Weather routeing: 
minimising the risk of 
containers overboard

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Panellist documents

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Page 21: Henry Chen, B2B7CS, LLC
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WEATHER ROUTEING: PREVENTING LOSS OF CONTAINERS

ALEXANDER OZERSKY
From unconnected traditional sails to data-driven intelligent ships and ports that make voyages safer, greener and more efficient: Wärtsilä Voyage is on a mission to build a Smart Marine Ecosystem. We combine hard- and software solutions to optimise the entire lifecycle of marine operations. Our technology is futuristic, but it is targeted to solve today’s shipping challenges. Be it energy efficiency, operational efficacy, decarbonisation or navigational safety – we are constantly researching, developing and investing in a wide range of products and solutions that help our partners and clients achieve their goals in every part of the world and oceans. With over 100 years of experience and one the broadest portfolio in the market, we are ready to build the future.

TECHNOLOGY SOLUTIONS. FOR A SAFER, GREENER AND MORE EFFICIENT MARINE INDUSTRY.
WEATHER ROUTING AND STAGES OF VOYAGE

Planning and loading → Execution → Post-voyage analysis → Long-term actions

Re-planning
ANATOMY OF AN INCIDENT

ERRORS

Training  Tools  Policies and procedures  Planning  Operation

INCIDENT
WEATHER ROUTING IN FLEET OPERATIONS SOLUTION (FOS)
TRACKING AND AWARENESS MODULE IN FOS

Strong wind forecasted when vessel is at anchor:
- Wind greater than 50 knots is forecasted within next 48 hours, and the vessel is at anchor.
- The weather plan is not yet updated, and there are no safety measures in place.

Approaching high-risk areas:
- In approximately 12 hours, the vessel is entering a high-risk area. Notice the area's identification and take necessary safety measures.

Vessel at anchor in a high-risk area:
- Monitor the weather conditions closely and implement safety measures as per the weather plan.
SIMULATION MODULE

17 dg roll
TAKEAWAYS

Voyage planning and execution is continuous and multi-role activity

Weather routing is needed before, during and after the voyage

Good tools provide more layers of defense against incidents
STAY IN TOUCH
Follow us and get updates delivered to your favorite social media channels.
wartsila.com/voyage
Protecting the oceans, navigation and improving the supply chain.

COBS
Container Overboard System
The Problem

According to the World Shipping Council (WSC), an average of 1,500 containers are lost at sea every year (est.).

- 3,000 boxes dropped into the sea last year, and more than 1,000 have fallen overboard so far in 2021.
The Problem

➢ Supply Chain
Loss of containers does not only affect shipowners, but many other stakeholders in the supply chain, creating a web of mixed liabilities

➢ Navigation Safety
Floating containers represent a collision risk for vessels, as they tend to float right beneath the surface of the sea.

➢ Environmental
Losing a single container may seem ‘harmless. However, when hundreds (if not thousands) break apart or start to sink, they become a significant source of pollution for deep-sea ecosystems.
Product

IMO’s Maritime Safety Committee 103rd session (May 2021)

“Development of measures regarding the detection and mandatory reporting of containers lost at sea that may enhance the positioning, tracking and recovery of such containers”.

- First real scenario prototype end of 2021
- Public organisms and private support
- Inflatable system patent under study
Improper loading and unloading of containers: wrong lashing equipment, misuse or unsuitability of twist-locks, poor quality of the container itself…

Non-compliance with international conventions, container guidelines and practice standards, such as the ship’s Cargo Securing Manual (CSM) or the stowage plan

Failure to accurately declare the container’s weight (VGM), whether it comes from grounds of negligence or wilful misconduct, resulting in incorrect stowage

Improper stuffing of goods inside containers, causing them to shift during transport and destabilize the vessel

Extreme weather conditions can worsen the ship’s parametric rolling and pitching, thereby increasing the likelihood of containers falling overboard
ULCS upright equilibrium position period vs wave period, resulting in rolling resonance, causing extreme heeling angles combined with high accelerations and forces due to high ship stability.

Heave within swallow waters, so ULCSs can touch seabed, causing high shocks and vibrations.

Breaking waves hitting the side of the ship, resulting in waterjets reaching the containers that can lead to substantial damage to different elements and pushing the containers stacks.
Route Shipping Planning

TRADITIONAL-REACTIVE

✓ Preliminary route in the planning
✓ Optimum speed recommendations (RTA)
✓ Aprox. Fuel consumption
✓ Fast and then slow it down when RTA
✓ AIS tracking
✓ Optimum routes based on requirements

TODAY’S - PROACTIVE AND PREDICTIVE

✓ **Weather forecast** to build optimal routes
✓ Safely and in time, RTA or constant speed
✓ Frequently updates (data and route)
✓ More integrated with vessel performance and onboard data
✓ Automatically provide several recommended routes

FUTURE

✓ Energy efficiency and emission reduction
Sailing Technologies
Protecting the oceans, navigation and improving the supply chain.

COBS
Container Overboard System
Can Weather Routing minimize the risk of container losses?
Plenty of blames to go around

• Global warming causing more severe and unpredictable storms in the ocean
• Class societies relaxed design criteria too much for those Ultra Large container ship because of their size
• Shipyards “optimizes their designs” in order to minimize the building cost
• Containers not properly lashed due to tight schedule
• Ship crews lack experience in operating this class of ships
• Weather routing companies not doing their job
Enabling technologies that can be utilized for improving ship safety and efficiencies

- D-Day Landing
- Weather Briefing
- Super Computer
- Powerful PC
- Weather forecast
- Satellite Communication
- Low cost sensor
- Satellite AIS tracking
- Cloud Computing
- CFD modelling

1940: Ship Motion Theory
1950: MEM Sensor
1960: Resonance Diagrams
1970: Seakeeping Guidance System
1980: NWPS and WAM models
1990: Ensemble Forecast For wind and waves
2000: Hi-Res Current + Sea surface temp. Model
2010: Electronic Charts

Telex Routing advisory

Weather Routing

Voyage Optimization
Advances in hurricane prediction

Data from the NOAA National Hurricane Center (NHC) (13) show that forecast errors for tropical storms and hurricanes in the Atlantic basin have fallen rapidly in recent decades. The graph shows the forecast error in nautical miles (1 n mi = 1.852 km) for a range of time intervals.
A total of **7** incidents and **3079** containers lost during the past winter in Pacific Ocean

<table>
<thead>
<tr>
<th>Incident</th>
<th>Size</th>
<th>Build Year</th>
<th>Port Rotation</th>
<th>Date</th>
<th>Location of Accident</th>
<th>Impact: Containers Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number 1</td>
<td>14000 TEU</td>
<td>2018</td>
<td>Eastbound: China - Long Beach</td>
<td>Oct 30, 2020</td>
<td>&quot;in vicinity 40.00N 178.10E in the morning Oct 30&quot;</td>
<td>100</td>
</tr>
<tr>
<td>Number 2</td>
<td>14000 TEU</td>
<td>2019</td>
<td>Eastbound: China - Long Beach</td>
<td>Nov 30, 2020</td>
<td>&quot;1,600nm NW of Hawaii&quot;</td>
<td>1816</td>
</tr>
<tr>
<td>Number 3</td>
<td>8452 TEU</td>
<td>2014</td>
<td>Eastbound: S. Korea - Los Angeles</td>
<td>Dec 31, 2020</td>
<td>&quot;20nm off the cost of Kyushu, Japan&quot;</td>
<td>36</td>
</tr>
<tr>
<td>Number 4</td>
<td>8204 TEU</td>
<td>2006</td>
<td>Eastbound: S. Korea - Vancouver</td>
<td>Jan 2, 2021</td>
<td>NW Pacific</td>
<td>76</td>
</tr>
<tr>
<td>Number 5</td>
<td>13100 TEU</td>
<td>2010</td>
<td>Eastbound: N. China - Los Angeles</td>
<td>Jan 16, 2021</td>
<td>N of Hawaii, approximately 30N155W</td>
<td>750</td>
</tr>
<tr>
<td>Number 6</td>
<td>14300 TEU</td>
<td>2020</td>
<td>Westbound: Long Beach - China</td>
<td>Jan 26, 2021</td>
<td>SE of Japan, approximately 25N165E</td>
<td>41</td>
</tr>
<tr>
<td>Number 7</td>
<td>13100 TEU</td>
<td>2010</td>
<td>Eastbound: China - Los Angeles</td>
<td>Feb 17, 2021</td>
<td>&quot;45nm off Northern Japan&quot;</td>
<td>260</td>
</tr>
</tbody>
</table>

Courtesy of Weathernews Inc.
What can we learn from past incidents?

• Most incidents occurred at night. Crew only found the extent of damage caused by excessive roll or boarding waves next morning.

• The wave conditions were severe (up to 6-7 meter Sig Height), but ships had experienced worse weather before.

• Most likely cause of the damage was large roll angles and accelerations due to Synchronous or Parametric roll resonance, resulting lashing failures.

• Severe motions can also cause propeller racing, tripping the engine and lost of power.

• Weather routing service providers and onboard software were not able to predict such risks and re-route the ship or advise the captain.

• Crew were not trained to make tactical maneuvers to reduce the motions when resonance started to occur.
Ship motion predictions were established decades ago

• Ship motion theory has been well established and widely used by Classification Societies and ship designers

• Algorithm takes hull geometry, actual drafts and GM into account when predicting ship motions

• Responses includes roll & pitch angles, accelerations, slamming, deck submergence, and propeller racing

• Parametric roll and tank sloshing predictions are based on the computed response periods and angles using three wave trains (sea and swells)
Seakeeping Guidance Polar Diagram vs. Resonance Diagram

- Allows user to see at a glance speed/heading combinations that would not exceed safe operating limits
- Automatic and on-demand
- Provides a quick reference to maneuver ship to safer and more efficient state
- Captain may define Safe Operating Envelope
- Linked to GPS and wave forecasts
- Optional multi-axis solid-state motion sensor

IMO recommended

Resonance diagram Offers general guidance on a range of speed and heading without predicting amplitude or period of the motions
Cargo Safety at Sea is a concerted effort by all parties

**Ship Owners/Managers**

- Insist on safety measures in selecting class/builder and service provider
- Invest into digitization of operations and shore-side decision support centers
- Improve crew training
- Reduce crew workload by replacing manual reporting tasks with automate monitoring system
- Eliminate silos with competing KPIs in ship management metrics
- Incentivize safety culture in all aspects of ship operations
Cargo Safety at Sea is a concerted effort by all parties

**Ship Operators**

- Work as a team with weather routing companies in seeking advice on latest forecast of storm movements
- Embrace digitization and learn new computer skills
- Understand and support safety culture with continual online training courses in navigation and ship handling
- Rely on sensors when one cannot “feel in the leg” due to the sheer size of the ultra large ships
- Utilize digital technology for organizing daily routines and managing time
- Work as a team with shore-side management on voyage optimization
Cargo Safety at Sea is a concerted effort by all parties

**Class Societies and Shipbuilders**

- Learn from past accidents and improve design criteria especially for those new, ultra large ship types with relatively short operating history
- Make the design transparent and document features that can affect the safety of cargo and ship structure.
- Create a centralized shipboard as well as shoreside depository of operational data for helping accident investigation and create an early warning systems using AI and DL techniques
- Assist in create/validate ship response/seakeeping models
Cargo Safety at Sea is a concerted effort by all parties

Port Authorities

- Provide an open platform/website and free WIFI connection to ships in port as well as anchoring areas for exchange of information
- Update of port congestion conditions on the website
- Update weather current conditions in port as well as anchoring areas
- Use AI to estimate loading/unloading times for planning port schedules
- Ensure proper container lashing rules taking into consideration of forecast storm conditions.
Cargo Safety at Sea is a concerted effort by all parties

Weather Routing Companies

• Understand the ultimate goal is to advise captain on how to arrive at the destination without damage to ship, cargo and crew within the safety envelop
• True voyage optimization needs to use seakeeping and propulsion models (Digital Twin) to accurately predict the ship performance using the latest wind/wave/current forecast
• The ship seakeeping model should be able to predict motions and deck submergence, propeller emergence etc. for the specified drafts and GM.
• Utilize Ensemble Forecast to predict probability of exceeding safety envelop and quantify the uncertainties of fuel consumption, arrival time for better route selection.
Ship Operations Digital Twins

Environment and Chart databases

Other data sources:
• Noon Reports
• Design Data
• Trial Data

Big Data

Neural Network

Ship Maneuvering Model

• Collision Avoidance
• Docking Assistant
• Autopilot/ECDIS

Ship Propulsion Model

• Charter party performance
• ETA for port operations
• Ship deployment scheduling

• Optimum Ship Routing
• Fleet Performance monitor
• Efficiency/safety optimization

Ship IoT Box 6D Motion

AIS

Shipboard Sensors

Ship motion Seakeeping Model

6D Motion

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6D Motion
In conclusion:

“Given the right tools, the future of weather routing as a decision support service can minimize container losses while reducing fuel consumption and arrive on-time”

For further detailed explanations, please read my articles posted on LinkedIn:


Thank you for your attention

Henry Chen, Ph.D.
Streamlined operations - one interface of secure information flow between vessels and all port actors

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MISSION

Our mission is to help our clients with unmatched service and exceptional software talent.

400+ EXPERTS

400+ deep tech experts
Embedded & full-stack software developers and data scientists
Integration expertise

UNIKIE REVENUE 2015-2020

- 2015: 0.3M€
- 2016: 2.7M€
- 2017: 5.8M€
- 2018: 14.1M€
- 2019: 28M€
- 2020: ~40M€
UNIKIE – Smart Port Solutions

Port Digitalization and Automation

**POLO**
Port Flow Optimization tool
Framework for data sharing, enhanced collaboration, and joint situational awareness

**AI Vision**
Automated and Autonomous operations
Machine Vision based autonomous driving and dynamic safety zone solutions for port machines

**Staffer**
Port staff and dockworker management tool
Hands-On tool for organizing and managing the staffing in ports

**Aino.io**
Securing integrated systems and processes
Monitoring and securing system for integrated IT systems and processes
UNIKIE POLO – Web & Mobile

- Accurate information at your fingertips and pockets.
- Configurable features and user rights
FAST EVOLVING OPEN PLATFORM – FROM PORTS TO PORTS

New development requirements 100% directly from ports – New features available for all users

Functional features
- Communication features
- AI based info features
- Port Call Process
- Port Operations
- Hinterland Operations
- Business Process
- Situational Awareness Features (Integrations)

Development started in 4.5Meur Central Baltic Efficient Flow Project:

- RAUMAN SATAMA PORT OF RAUMA
- Port of Gävle
- SWEDISH MARITIME ADMINISTRATION
- VTS FINLAND
- Samk University of Applied Sciences
- Ports of Stockholm
- Port of Turku
- Interreg Central Baltic

IALA S-211 compliant
THANK YOU!

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