

# STRUCTURE AND MOTIONS OF HIGH SPEED CRAFT

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A REVIEW OF WORK UNDERTAKEN BY THE  
RNLI AND FRAZER-NASH

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PRESENTED BY SIMON REES

# The RNLI exists to save life at sea

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- > RNLI provides a lifeboat service around the British Isles
- > There are over 220 lifeboat stations around the coast of the UK and Ireland
- > There are 310 boats in the regular fleet, with 135 held in the relief fleet
- > 24 hours a day, 365 days a year

# The RNLI exists to save life at sea

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In 2003 RNLI lifeboats :

- > launched on 8,047 occasions (20 times a day)
- > Rescued 7,815 people (21 per day)

Average time to launch from call-out

- > ALB 11 mins
- > ILB 7 mins

## RNLI FACTS:

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- > Volunteer crews
- > Funded entirely from voluntary contributions
- > In 2002 it cost £103 million to run the RNLI
- > For every £1 spent :
  - 80p is spent on the service
  - 17p is spent on fundraising
  - 3p is spent on administration



# Initial Aims

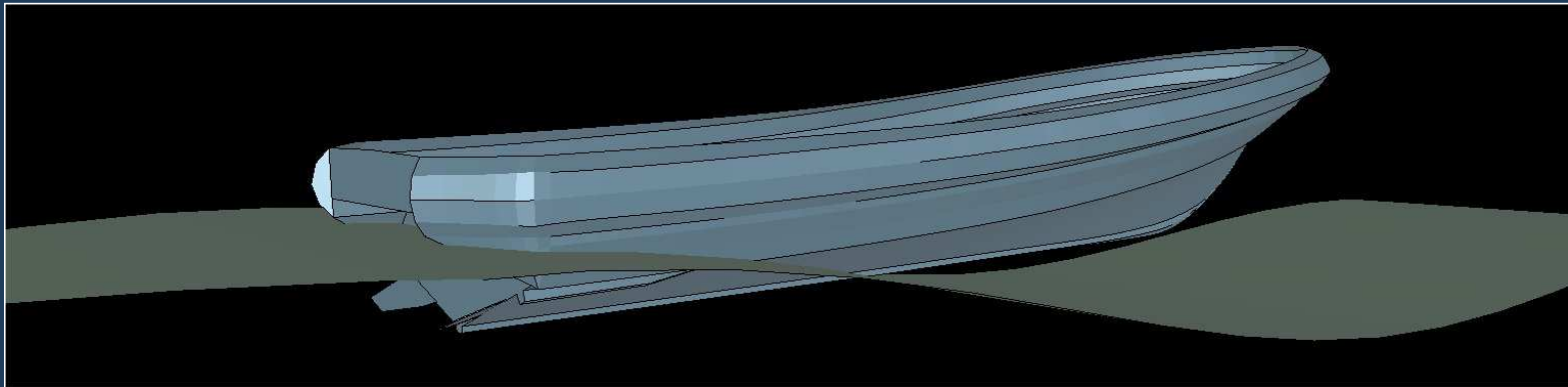
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- > To generate a modelling environment capable of simulating three-dimensional wave slam pressure distributions on a given hull form in a range of sea-states starting with no more than a hull-form geometry.
- > To generate typical slam pressure distribution functions for any hull form in a given sea-state suitable for initial structural design purposes.
- > To generate a detailed structural design methodology that applies the first-principles pressure distributions to a structural model and predicts the necessary scantling layout and hull lay-up.

# Hydrodyna - Background

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- Based on LL-DYNA3D dynamic FEA programme.
- Predicts boat motions in rough water
- Records wave slam event distribution and force



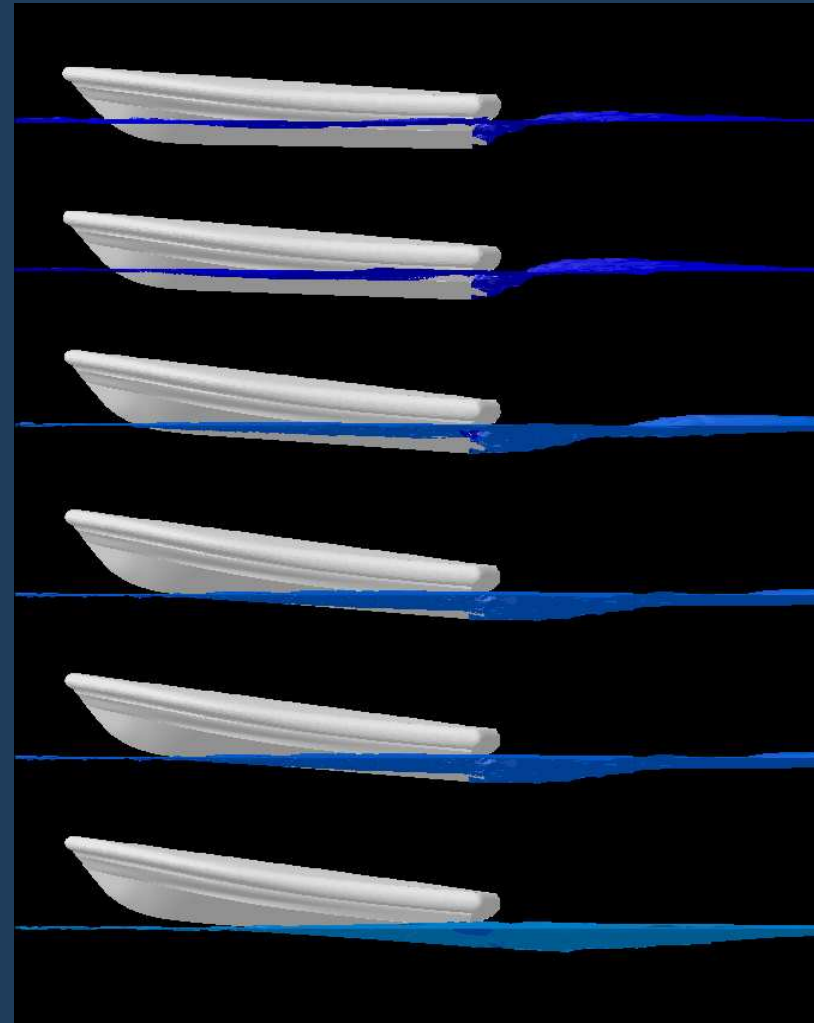
# Inputs/Outputs

## Input

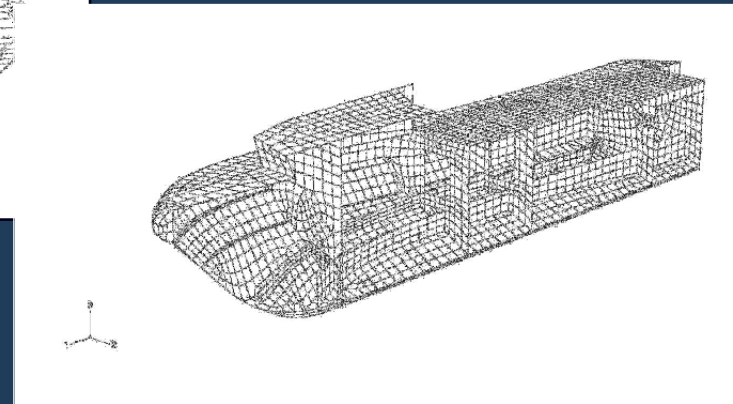
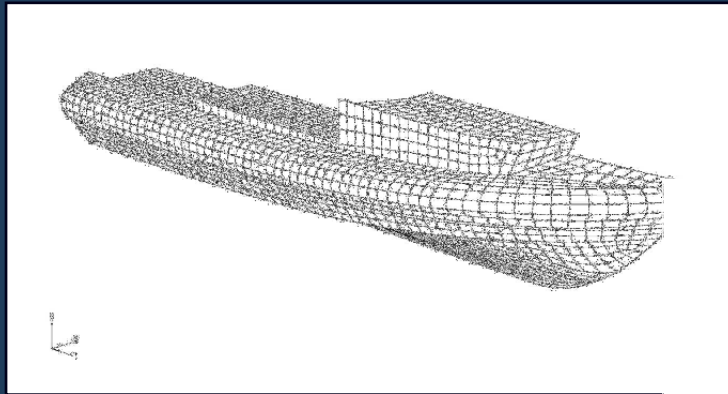
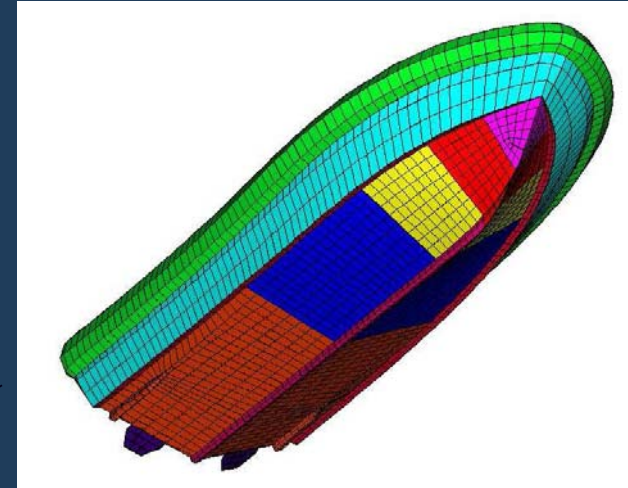
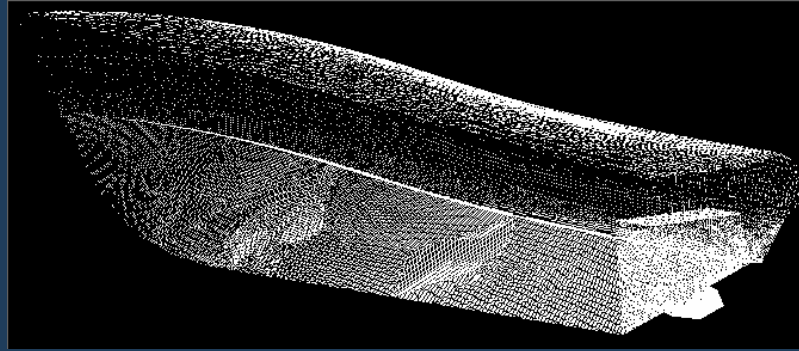
- Numerical tow-tank data
- Sea state
- Hull geometry

## Output

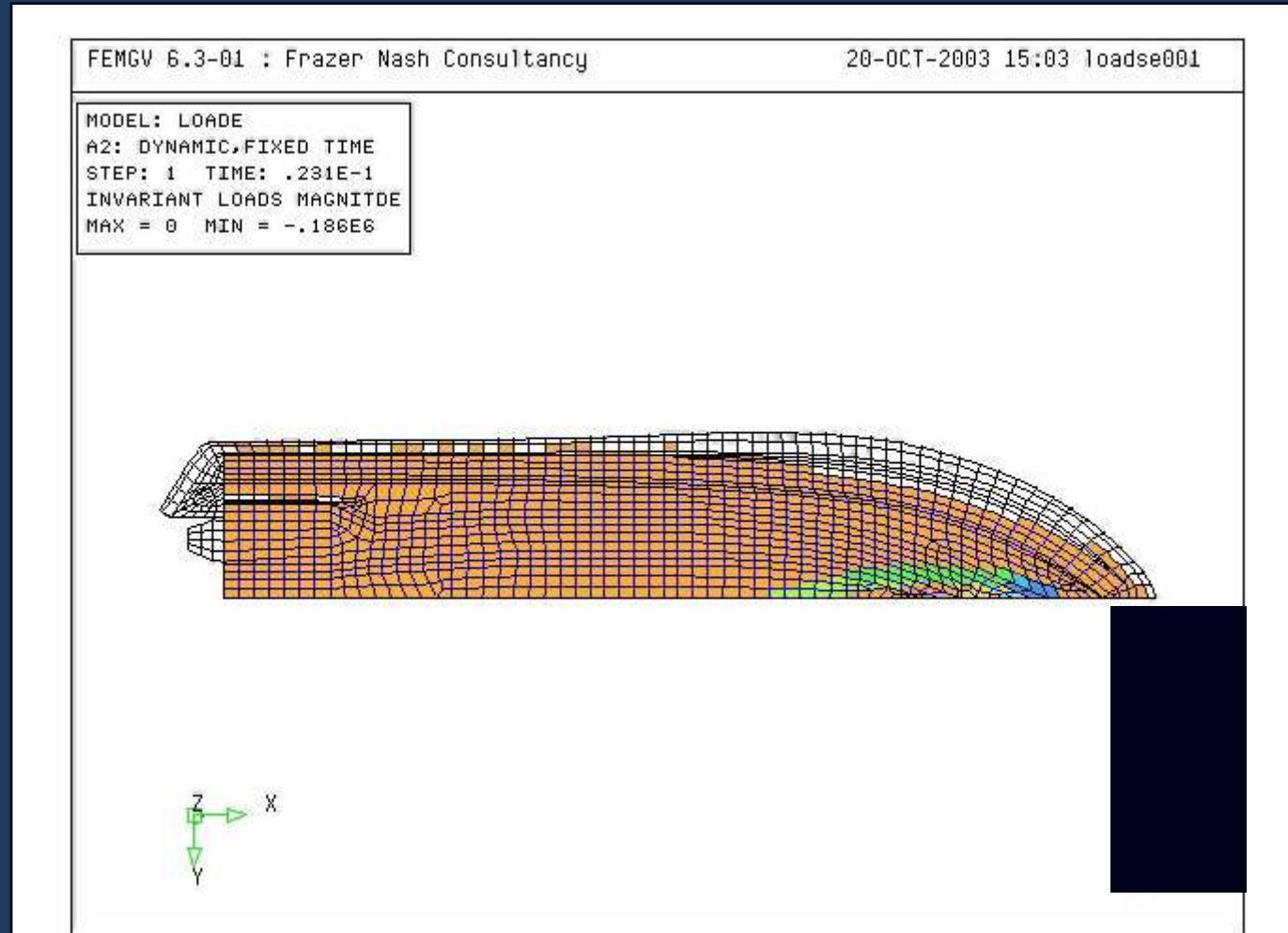
- FEA analysis slam history
- Motions



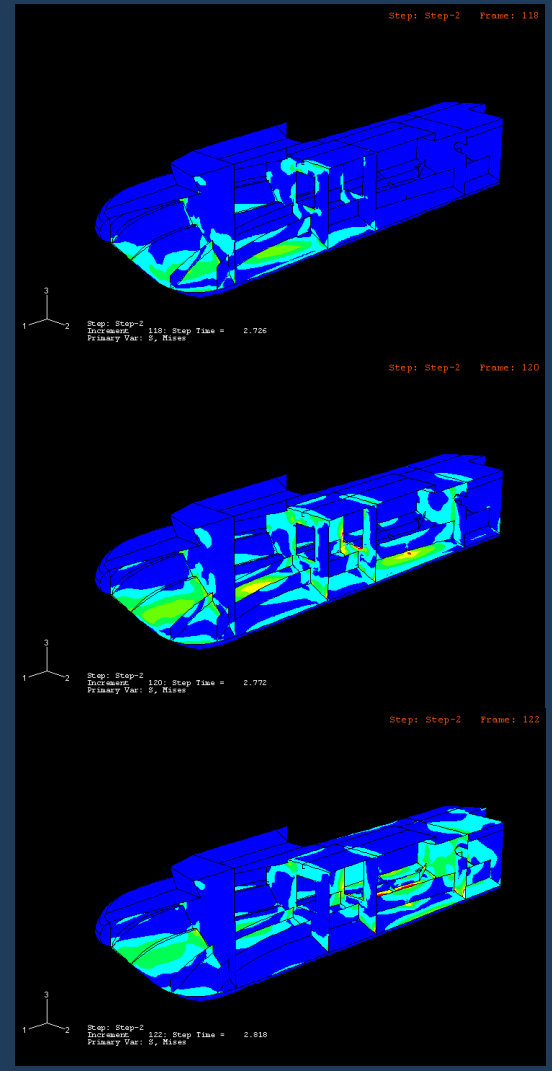
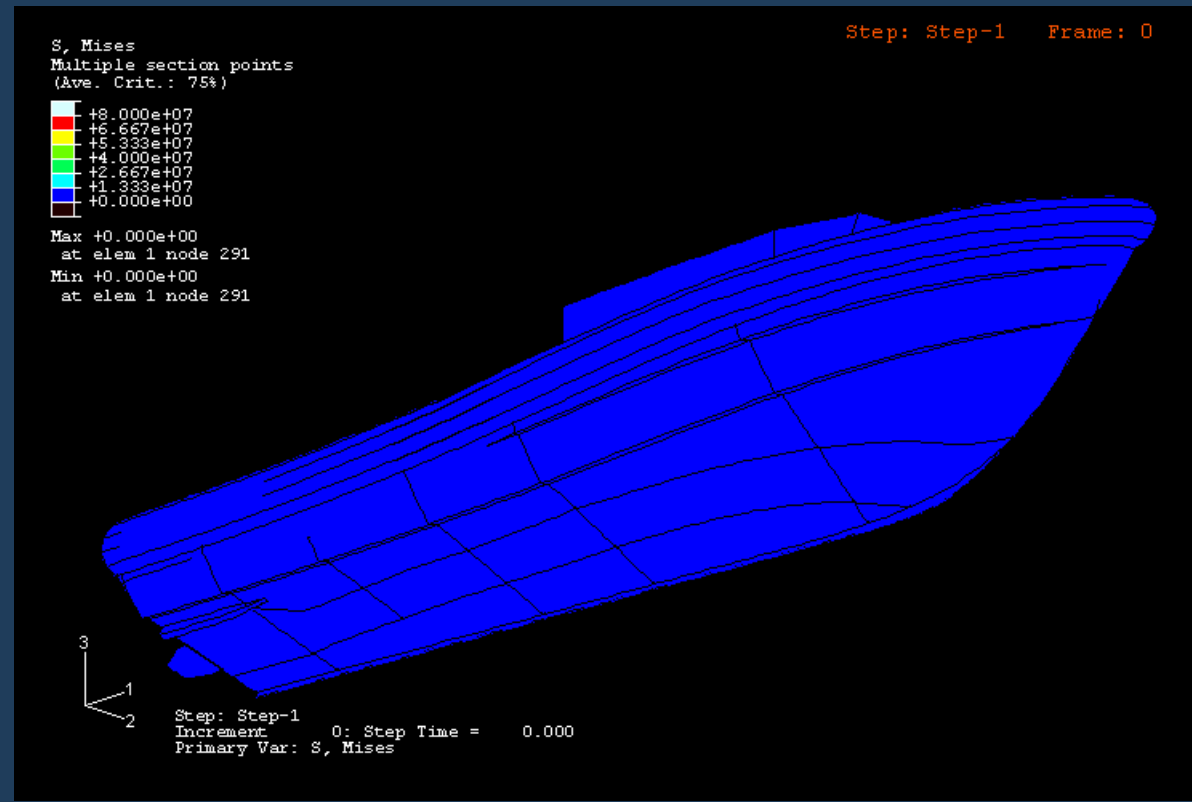
# Hull FEA Model



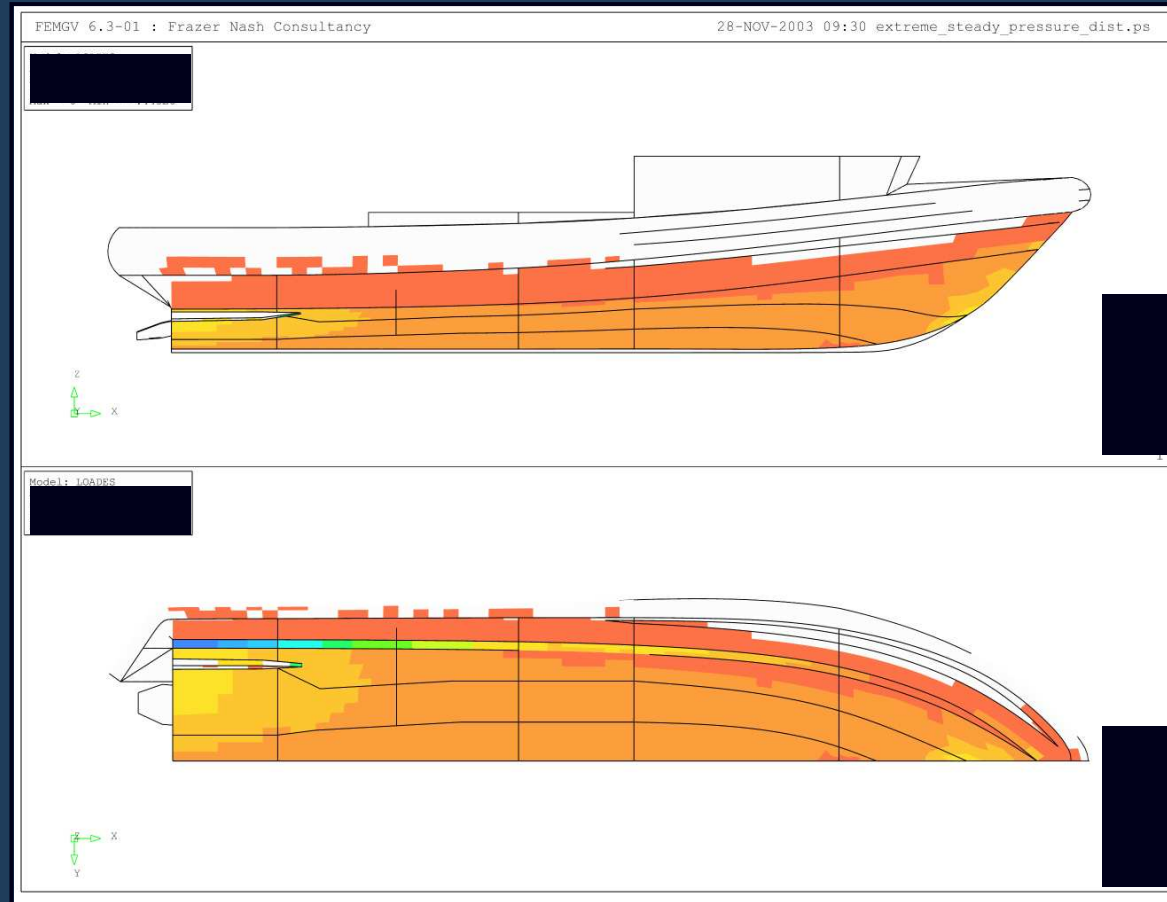
# Slam History Visualisation



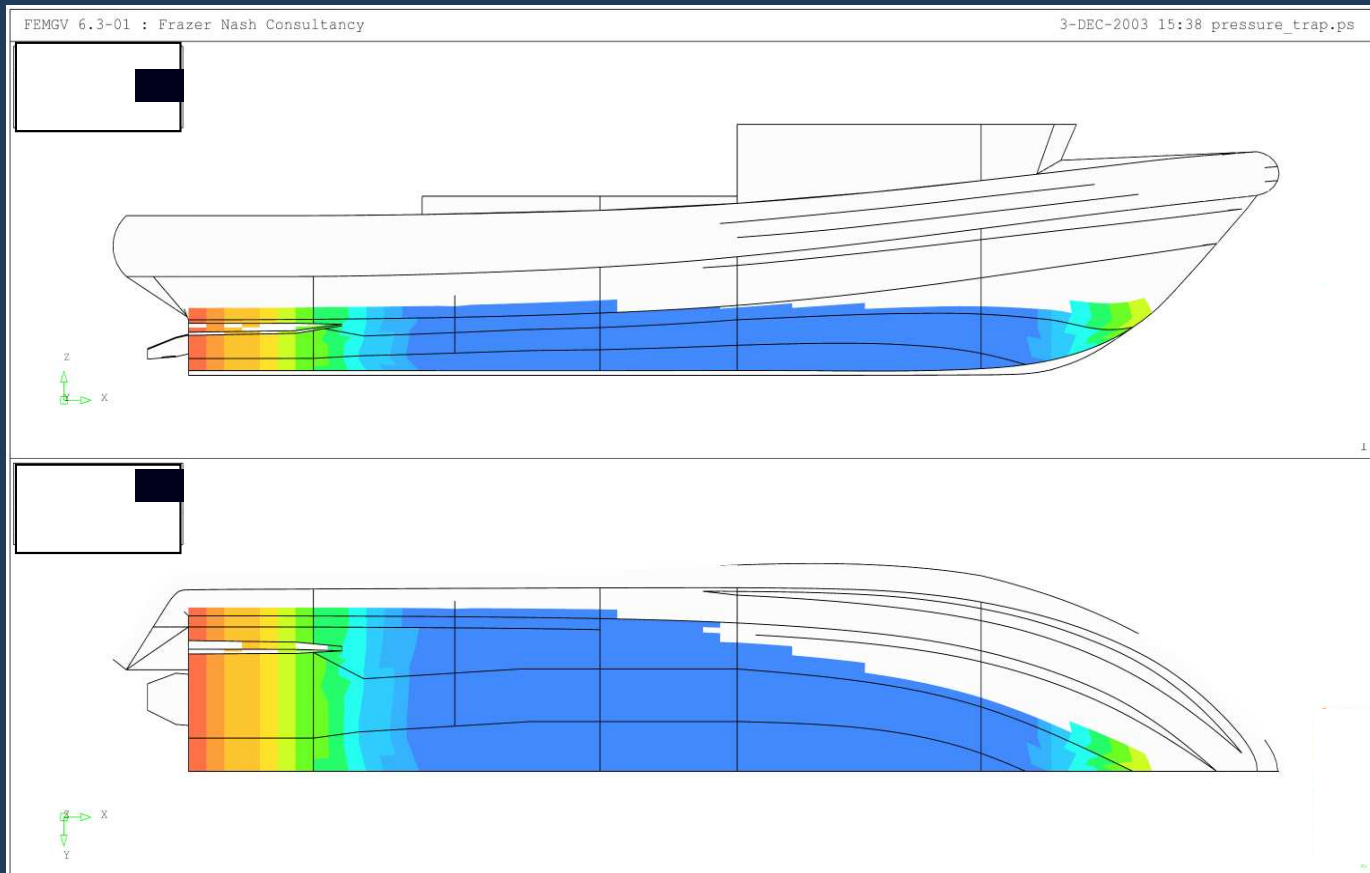
# Stress Distribution



# Peak pressure distribution

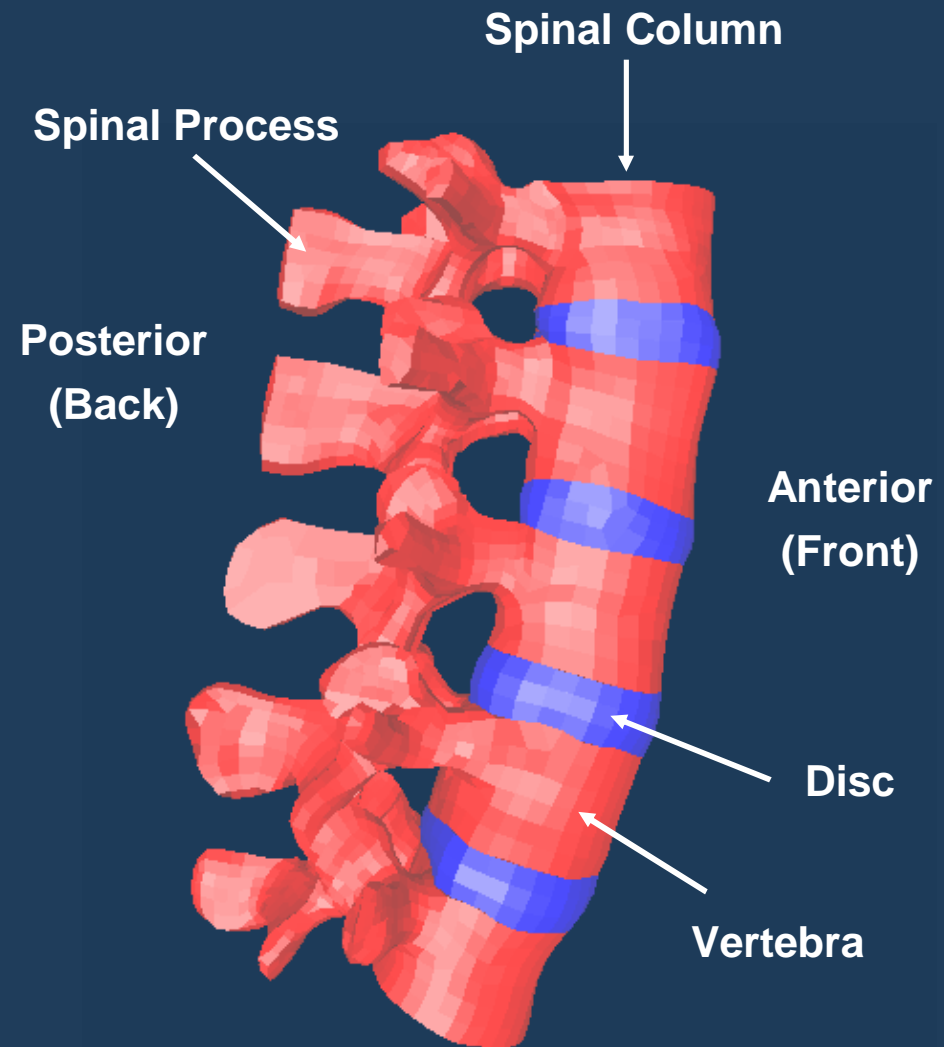


# Standard Design Curve



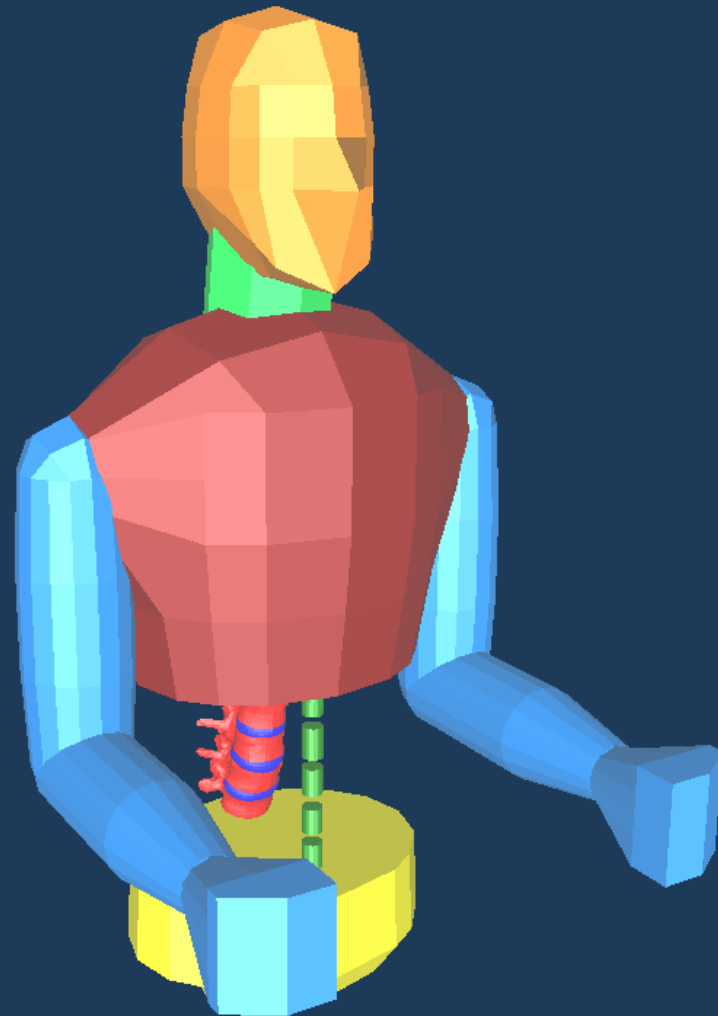
# Spine Model

- Spine made up of
  - bones called vertebrae with spinal processes
  - separated by compliant discs
  - connected together by several sets of ligaments
- Lumbar region modelled since most injuries caused by vertical vibration occur here



# Whole Body Model

- Based on model in Pankoke *et al*, to predict response of seated human to vertical vibration
- Body parts represented with masses connected by spring-dampers and constrained to move vertically
- Validated against data in ISO 5982



# Aims

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- Demonstrate a method to develop an injury criteria relating seat acceleration to spine injury
- Investigation of key parameters affecting the calculation of spine injury including those affecting the design of shock absorbing seats

# Injury Criteria Development

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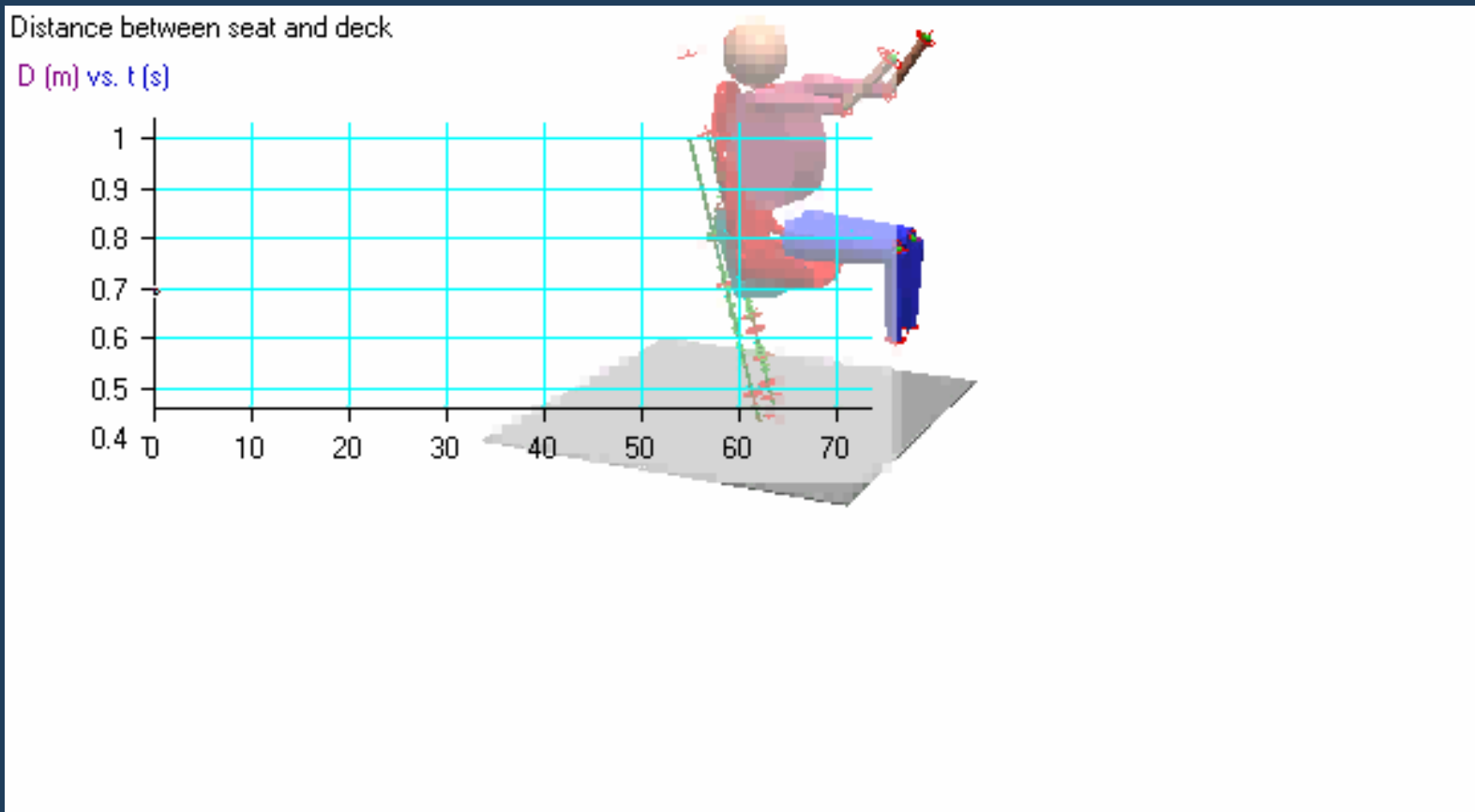
➤ From data  $N = \left( \frac{\sigma_c}{\sigma_u} \right)^{-s}$

➤ Number of cycles to failure for each pulse calculated

➤ Total damage due to all pulses summed using Miner's Rule

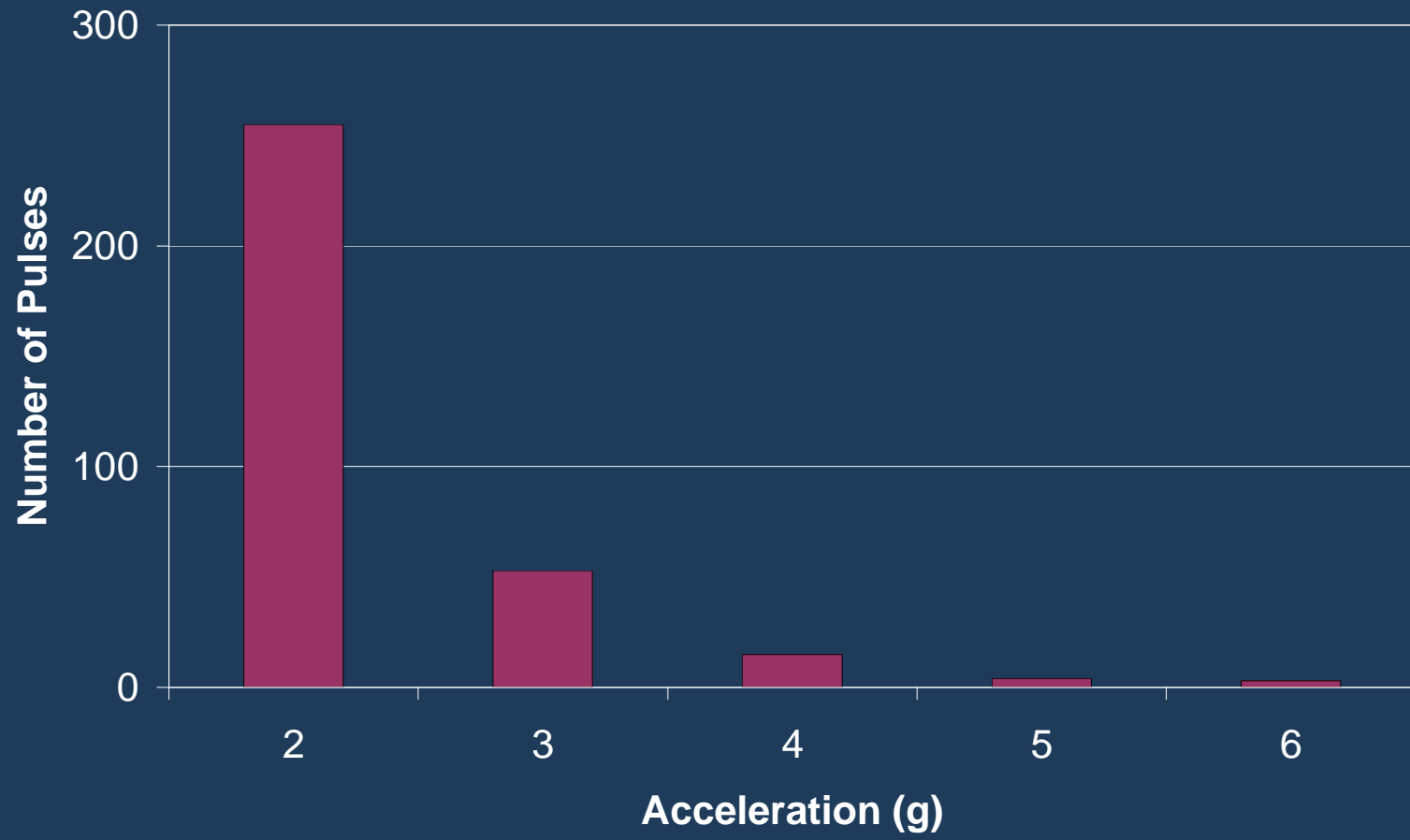
$$\text{Damage} = \frac{1}{N_1} + \frac{1}{N_2} + \dots + \frac{1}{N_n}$$

# Motion visualisation



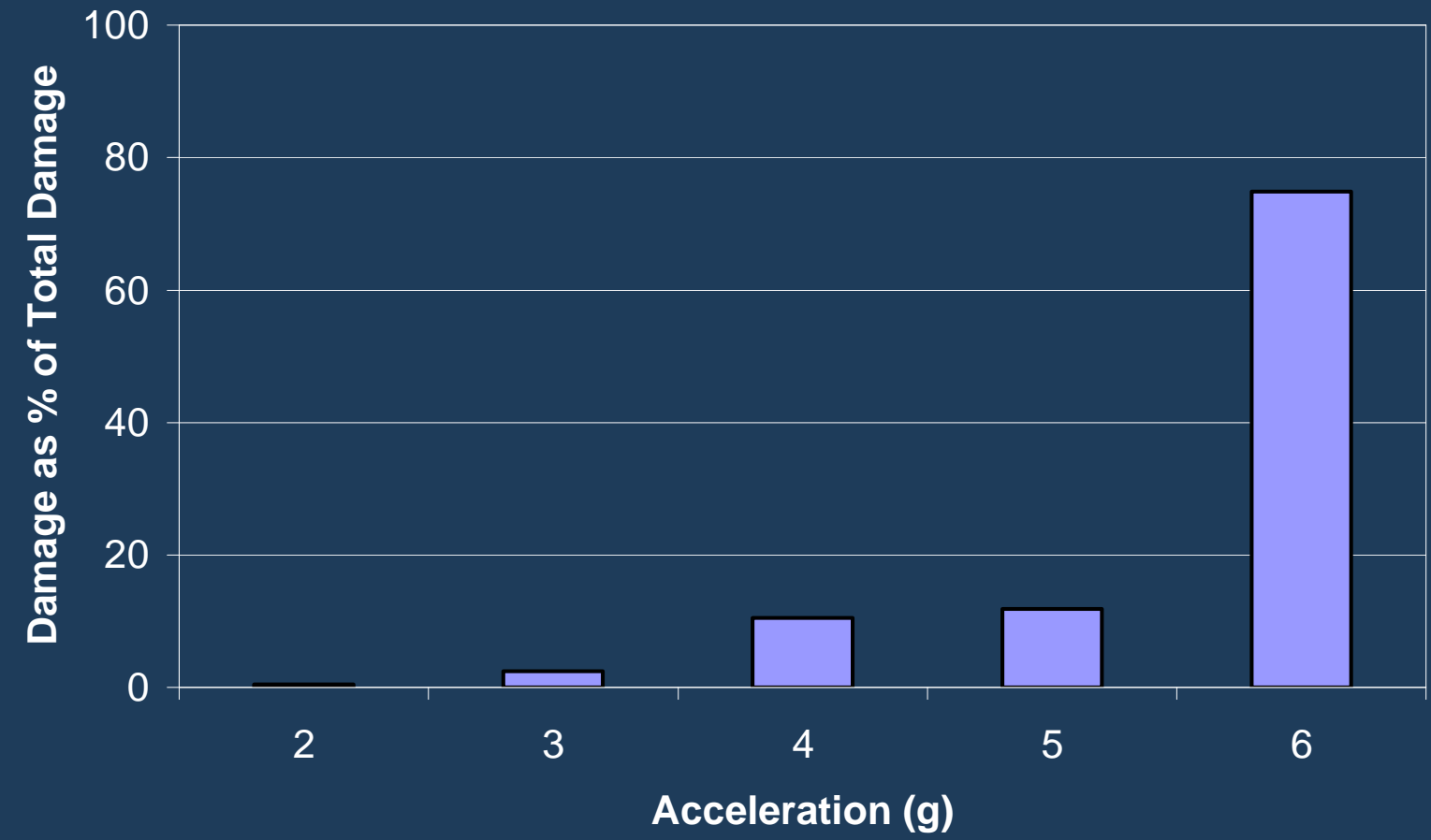
# Investigate Parameters

## Distribution of Pulses with Magnitude

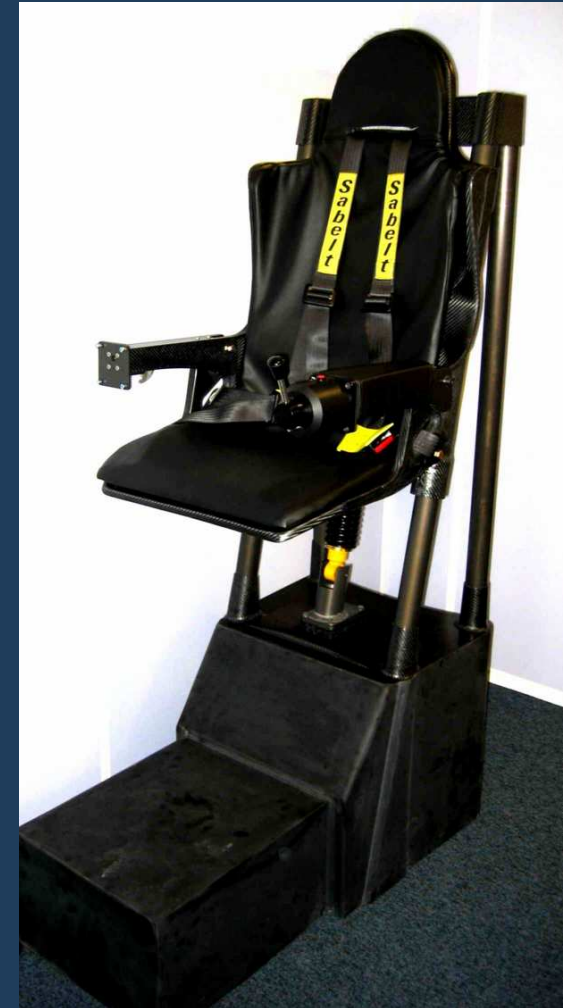


# Investigate Parameters

## Distribution of Damage with Magnitude



# Seat Design



# Conclusions

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- The process of both hydrodynamic and structural hull design can now be undertaken from first principles without reference to tank tests or standard load distributions.
- It is possible to generate a quasi-static load curve from theory. However the shape and magnitude of this distribution require further validation.
- Most human injury is likely to result from a small number of large impacts rather than a large number of smaller slams. However this conclusion requires further validation.

# Questions?

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