

# *– Shipboard Weather Routing – Operational Benefits*



Ship Efficiency 2009

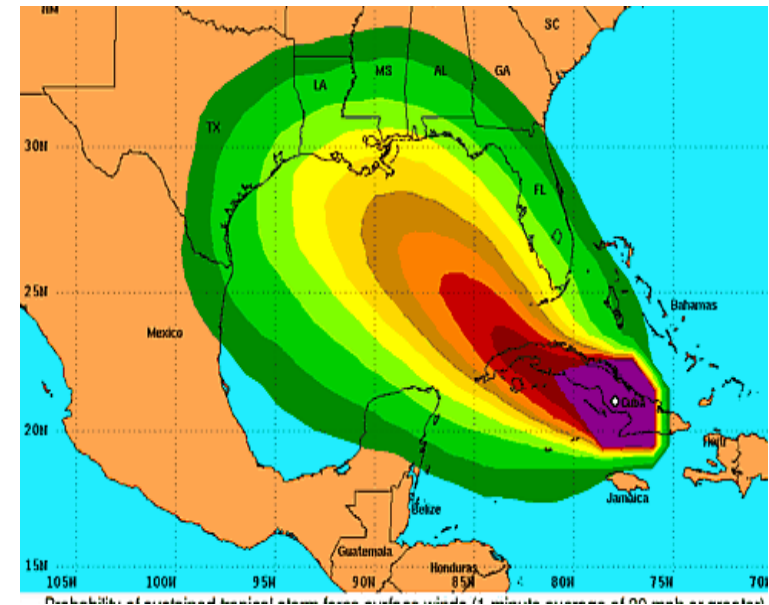
Hamburg, 2009-09-28/29



# Germanischer Lloyd

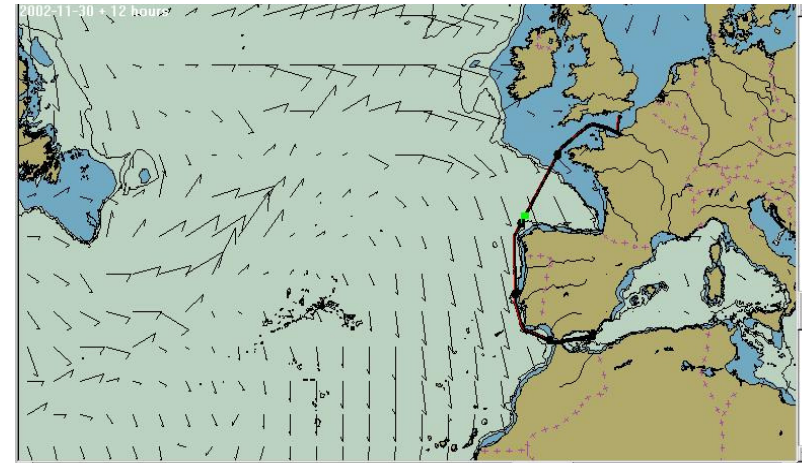
# Outline

- **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



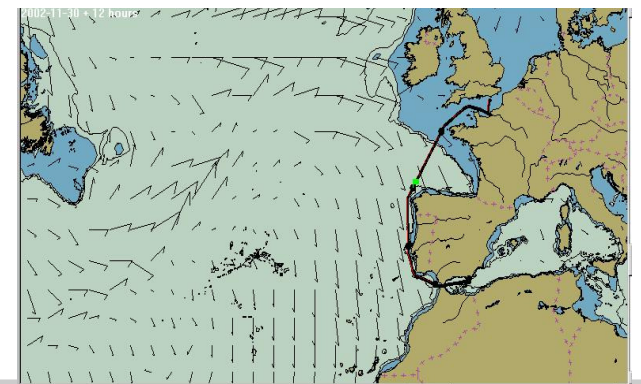


# *Principal objective of SWR*

## 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**



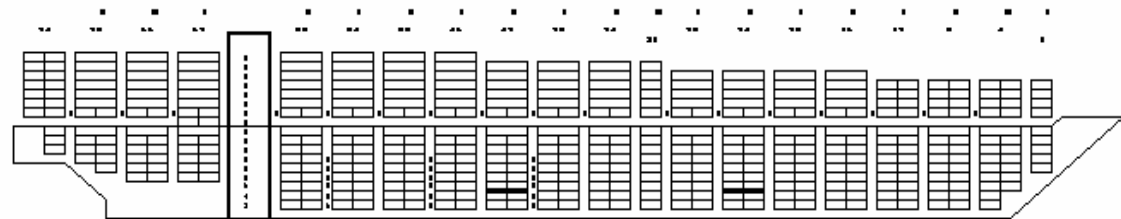
# *Motivation and objectives of SWR*

## **(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

Hs/Tz	1,5	2,5	3,5	4,5	5,5	6,5	7,5	8,5	9,5	10,5	11,5	12,5	13,5	14,5	15,5	16,5	17,5	18,5	SUM
0,5	0	0	3	293	1896	2597	1389	408	81	12	2	0	0	0	0	0	0	0	6680
1,5	ECONOMY			64	2159	10897	16946	12198	5203	1541	352	67	11	2	0	0	0	0	49440
2,5	ECONOMY			5	433	4728	13644	16314	10644	4525	1411	351	74	14	2	0	0	0	52145
3,5	0	0	0	0	76	1523	7066	12428	11167	6215	2440	740	185	40	8	1	0	0	41890
4,5	0	0	0	0	13	429	2966	7202	8448	5881	2793	997	287	70	15	3	0	0	29104
5,5	0	0	0	0	2	112	1091	3510	5196	4398	2466	1015	330	90	21	5	1	0	18239
6,5	0	0	0	0	0	28	366	1512	2755	2778	1809	847	308	92	24	5	1	0	10526
7,5	0	0	0	0	0	7	114	592	1302	1540	1150	606	245	80	22	5	1	0	5664
8,5	SAFETY			0	0	2	34	214	560	768	650	382	170	61	18	5	1	0	2866
9,5	SAFETY			0	0	0	9	73	223	350	333	217	106	41	13	4	1	0	1371
10,5	0	0	0	0	0	0	3	23	83	148	157	113	60	25	9	3	1	0	624
11,5	0	0	0	0	0	0	1	7	29	58	69	54	31	14	5	2	0	0	271
12,5	0	0	0	0	0	0	0	2	10	22	28	24	15	7	3	1	0	0	112
13,5	0	0	0	0	0	0	0	1	3	8	11	10	7	4	2	0	0	0	45
14,5	0	0	0	0	0	0	0	0	1	3	4	4	3	2	1	0	0	0	17
15,5	0	0	0	0	0	0	0	0	0	1	1	2	1	1	0	0	0	0	6
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
SUM	0	0	3	362	4580	20323	43629	54485	45705	28248	13676	5429	1832	542	144	35	7	2	219000
Tp [s]	2,1	3,5	4,9	6,3	7,7	9,2	10,6	12,0	13,4	14,8	16,2	17,6	19,0	20,4	21,8	23,2	24,6	26,0	
$\lambda$ [m]	7	19	38	63	94	131	174	224	279	341	410	484	564	651	744	843	948	1060	

Felder in Stunden bezogen auf 25 Jahre Beobachtung



# *Class notation HRMS (1/5)*

- **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 HRMS (4/5)*

## **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.



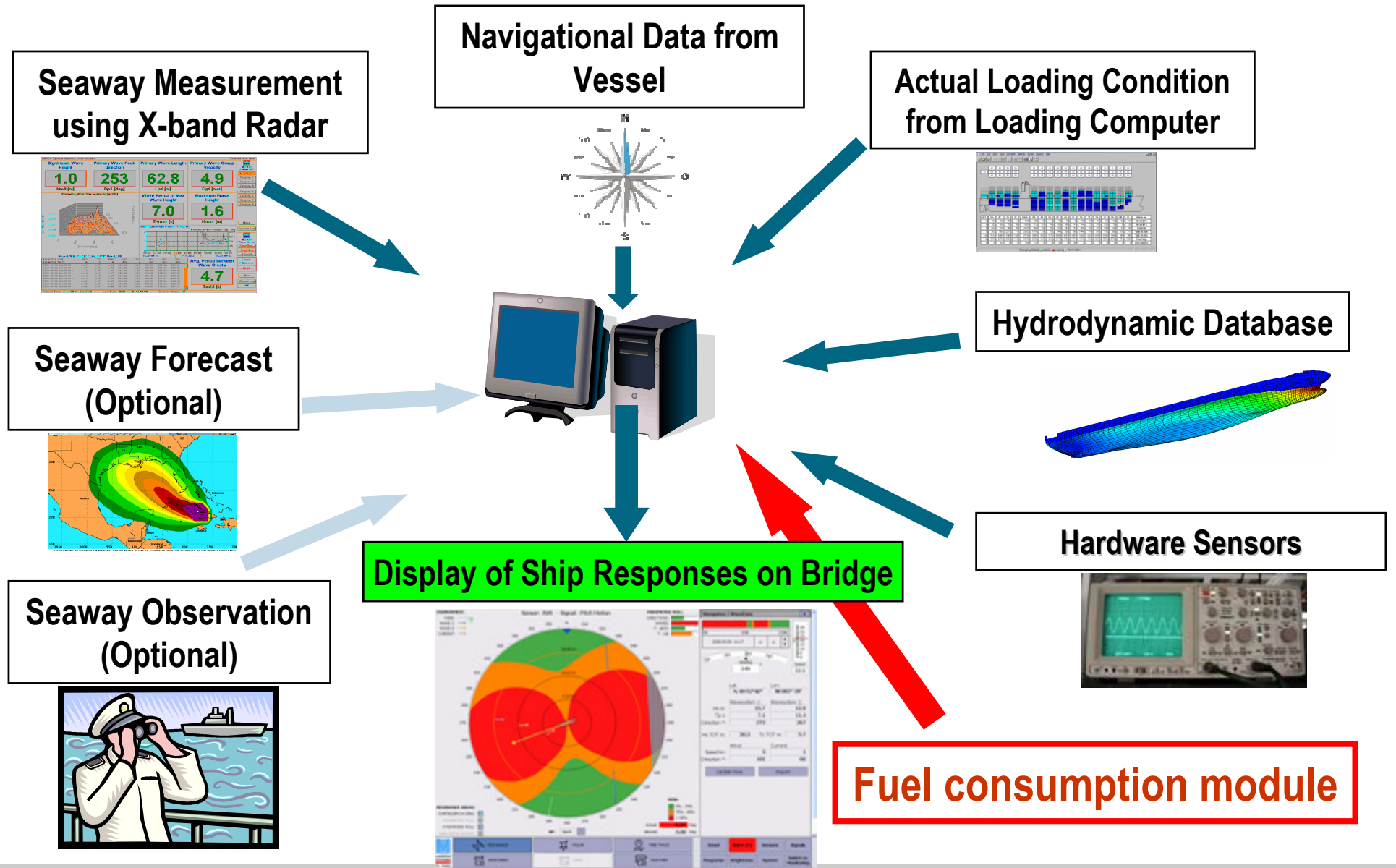
# *Class notation HRMS (5/5)*

## **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



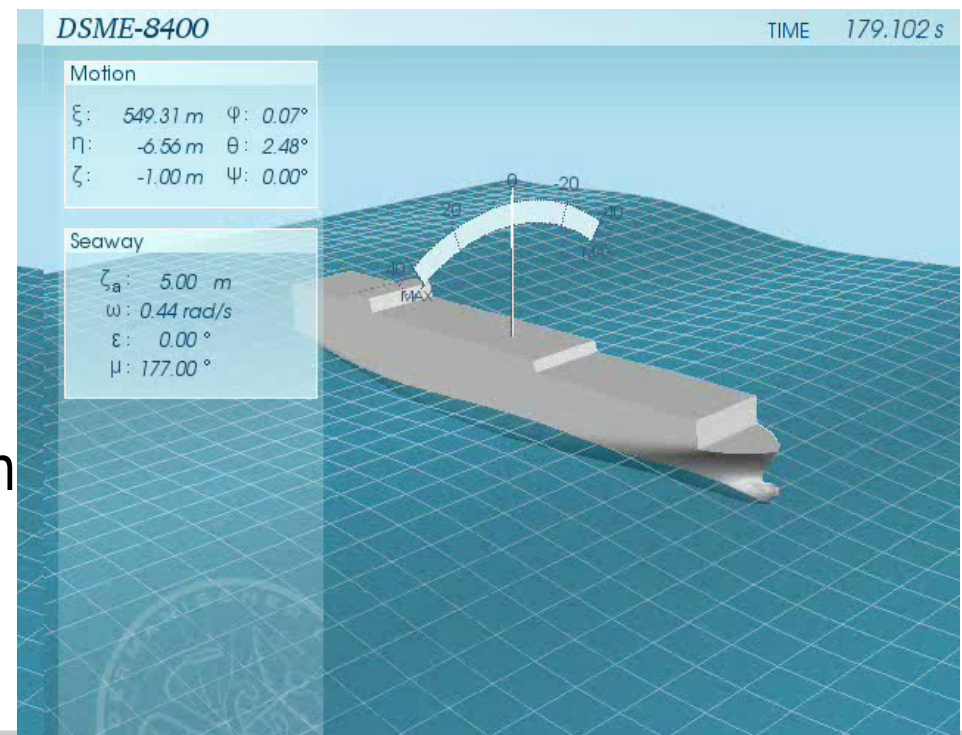
# Typical monitored ship response (1/2)

- **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**

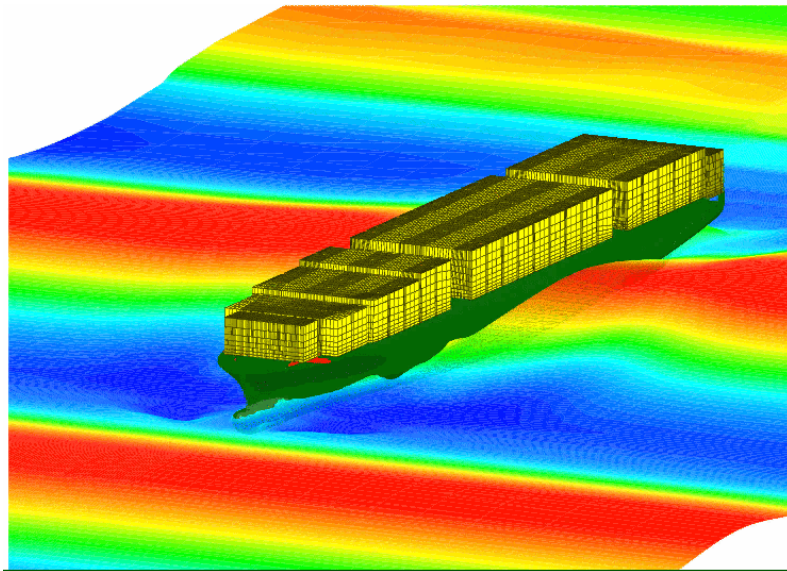
- Head seas:  $T_{\text{Roll}} = 2 T_{\text{Encounter}}$
- Following seas:  $T_{\text{Roll}} = T_{\text{Encounter}}$
- Primary wave system's wave length in the order of ship length
- Wave height > threshold level
- Low roll damping





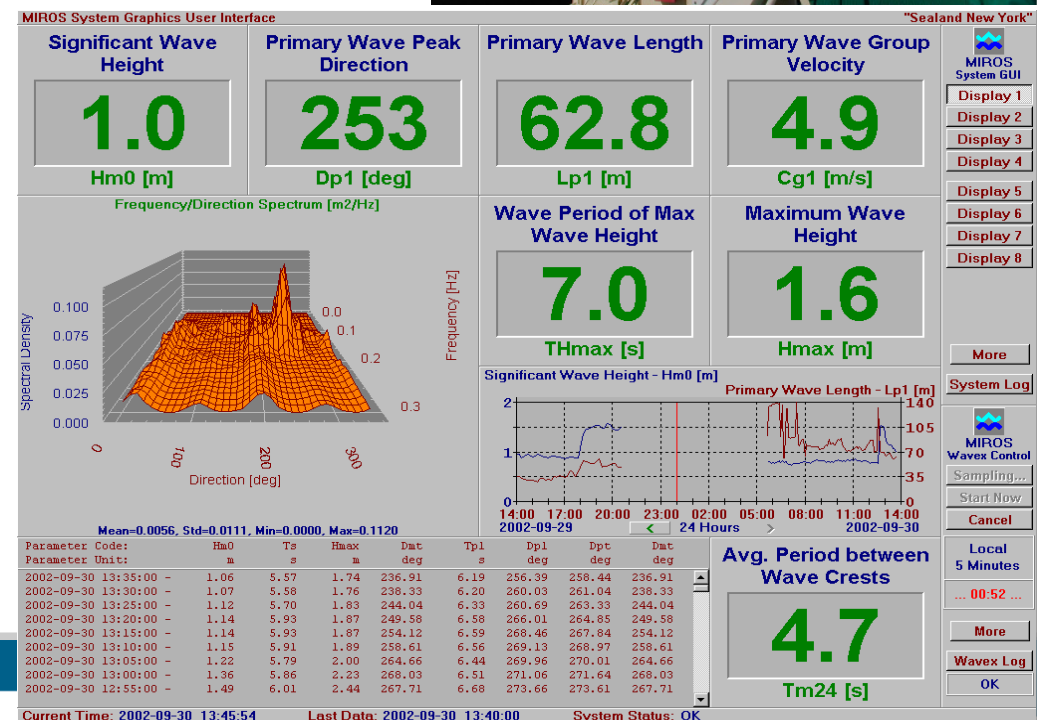
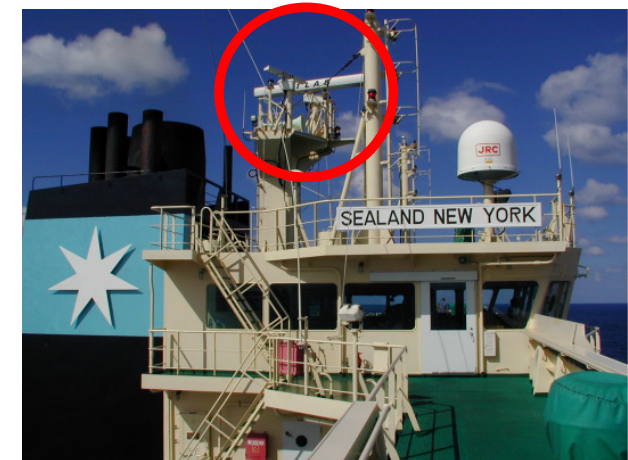
## *Typical monitored ship response (2/2)*

- **Likelihood for slamming**
- **Water on deck**
- **Sectional loads**
  - Vertical wave bending moment at section amidships,  
Vertical shear force at  $1/4L$  and  $3/4L$



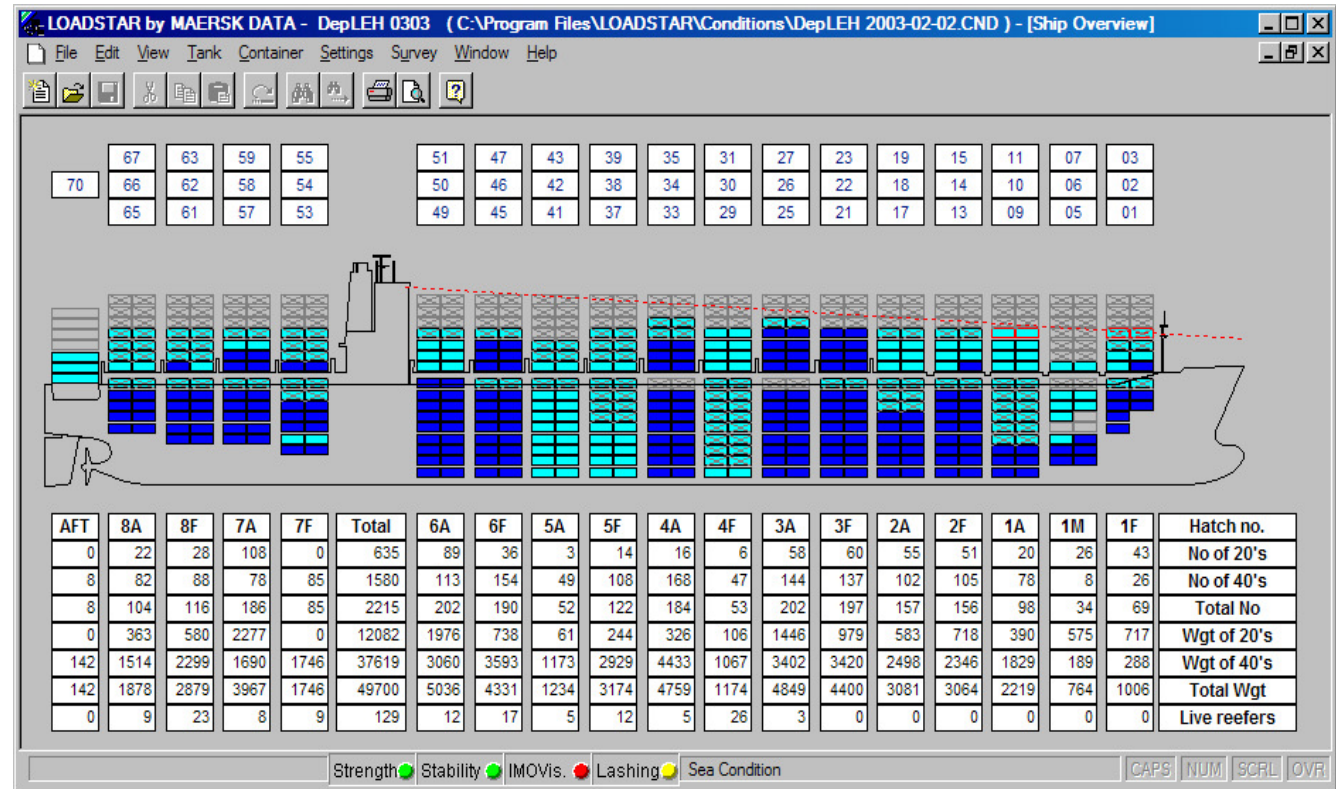
# Advanced technique uses nautical X-Band radar for continuous seaway measurements

- **Wave spectra**
  - Directional wave spectra
- **Wave height**
  - Significant wave height
  - Maximum wave height
- **Wave length**
- **Wave direction**



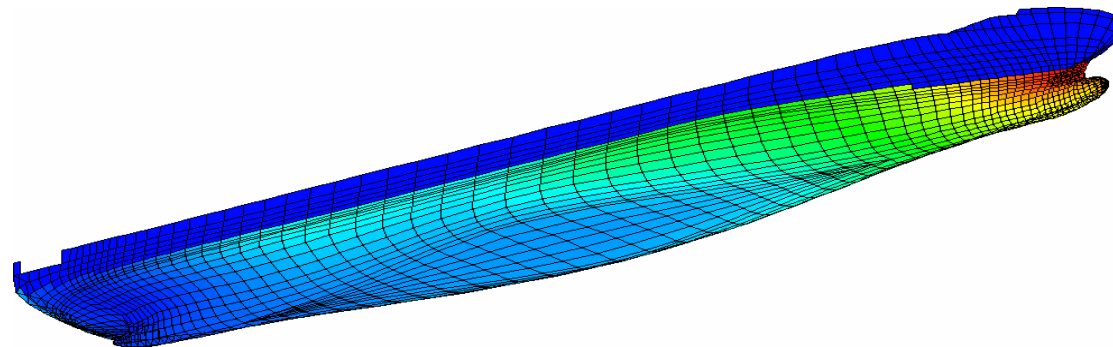
# Loading computer

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



# *Hydrodynamic database*

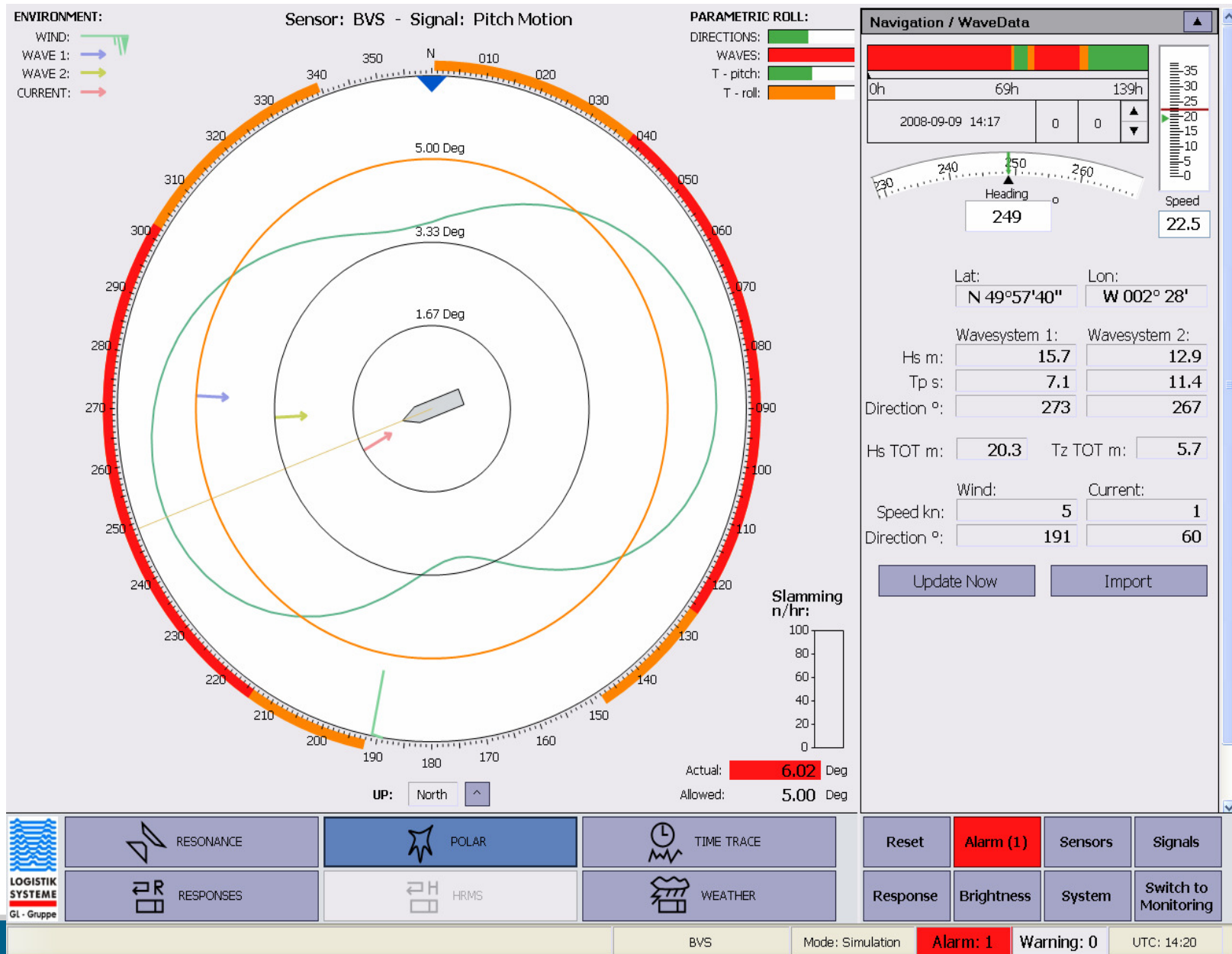
- **5 Speeds**
- **4 Draughts (5m to 14m)**
- **13 Headings**
- **Wave lengths from L/4 to 5L**



**Seakeeping code GL PANEL**

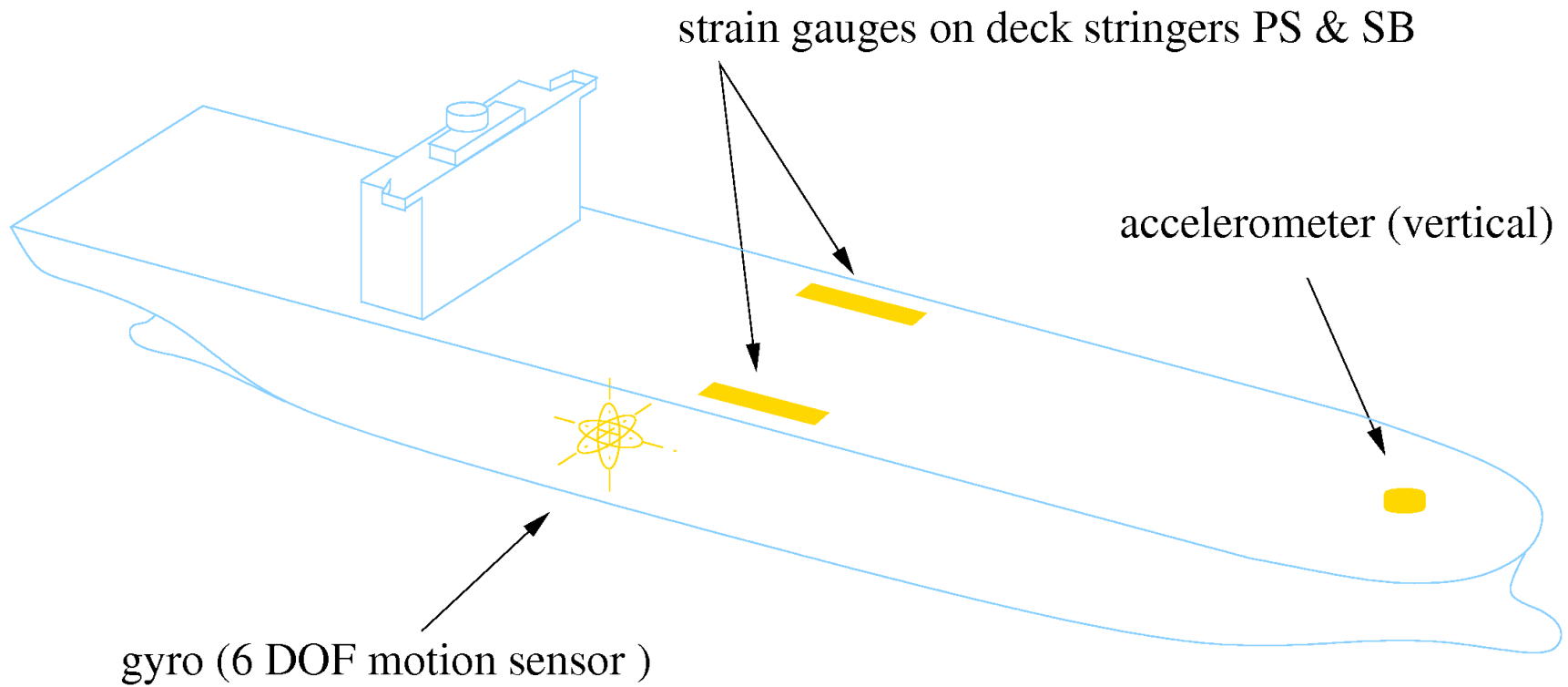


# SRA display on the bridge

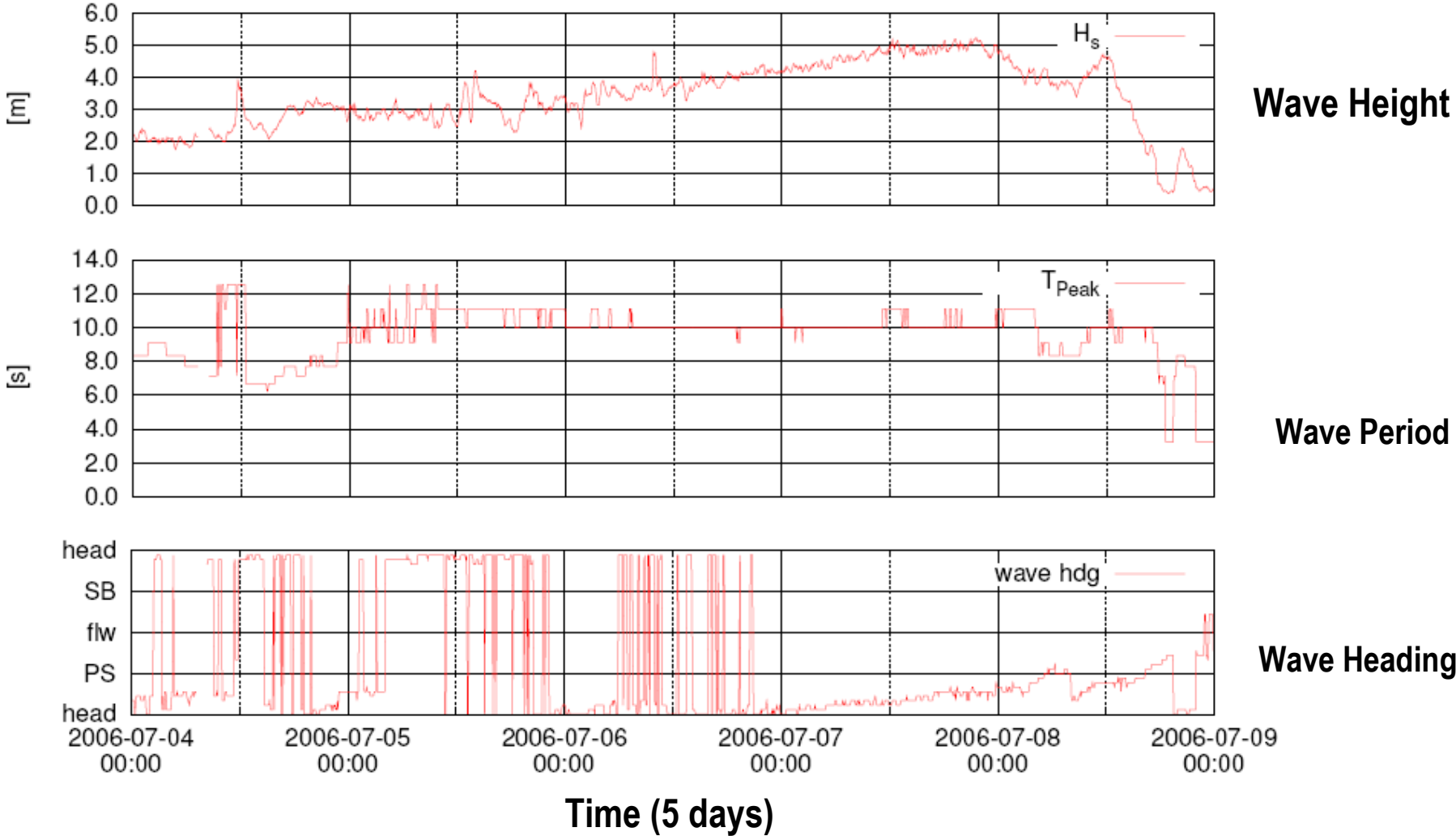




# Validation

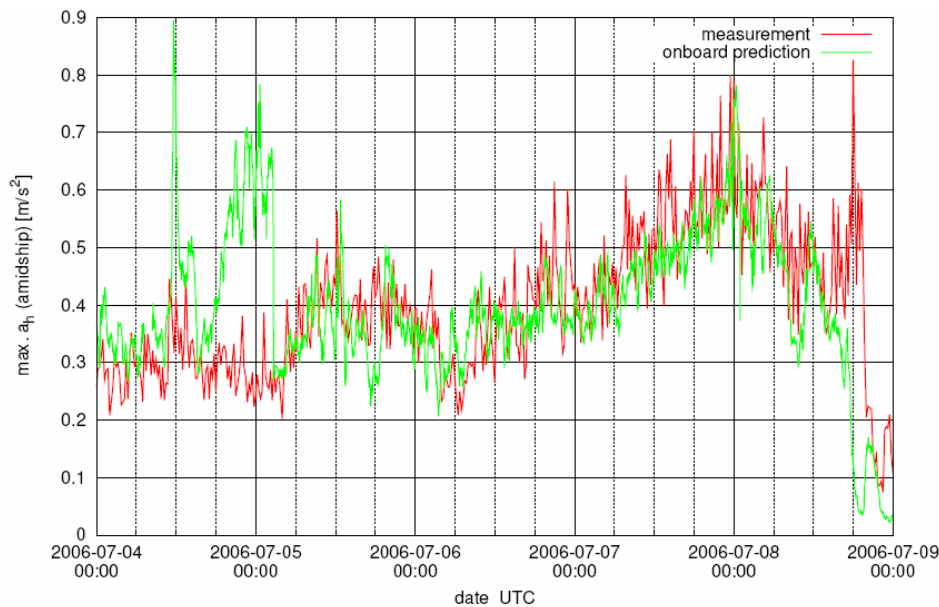


# Full-scale validation: Environmental parameters



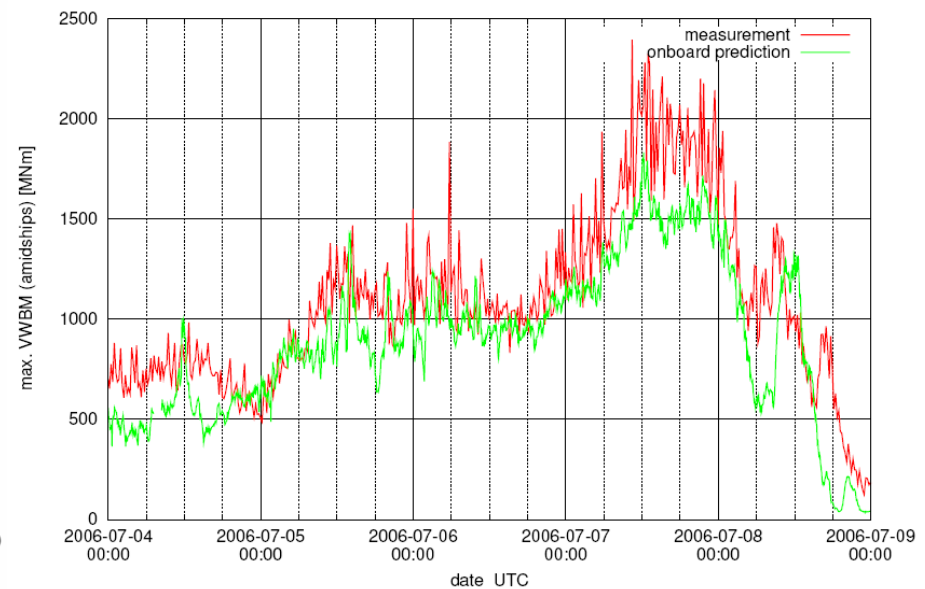
# Full-scale validation: Comparison of ship response

## Horizontal acceleration amidships



Time (5 days interval)

## Vertical wave bending moment amidships



Time (5 days interval)



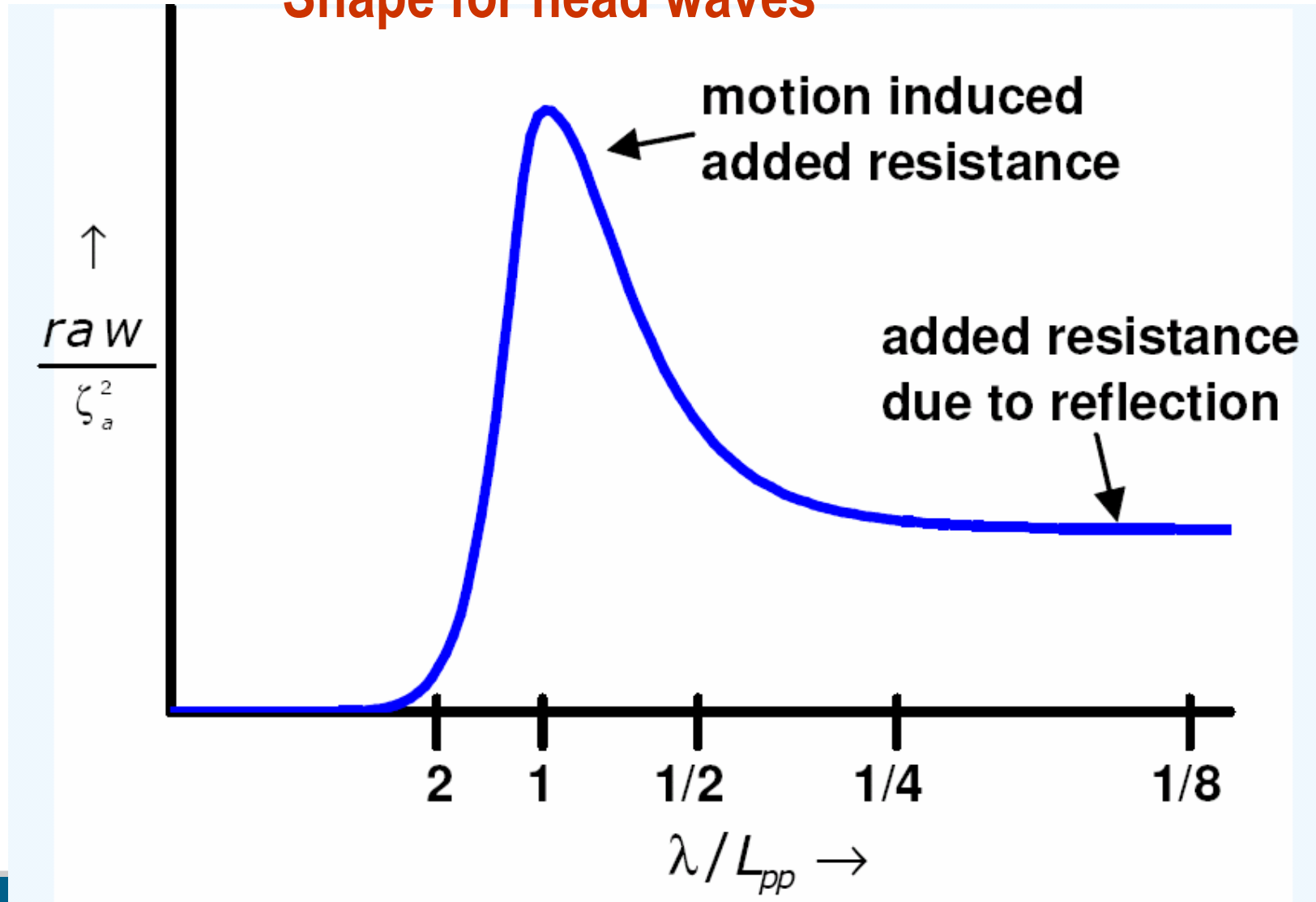
# *Fuel consumption (FC) in waves*

- **Most of their time ships operate at sea**
  - Calm water assessment not sufficient
  - However, most seaways mild to moderate (70%  $H_s < 4.0$  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

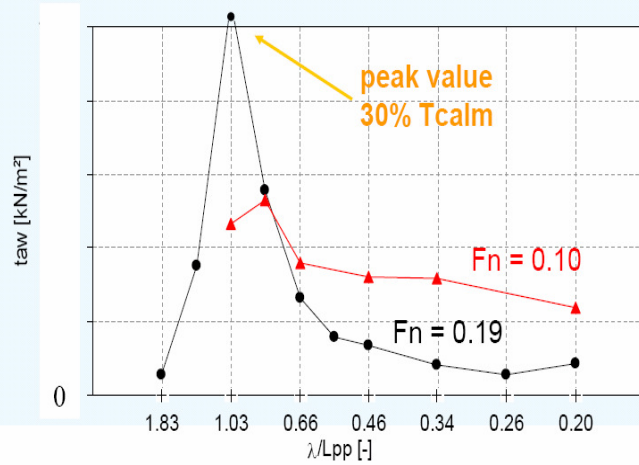
## Shape for head waves



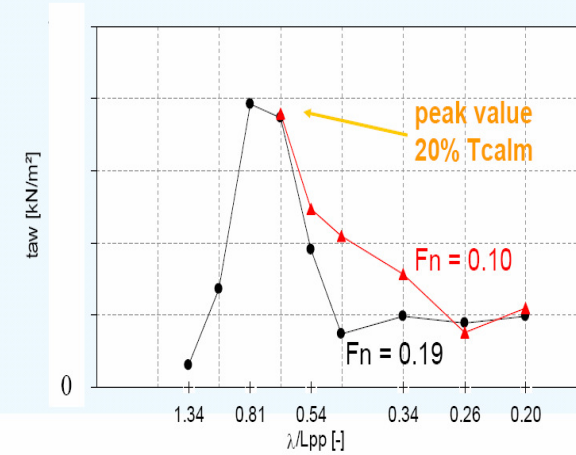


# Added resistance in waves

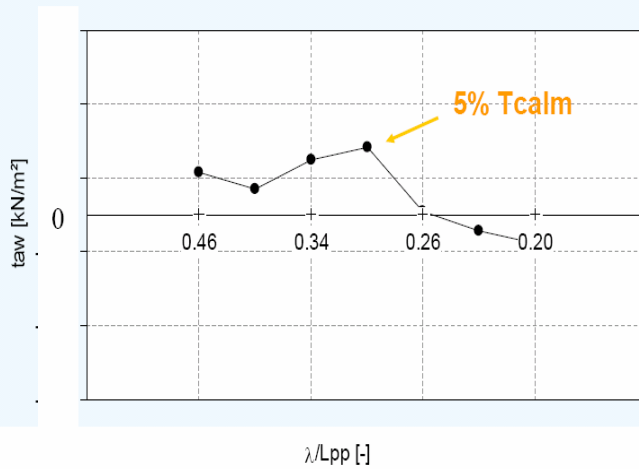
Container – Transfer function head seas



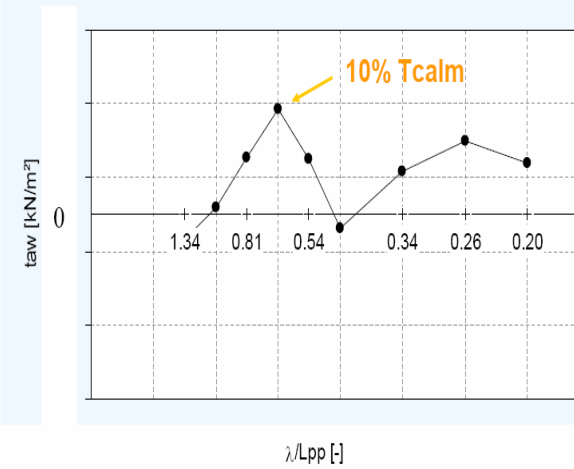
Container - Transfer function bow quartering seas



Container – Transfer function beam seas

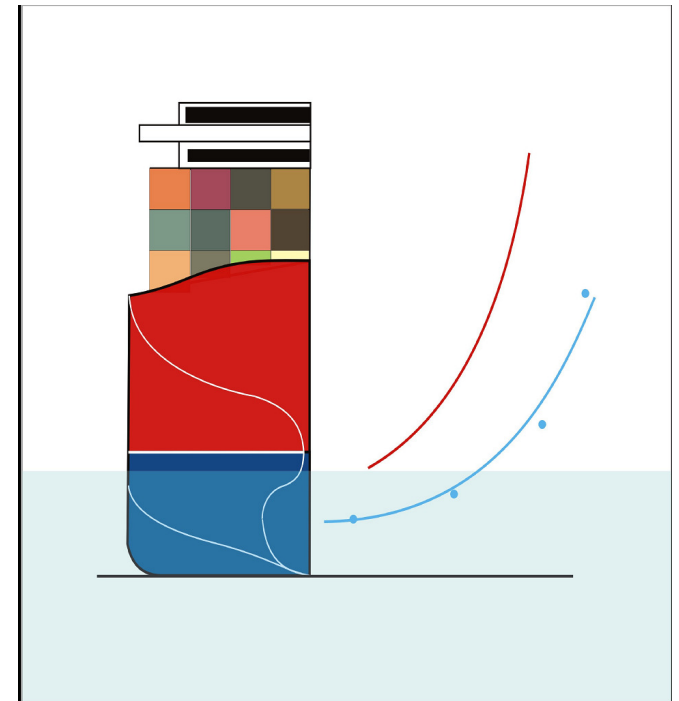


Container – Transfer function stern quartering seas



# *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*

