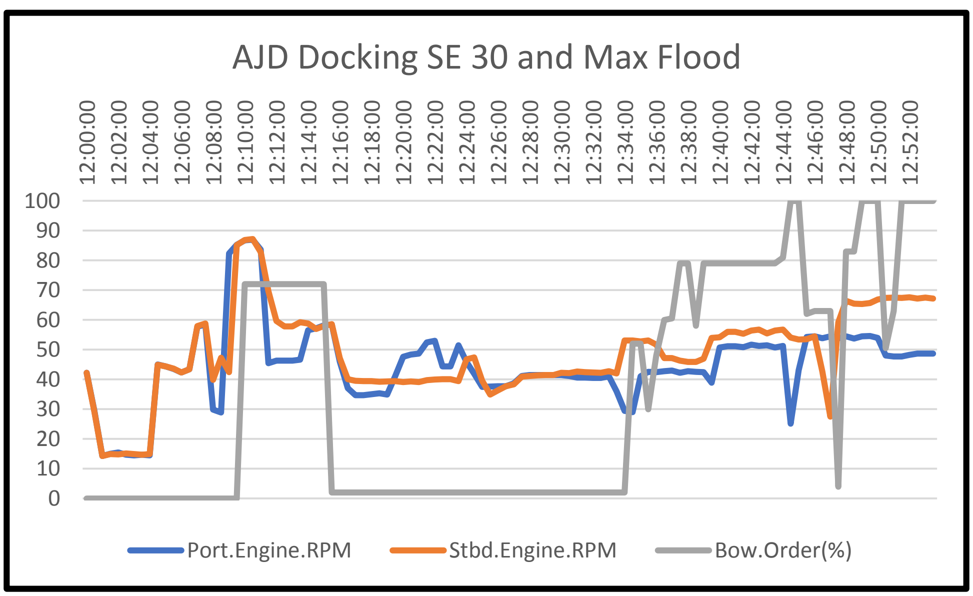


Figure 8. Analysis of simulator recorded data for approach to Juneau's AJD Berth

Open House

On the last day of simulation, the Committee and PMI hosted an Open House for industry stakeholders to provide a demonstration of a simulation scenario (Image 12) and a briefing of the risk-assessment and data-gathering process. The get-together concluded with a round-table discussion of the process and the draft, season-start guidelines for the *Norwegian Bliss* (Table 1).

Image 12. Simulation demonstration

Attendees to the Open House included: the USCG COTP for Juneau, the USCG COTP for Seattle, the USCG Deputy Sector Commander for LA / Long Beach, the Executive Director of the Marine Exchange of Alaska, representatives of multiple cruise companies, the American Pilots' Association, and West Coast Pilot groups (Image 13).

Image 13. Open House discussion

The round-table discussion included dialogue on broader scopes of risk assessment to include port infrastructure, local and standby resources; comparative guidelines from other operating areas; verbal endorsements of this study and process; and a commitment by NCL and Royal Caribbean Cruise Lines (RCCL) to attend an end-of-season debrief session to review lessons learned and revisit the safe operational guidelines.

The *VLCS Norwegian Bliss*

Dimensions

At the time of this publication, the VLCS *Norwegian Bliss* is in sea trials; she is 168,028 GT, 1094 feet (333 m) in length, 136 feet (41.4 m) in beam, and has an approximate sail area of 162,782 square feet (15,123 sq. m) (Images 14 and 15).

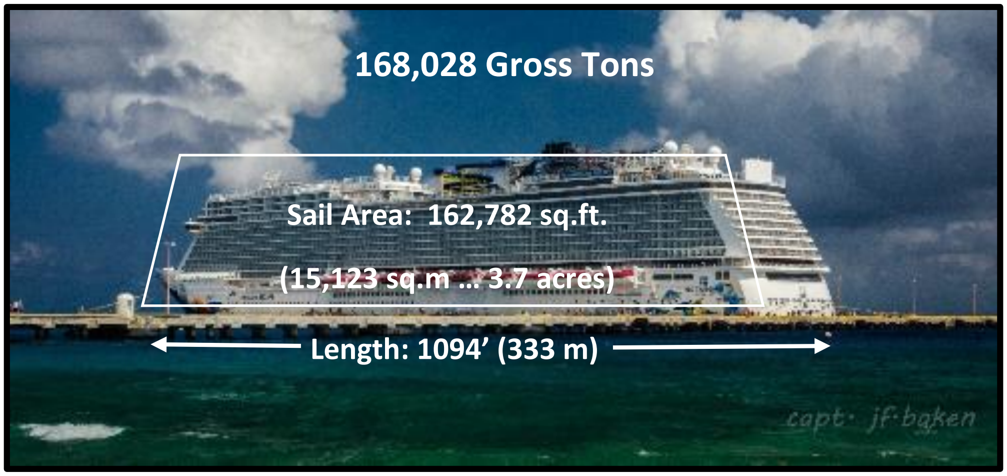


Image 14. Sail area for VLCS Norwegian Bliss (sister ship Norwegian Escape shown)

Image 15. Beam for VLCS Norwegian Bliss (sister ship Norwegian Escape shown)

Propulsion

The *Norwegian Bliss* is powered by five diesel electric engines with apropulsion output of 44,000 KW (59,005 HP), powering twin ABB azipods, each with a propulsive force of 22 MW (29,503 HP) in Open Sea Mode, and 11 MW (14,751 HP) in Aziman Mode (Image 16). The propellers are fixed pitch and 5.9 m in diameter. The *Bliss* is equipped with three, 3500 KW (each) bow thrusters for a total output of 10,500 KW (14,081 HP).

Image 16. VLCS Norwegian Bliss twin azipod propulsion (sister ship Norwegian Escape shown)

Simulation Highlights

Run Matrix

The following scenarios were simulated on December 11-15, 2017:

NORWEGIAN BLISS SCENARIOS RUN RECORD - DEC. 11-15, 2017						
RUN NUMBER Day#-Area-Run#-Cum#	✓	WATERWAY / PORT	MANEUVER / DIRECTION	INITIAL CONDITIONS		REMARKS
				CURRENT	WIND	
Monday: Day One						
1-A-1-1	✓	East Channel Transit	Inbound		SE 20 KTS	Transit Mtn Pt through CA/ID with strong SE wind - NO CURRENT.
1-A-2-2	✓	East Channel Transit	Inbound		SE 30 KTS	Transit Mtn Pt through CA/ID with strong SE wind.
1-A-3-3	✓	East Channel Transit	Inbound		SE 40 KTS	Transit Mtn Pt through CA/ID with strong SE wind. FAILED APPROACH...ABORT.
1-C-1-4	✓	Ketchikan Berth 3	Docking		SE 25 KTS	Docking with strong SE wind - NO CURRENT.
1-C-2-5	✓	Ketchikan Berth 3	Docking		SE 35 KTS	Docking with strong SE wind - NO CURRENT.
1-CB-1-6	✓	Ketchikan Berth 3 / East Channel Transit	Undocking / Transit		WNW 35 KTS	Undocking & transit with strong WNW wind - NO CURRENT.
1-F-2-8	✓	Juneau AJD	Docking - PST		SE 30 KTS	Docking with strong SE wind - NO CURRENT. RE-RUN.
1-F-3-9	✓	Juneau AJD	Docking - PST	Max Flood	SE 20 KTS	Docking with strong SE wind - AND MAX FLOOD CURRENT.
Tuesday: Day Two						
2-A-4-10	✓	East Channel Transit	Inbound		SE 40 KTS	Transit Mtn Pt through CA/ID with strong SE wind. RE-RUN.
2-A-5-11	✓	East Channel Transit	Inbound	Max Flood	SE 30 KTS	Transit Mtn Pt through CA/ID with strong SE wind ADDING STRONG FLOOD CURRENT.
2-A-6-12	✓	East Channel Transit	Inbound		SW 30 KTS	Transit Mtn Pt through CA/ID with strong SW wind - NO CURRENT.
2-F-4-13	✓	Juneau AJD	Undocking - PST	Max Flood	SE 30 KTS	Undocking with strong SE wind - ADDING STRONG FLOOD CURRENT.
2-F-5-14	✓	Juneau AJD	Docking - PST	Max Flood	SE 30 KTS	Docking with strong SE wind - AND MAX FLOOD CURRENT.
2-F-6-15	✓	Juneau AJD	Undocking - PST	Max Ebb	WNW 30 KTS	Undocking with strong WNW wind - ADDING STRONG EBB CURRENT.
2-CB-2-16	✓	Ketchikan Berth 3 / East Channel Transit	Undocking / Transit		WNW 30 KTS	Undocking & transit with strong WNW wind - NO CURRENT.
2-D-1-17	✓	Tracy Arm Entrance	Inbound	Max Ebb		Light Ice on the bar and the approach - STRONG EBB CURRENT.
2-E-1-18	✓	Tracy Arm S-Turn	Inbound	Max Ebb	SE 20 KTS	Transit with strong SE wind and LIGHT ice - MAX EBB CURRENT
2-E-2-19	✓	Tracy Arm S-Turn	Outbound	Max Ebb	SE 30 KTS	Transit with strong SE wind and LIGHT ice - ADDING STRONG EBB CURRENT.
Wednesday: Day Three						
3-H-1-20	✓	Tongass Narrows Transit	Southbound		WNW 30 KTS	Transit Rosa Rf to south of the airport/drydock strong WNW wind -
3-CB-3-21	✓	Ketchikan Berth 3 / East Channel Transit	Northbound	Max Flood	WNW 30 KTS	Transit to north of the airport/drydock strong SE wind from KTN HBR - ADDING STRONG FLOOD CURRENT. PLACE SHIP/BARGE AT DD.
3-D-2-22	✓	Tracy Arm Entrance	Inbound	Max Ebb		Light Ice on the bar and the approach - STRONG EBB CURRENT.
3-D-3-23	✓	Tracy Arm Entrance	Outbound	Max Ebb		Light Ice on the bar and the approach - STRONG ebb CURRENT AT LOW TIDE.
3-D-4-24	✓	Tracy Arm Entrance	Outbound	Max Ebb		Light Ice on the bar and the approach - STRONG EBB CURRENT.
3-D-5-25	✓	Tracy Arm Entrance	Inbound	Max Ebb		Light Ice on the bar and the approach - STRONG EBB CURRENT.
3-G-1-26	✓	Skagway Railroad Aft	Docking - SST		SSW 35 KTS	Docking strong SSW wind - NO CURENT.
3-G-2-27	✓	Skagway Railroad Aft	Docking - SST		SSW 35 KTS	Docking strong SSW wind - NO CURRENT. TUG AVAILABLE, USING AZIPOD COMMANDS
3-G-3-28	✓	Skagway Railroad Aft	Undocking - SST		SSW 35 KTS	Undocking strong SSW wind - NO CURRENT. TUG AVAILABLE, USING AZIPOD COMMANDS
Thursday: Day Four						
4-F-7-29	✓	Juneau AJD	Docking - PST	Max Flood	SE 30 KTS	Docking with strong SE wind - AND MAX FLOOD CURRENT with Tug
4-F-8-30	✓	Juneau AJD	Undocking - PST	Max Ebb	WNW 35 KTS	Undocking with strong WNW wind - ADDING STRONG FLOOD CURRENT, w/ Tug
4-CB-3-31	✓	Ketchikan Berth 3 N/B with Transit	Undocking/Transit	1 kt Flood	SE 25 KTS	Undocking with strong SE wind - 1 kt of CURRENT.
4-CA-1-32	✓	Ketchikan Berth 3 S/B with Transit	Undocking/Transit	1 kt Ebb	SSW 25 KTS	Docking with strong SSW wind - 1 kt of CURRENT w/ traffic
4-A-7-33	✓	East Channel Transit	Inbound	1 kt Flood	SE 20 KTS	Transit Mtn Pt through CA/ID with strong SE wind ADDING STRONG FLOOD CURRENT.
4-F-9-34	✓	Juneau AJD	Docking - PST	1 kt Flood	SE 20 KTS	Docking with strong SE wind - AND 1KT FLOOD CURRENT, w tug
Thursday: Day Five						
5-F-10-35	✓	Juneau AJD	Docking - PST	1 kt Flood	SE 20 KTS	Docking with strong SE wind - AND 1KT FLOOD CURRENT, w tug. DEMONSTRATION FOR OPEN HOUSE
Total Simulations:	34					

Table 2. List of Scenarios

Example Concerns

Swept Path.

As mentioned above, the large outline of the *Norwegian Bliss*'s swept path proved to be a concern. Multiple simulations were conducted in winds of 20 to 40 knots, subsequently adding characteristic tidal current maximums for each area (for example, up to 6 knots was used at Tracy Arm Bar). The intent of testing was to identify the environmental and operational parameters above which drift angles and swept path (effective beam) became problematic.

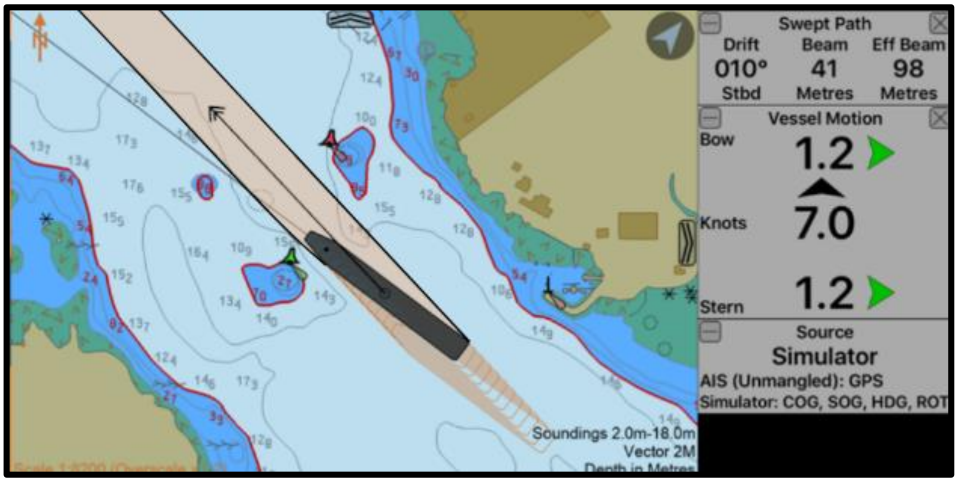


Image 17. Illustration of Swept Path

Images 17 and 18 illustrate a problematic swept path of 10 degrees (100 m effective beam) in the California Rock / Idaho Rocks area of Tongass Narrows East Channel where the channel is 150 m wide, allowing for 55 m of safe space on both sides of a ship (with a 41 m beam) and the edges of the channel. However, when a crossing wind requires a 10° drift angle, with a 98 m swept path, that space is reduced to a problematic 26 m of space on both sides (assuming the ship is passing through the exact center of the channel).

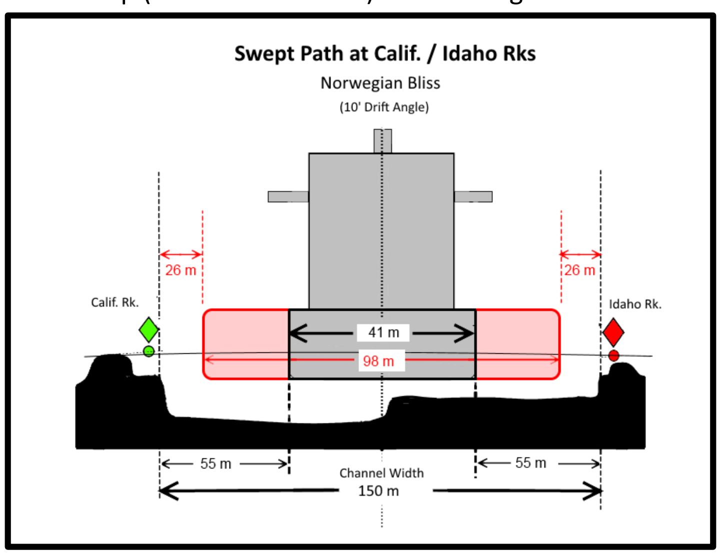


Image 18. Cross section at California and Idaho Rocks

Areas Tested: Individual Berths and Waterways. The most unfavorable (and common) wind and current conditions were tested in seven critical areas (based on the 2018 itinerary of the *Norwegian Bliss*): Tongass Narrows East Channel (from Spire Island Reef to north of California- and Idaho Rocks), Ketchikan's Berth 3, North Tongass Narrows (from Berth 3 to north of the airport/dry dock area), Tracy Arm Bar, the 'S' Turns in Tracy Arm, Juneau's AJD berth, and Skagway's RRA berth (Images 19 - 26).

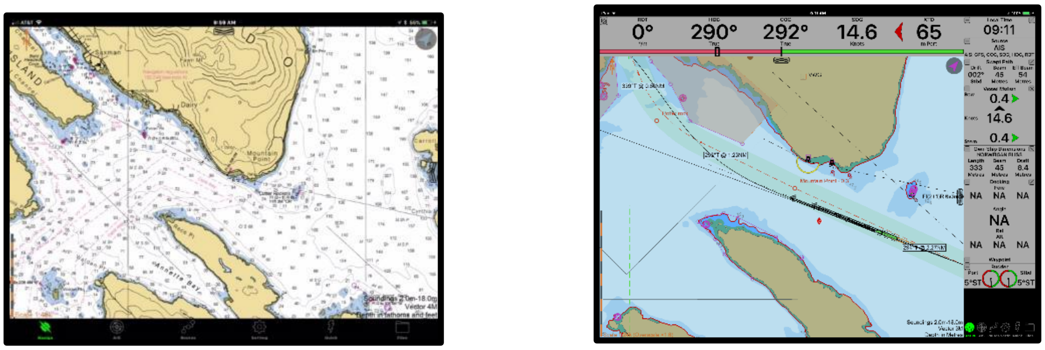


Image 19. Tongass Narrows East Channel

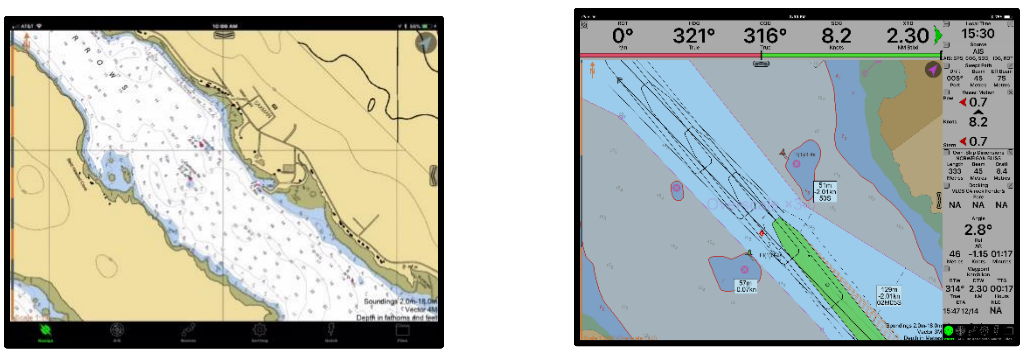


Image 20. Tongass Narrows East Channel at California / Idaho Rocks

Image 21. Ketchikan Berth 3

Image 22. Tongass Narrows at the Airport

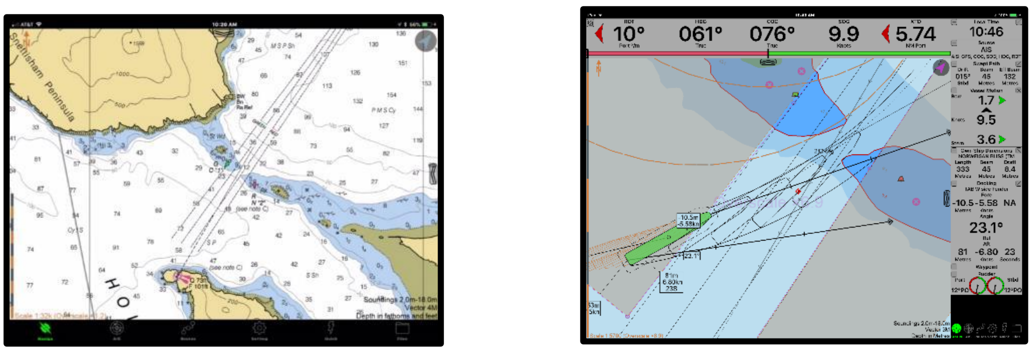


Image 23. Tracy Arm Bar

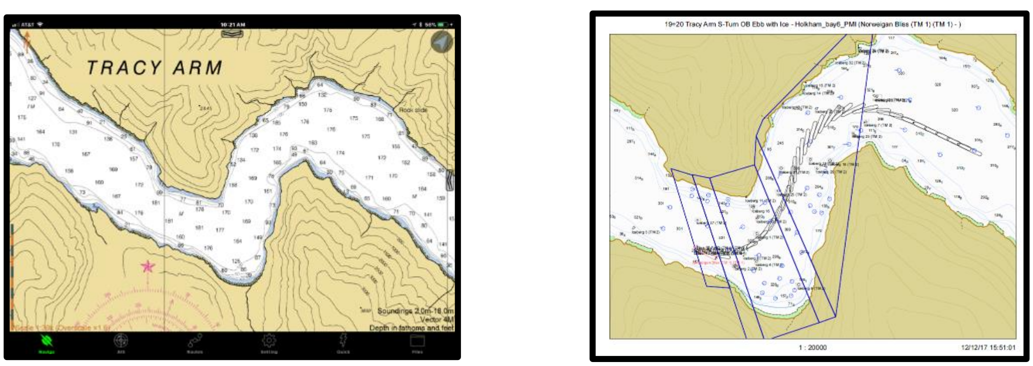


Image 24. Tracy Arm 'S' Turns

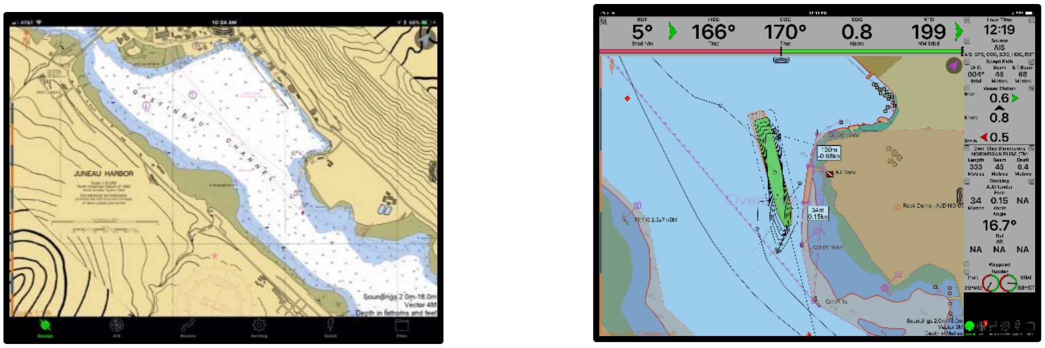


Image 25. Juneau AJD Berth

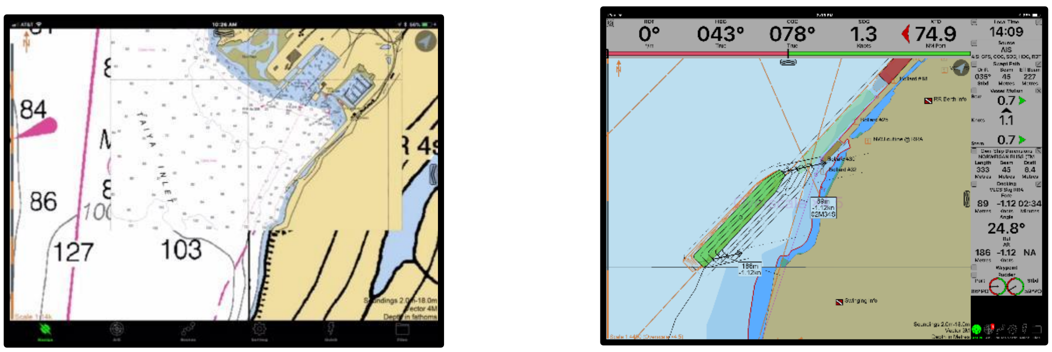


Image 26. Skagway RRA Berth

Summary and Lessons Learned

This study was not undertaken with preconceived port guidelines or vessel operating limitations in mind. The intent was to bring maritime professionals (both industry and pilots) together and, through the use of realistic simulations, formulate risk assessments and guidelines based on a reliable process. The mariners' input, coupled with an honest dialogue, were influential elements in this study. The simulations and the attendant observational data on risk assessment forms, video records, navigation playback records, and tabular data served as references and documentation to verify the process.

Significant effort was expended to eliminate bias, articulate risk, and establish a process for future cooperation. Spin-off benefits included insights into the different participants' operating perspectives and improved cooperation between industry and pilots.

The joint sponsorship and manufacture of a new *Norwegian Bliss* visual and hydrodynamic model was integral to the accuracy of the study.

The introduction and use of a clear, concise, and consistent command syntax for Azipod maneuvering commands was successfully exercised throughout the simulations.

This effort involved over 5000 man-hours and was a challenge to self-administer, particularly in the limited window of opportunity prior to the deployment of the *Norwegian Bliss* in 2018.

Southeast Alaska's waterways are characterized by large tidal ranges; extreme water movement; asymmetrical channels with hard bottoms; high winds; and very limited, real-time hydro-meteorological data. As ships continue to increase in size and, given the complexities of the operating environment, the margin for error may be reduced significantly. Therefore, the need for better real-time wind- and tidal-current data is increasing, as well. Additionally, feedback and sharing of experiences between masters and pilots of these large ships will take on even greater importance.

The Committee recommendation that the *Norwegian Bliss* not schedule, or transit, Tracy Arm is in keeping with the current Wilderness Best Practices Management Agreement (U.S.Forest.Service, 2017) which allows for visits to Endicott Arm when safety limits operations elsewhere. Accordingly, this study's conclusion, that it is unsafe for the *Norwegian Bliss* to operate in Tracy Arm, under any conditions, is consistent with the agreement that the ship operate in Endicott Arm for 2018.

Feedback during the Open House discussion questioned the scope of this risk assessment (specifically beyond navigational risk), with suggestions for follow-on studies of risk to include risks to port infrastructure and resource availability.

One objective of this study was not met; that was, to identify appropriate pilot training for VLCS vessels. However, as of the date of this publication, two manned-model azipod courses have been conducted at the Maritime Pilots Institute (MPI) in Covington, LA; and two follow-on pilot training courses have been conducted at PMI, using the *Norwegian Bliss* model. Additional efforts have been successful in securing the transfer of the *Norwegian Bliss* model to an Alaskan-based simulator for pilot training.

Acknowledgements

The Committee would like to thank the following individuals and organizations for their support in the form of time, efforts, and resources to make this study possible: Captain's Frank Didier, Lew Picton, Michael Clinkscales, Greg Styrk, Jill Russell, Chad Clapp, Jake Baken, Marienus Hazelman, Christine Klimkowski, and Colby Grobschmidt; Norwegian Cruise Line; Captains Niklas Perrson and Konstantinos Gkokas and the crew of the *Norwegian Escape*; Mark Hayden of SEAiq; Captain Jorge Viso and the American Pilots Association; the Biscayne Bay Pilots; the Port Everglades Pilot Association; the San Francisco Bar Pilots; the Hawaii Pilots Association; the Puget Sound Pilots; and the British Columbia Coast Pilots.

Many thanks to the staff of the Pacific Maritime Institute for a job well done.

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