– Shipboard Weather Routing –
Operational Benefits

Ship Efficiency 2009
Hamburg, 2009-09-28/29

Germanischer Lloyd
Outline

• Shipboard weather routing (SWR)
  • Characteristic features
  • Motivation and objectives

• Class notation HRMS
  • Advanced SRA system
    • Typical components
    • Full scale validation

• Fuel consumption module
  • Added resistance in waves

• Conclusion
Characteristic features

• **Status**
  - Navigator estimates ship response based on weather forecast

• **Computed or measured ship response**
  - Onboard (not land-based)
  - Based on weather data

• **Key weather data**
  - Seaway (Hs, Tp)
  - Wind

• **Routing**
  - Course and/or speed
  - Present
  - Future / planning
Principal objective of SWR

Onboard support for decision-making of the navigator

• Reduce risk for crew injuries, hull damage and cargo loss
• Reduce fuel consumption
• Provide active route planning

⇒ Quantify and improve service performance
Motivation and objectives of SWR

(1) Safety at sea
- How well can you see from the bridge?
- How well can you judge the sea?
- Danger of underestimating the severity of the sea state
- Danger of navigating at too high speed

(2) Economy/efficiency
- Reduced repair time
- Soaring fuel prices

About 50% of containers are stowed on deck
# IACS Rec. 34 wave climate North Atlantic

## 70% operation in seaways with $H_s \leq 4$ m

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| $\lambda$ [m] | 7   | 19  | 38  | 63  | 94  | 131 | 174  | 224  | 279  | 341  | 410  | 484  | 564  | 651  | 744  | 843  | 948  | 1060 |
New Structural Rules for containerships launched at SMM 2008

- HRMS class notation draft due in May 2009
- HRMS class notation rule text due for next update 2010

Other ship types will follow

HRMS notation for
- conventional sensor based systems
- more advanced routing systems
Class notation HRMS (2/5)

Rule structure

- General (application, class notations, liability, ...)
- System types (notations HRW, HRM, HRS, HRD, HRSRA)
- System requirements (sensor types, robustness, accuracy)
- Installation and testing
- Survey requirements
- Guidance on selection (sensors, VDR, training, ...)

Class notation HRMS (3/5)

Class notation HRW

- This notation will be assigned to ships provided with a shipboard seaway measurement system that can display and record the wave information.
- SRA type systems are to be identified by their main function or purpose.

Class notation HRD

- This notation will be assigned to ships provided with a hull response monitoring system that records voyage data for later analysis.
- Voyage data recorders are to be identified by the extent of their recording capability, the time scale of their recording, and the survivability of their recordings.
Class notation HRM

- This notation will be assigned to ships provided with a hull response monitoring system that can display and record the motion information from either one accelerometer or pressure transducer.
- Motion monitoring systems are to be identified by their main function or purpose.

Class notation HRS

- This notation will be assigned to ships provided with a hull response monitoring system that can display and record the hull stress information from at least two strain gages.
- Stress monitoring systems are to be identified by their main function or purpose.
Class notation HRMS (5/5)

Class notation HRSRA

- This notation will be assigned to ships provided with a shipboard routing/planning assistance system with the aim to recognize situations potentially dangerous to the ship and its cargo.
- SRA type systems are to be identified by their main function or purpose.
SeaScout Basic and SeaScout Premium

- Seaway Measurement using X-band Radar
- Navigational Data from Vessel
- Actual Loading Condition from Loading Computer
- Hydrodynamic Database
- Hardware Sensors
- Seaway Forecast (Optional)
- Seaway Observation (Optional)
- Display of Ship Responses on Bridge
- Fuel consumption module

Seaway Observation (Optional)

Seaway Forecast (Optional)

Navigational Data from Vessel

Actual Loading Condition from Loading Computer

Hydrodynamic Database

Hardware Sensors

Display of Ship Responses on Bridge

Fuel consumption module
Typical monitored ship response (1/2)

- Ship motions and accelerations
  - Heave, pitch and roll
  - Vertical acceleration at AP, L/2 and FP
  - Horizontal acceleration at top container level at AP and FP

- Parametric roll warning
  - Head seas: $T_{\text{Roll}} = 2 \ T_{\text{Encounter}}$
  - Following seas: $T_{\text{Roll}} = T_{\text{Encounter}}$
  - Primary wave system’s wave length in the order of ship length
  - Wave height > threshold level
  - Low roll damping
Typical monitored ship response (2/2)

- Likelihood for slamming
- Water on deck
- Sectional loads
  - Vertical wave bending moment at section amidships,
    Vertical shear force at 1/4L and 3/4L
Advanced technique uses nautical X-Band radar for continuous seaway measurements

- Wave spectra
  - Directional wave spectra

- Wave height
  - Significant wave height
  - Maximum wave height

- Wave length

- Wave direction
Loading computer

- Actual Mass Distribution
- Hydrostatic Properties
  - GM / GZ
  - LCG
  - Trim
Hydrodynamic database

- 5 Speeds
- 4 Draughts (5m to 14m)
- 13 Headings
- Wave lengths from L/4 to 5L

Seakeeping code GL PANEL
SRA display on the bridge
Validation

strain gauges on deck stringers PS & SB

accelerometer (vertical)

gyro (6 DOF motion sensor)
Full-scale validation: Environmental parameters

Wave Height

Wave Period

Wave Heading

Time (5 days)
Full-scale validation: Comparison of ship response

Horizontal acceleration amidships

Vertical wave bending moment amidships

Time (5 days interval)
Fuel consumption (FC) in waves

- Most of their time ships operate at sea
  - Calm water assessment not sufficient
  - However, most seaways mild to moderate (70% Hs < 4.0 m in NA)
- FC = f (hull form, wave amplitude and length, heading, speed, draft)
- Added resistance in waves relatively higher for smaller ships
  - Must the sea margin account for this?
Added resistance in waves

Shape for head waves

\[ \frac{r a w}{\zeta^2} \]

- motion induced added resistance
- added resistance due to reflection

\[ \frac{\lambda}{L_{pp}} \rightarrow \]

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Added resistance in waves

Container – Transfer function head seas

Container - Transfer function bow quartering seas

Container – Transfer function beam seas

Container – Transfer function stern quartering seas
**Added resistance in waves**

- Added resistance represents dominant part
- Physical model preferred due to large scatter in empirical formulation (ref. SPA JIP)
- \( R = f \) (hull form, wave amplitude and length, heading, speed, draft)
Conclusion

• Larger ship dimensions call for SWR navigational aid
  • HRMS class notation
    • Classical sensor based systems
    • Routing systems

• SWR technology still under development
  • Wave sensor
  • Current setup (especially roll affected ship response)
  • Onboard evaluation of FC

⇒ Routing based on safety and economy
Thank you for your attention