ONBOARD STABILITY MONITORING THROUGH ROLL MOTION ANALYSIS

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Probability of capsizing of naval ships, May 16th 2025, DGA TH / ATMA

- Introduction
- How to assess stability?
- Methodology based on the FFT
- EMD + HHT + detector
- Conclusions

Motivation

- High accident rate

Possible causes

- Incorrect risk assessment on board

Guidance systems → group of procedures and recommendations to provide clear information about the stability of the ship

Main requirements:

1. Ease of use
2. Simple implementation and installation on board and low cost
3. Minimum crew interaction

Main parameters that affect the stability of the vessel:

- Metacentric height

- Vertical centre of gravity $\longrightarrow$ $KG = KM - GM$

- Righting arm $\longrightarrow$ $GZ = GM \cdot \sin(\theta);\ \theta < 10°$

  $GZ = KN - KG \cdot \sin(\theta);\ \theta > 10°$

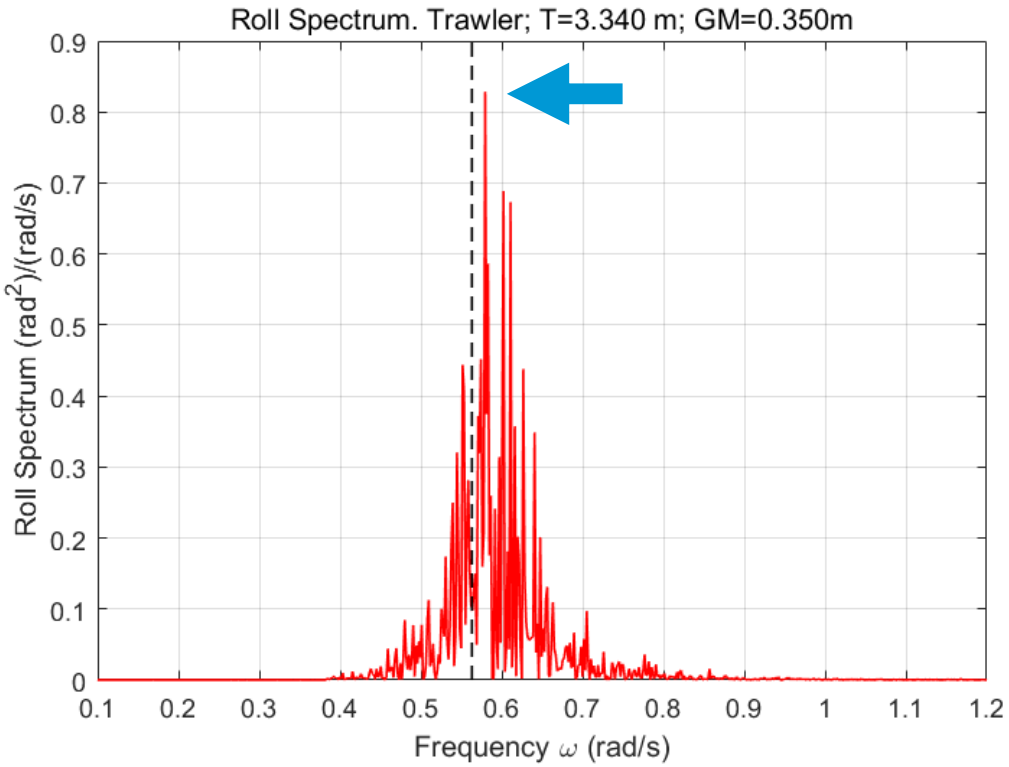
- Freeboard

$$GM = \frac{(I_{xx} + A_{44}) \cdot {\omega_0}^2}{g \cdot \Delta} \rightarrow GM = \frac{{k_{xx}}^2 \cdot {\omega_0}^2}{g}$$

(Weiss formula)

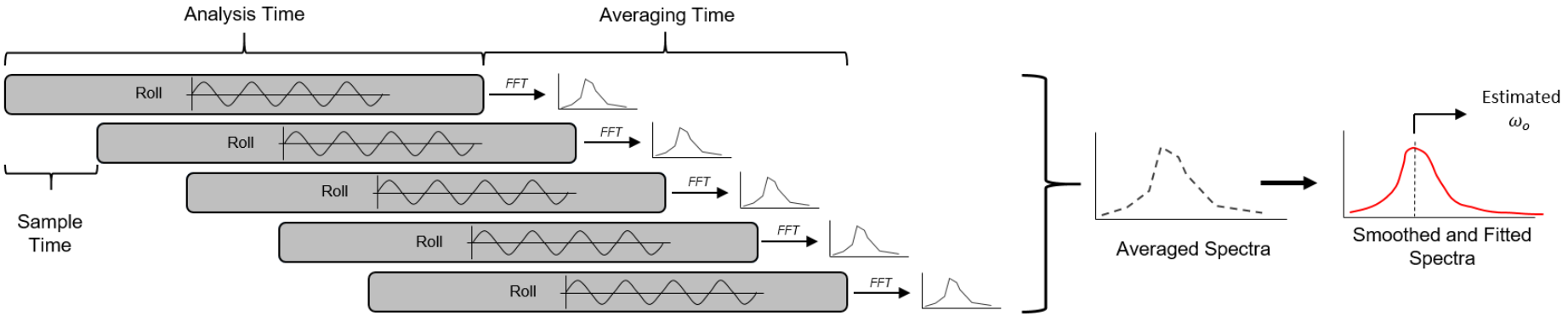
Methodology based on the FFT

EMD + HHT + detector



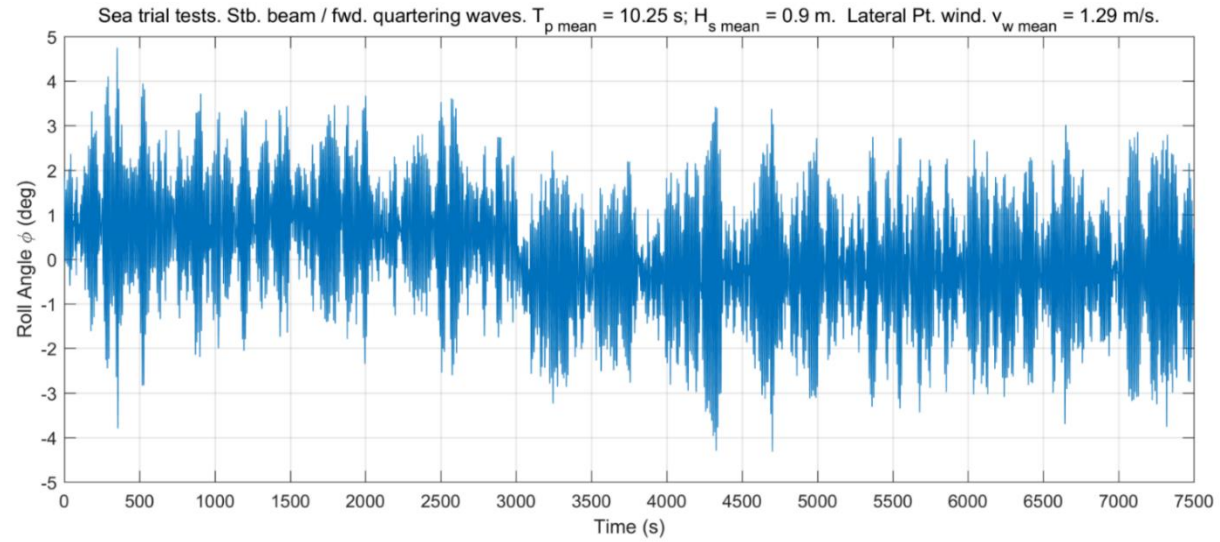
Stability monitoring system:

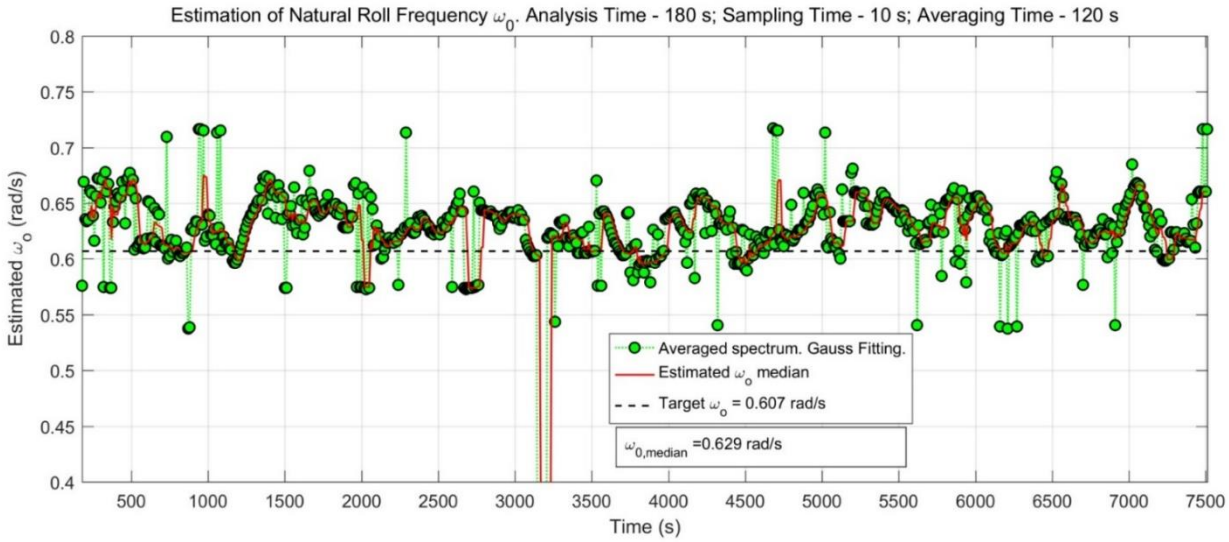
1. Real-time estimation of stability from roll motion
2. Minimize crew interaction

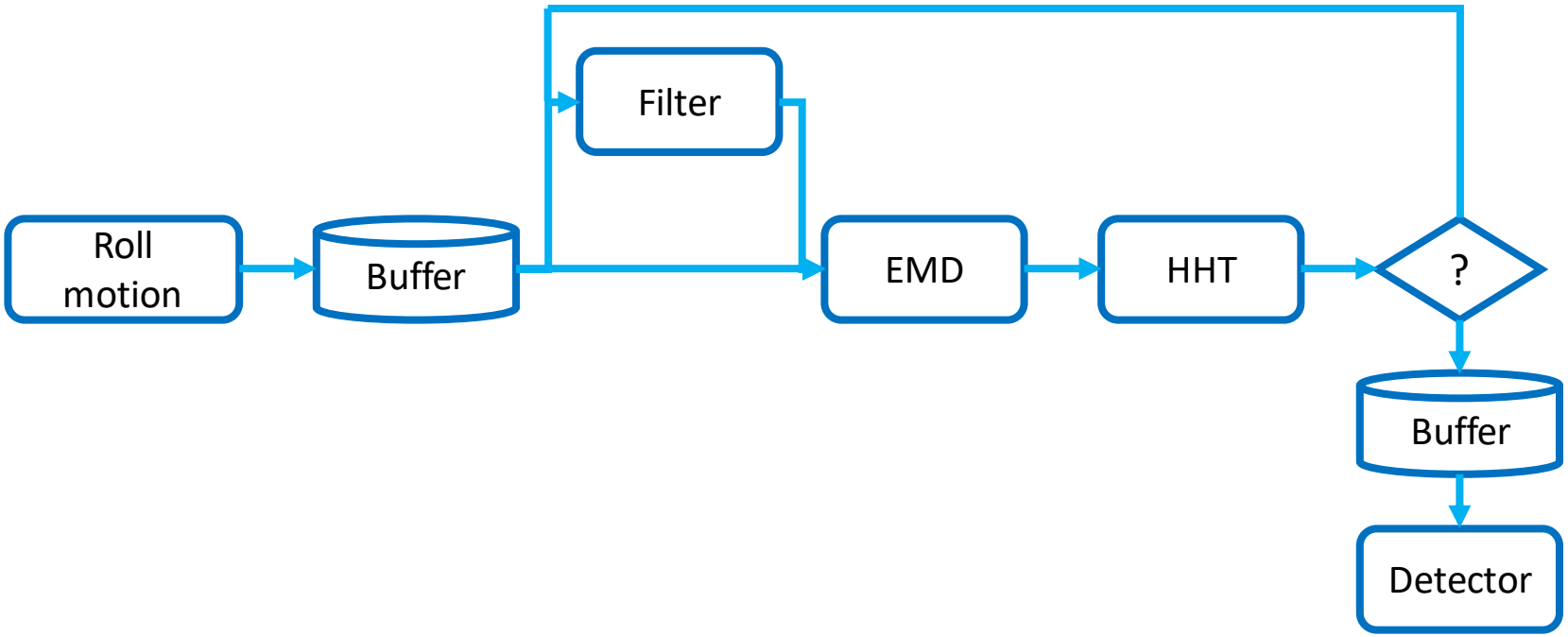


*Performance depends on external excitations

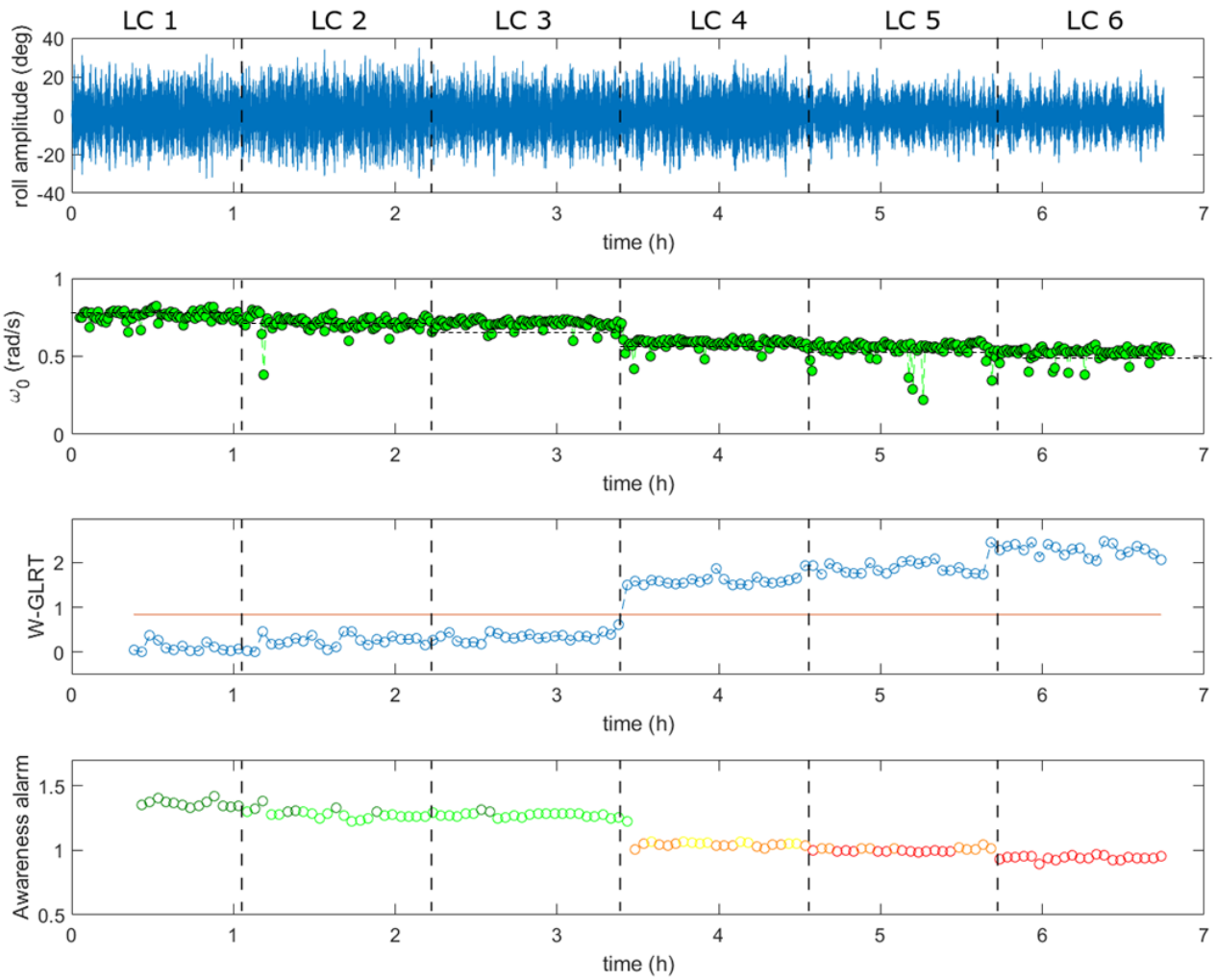
METHODOLOGY BASED ON THE FFT






Roll motion
Buffer
Filter
EMD
HHT
?
Buffer
Detector

EMD + HHT + DETECTOR



- Two methodologies for estimating in real-time $\boldsymbol{\omega_0}$ have been proposed.
- Validation has been performed with:
  - Simulated time series
  - Experimental tests
  - Fishing campaign
- Direct application to any other type of vessel
- Main advantage: the methodology is vessel model independent

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