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Health Monitoring of the SA Agulhas-II Propulsion Shaft

1944 - 2024

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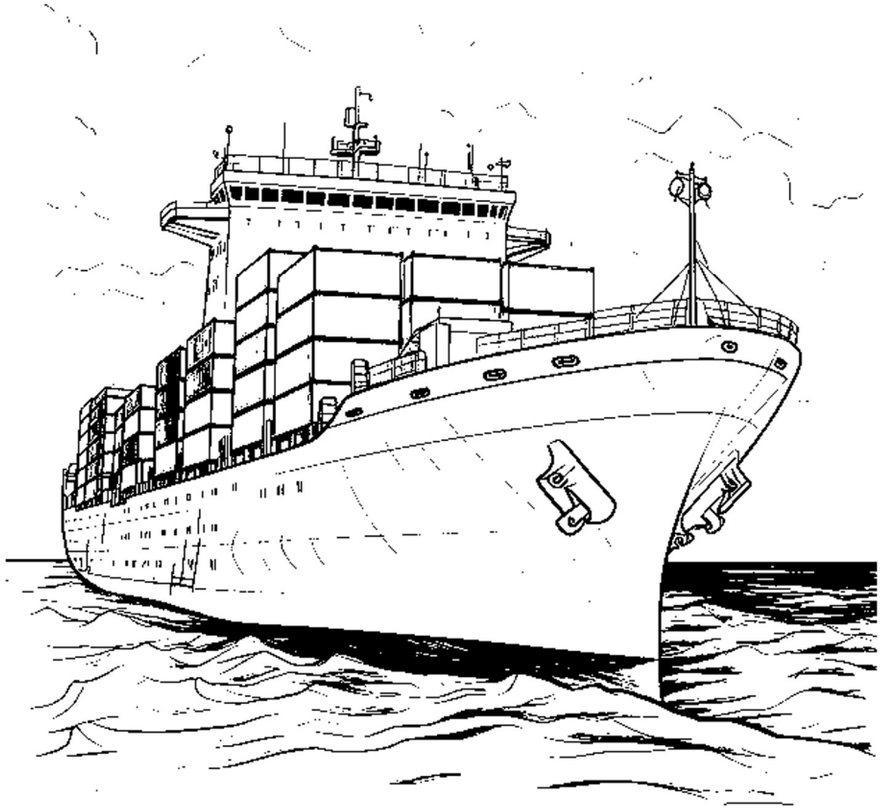
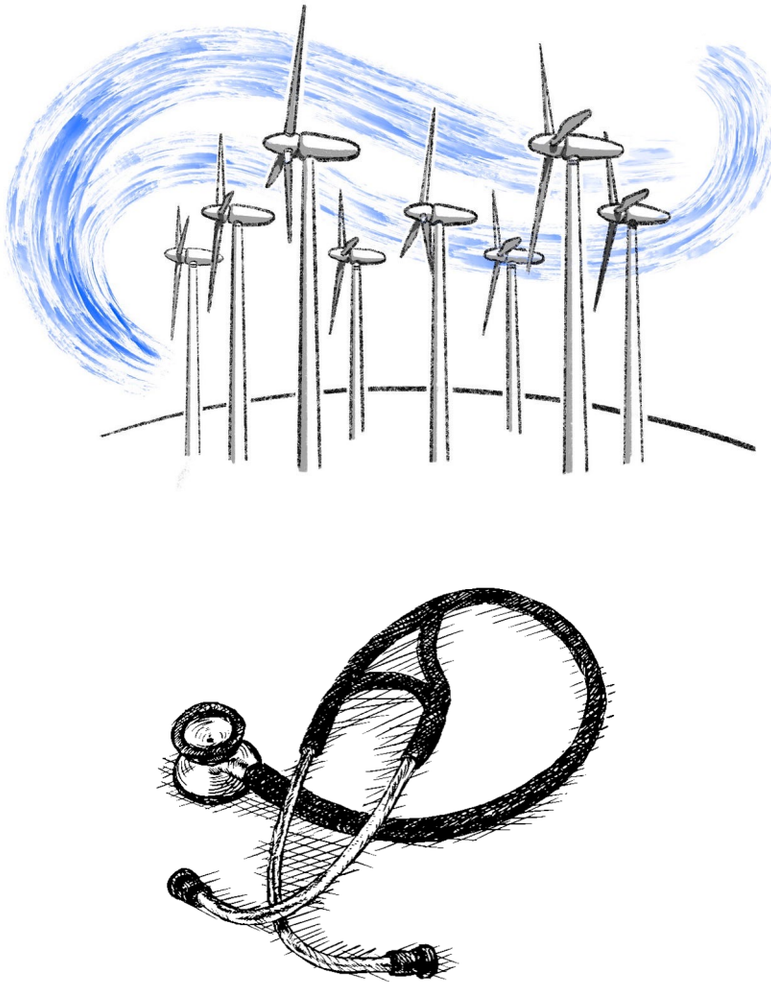
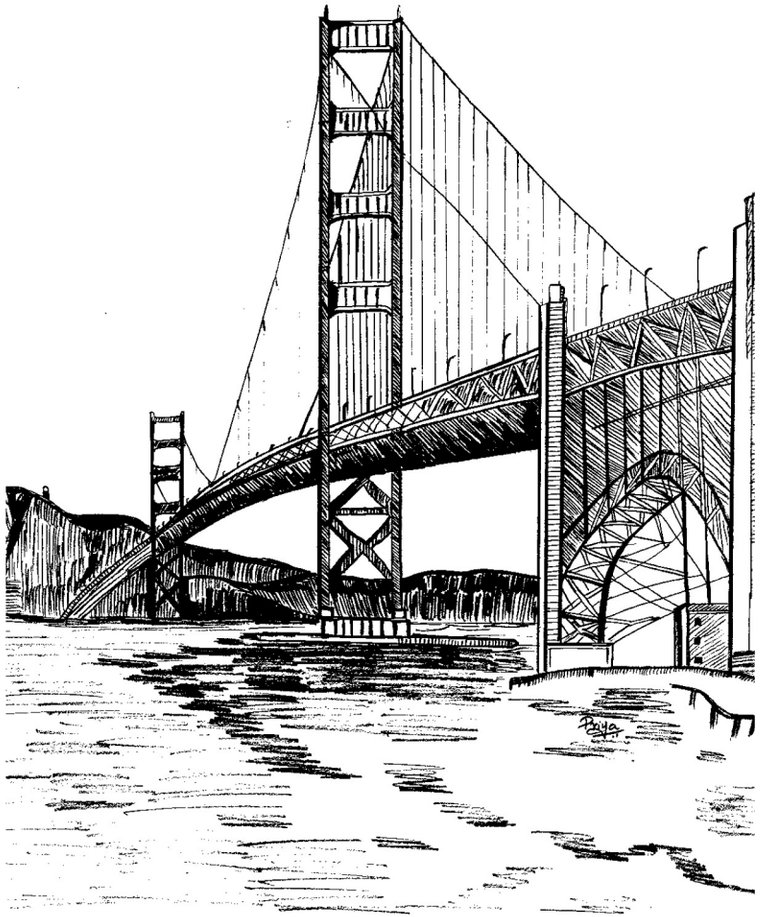
Health Monitoring of Engineering Structures





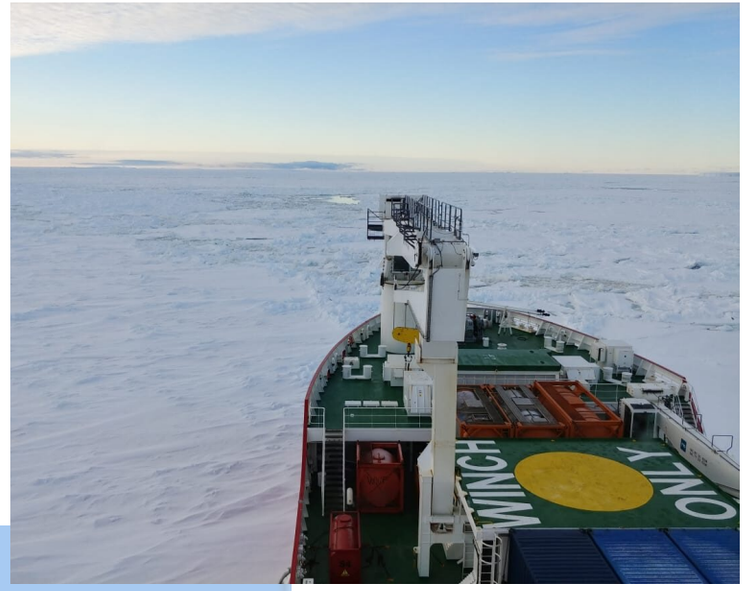


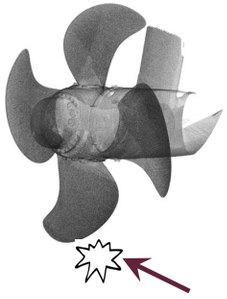
SA Agulhas II

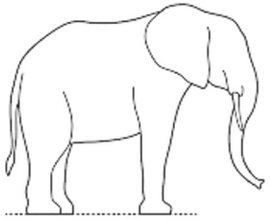
Photo: James-John Matthee

Sources of Adverse Loading

Sea-Ice:
Impact Loading on Propellers (Entrained Ice)





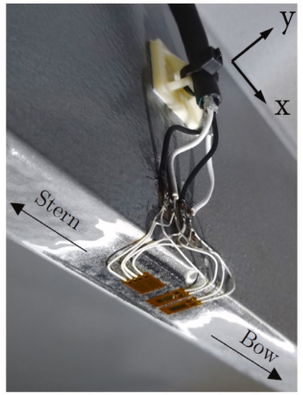


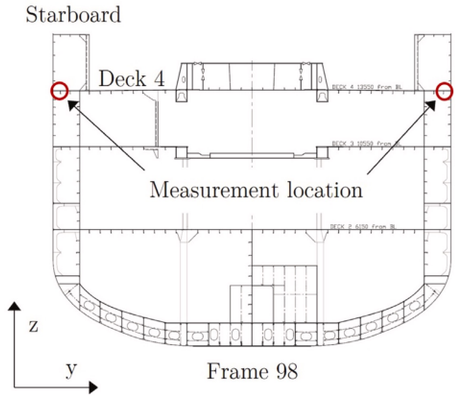
Open Ocean:
Deformation of the Hull (Wave Slamming)

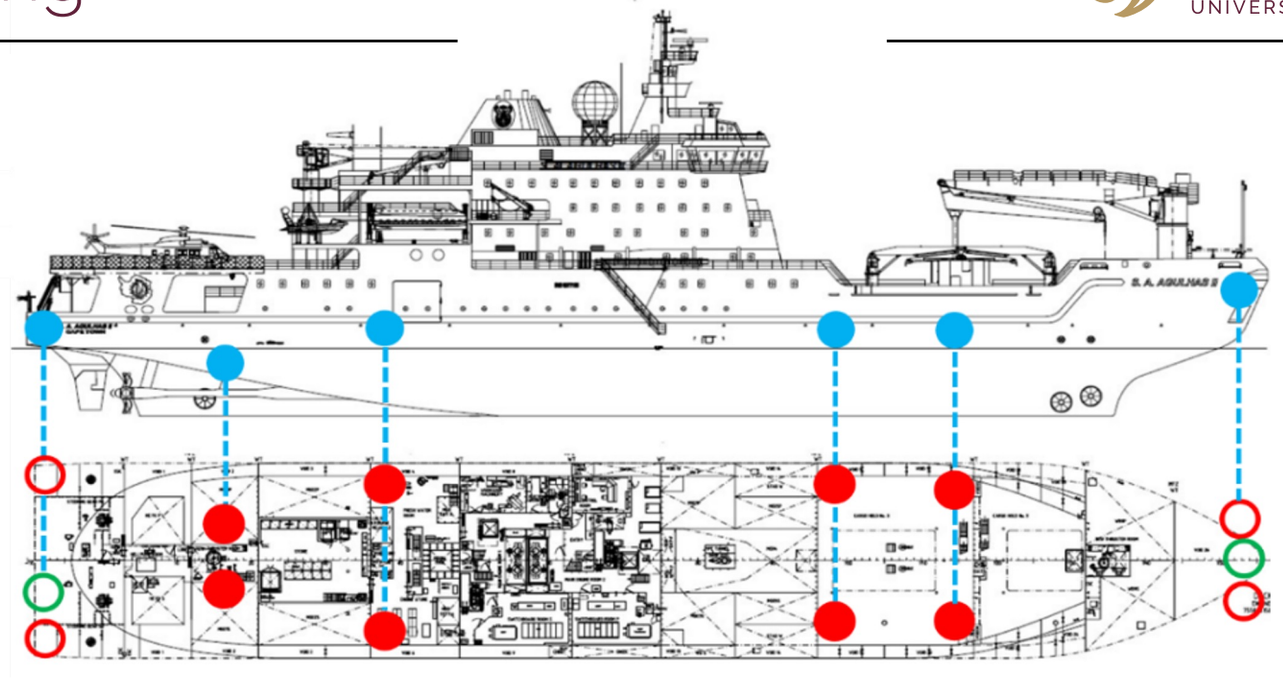
Full-Scale Structural Monitoring

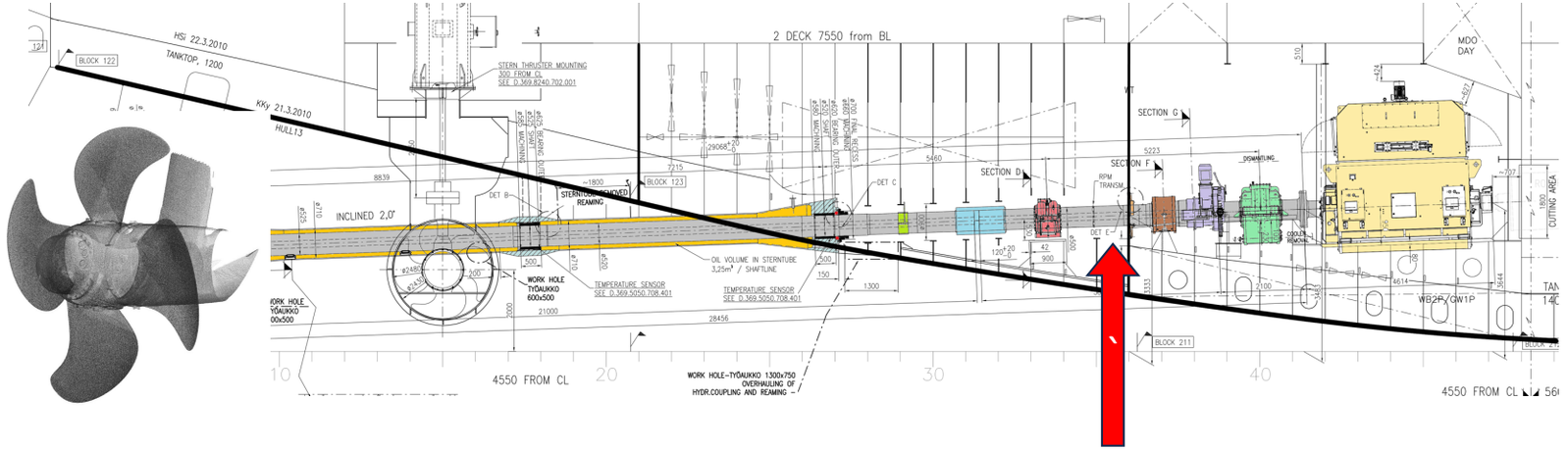
Measure (and archive):

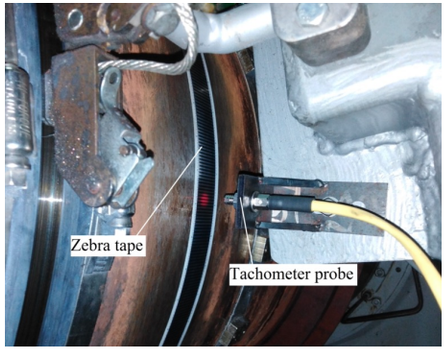
- Strain
- Rotational velocity



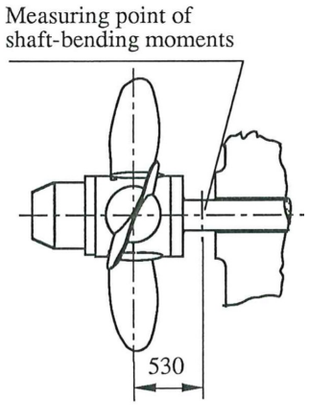








Loading Specification for Propeller Design



[JRPA#6]

Ice trials on various ice-faring vessels in 1980's

→ Measurements directly on propeller blades

→ Extreme value analysis

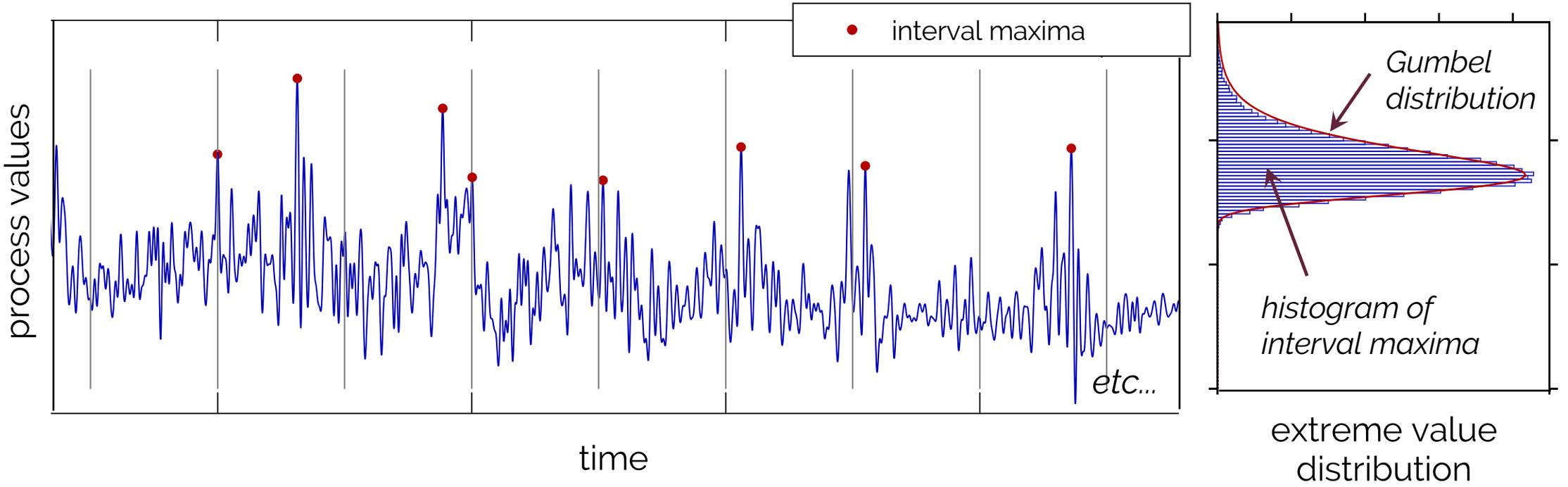
SAAII operational classification

→ PC-5

→ Real-Time Monitoring

→ Design specification for SAAII shaft-line in context of probability / risk

Extreme Value Analysis: Exceedance Probability



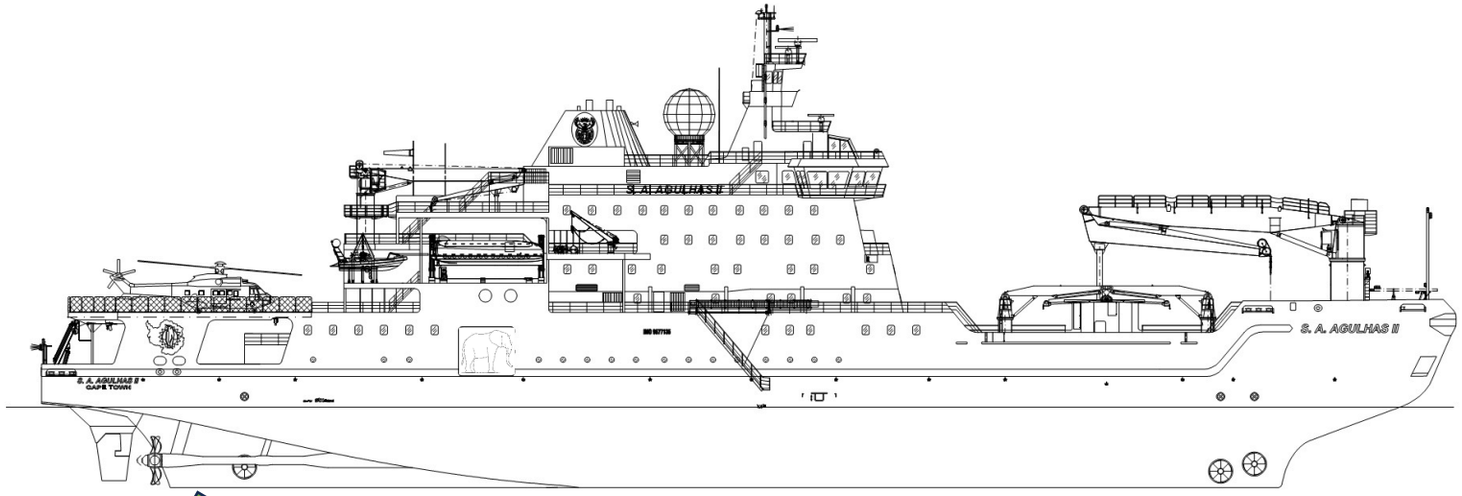
Parent data series

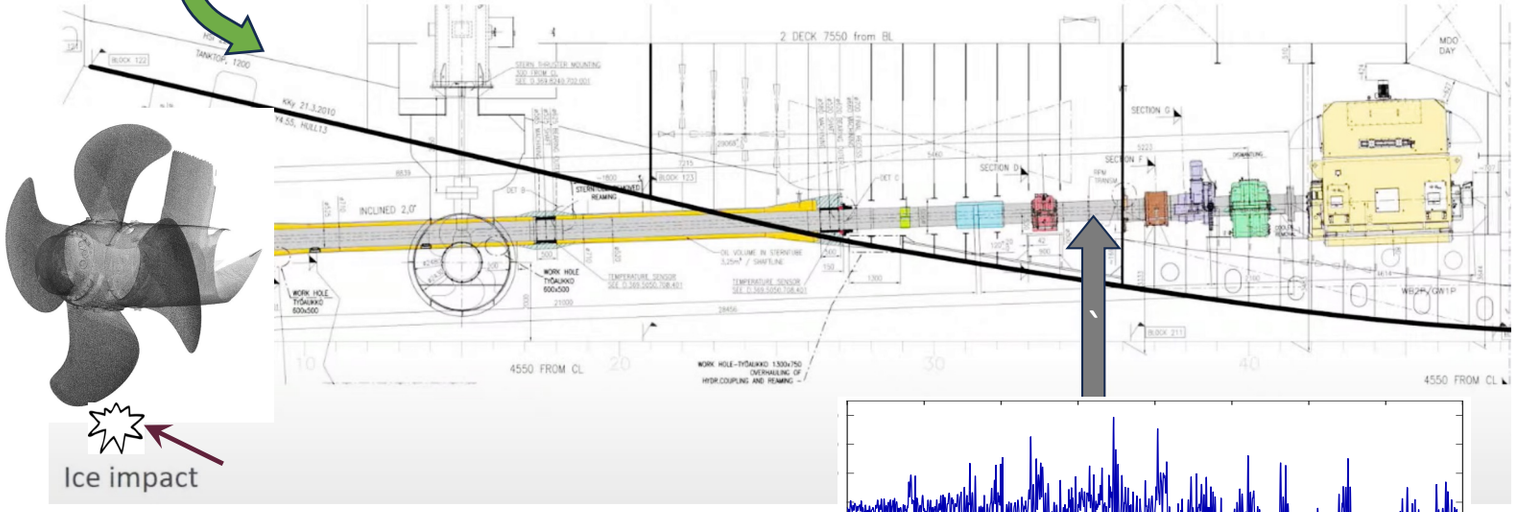
→ Distribution of interval maxima

→ Exceedance probability in reference interval

→ Exceedance probability in any interval

Monitoring Impact Loading on the Propeller





$Q(t)$ $\dot{\theta}(t)$ Shaft-line measurements

Accelerated inverse model

$Q^{(c)}$ Impact-induced torsion

- **Loading analysis**
- **Real-time monitoring**

Endurance-22 Voyage

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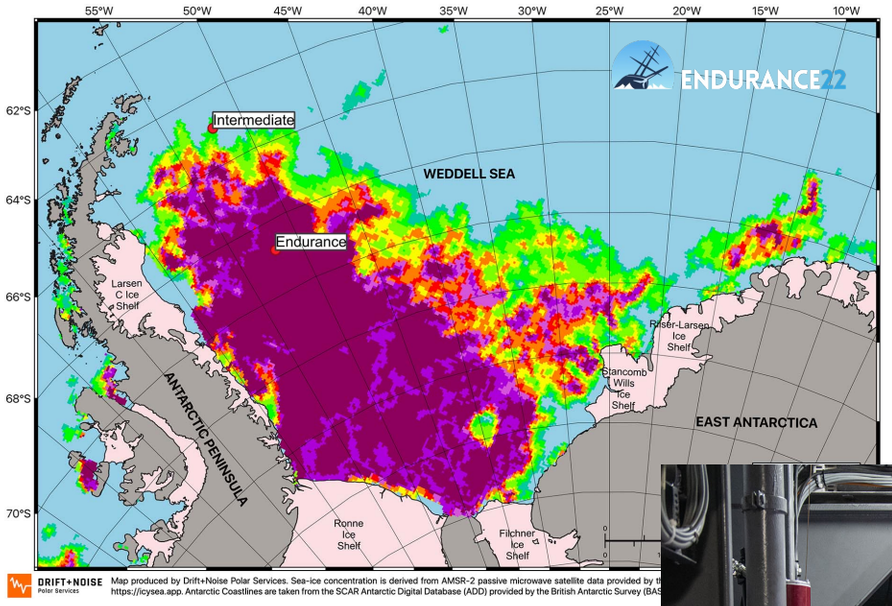

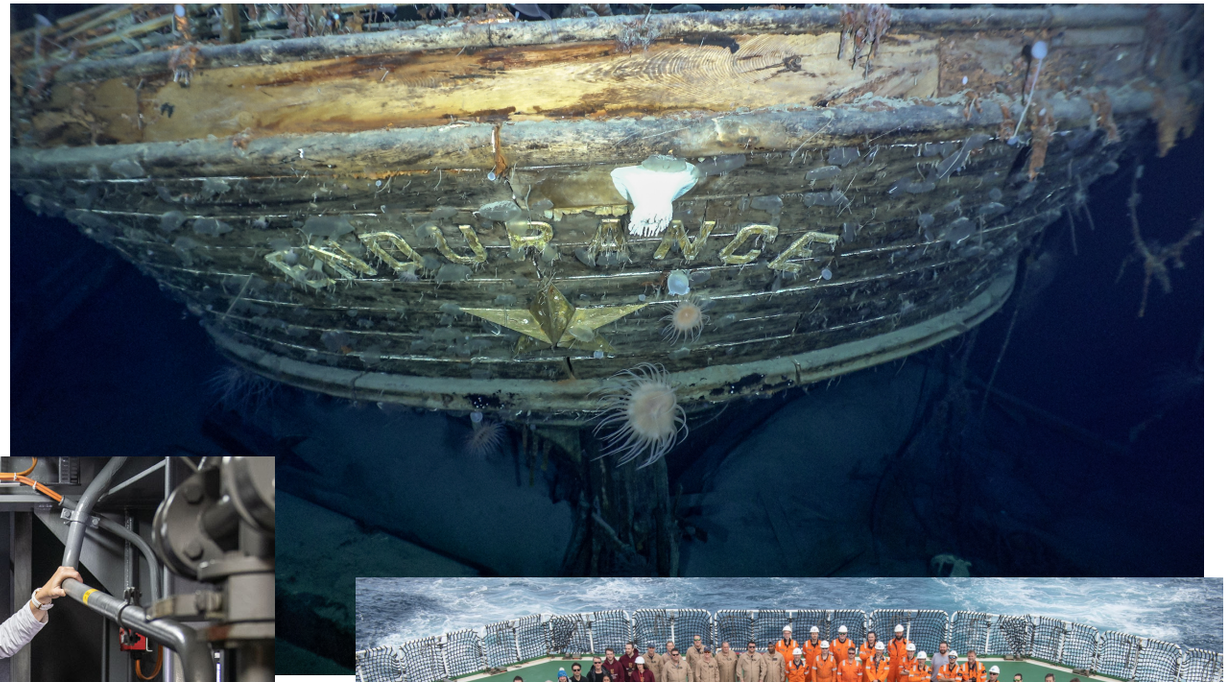

FALKLANDS MARITIME HERITAGE TRUST

ENDURANCE22

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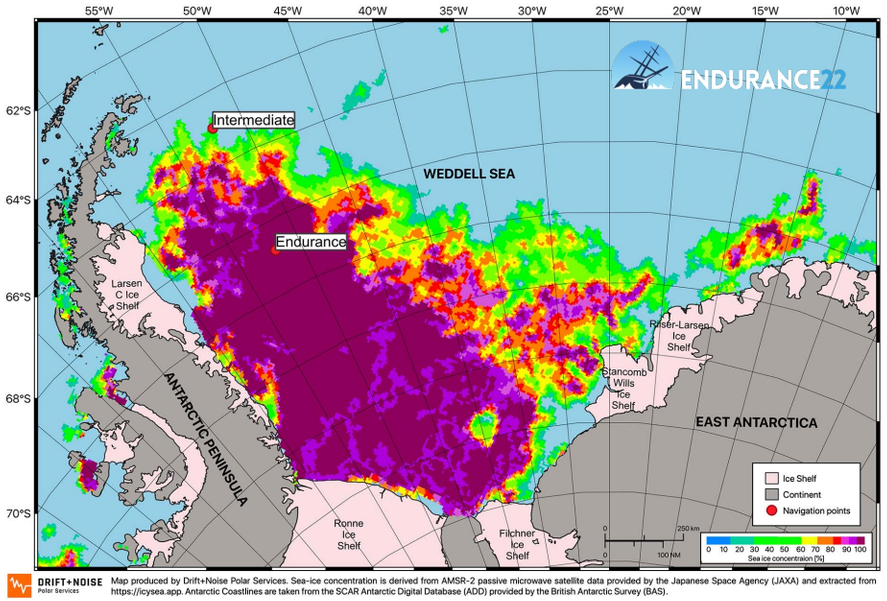
Endurance-22 Voyage: Monitoring Data

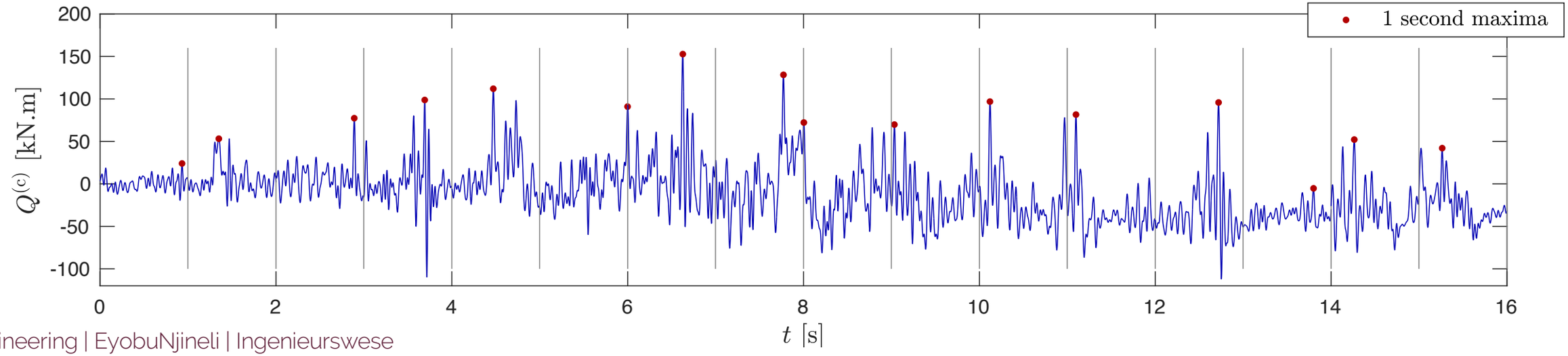


Methodology:

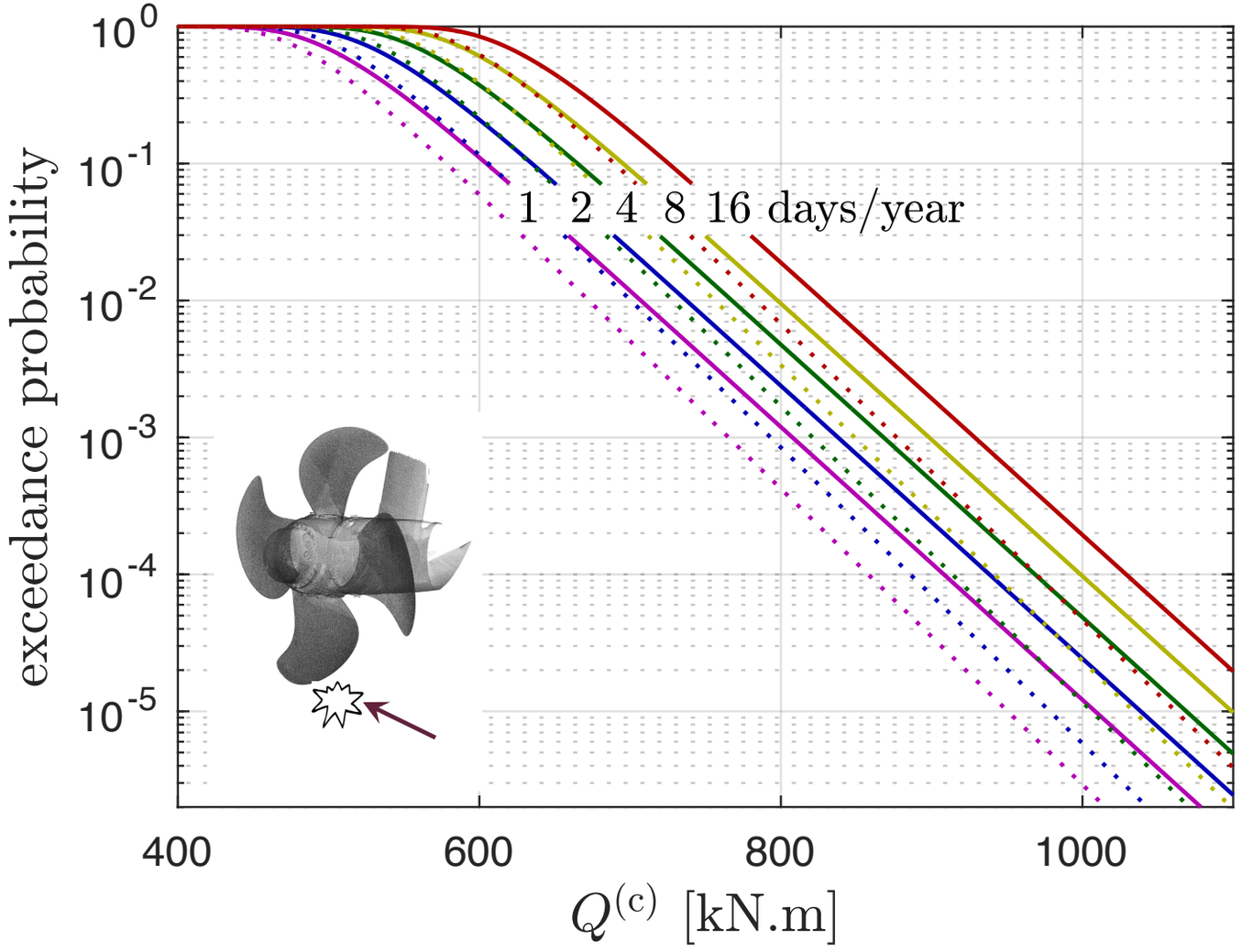
Record $Q(t)$ and $\dot{\theta}(t)$ for navigation of sea-ice during Endurance22 voyage (~13 days of data)

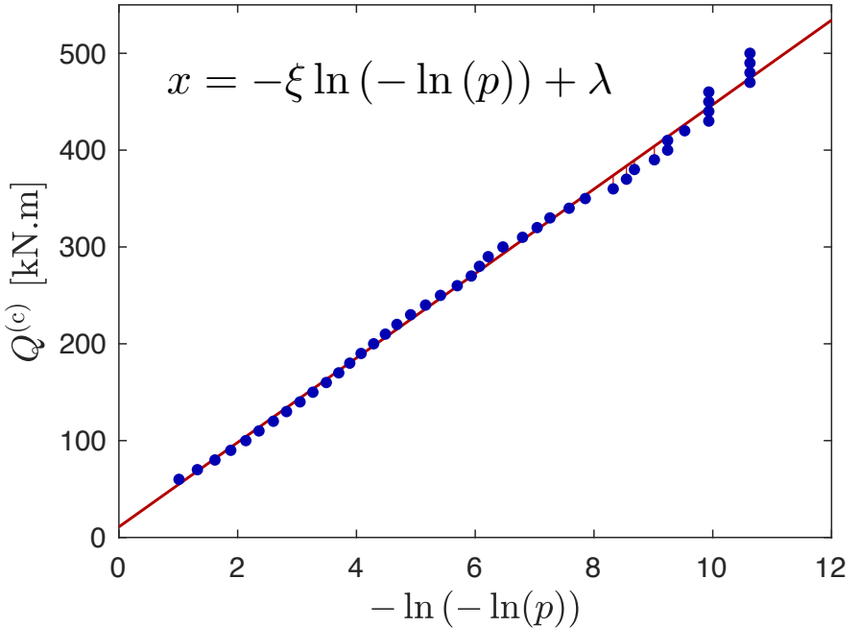
Compute time series of $Q^{(c)}$

Find maximum $Q^{(c)}$ value in each 1-second window for total of ~1.1 million seconds

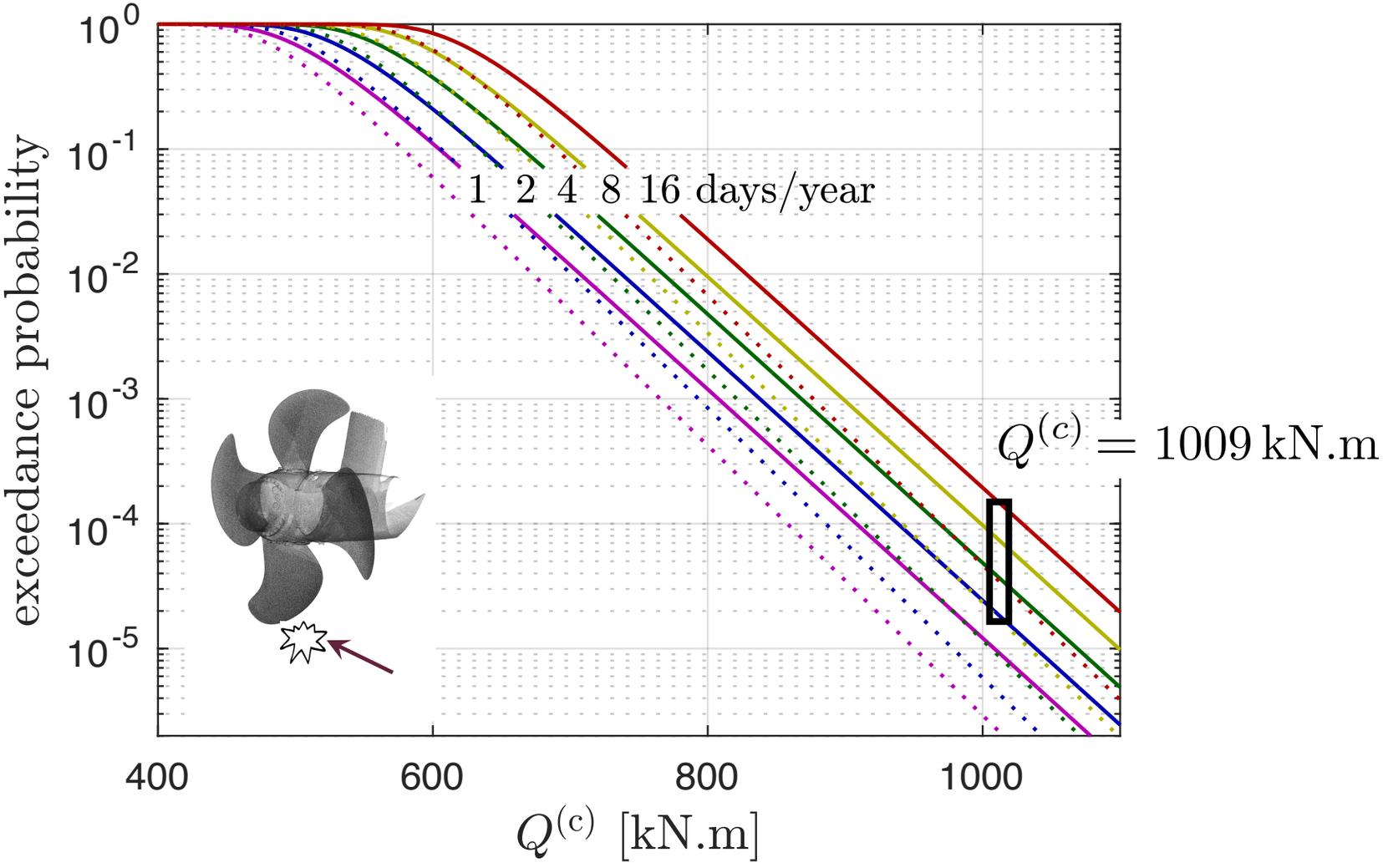


Result: Distribution of Impact Loading

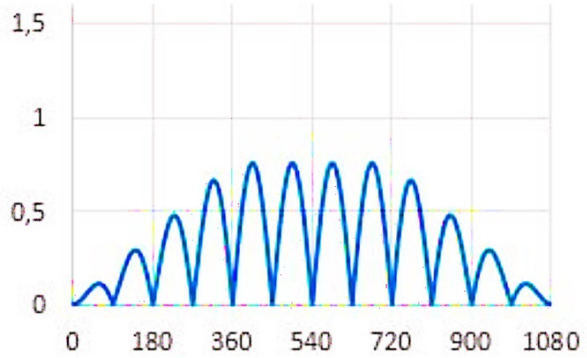


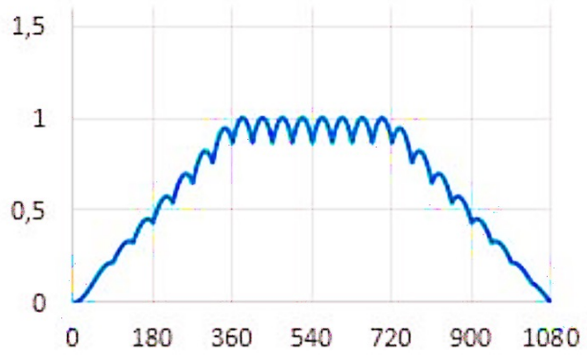


Interpretation: Distribution of Impact Loading

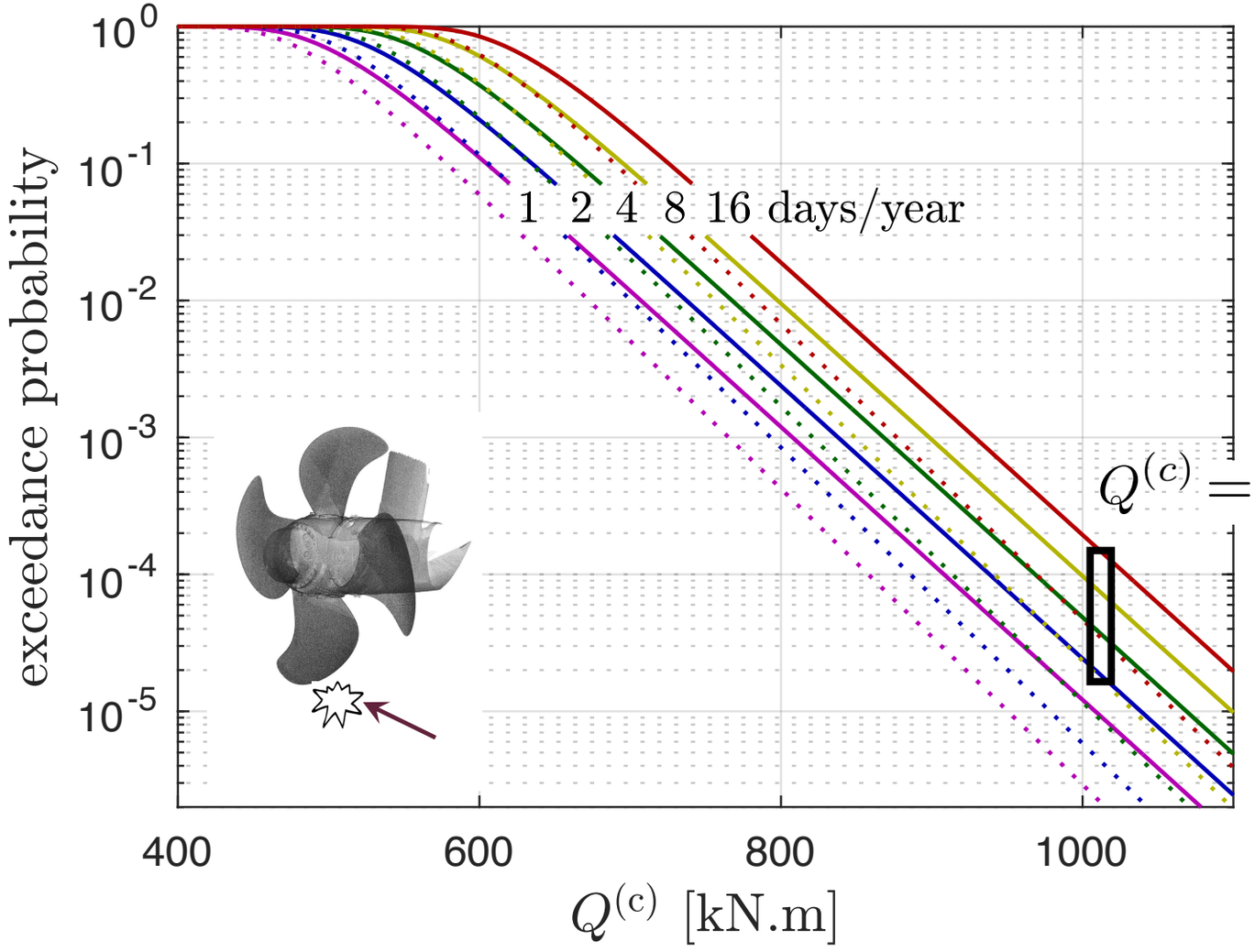


Design loading:





Structural Health Monitoring



Societal tolerance for risk of failure resulting in: environmental damage, serious injury / death:

1/10,000 – 1/100,000 chance/year

→ Appropriate in context of societal risk tolerance

To Conclude

- Algorithms for faster-than-real time analysis:
  - → monitoring for situational awareness
  - → full voyage analysis
- Analysis results enable:
  - → guidance on design specifications
  - → assessment of exiting system of SAAII

- Ongoing monitoring work on SAAII hull and propulsion shaft
- Do you have an interesting monitoring problem? Get in touch!

– Thank You –