NUMERICAL SIMULATION OF
SIDE SHIP LAUNCHING

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OUTLINES

01 INTRODUCTION

02 LAUNCHING CONFIGURATION

03 COMPUTATION PROCEDURE

04 COMPUTATION RESULTS

05 CONCLUSION AND FUTURE WORK

INTRODUCTION

- MOTIVATION
- OBJECTIVE
- RECENT RESEARCH

MOTIVATION

Predict launching phenomena

Less time consuming of calculation

WHY IS IT IMPORTANT?

Simple application to show motion behavior

Minimize potential risks of capsizing or hitting seabed

OBJECTIVE

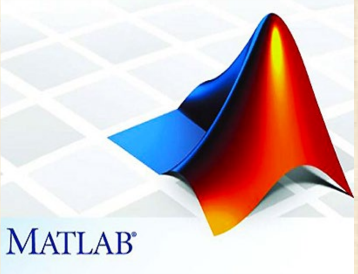
01 To develop an automated numerical simulation of side launching

02 To predict the whole process of launching

03 Investigate the effect of different water level on side launching

TOOL:

A programming language and numerical computing developed by ***MathWorks***



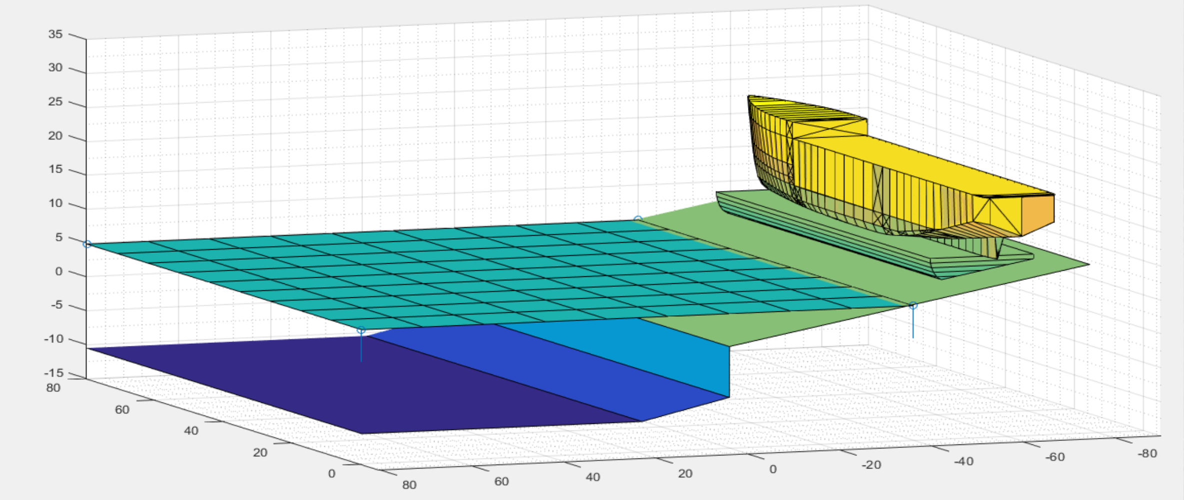
RECENT RESEARCH

Author	Focus
Ye. Z. (1994)	Mathematical model of 2D box shape with 3 DOF motion,4 phases, and added mass
Jong P. D. (2004)	simplified numerical model of 2D & 3D numerical problems found causing of draught reducing during simulations.
Kraskowski M. (2007)	Simplified RANSE simulation of a side launching for small vessel compared with experiment result
Fitriadhy A. and Malek A. (2017)	CFD analysis of a ship's side launching with variation of slipway angle and slipway distance
Cardona J. S. (2017)	Controlled design of side launching system for tugboats, introducing simplified two-dimension simulation and new design of tipping table cradle

LAUNCHING CONFIGURATION

- ***GEOMETRY MODEL***

GEOMETRY CONFIGURATION



CRADLE Data :
L = 22.5 m
B = 2.225 m
T = 3.194 m
Δ = 301.7 Ton

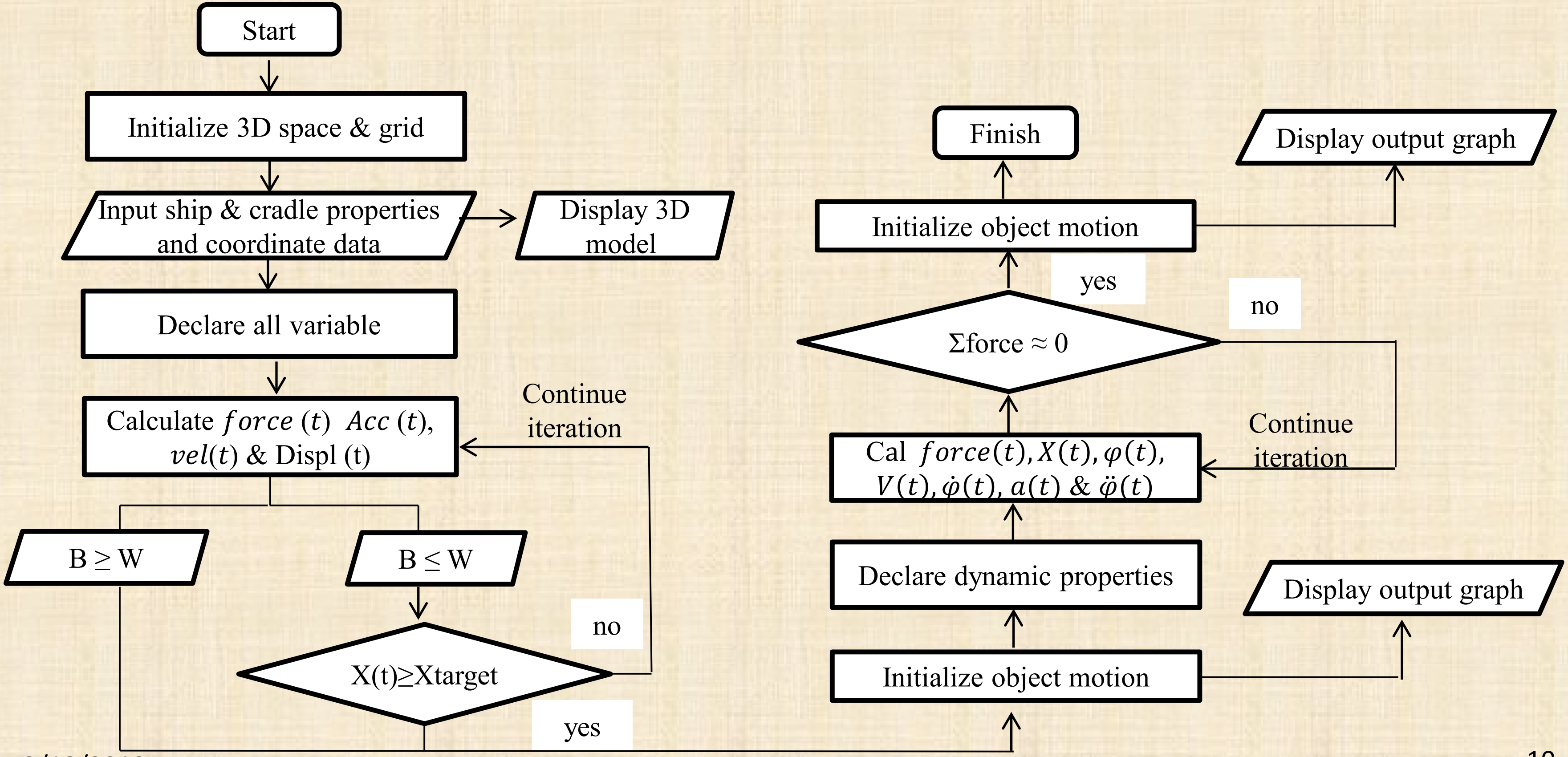
SLIPWAY data :
L = 100 m
B = 64 m
D = 10.5 m
θ = 7.13 deg

SHIP Data :
Lpp = 74.68 m
B = 16.2 m
T = 2.652 m
Δ = 1933.76 Ton

COMPUTATION PROCEDURE

- COMPUTATION STRATEGY
- MATHEMATIC MODEL
- LAUNCHING PHASES
- LAUNCHING SCENARIO

COMPUTATION STRATEGY



MATHEMATIC MODEL

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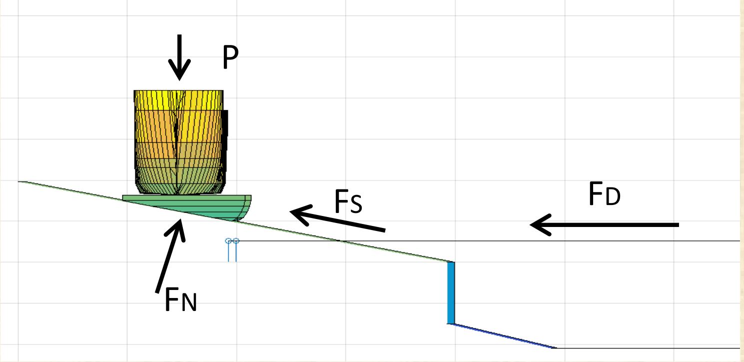
Force Components :

Gravity force (P), Friction force (F_S), Normal force/Reaction force (F_N), Drag force (F_D)



EQUATION OF MOTION

Sliding Equation of Motion Phases

$$m\,x'' = \sum P + Fs + Fn + Fd$$

Free damped equation of motion

$$(m + ma)\,X(\omega)\omega^2 + B\;X(\omega)\omega + K_h X(\omega) = 0$$

Frequency domain to Time domain

$$X(t) = X(\omega)\;e^{(-\zeta\omega t+\varphi)}\cos(\omega_d t + \varphi)$$

Computation condition :

- Friction coefficient (μ) = 0.03
- Velocity at initial condition = 0 m/s
- Critical damping coefficient = 5 %
- Density of water = 1 ton/m^3
- No environment condition

LAUNCHING PHASES

EMship+ Advanced Design

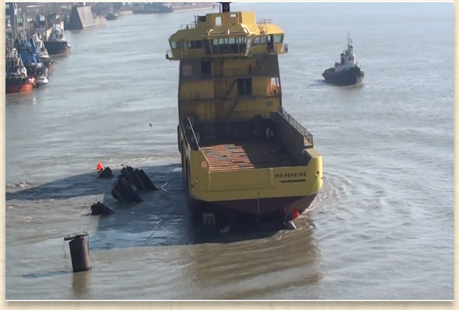
PHASE 1
the static of an inclined plane.

TIPPING
the static rotation motion with constant forces

PHASE 2
The Static Of An Inclined Plane + Drag Force on cradle

IMMERSION
the translation and rotation of motion + drag force and bouyancy

PHASE 3
The static of an inclined plane + drag force on cradle & ship



FREE DAMPED OSCILLATION

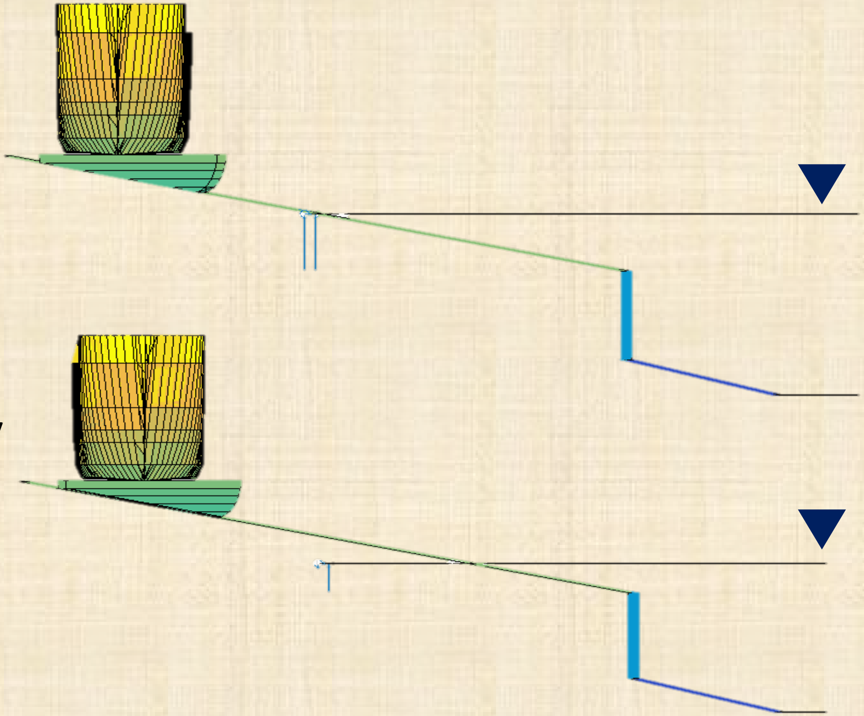
LAUNCHING SCENARIO

Case 1 (Optimistic condition)

water level : +4.84 m above edge of slipway

Case 2 (Worst condition)

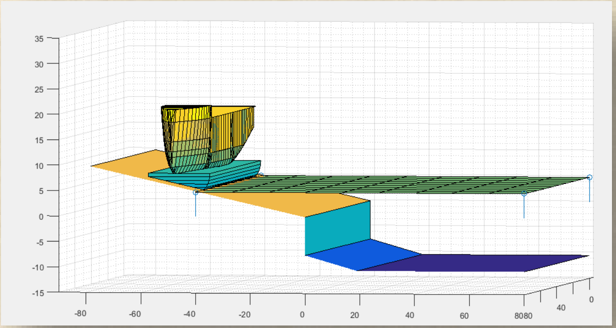
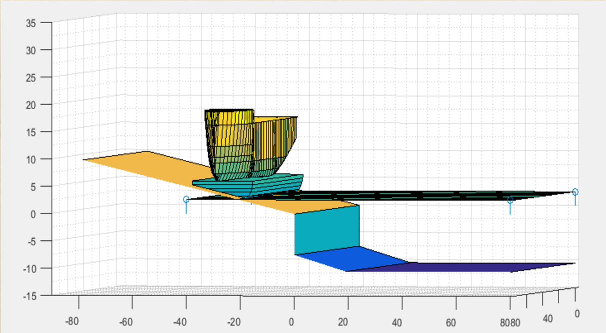
water level : +2.6 m above edge of slipway



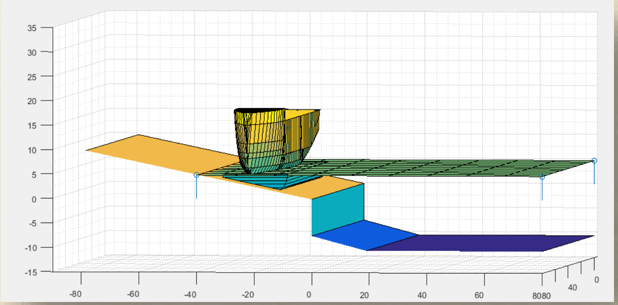
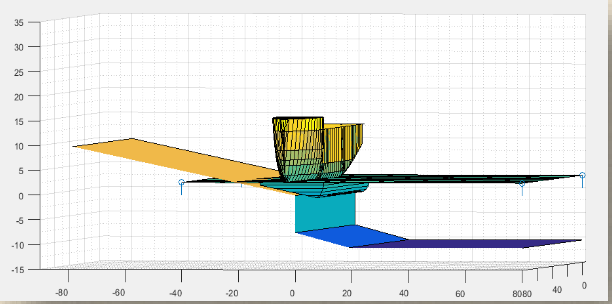
COMPUTATION RESULTS

- ***LAUNCHING PLOT***
- ***COMPARISON RESULT***
- ***SUMMARY RESULT***
- ***LAUNCHING RESULT***

LAUNCHING PLOT

1st scenario	2nd scenario
	

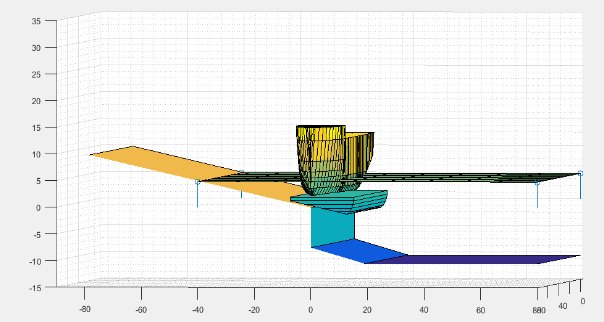
PHASE 1

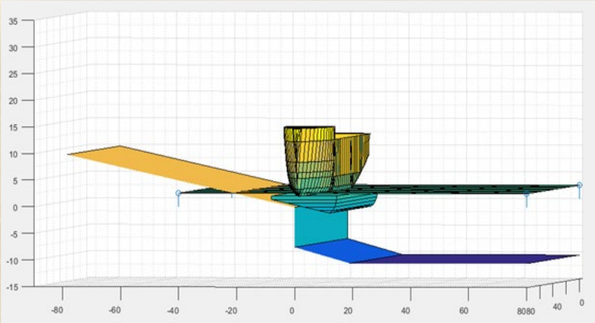
	

PHASE 2

LAUNCHING PLOT

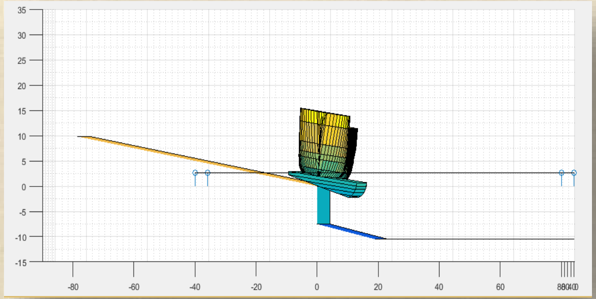
1st scenario	2nd scenario





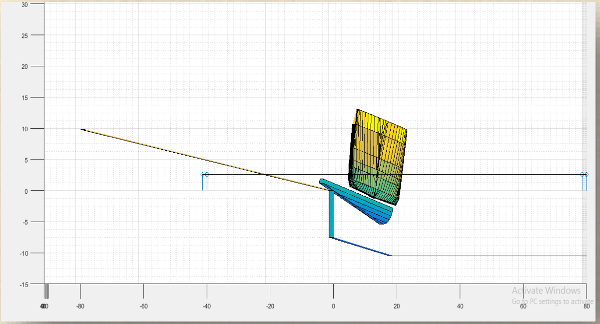
PHASE 3

No tipping

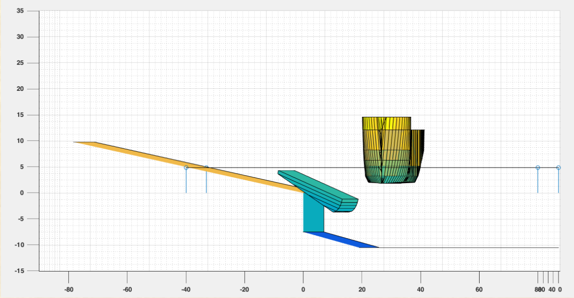
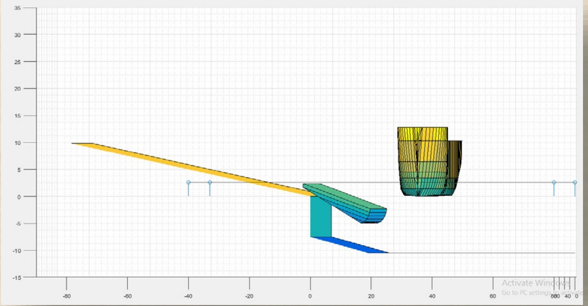


TIPPING

LAUNCHING PLOT

1st scenario	2nd scenario
No Immersion	

IMMERSION

FREE DAMPED OSCILLATION

COMPARISON RESULT

EMship+ Advanced Design

COMPARISON RESULTS BETWEEN NUMERICAL AND COMPUTATIONAL FROM REFERENCE

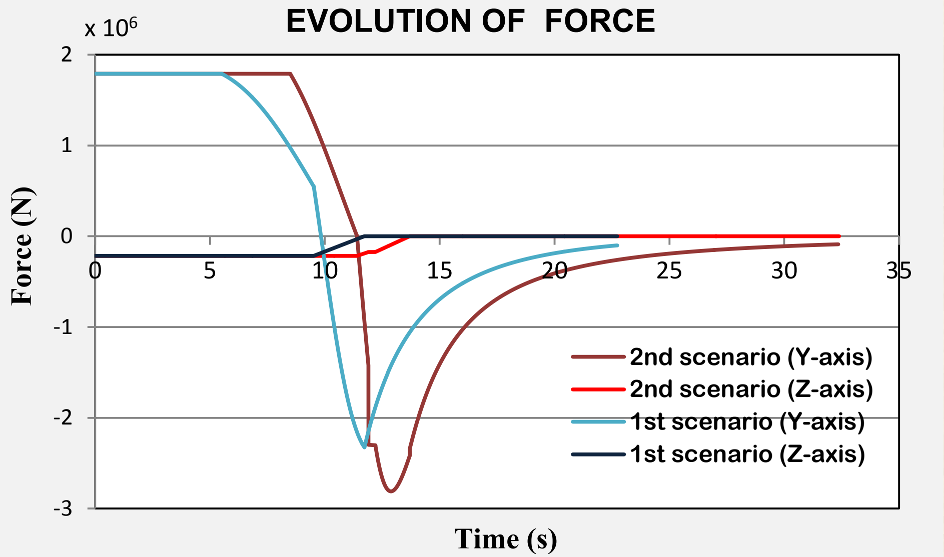
	DURATION		SLIDING PART RESULTS		
	Simulation	Real Case	Simulation	Data	Error
PHASE 1	5.53 s	5.53 s	x = 14.22 m v = 5.15 m/s a = 0.932 m/s²	x = [-] V = 5.3 m/s a = 0.93 m/s²	< 2.7%
PHASE 2	4.05 s	± 4 – 5 s	x = 42.44m v = 7.69 m/s a = 0.181 m/s²	x = 44.27 V = - m/s a = - m/s²	< 5%
PHASE 3	3.2 s	± 3 – 4 s	x = 63.79 m v = 5.18 m/s a = - 1.11 m/s²	x = 63.657 m V = - m/s a = - m/s²	< 1%
total	12.78 s	± 12 - 14 s			

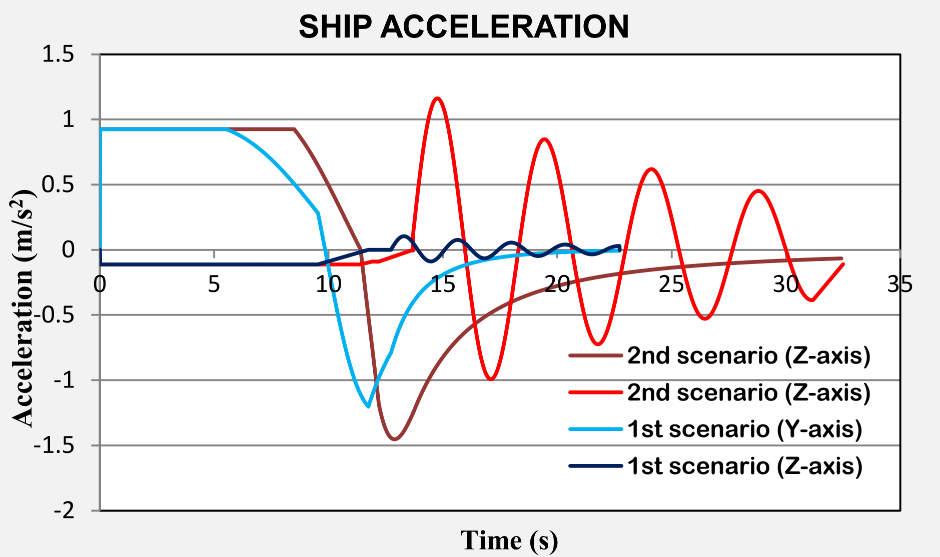
SUMMARY RESULTS

EMship+ Advanced Design

Phases	Case 1 (Optimistic Scenario)	Case 2 (Worst scenario)	Duration of Case 1	Duration of Case 2
Phase 1	x = 14.22 m v = 5.15m/s a = 0.932 m/s^2	x = 33.63 m v = 7.92 m/s a = 0.932 m/s^2	5.53 s	8.5 s
Phase 2	x = 28.22 m v = 7.69 m/s a = 0.181 m/s^2	x = 25.84 m v = 9.38 m/s a = 0.112 m/s^2	4.05 s	2.9 s
Phase 3	x =21.35 m v = 5.18 m/s a = - 1.11m/s^2	x = 4.68 m v = 9.21 m/s a = - 0.74 m/s^2	3.2 s	0.5 s
Tipping and immersion	-	φ = 0.215 rad $\dot{\varphi}$ = 0.473 rad/s a = - 1.453 m/s^2 x = 10.38 m	-	2.3 s
Free damped oscillation	ζ_{heave} = 0.23 m x = 22.73 m a = -0.0063 m/s^2	ζ_{heave} = 1.229 m φ_{roll} = 0.21 rad x = 38.8 m a = -0.066 m/s^2	10 s	18.8 s

LAUNCHING RESULTS

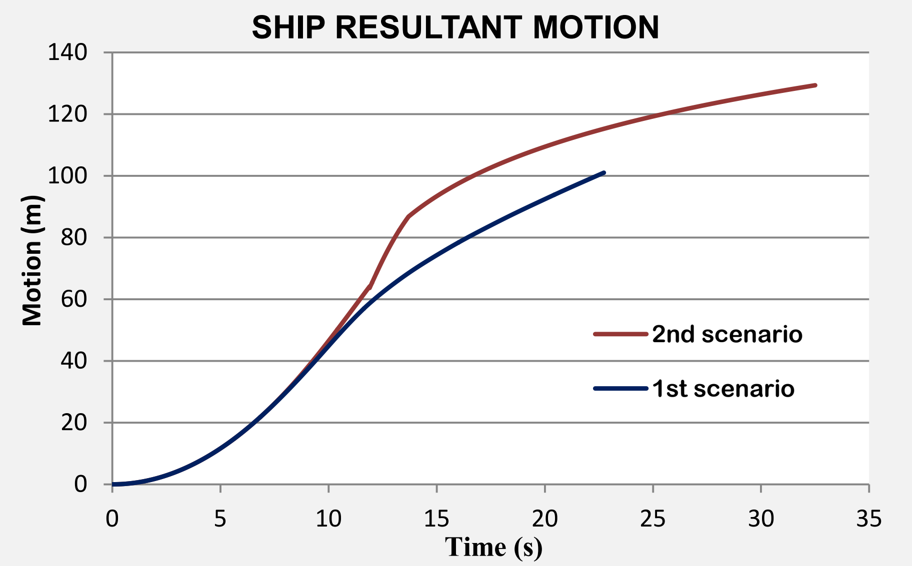


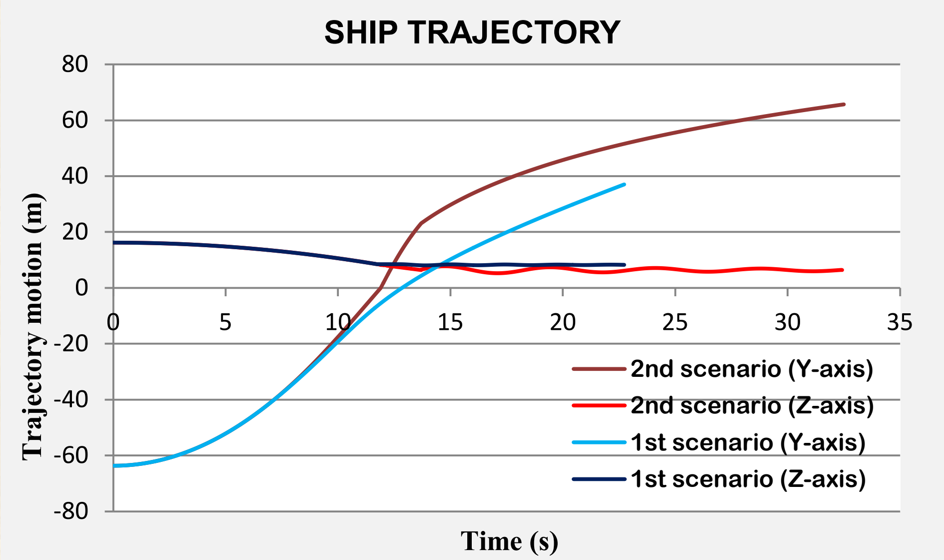


Phases	Case 1 (x10⁶ N)		Case 2 (x10⁶ N)	
	Y	Z	Y	Z
Phase 1	1.79	-0.217	1.79	-0.217
Phase 2	0.54	-0.217	0.0054	-0.217
Phase 3	-1.51	0	-2.29	-0.173
Tipping and immersion	-	0	-2.37	0
Free damped oscillation	-0.09	0	-0.089	0

Phases	Case 1	Case 2
Phase 1	0.932 m/s^2	0.932 m/s^2
Phase 2	0.181 m/s^2	0.112 m/s^2
Phase 3	- 1.11m/s^2	- 0.74 m/s^2
Tipping and immersion	-	- 1.453 m/s^2
Free damped oscillation	-0.0063 m/s^2	-0.066 m/s^2

LAUNCHING RESULTS

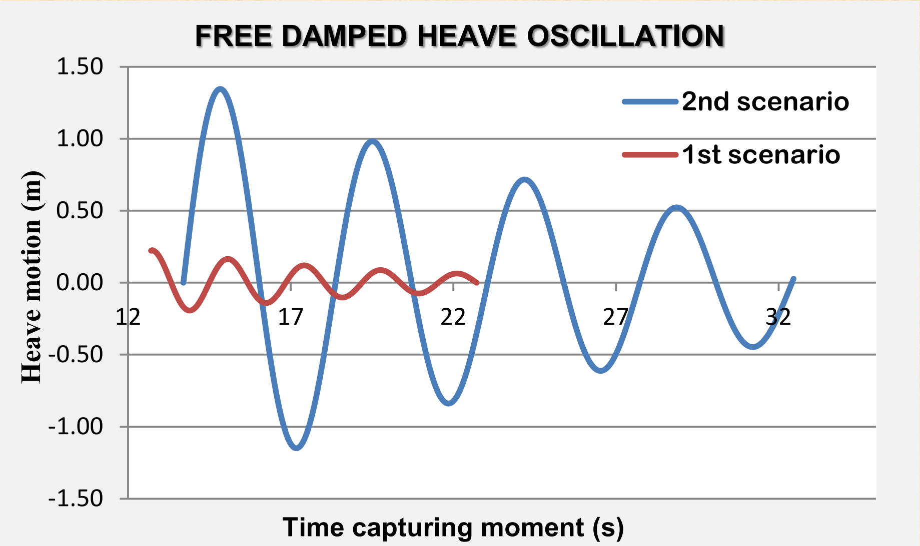


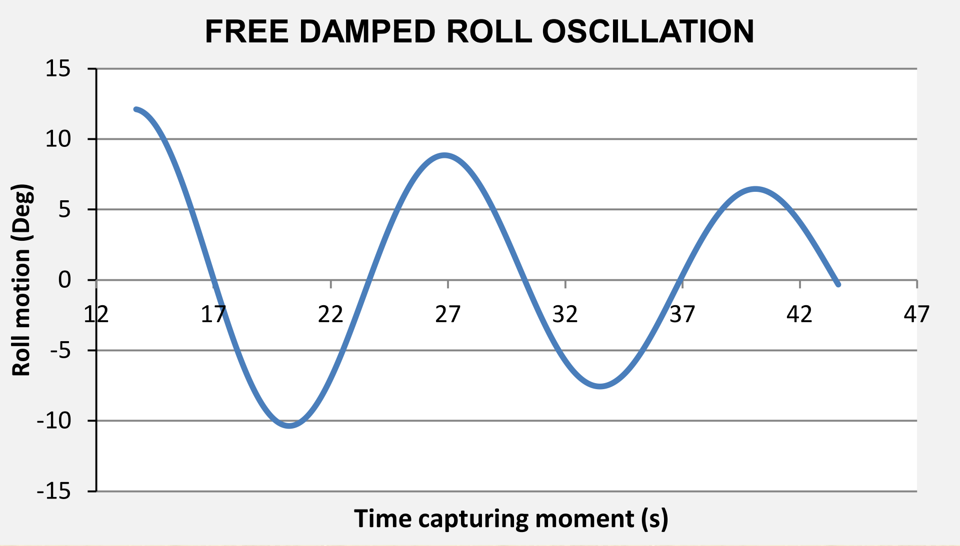


Phases	Case 1	Case 2
Phase 1	14.22 m	33.64 m
Phase 2	42.44 m	59.45 m
Phase 3	63.79 m	64.13 m
Tipping and immersion	-	87.33 m
Free damped oscillation	100.71 m	-0.066 m

Phases	Case 1 ($\times 10^6$ N)		Case 2 ($\times 10^6$ N)	
	Y	Z	Y	Z
Phase 1	14.12 m	-1.71 m	33.39 m	-4.04 m
Phase 2	41.80 m	-5.09 m	59.01 m	-7.28 m
Phase 3	63.02 m	-7.73 m	63.64 m	-7.94 m
Tipping and immersion	-	-	86.78 m	-9.73 m
Free damped oscillation	100.7 m	-7.95 m	129.27 m	-8.81 m

LAUNCHING RESULTS





Case 1
ω = 1.27 rad/s
ξ = 0.23 m

Case 2
ω = 1.344 rad/s
ξ = 1.229 m

Case 2
ω = 0.598 rad/s
φ = 0.218 rad

CONCLUSION AND FUTURE WORK

CONCLUSION

- The results from phase 1 to 3 of scenario 1 present good agreement to computation from reference by the indication of less than 5% differences
- Two scenarios of launching has been successfully automated into six phases by converting frequency domain into time domain
- Overall comparison of two scenarios, launching in higher water level provide a safer condition with less oscillation motion

FUTURE WORK

- *An upgrade of code is required to automate the program and create free surface effect*
- *Cradle as a part of launching components needs to be analyzed since it gives influence of ship motion*
- *Experimental analysis as a comparison to justify the result*

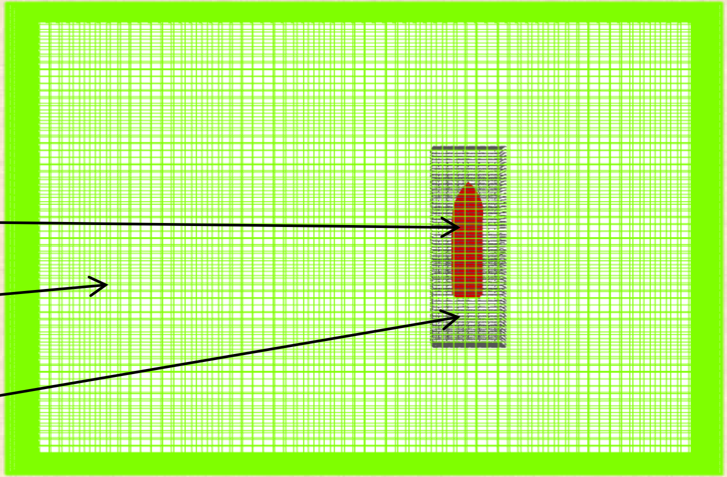
A progress of work has been made using *FINE™/Marine*

Set up model :

- Initial mesh about 1.4 – 8 million cells.
- Use overset grid mesh and adaptive grid refinement
- Assumes reaction force as vertical load on Cog
- Impose sway velocity to slide down

Problem :

Difficulties to maintain continuity equation due to overset grid and adaptive grid refinement



Thank You