



GOAL based Damage Stability



# Survivability of Passenger Vessels

*Progress in s-factor development*

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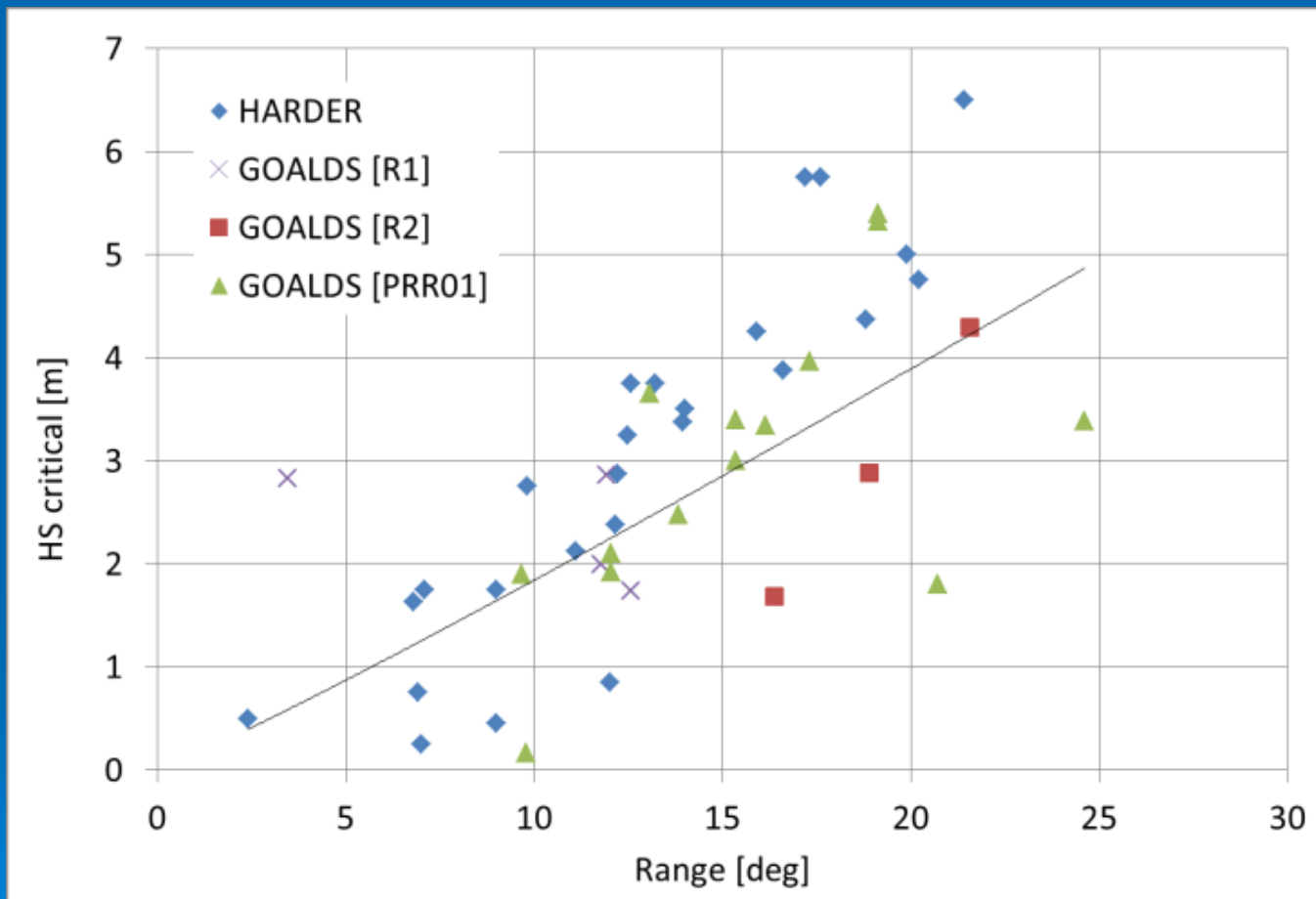
# Remarks on current formulae

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- Considering the actual physics of damage stability, it may be expected that significant inaccuracies occur if transient capsizes (caused by insufficient initial GM) or sinking due to progressive flooding (floatability failure) play a major role.
- The product of  $GZ_{\max}$  and Range, in current formula for s factor, constitutes an envelope to GZ area without clear reference to actual restoring moment
- No explicit reference to flooding process
- Questionable choice of critical wave height

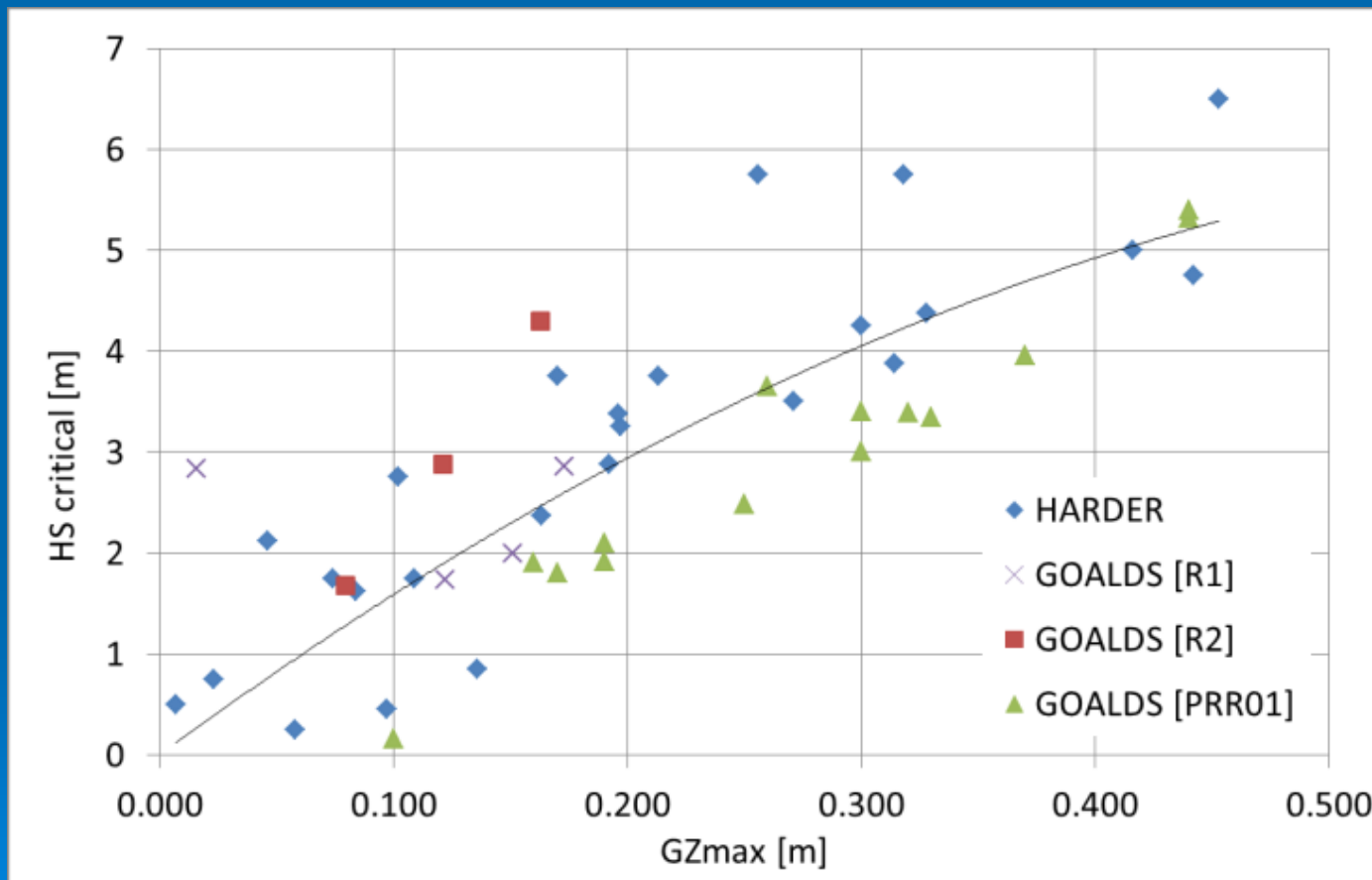


# Remarks on current formulation



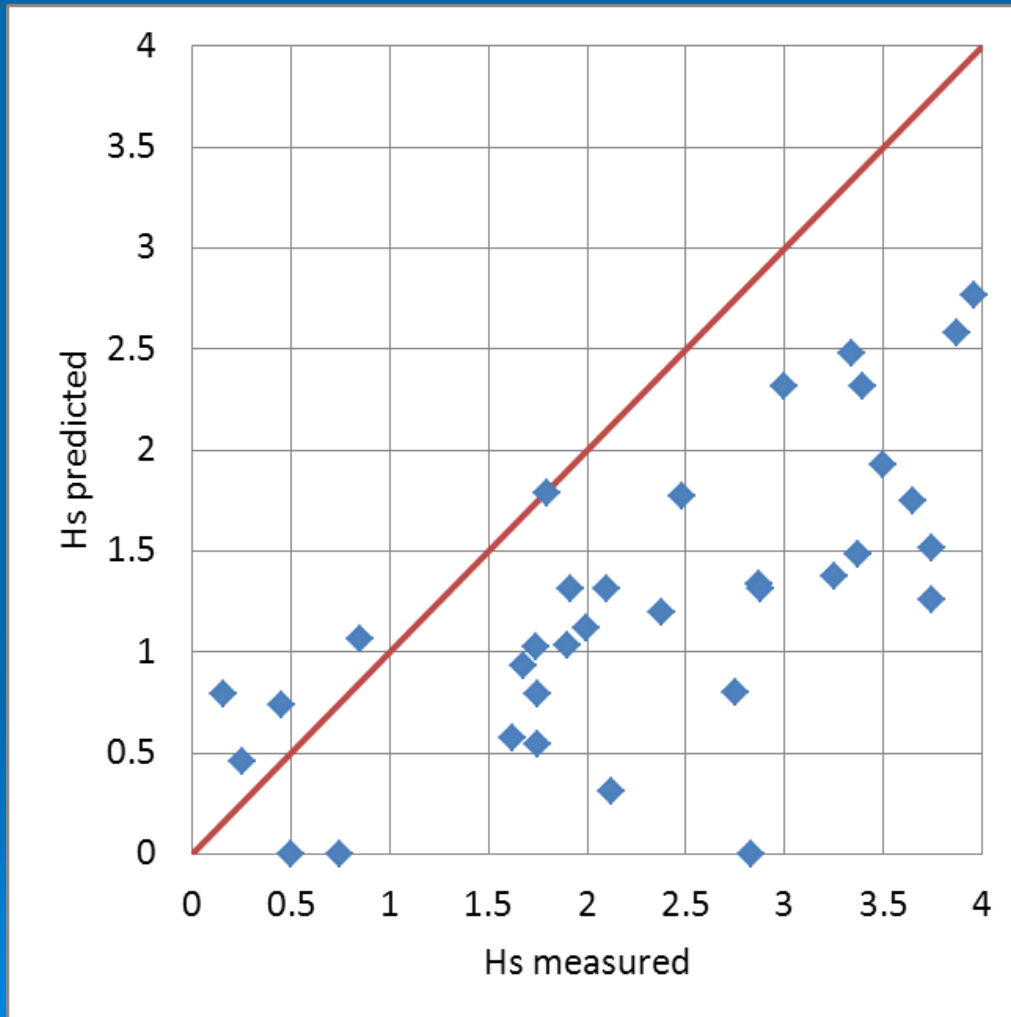


# Remarks on current formulation





# Remarks on current formulation





# Basic notions

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- One of the problems related to the current formulation is inconsistency in notions
- Although the term *survivability factor* does not distinguish between particular modes of loss, the formula itself relates mainly to [proper] capsizes and, as discussed, is unlikely to address another major failure modes accurately
- Therefore there is a need to agree on transparent and precise notations and definitions



# Basic notions

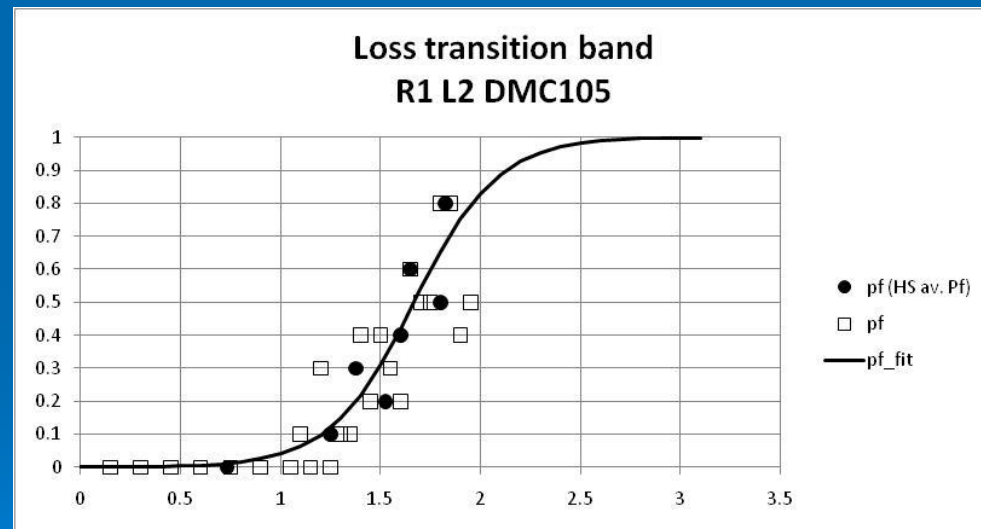
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- Categorisation based on mechanics of loss
  - *Capsize* – gradual process of diminishing stability caused by progressive flooding; it is a quasi-static phenomenon dependent on floodable volumes (floodwater) distribution and stability characteristics; outcome weakly dependent on opening geometry (which affects only time)
  - *Transient capsize* – stability failure due to rapid floodwater ingress; dynamic process dependent on opening size, floodwater distribution and stability (intact) characteristics
  - *Sinking* – floatability failure; usually gradual, quasi-steady process with time to loss depending strongly on rate of flow through damage and internal openings and floodable volume characteristics
- Categorisation based on time to loss
  - *Rapid loss – transient capsize*
  - *Gradual loss – capsize and sinking*



# Basic notions

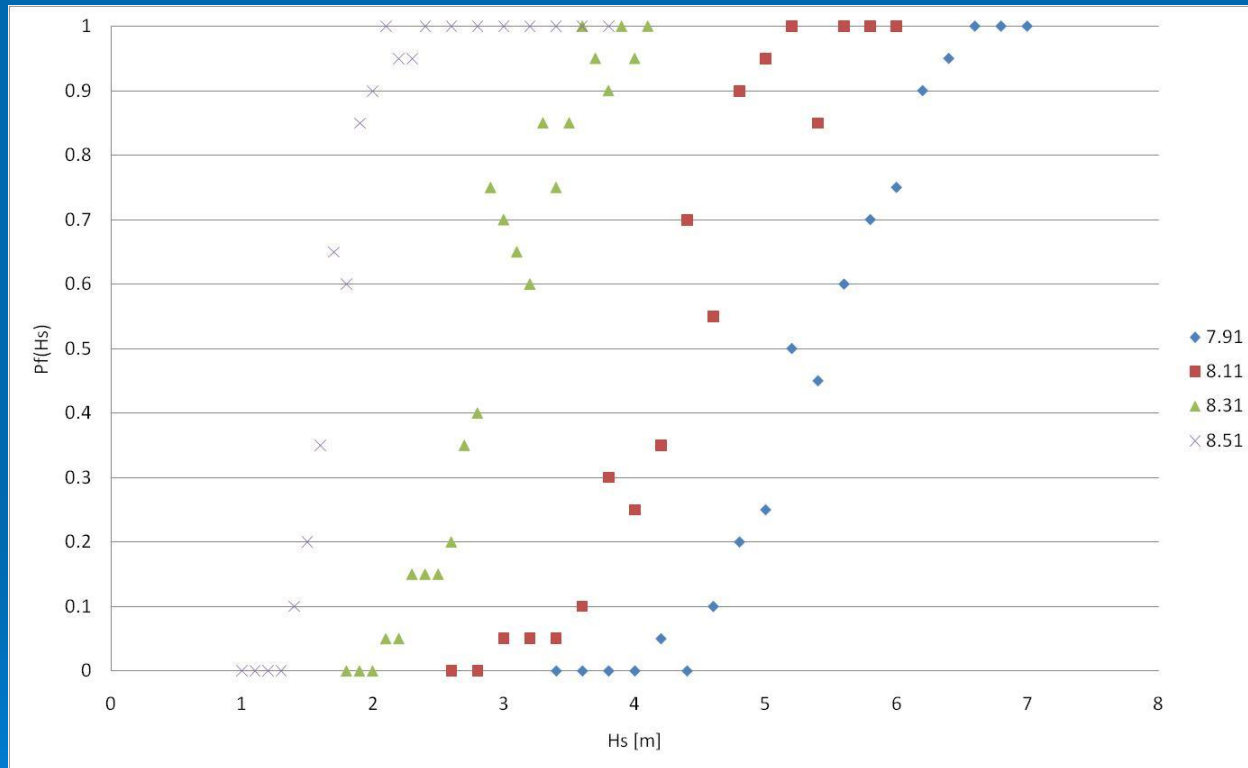
- Similarly when discussing transition from safe to unsafe sea states without distinguishing between modes of loss, may be better to consider using more precise term, e.g. *loss transition band*.





# Loss transition band

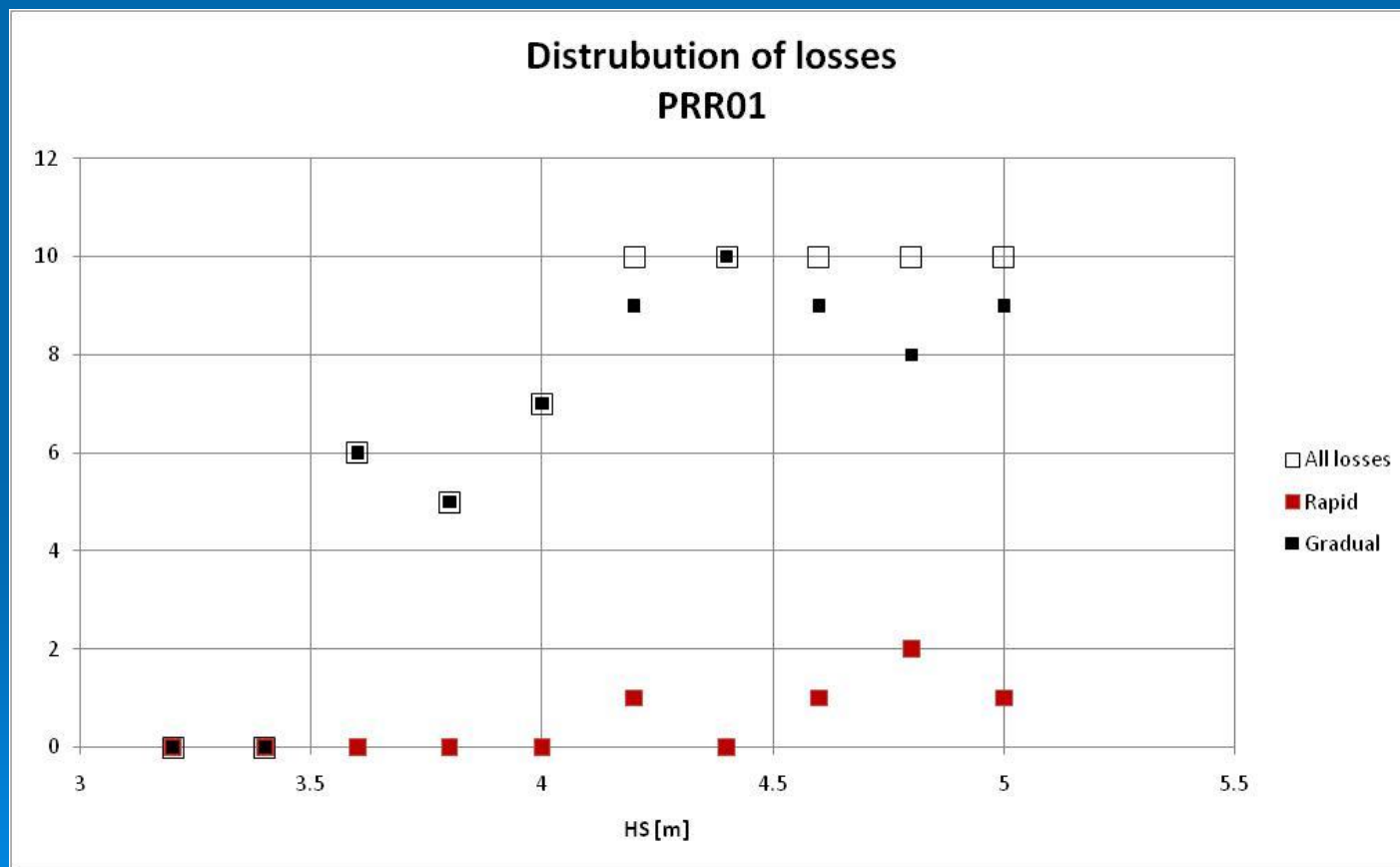
Sigmoid behaviour of loss count (or relative loss number)





# Loss transition band

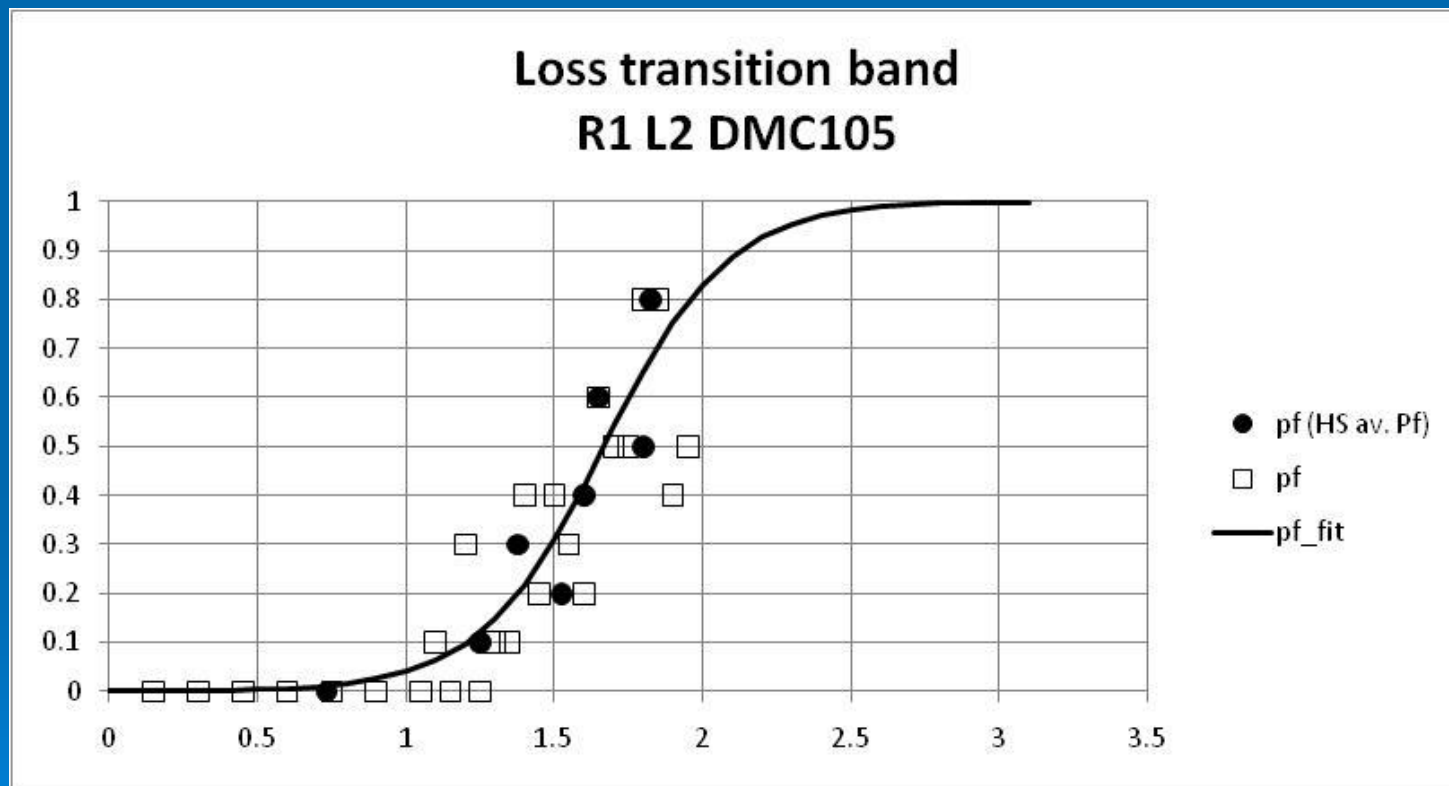
Different distributions of gradual and rapid losses (although not the best example)





# Loss transition band

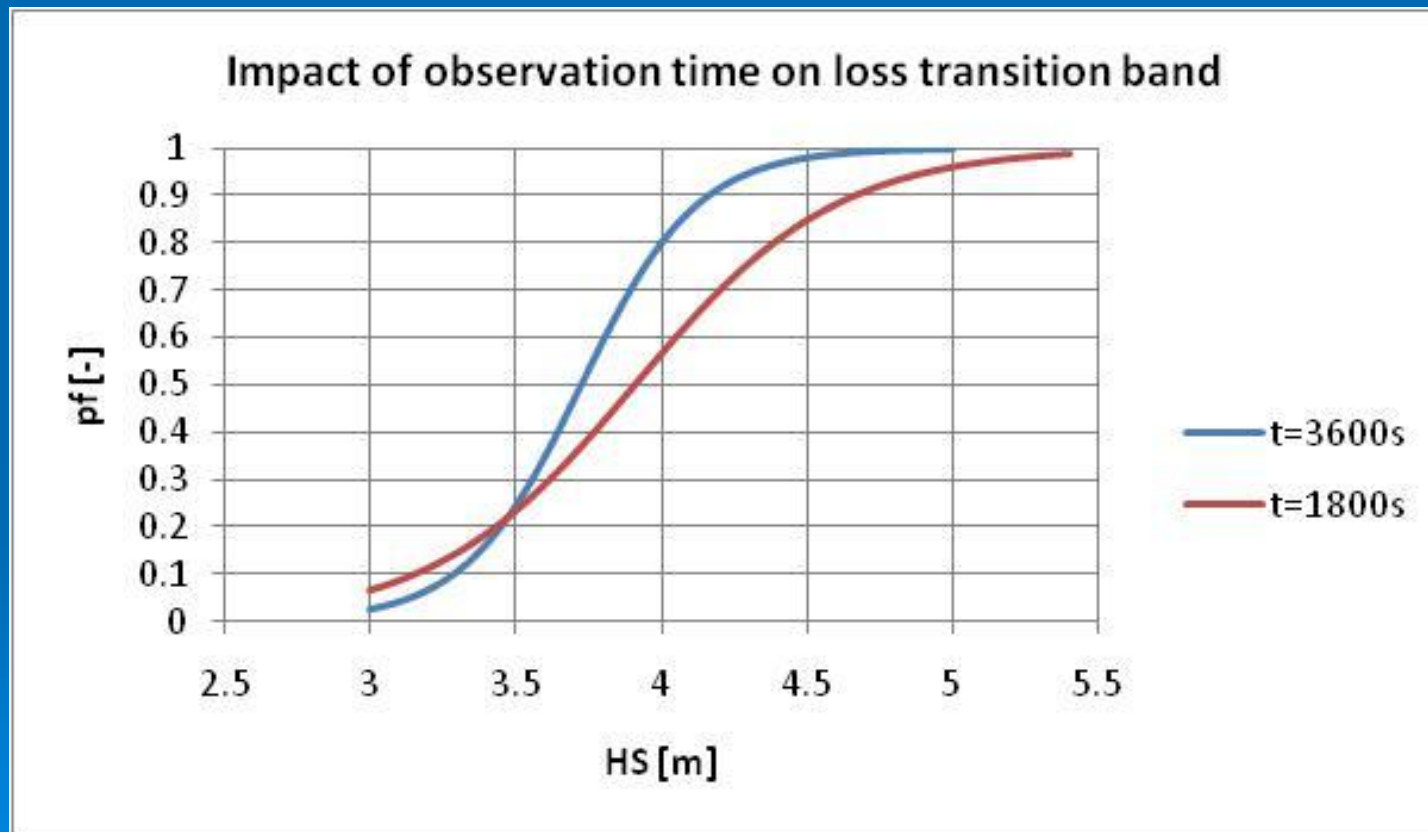
In case of rapid capsizes the sigmoid trend is questionable





# Loss transition band

Contraction towards the lower limit – time invariance. Is constructing of the s-factor around 50%  $p_f$  justified?





# Floodwater Accumulation

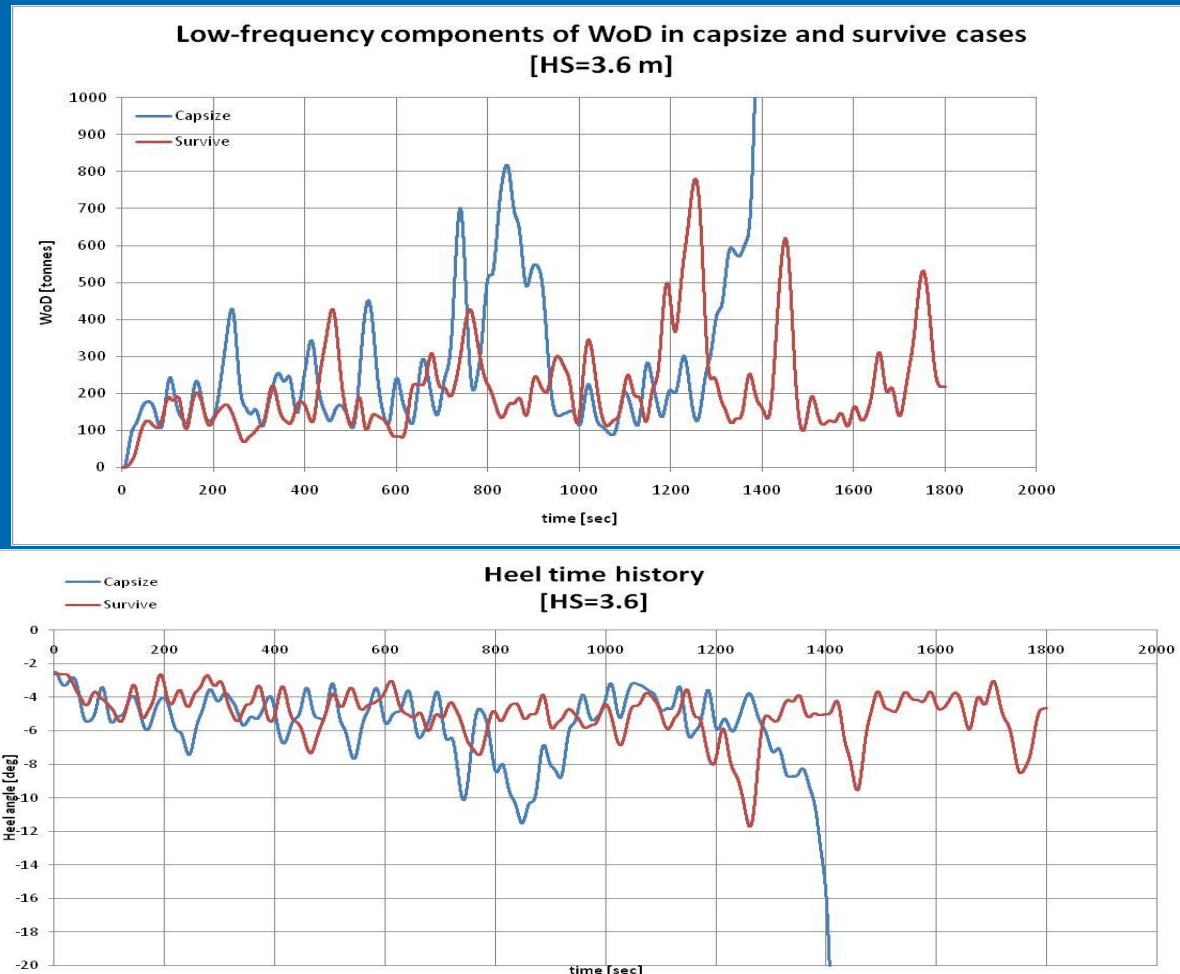
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- If could be used, i.e. expressed by means of single quantity it would allow to loss scenario to its origin.
- Furthermore it could complement stability (intact and damage parameters) to ensure rendering all the major modes.
- For regulatory purposes floodwater accumulation has to be expressed in a way ensuring feasibility of statistical approach based on association of ship and damage characteristic with floodwater-based parameters
- It should be general enough to be ship-type independent (not limited to WoD)



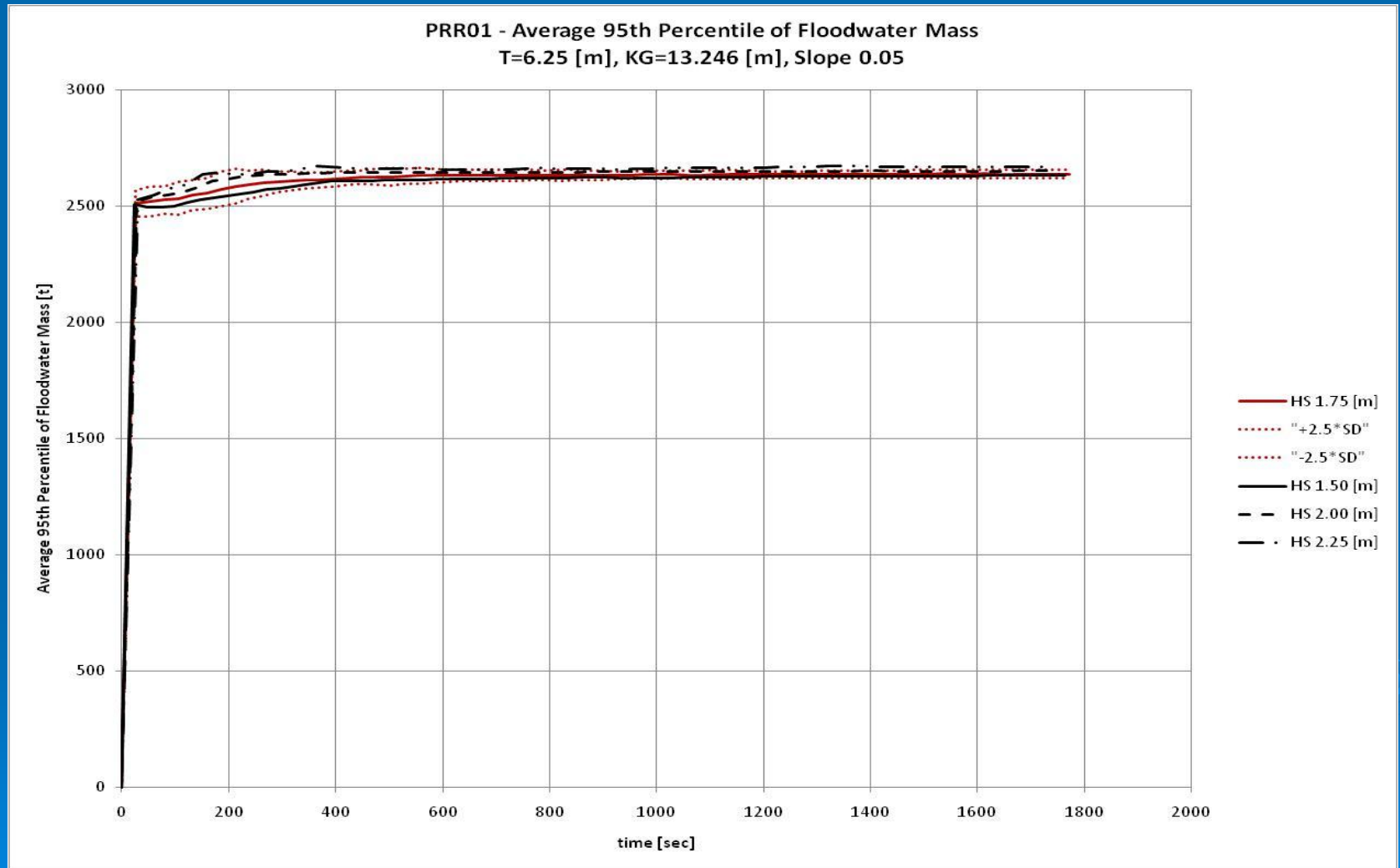
# Floodwater Accumulation

Starting point:





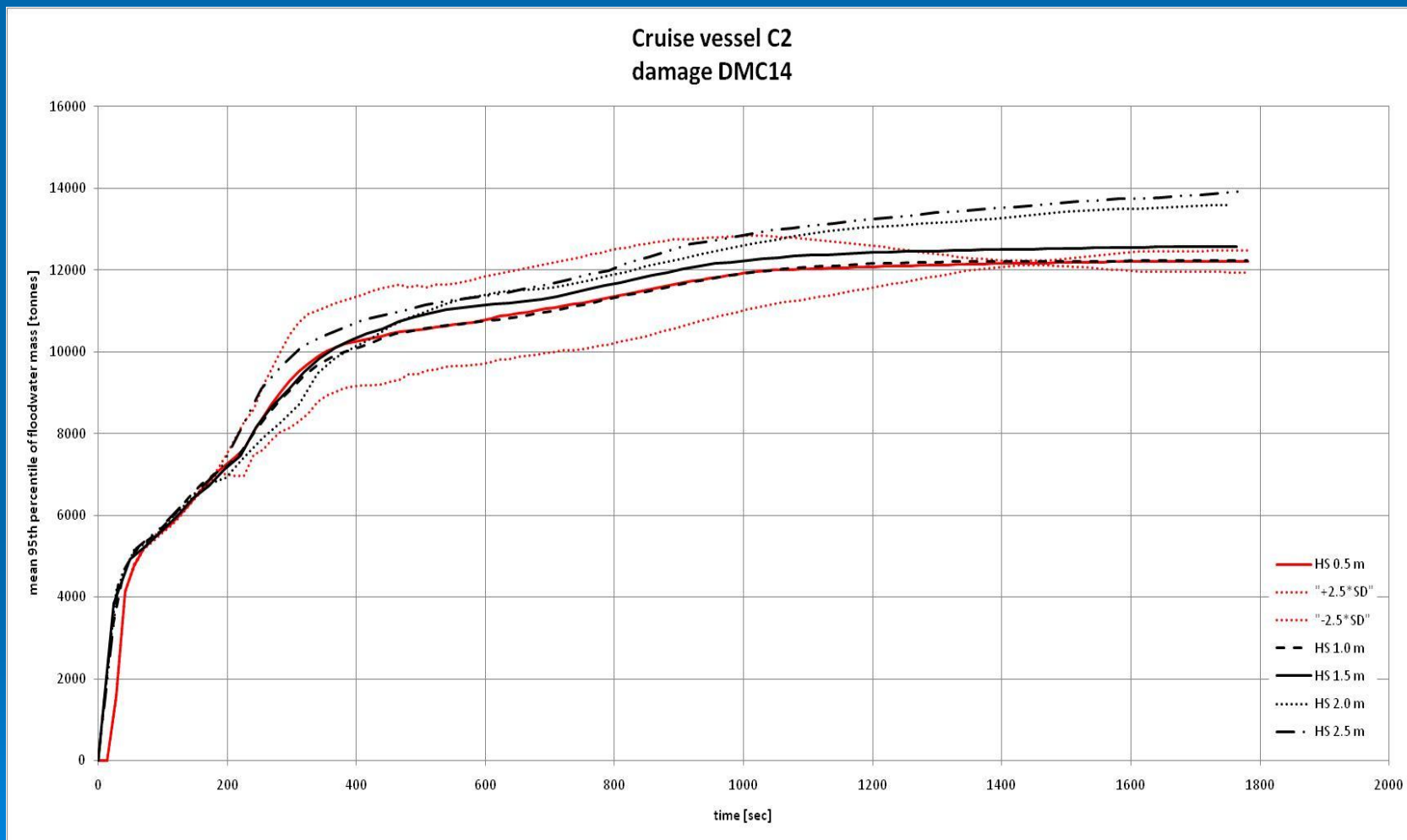
# Floodwater Accumulation







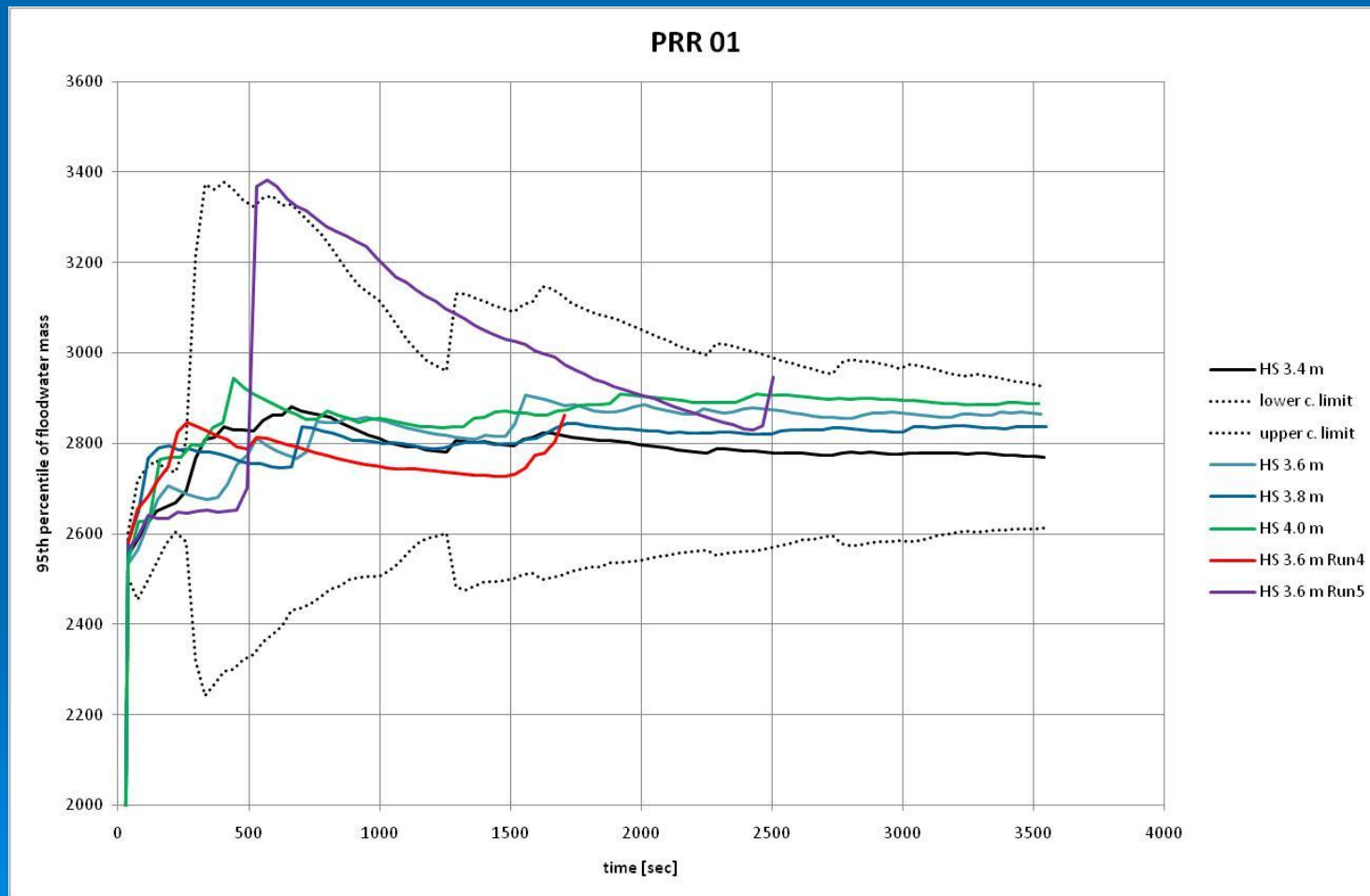
# Floodwater Accumulation





# Floodwater Accumulation

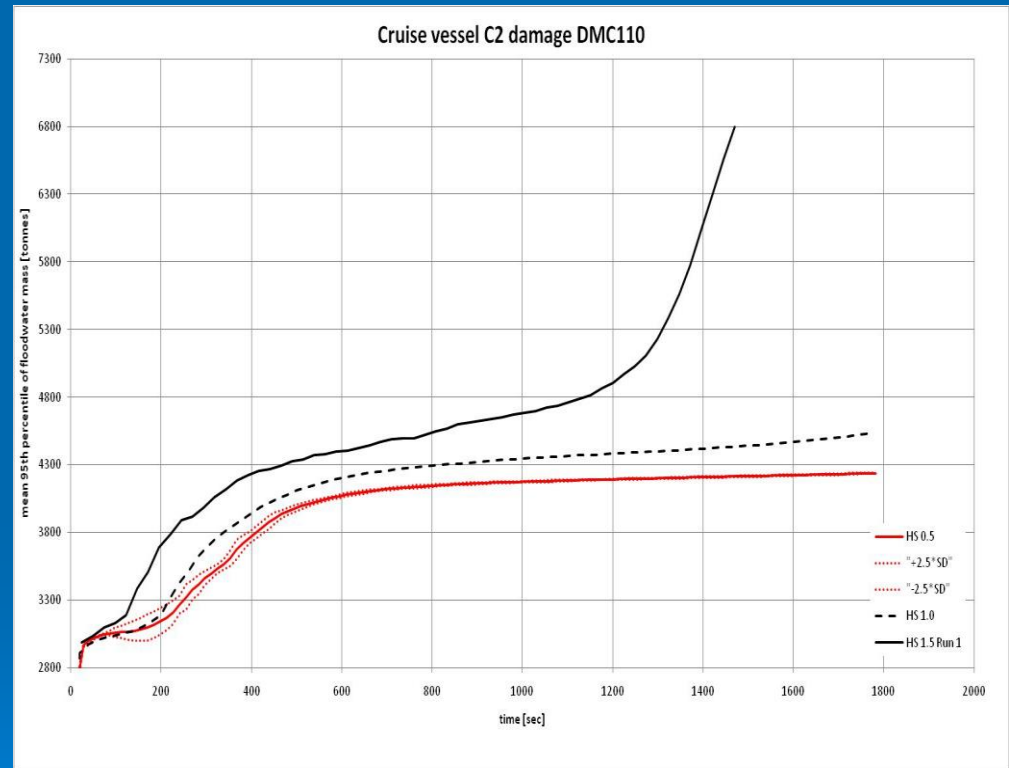
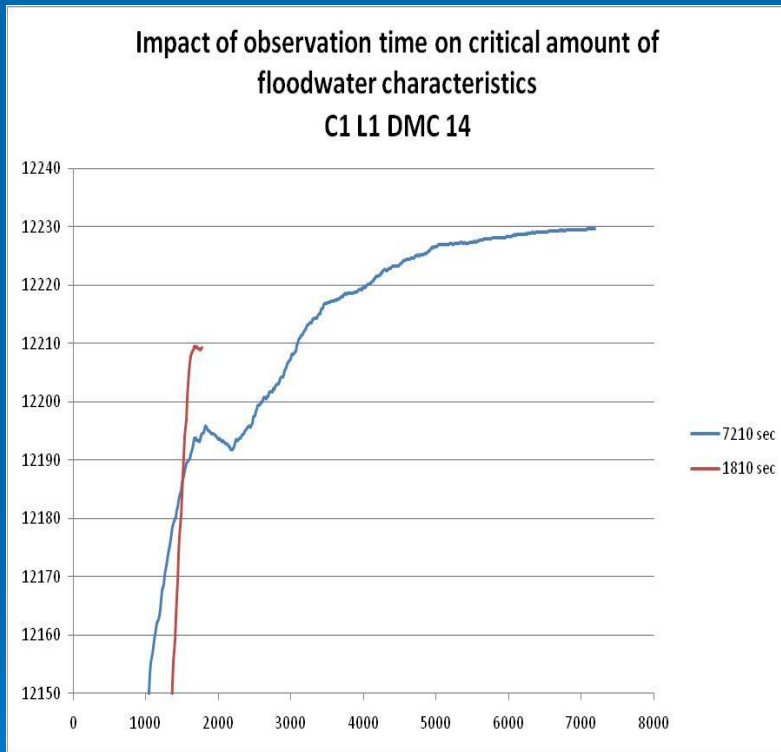
## Importance of confidence band





# Floodwater Accumulation

## Importance of confidence limit





# Discussion on future s factor

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- The future s-factor formulation should be based on the assumption of (probabilistically) infinite time to loss (i.e.  $s=1$  should translate as statistically unconditional survival)
- The parameter set used in the s-factor should be extended to include more stability related parameters, including volumetric parameters of watertight spaces
- It should be attempted to express the s-factor formulation so that it is valid for the all modes of loss-failure; furthermore, time-based criteria should be used instead of standards which derive from mechanics of loss