Submarine Delivery Agency

NAVAL AUTHORITY & TECHNOLOGY GROUP
advise | assure | certify | enable

Modelling Partially Effective Structure for Damage Strength Analysis

Naval Damage Control

Introduction

- What is a Residual Strength Assessment – and how we do it
- What do we mean by Partially Effective Structure
- Development of our approach
- Case Study

Naval Ship Code

- Chapter II (Structure) Regulation 3.28:
  - Foreseeable
  - Extreme Threat iaw CONOPs

- Protect the embarked persons and essential safety functions in the event of foreseeable emergencies and accidents at least until the persons have reached a place of safety or the threat has rescinded.

- Minimise the risk of loss of the ship.


NATO STANDARD

ANEP-77 PART 1

NAVAL SHIP CODE: GOALS, FUNCTIONAL OBJECTIVES AND PERFORMANCE REQUIREMENTS

Edition G Version 3

JULY 2019

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED NAVAL ENGINEERING PUBLICATION

Published by the
NATO STANDARDIZATION OFFICE (NSO)
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Residual Strength Assessment

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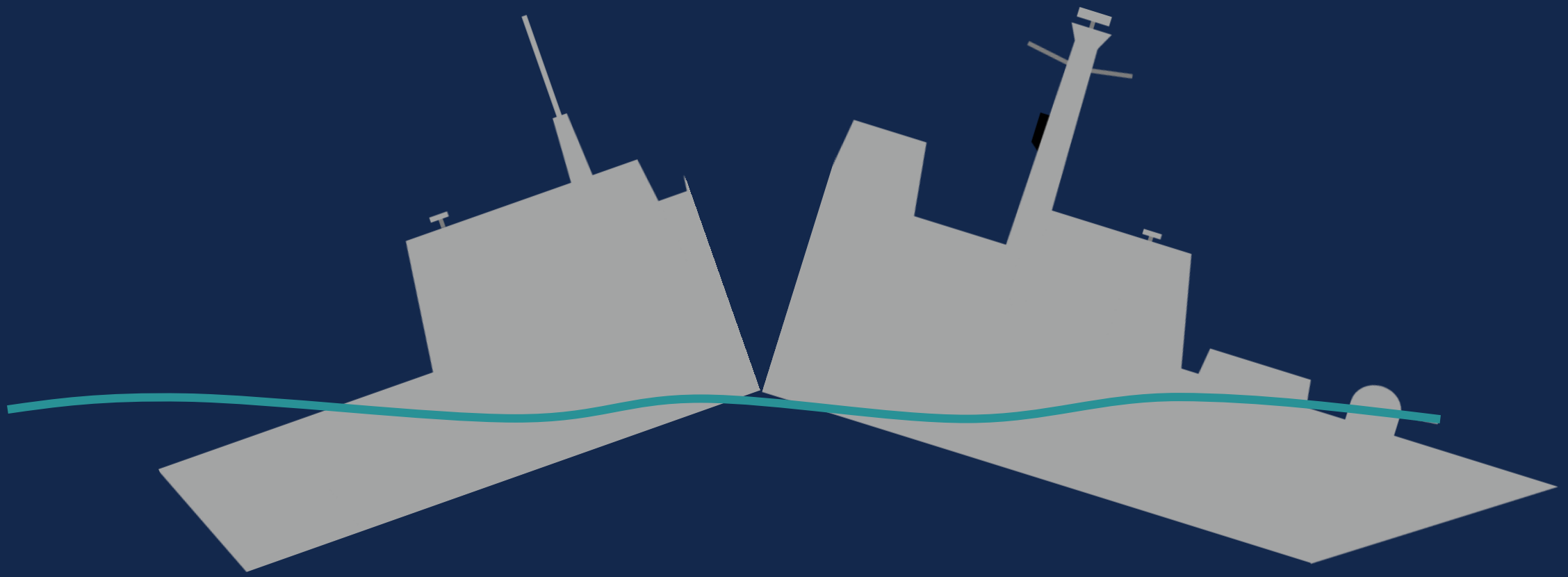


RSA Approaches

Level	Analysis Type	Method
1	2D Elastic	Spreadsheet
2	2D Elasto-Plastic Beam	Specialist Code
3	3D Material Model	Non-Linear Finite Element Analysis

Increasing Cost
& Accuracy

Smith Progressive Collapse Method

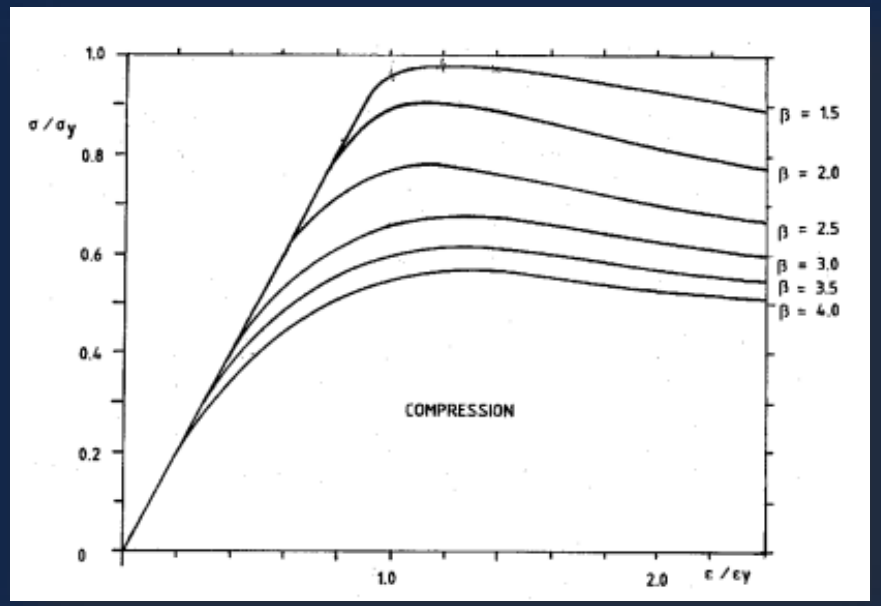
Column-Buckling

$$\sigma_{CR1} = \phi . \sigma_{c1} \left(\frac{A_{s-net} + A_{pE-net}}{A_{s-net} + A_{p-net}} \right)$$

Plate-Buckling

$$\sigma_{CR5} = . \left\{ \phi . \sigma_{y_{plate}} \left[\frac{s}{l} \left(\frac{2.25}{\beta_e} - \frac{1.25}{\beta_e^2} \right)^{\sigma_{Y_{plate}} . \phi} + 0.1 \left(1 - \frac{s}{l} \right) \left(1 + \frac{1}{\beta_e^2} \right)^2 \right] \right\}$$

Lowest σ



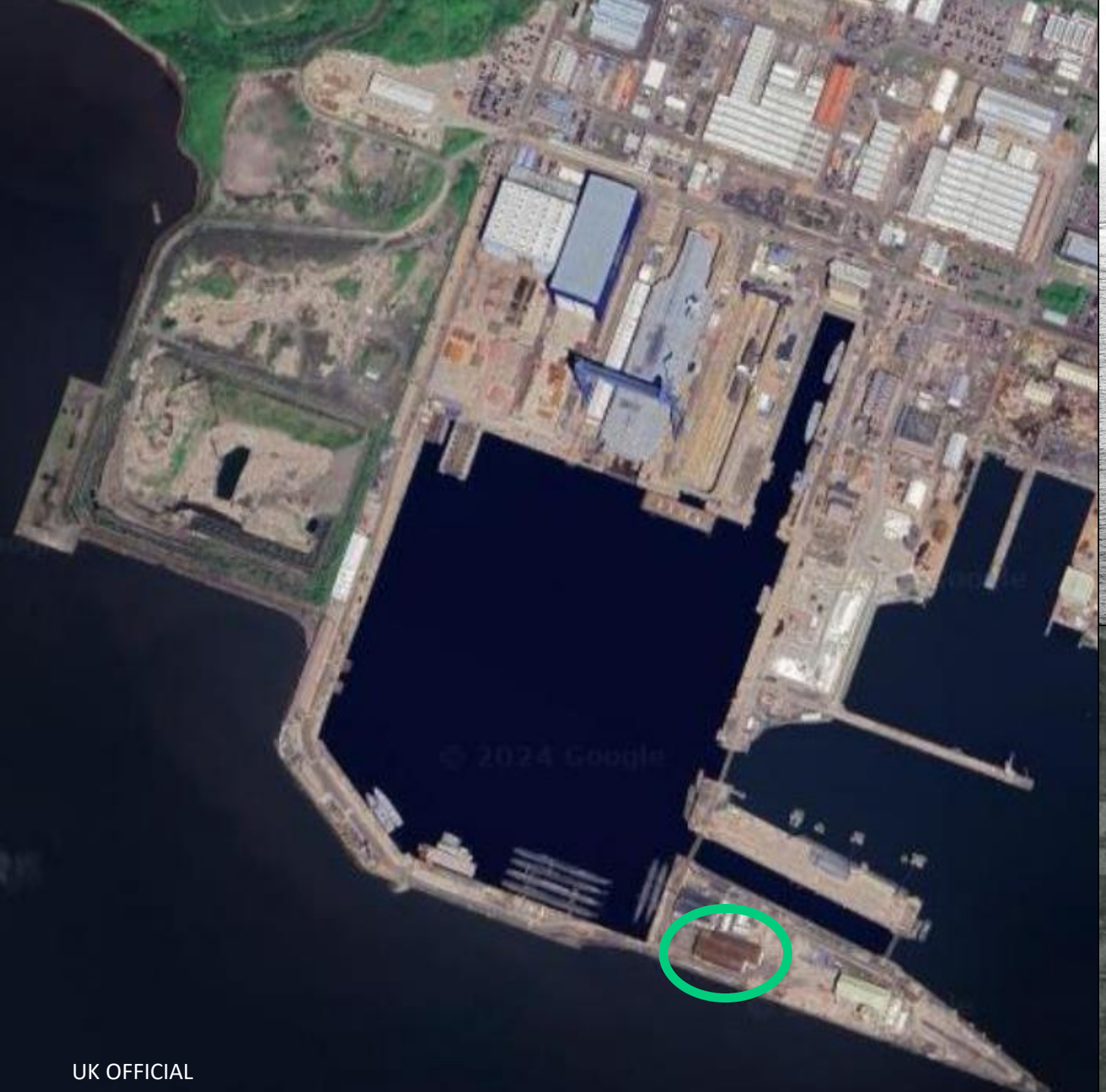
$$\chi 1 = \Delta_\chi = 0.01 \frac{\sigma_C}{E} \frac{1}{y_e}$$

Knockdown Factor

$$\phi = -1 \; for \; \varepsilon < -1$$
$$\phi = \varepsilon \; for - 1 \leq \varepsilon \leq 1$$
$$\phi = 1 \; for \; \varepsilon > 1$$

$$M = \sum \sigma_{e_C} . A_e . y_e$$

$$NA \; SHIFT = \frac{\sum A_e . \sigma_{e_U}}{\chi . \sum E_e . A_e}$$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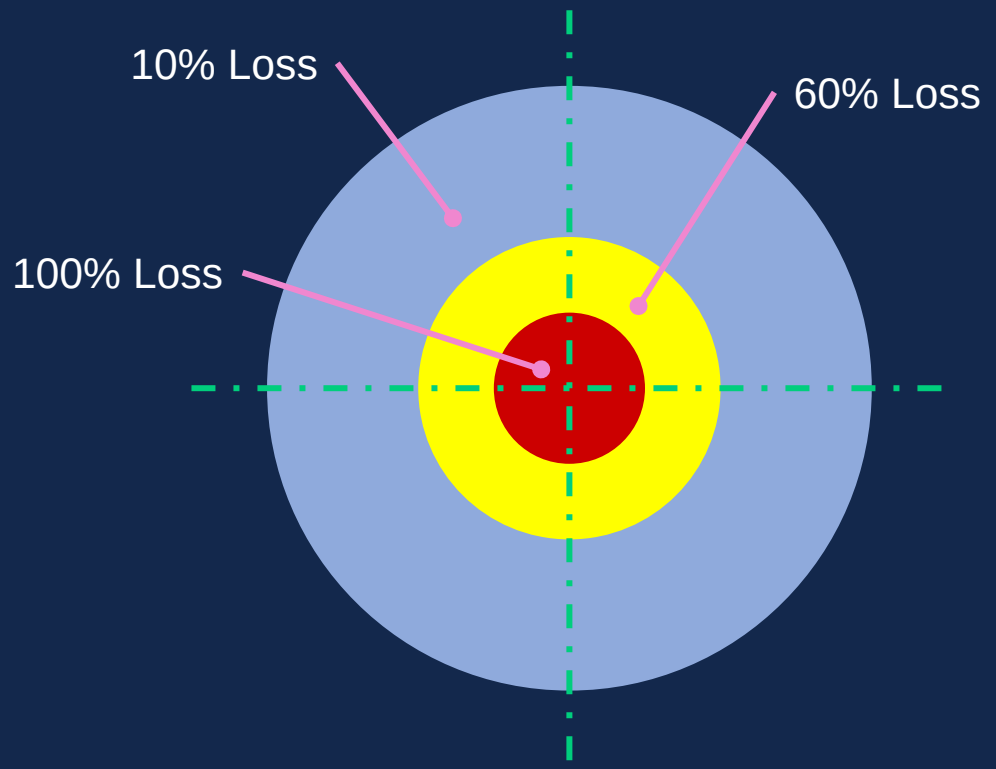
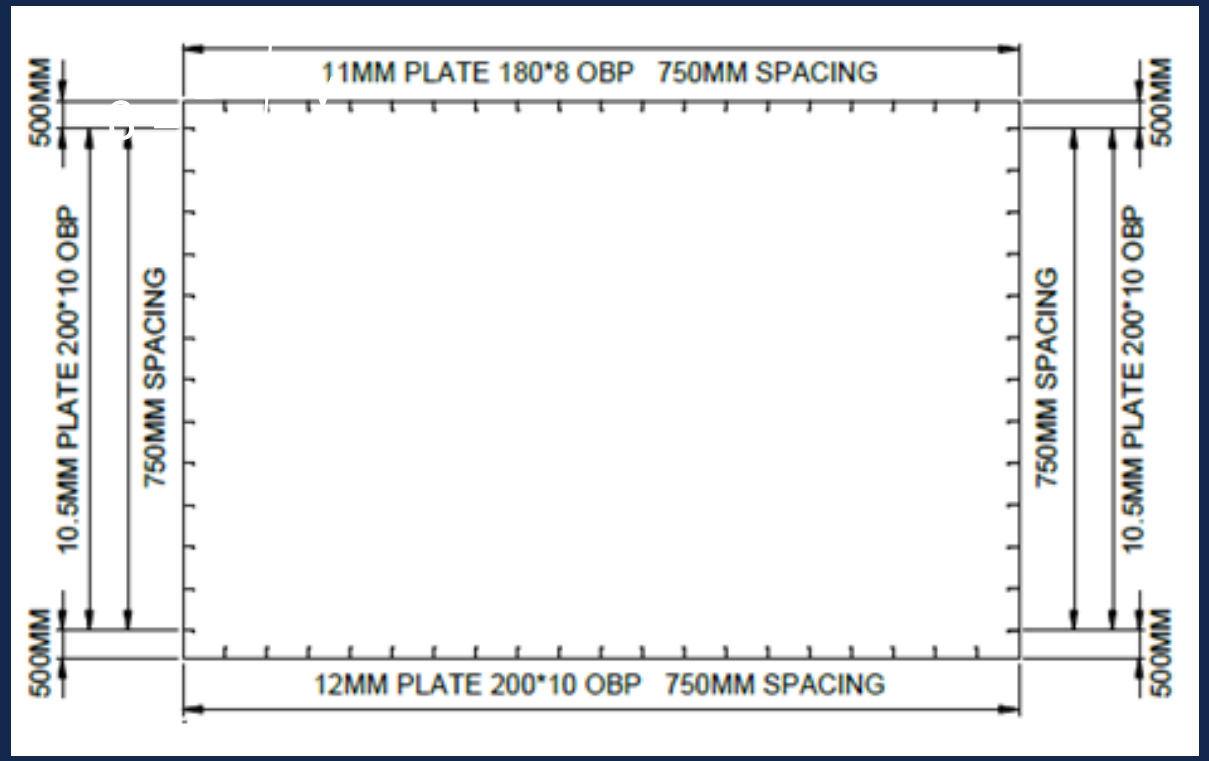
Partial Effectiveness

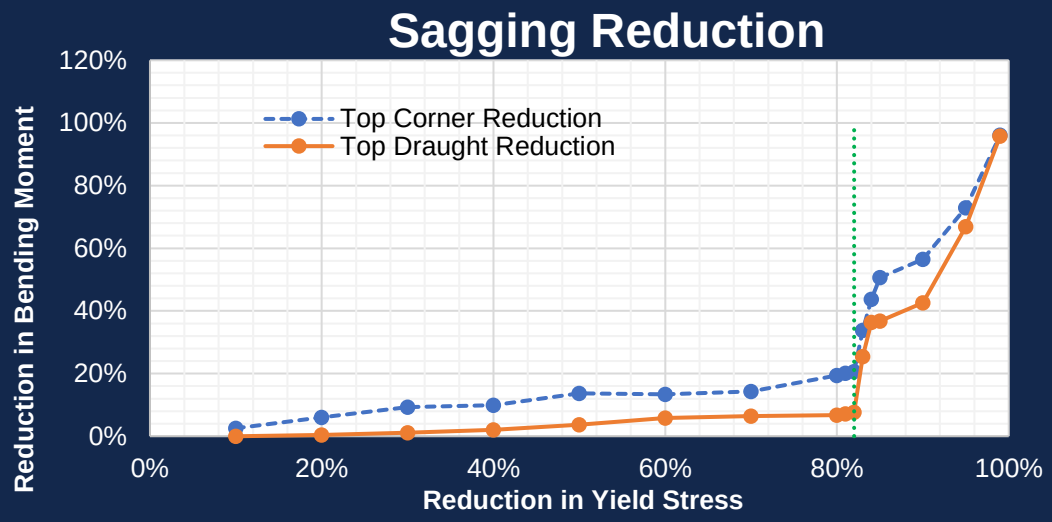


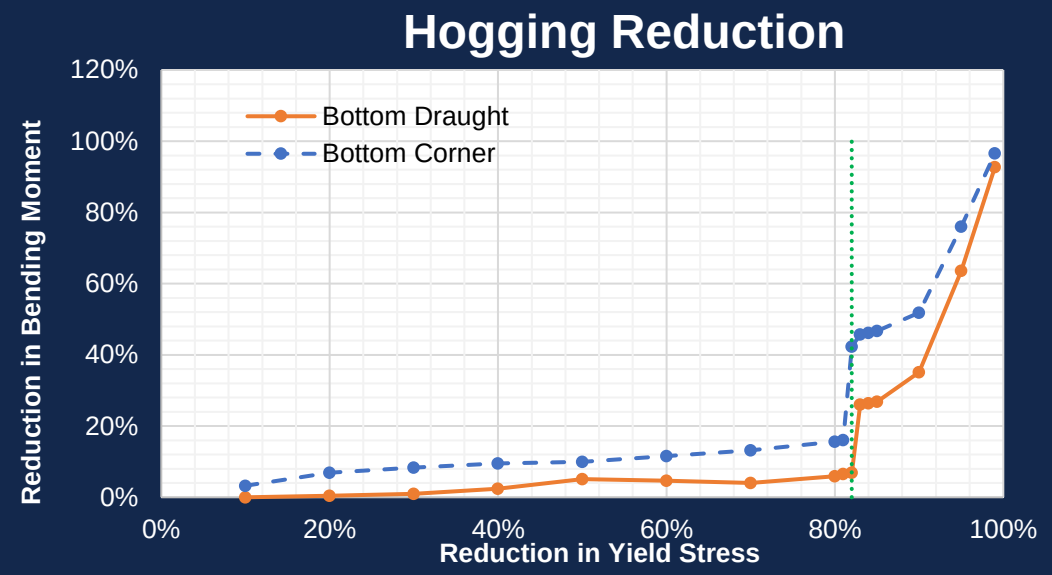
Typical Above Water Hostile Damage
Structural Loss Template

- Refine modelling of Structural Loss Templates used for RSA
- Achieved through manipulation of σ_y
- Partial Effectiveness approach tested against:
  - LR NSR s/w (LR20202)
  - PARAMARINE 2020.2 (NS94D)

Range of Effectiveness

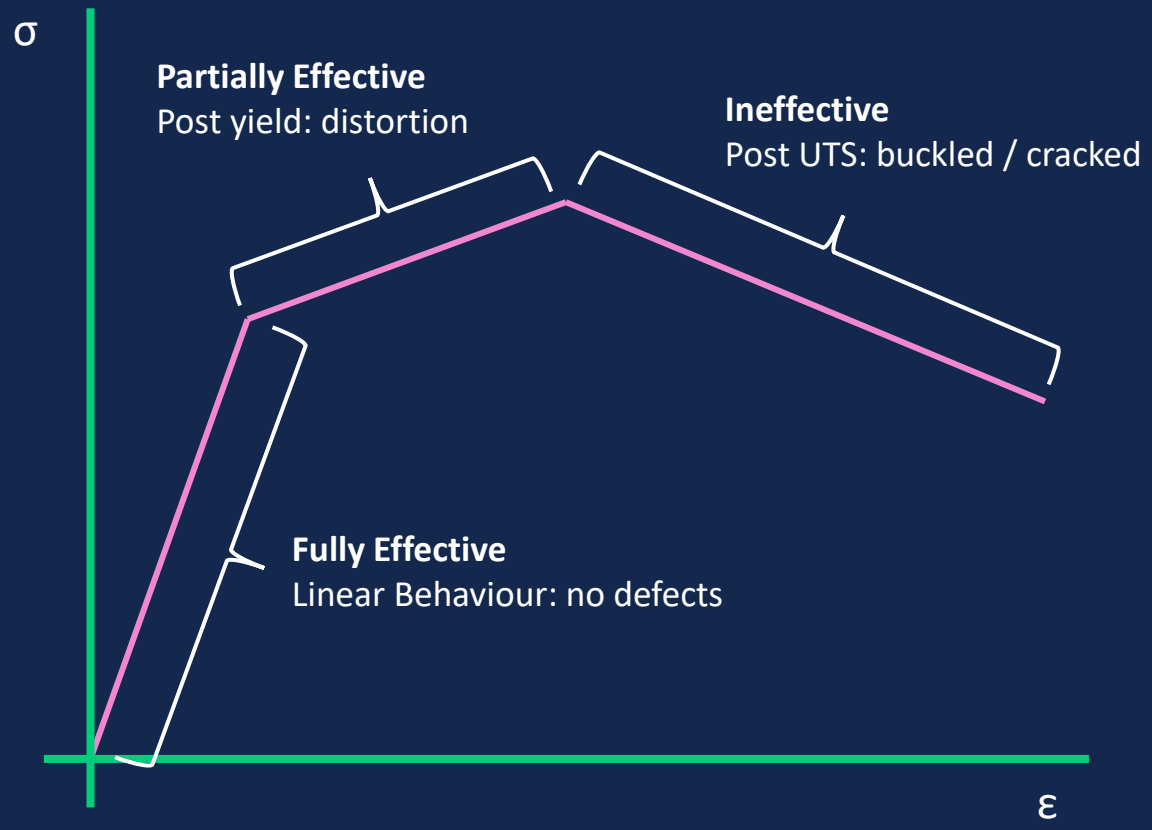







DANGER
TURRET
MAY TRAIN
AIR ESCAPE
AIR ESCAPE

Defect Model



- If in doubt take it out

i.e. default will be to make structure ineffective by removing it from the model

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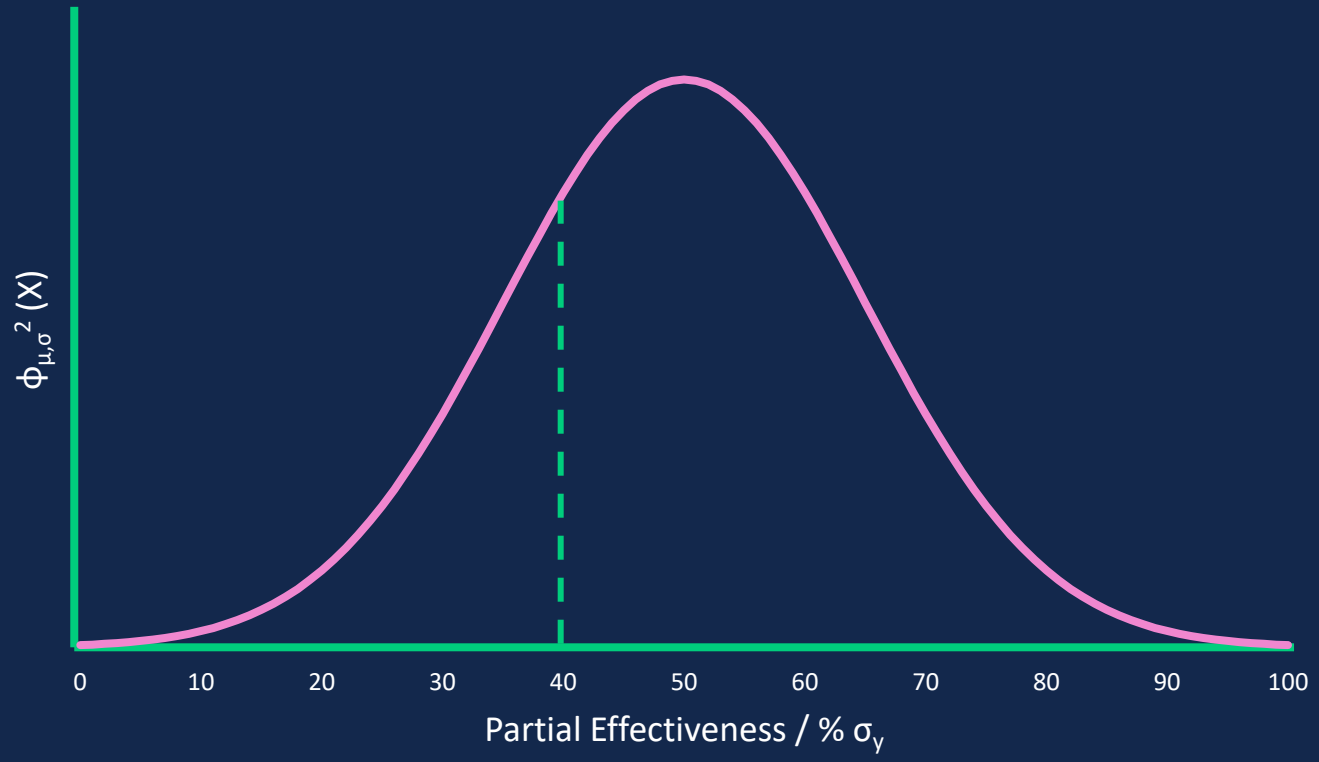

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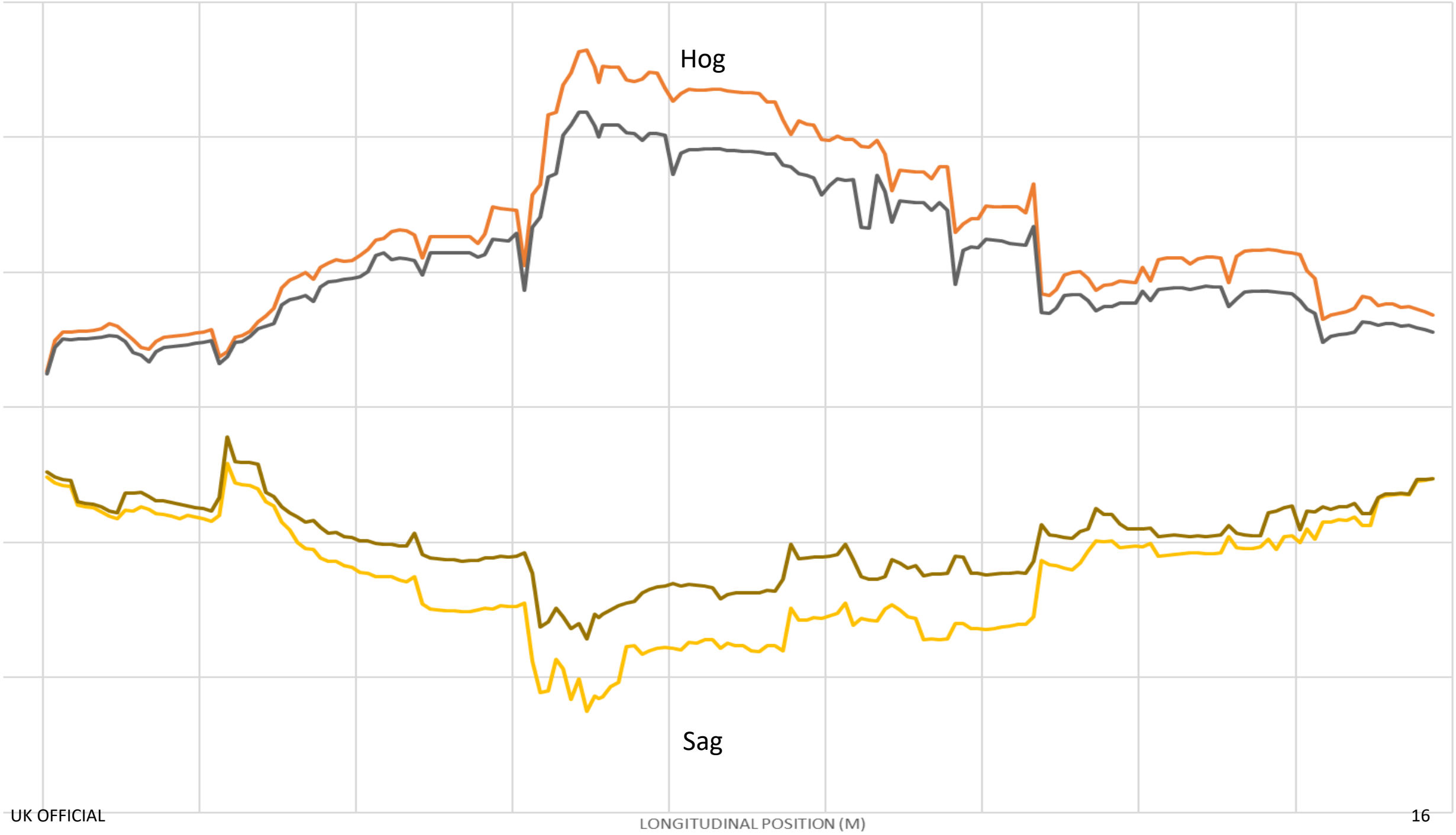
Hog
Sag
ULTIMATE MOMENT (MNM)
LONGITUDINAL POSITION (M)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