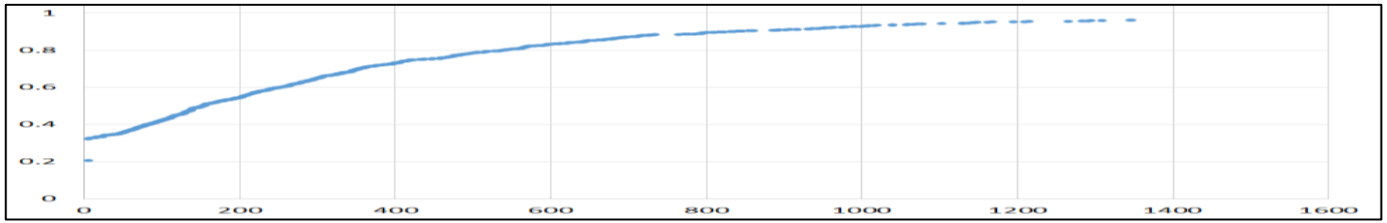
MINISTÈRE
DES ARMÉES
ET DES ANCIENS
COMBATTANTS

Liberté
Égalité
Fraternité

Capsize probability

Luthy Vivien DGA TH



DGA

Overveiw

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   a. Historical key fact
   b. Aim of the study

2. **Loss of operational capability**
   a. Survey method
   b. Results
   c. Conclusion

3. **Toward capsize probability**
   a. Previous work
   b. Survey method
   c. Conclusion

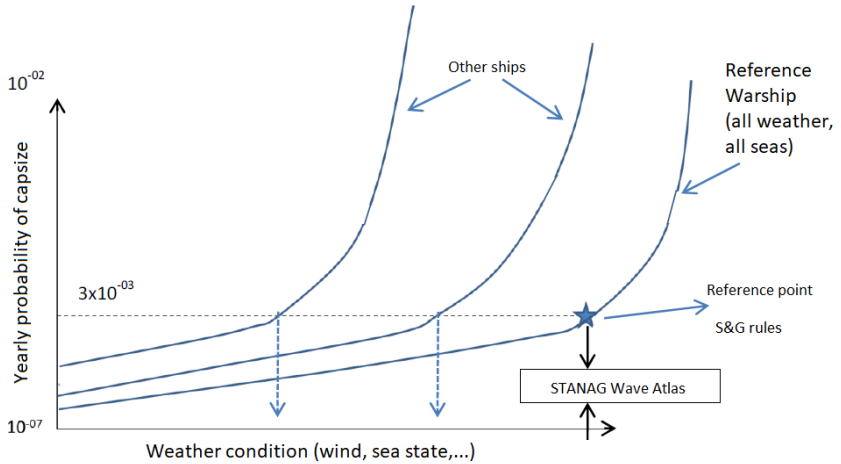
Introduction

Historical key fact

1962 : Sarchin and Goldberg : « determine the power of survival of the ship when subjects to the effects of wind, sea… »

2020 : IMO Explanatory note SGISC : Closely look to the risk and probability of capsize

CAT 12106 (French stability rule)



Tolerable risk

Introduction

Aim of the study

Define the loss of operational capabilities of vessels

Determine the capsize probability with a reduced simulation time

=> Aim to a goal based standard

=> Set Operational Limits related to the capsize risk

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Loss of operational capability

Survey method

Define operational loss due to KG increase

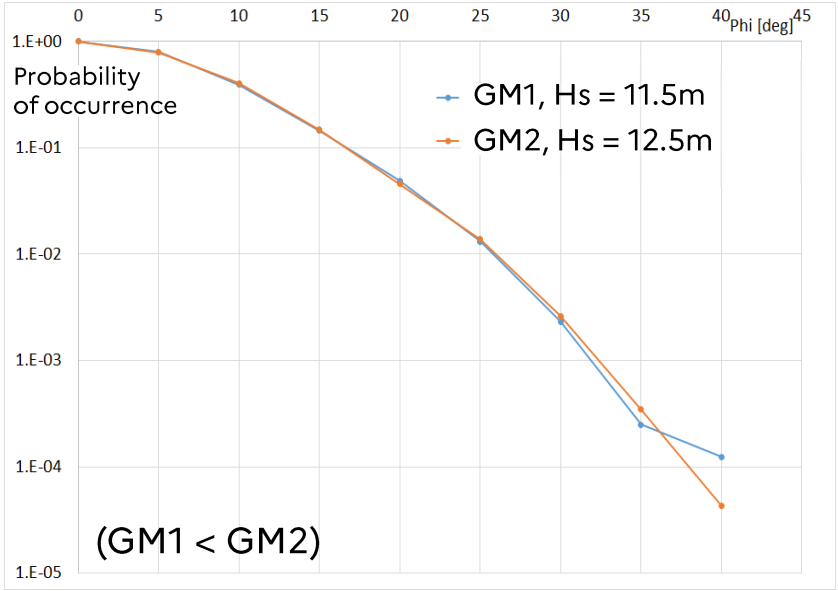
- Time domain hydrodynamic solver (FREDYN)
- 1 Patrol boat, 1 displacement (for this example)
- 2 GM
- 4 DoF simulations, dead ship condition
- 5 simulations of 1h per sea state (transversal sea state)

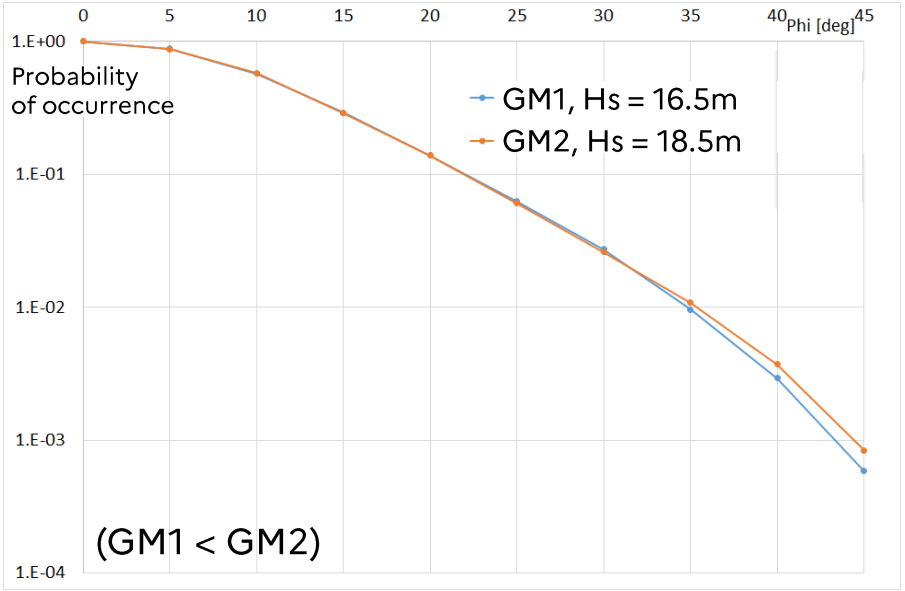
Sea state selection :

- All sea state with non zero probability of occurrence (for one Hs cover all periods)

Loss of operational capability

Results





Roll angle, probability of occurrence

Loss of operational capability

Conclusion

Operational loss can be easily obtained by doing this type of study

Here an operation loss of 2m wave height is observed for the extreme sea states

Such method ca be used during :

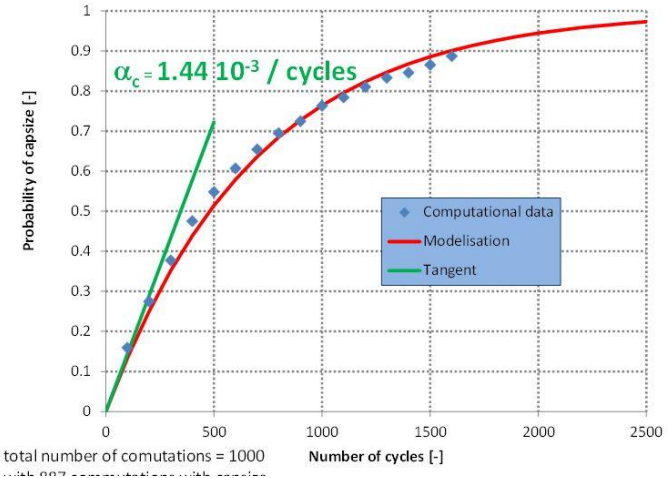
Design stage

Retrofit analysis

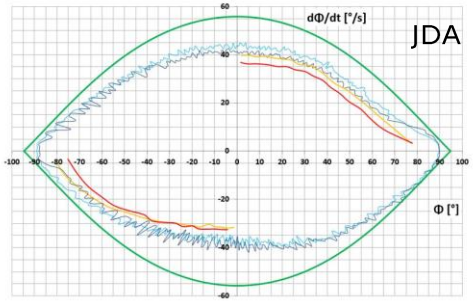
Exemption from regulation analysis (for any input)

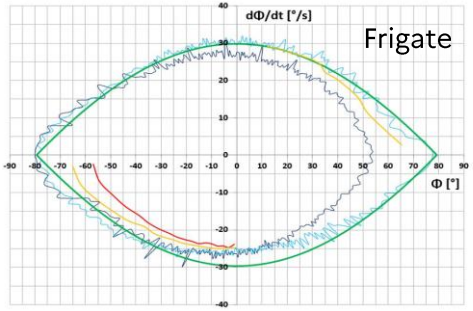
Toward capsize probability (Pioneer work)

Work presented for STAB Kobe : Huge sea states, 1000 simulations



Capsize probability (Monte-Carlo)





Attraction basin

Capsizing SS1
Capsizing SS2
Noncapsizing SS2
Noncapsizing SS1
Attraction basin still water

Convergence of maximum observed angle both during capsizing and noncapsizing cycle with φ_v suggest a strong correlation of α with the exceedence of φ_v non completely achieved in this pioneer work

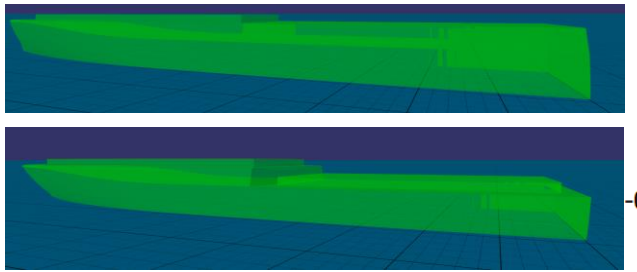
Toward capsize probability

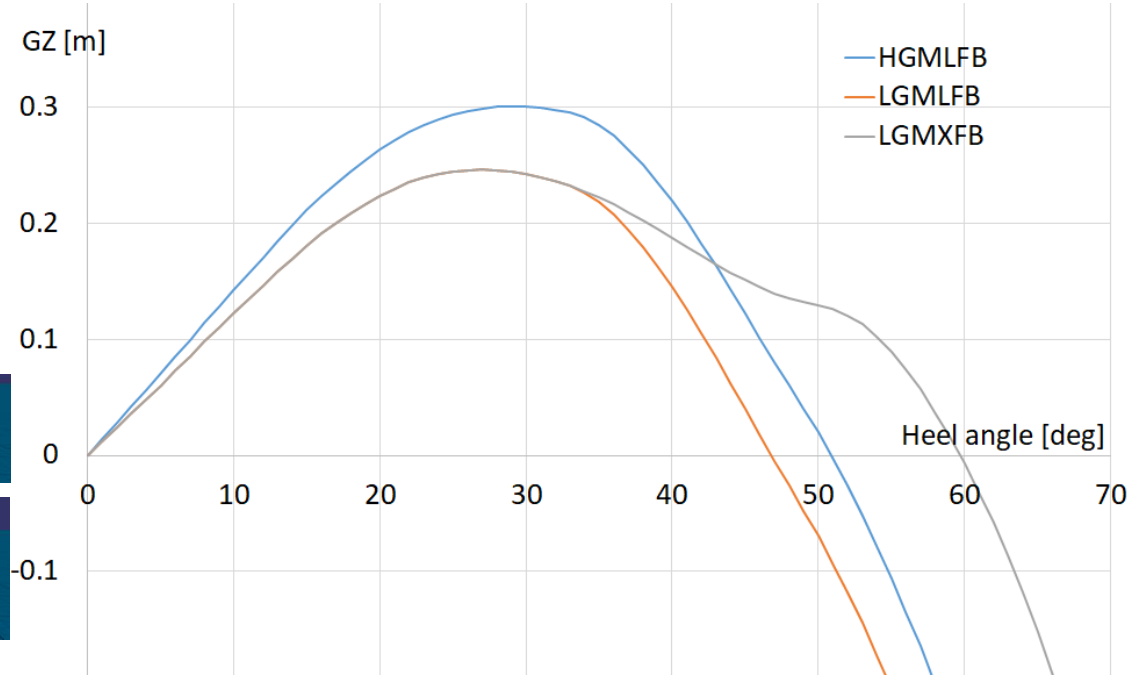
Survey method

CRF 130 : 3 loading conditions

LGMLFB: Low GM, Low freeboard
HGMLFB: High GM, Low freeboard
LGMXFB: Low GM, Extra freeboard

Same area under GZ Curve for HGMLFB and LGMXFB





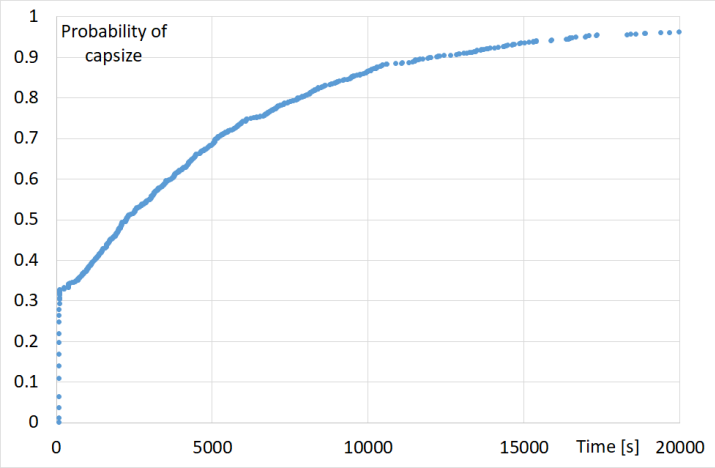
Toward capsize probability

Survey method

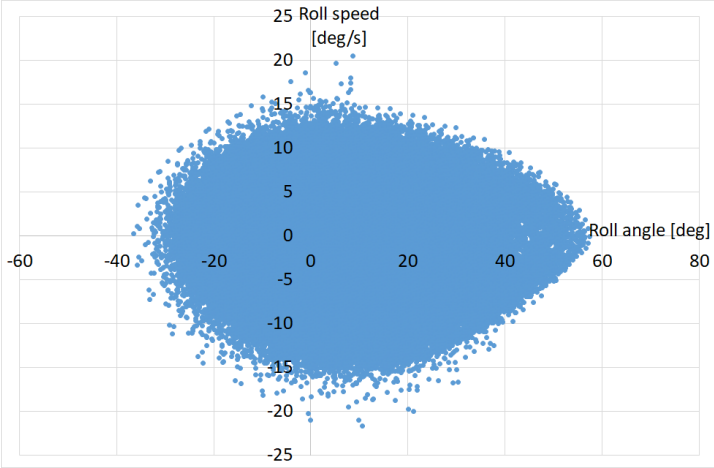
Use Fredyn V16 to simulate the ship behaviour, aim compare the capsize probability

1 sea state Hs = 14.5m Tm = 14 s (JONSWAP), transversal sea state

1000 simulations in 4DoF dead ship of maximum 20000s (stop if capsize), damping Ikeda



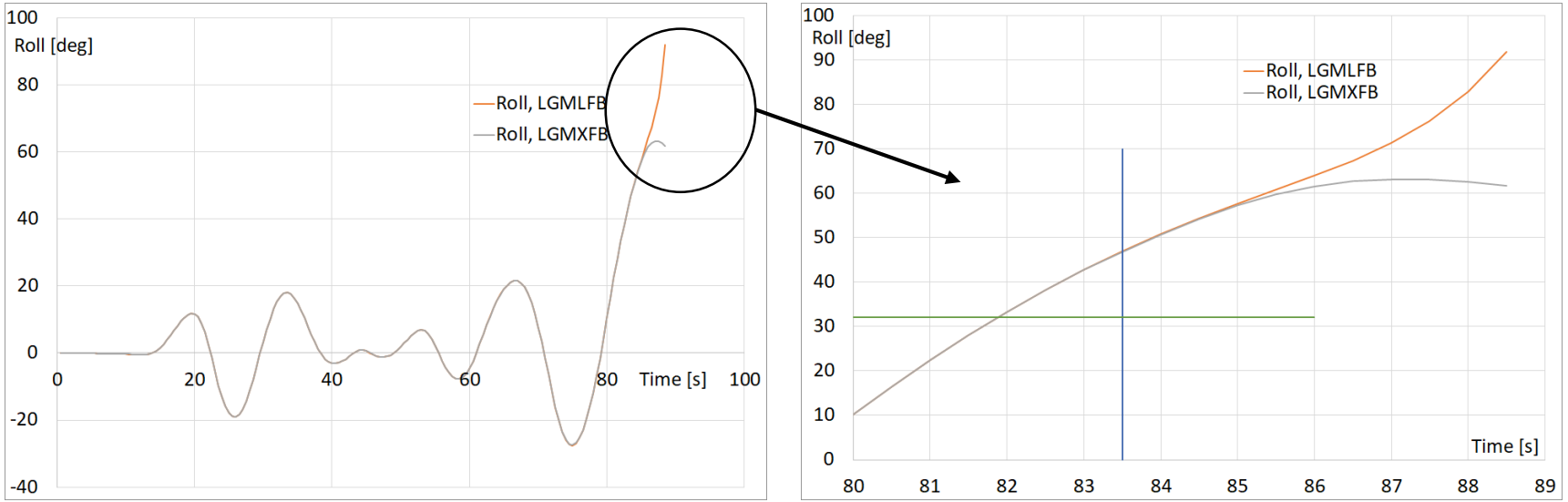
Probability of capsize as a function of time HGMLFB



Roll angle/speed diagram HGMLFB, not leading to capsize

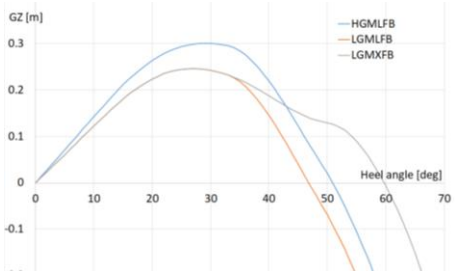
Toward capsize probability

Survey method

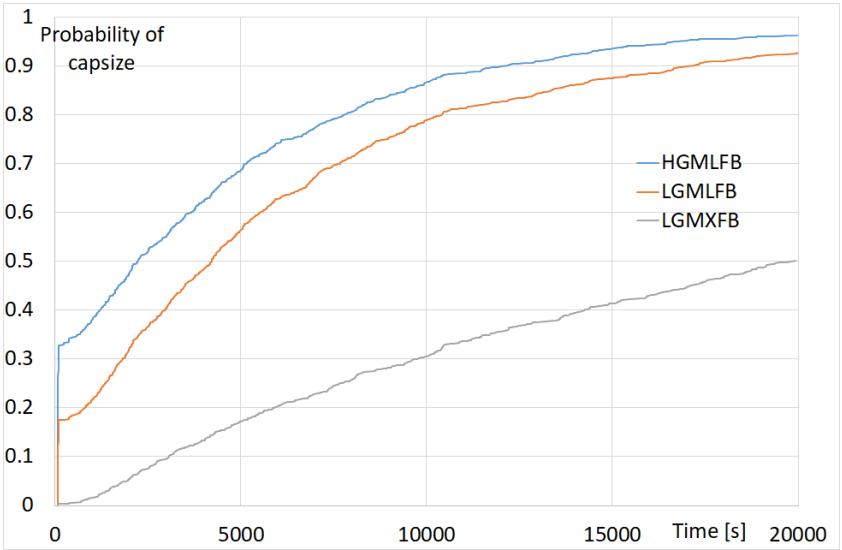


Time domain capsize comparison, LGMLFB (capsized) and LGMXFB (did not capsize)

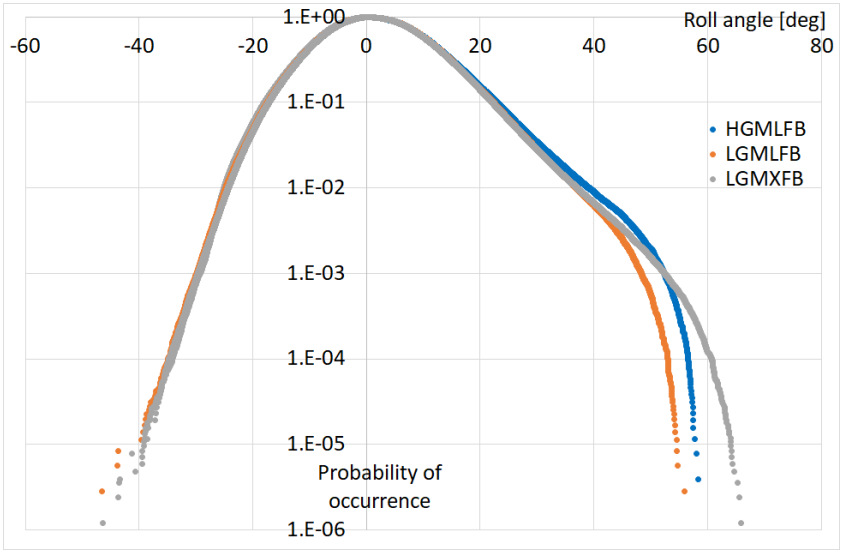
Toward capsize probability



Survey method



Probability of capsize, CRF130, comparison



Roll exceedance probability, CRF130

Other vessels were simulated as well in several sea states, results will be processed for validation.

Toward capsize probability

Conclusion

This study shows that the area under GZ curve (up to static capsize heel angle) does not permit to obtain the same capsize probability on all sea state (relevant, however not sufficient alone).

Further study :

- Define a criteria based on probability up to a smaller roll angle and extrapolate the results up to capsizing
- Determine a $\varphi/\dot{\varphi}$ envelope with 95% confidence leading to capsize
- Validate it on a larger based of data on other vessel (data set ready)