

APPLICATION FOR GRANT OF RESEARCH PROJECT

ON

CONTROLLABILITY OF SHIPS IN HARBOUR AND

NAVIGATIONAL CHANNELS

Submitted to

Ministry of Shipping

Government of India

under

**National Technology Centre for Ports, Waterways and
Coasts (NTCPWC)**

Investigator

Dr.P.Krishnankutty
Professor



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APPLICATION FOR GRANT OF RESEARCH/DEVELOPMENT PROJECT

1. Title of Research proposal: **Controllability of ships in Harbours and Navigational Channels**

2.

- a) Name of the Principal Investigator : ***Dr.P. Krishnankutty***
b) Designation : *Professor*
c) Name of Institution : *Department of Ocean Engineering*
d) Address : *IIT Madras, Chennai - 600 036*

3.

- a) Proposed duration of the Research/Development proposal : 3 years
b) Proposed date of commencement of project/ facilities : Immediate

4. Specific Aim of the Project

The overall aim of the project is to study the controllability of the ships in harbour which is characterised by dense traffic situations and channel restrictions. The manoeuvring motion control is much more critical in restricted and shallow waters, given the risk of lack of control and collision. Hence it is important to study the manoeuvring characteristics of the ships in those water regions such as harbour, ports etc.

5. Background and justification

a. **Ships in harbour**

Due to the scale enlargement in the maritime fleet the accessibility of existing harbours worldwide is getting more and more complex. Smooth, efficient and safe voyage of vessels in harbours require complete knowledge about the manoeuvring characteristic of the ships. It also helps to reduce the infrastructural and operational costs for the harbour by designing a cost effective access channel and harbour facilities.

Effect on manoeuvring of a ship which is entering from deep sea condition to a harbour or port can be listed because of the following reasons

- Shallow water or restricted draft.
- Confined water or banking effect
- Ship to ship interaction

Ship manoeuvrability will change considerably due to the effect of decrease in water depths as well as decrease in clearances by sideways compared to deep sea conditions. Hence it is important to study the manoeuvring behaviour of ships for the safe as well as efficient voyage through harbours and ports.

b. Manoeuvring Tests in Shallow Water

The directional stability and control characteristics of a surface vessel are generally understood by solving the manoeuvring equations of motion, for which the knowledge of hydrodynamic derivatives are essential. Accurate prediction of these derivatives determines the quality of prediction of the manoeuvring characteristics of a vessel. Harbour or port regions are characterised with lesser draft and restricted clearances on sideways. Hence the importance of shallow water effects in ship manoeuvring. In shallow water, the flow around the vessel modifies drastically and thus also the hydrodynamic derivatives. Hence the correct estimation of these derivatives become detrimental in the prediction of vessel controllability when it operates in water depth restricted region. Vessels operating in such region become more sluggish and also respond poorly to the use of control surface. A vessel operating in a harbour area, which is a shallow water region with vessel crowding, warrants better controllability for it

The experimental facilities required for ship model tests to determine the hydrodynamic derivatives are rare and that too are limited only to deep water conditions. Manoeuvring characteristics of the ship considerably changes when it enters into the harbour or port from deep water. Static and dynamic confined model tests are largely carried out in towing tanks for the experimental determination of the hydrodynamic derivatives. The static tests give only velocity dependent derivatives and mostly the linear ones, whereas the dynamic tests provide data for the estimation of almost all the hydrodynamic derivatives, both velocity and acceleration dependent ones.

Mainly 2 types of model tests are carried out to find out the manoeuvring characteristic of ships.

1. Free running tests
2. Captive model tests

Planar motion mechanism (PMM) facility, which comes under captive model test, installed in a towing tank enables to perform the dynamic tests in pure sway, pure yaw and combined sway and yaw modes of model motion. The force and moment time histories recorded from the model during these tests leads to the determination of the hydrodynamic derivatives. The use of the floating false bottom facility in the towing tank along with the PMM will enhance the experimental facility to study the effect of water-depth on the hydrodynamic coefficients. This will help in predicting the vessel manoeuvring performance in shallow water regions such as harbour, inland and back waters.

Planar Motion Mechanism (PMM)

Planar Motion Mechanism (PMM) Equipment is a facility provided in a Towing Tank to perform experimental studies with ship models to determine the manoeuvring characteristics of a ship. The experiment is conducted in the towing tank where the PMM setup is attached with the carriage. The ship model is oscillated, at prescribed frequency and amplitude, in different modes of motion in the horizontal plane while it is towed along the tank at a pre-determined speed. The hydrodynamic forces and moments acting on

the ship model are measured, recorded and processed to get the hydrodynamic derivatives appearing in the ship manoeuvring equations of motion.

6. Summary of Proposed Research.

Behaviour of ships in harbour can be analysed by studying the hydrodynamic derivatives and manoeuvring equations which can be found by using Planar Motion Mechanism (PMM) arrangement with floating false bottom setup installed in the towing tank. The PMM facility which is being created in the towing tank at IIT Madras will be available for the proposed study. The shallow water facility need to be created for the implementation of the proposed project.

7. Amount of grant proposed for the project (INR)

Item	1 st year	2 nd year	3 rd year	Total
a) Research Staff:				
Project Officer - (Rs.40,000 pm &Rs.2500annual increment)	4,80,000	5,10,000	5,40,000	15,30,000
Project Associate - (Rs.35,000 pm & Rs.2000 annual increment)	4,20,000	4,44,000	4,68,000	13,32,000
Project Technician – (Rs.20,000 pm & Rs.1000 annual increment)	2,40,000	2,52,000	2,64,000	7,56,000
b) Equipments:				
b.1 Shallow water platform(To be installed in the present deep water towing tank for shallow water study)	40,00,000	----	----	40,00,000
b.2 Propeller Dynamometer (2 Nos.) for twin screw vessel model propulsion and wake tests	9,00,000	-----	-----	9,00,000
b.3 Multi-component load cell (2 Nos.) for force measurements in the Planan Motion Mechanism tests	12,00,000	----	----	12,00,000
b.4Laptop based PMM SCADA system	10,00,000	-----	-----	10,00,000
b.5 Making of models of Ship, propeller, rudder & appendages	8,00,000	6,00,000	-----	14,00,000
b.6 Model Loading and unloading system	21,00,000	-----	-----	21,00,000
b.7 Servo Drive system	-----	4,00,000	-----	4,00,000
b.8 PAC system spares	-----	6,50,000	-----	6,50,000
b.9 PMM system AMC for 3 years after warranty	-----	7,50,000	-----	7,50,000
c) Consumables	3,50,000	3,50,000	2,50,000	9,50,000
d) Contingencies	5,00,000	4,50,000	3,50,000	13,00,000
e) TA/DA (including for attending project review meetings, relevant Conferences, holding Workshop, etc.)	3,00,000	3,00,000	5,00,000	11,00,000
f) Others (Please Specify)	122,90,000	47,06,000	23,72,000	193,68,000
g) Institute Overhead Charges (@ 20%)	3,17,276	1,21,489	61,235	5,00,000
Total (INR)	126,07,276	48,27,489	24,33,235	198,68,000

16. Biographical Sketch

I. Principal Investigator

- a) Name : *Dr. P. Krishnankutty*
b) Designation : *Professor*
c) Age : *60 years*
d) Education & Experience: *35 years*
e) Degrees conferred

Degree	Institution	Field(s)	Year
B.Tech	Cochin University	Naval Architecture and Shipbuilding	1981
M.E	Stevens Tech., USA	Ocean Engineering	1988
PhD	IIT Madras	Ocean Engineering	1994

- f) Other research training and experience especially establishing research qualification in area covered by this application including previous/present position.

- **Teaching and research experience:** *34 years of experience in teaching related to Naval architecture and Ocean engineering.*
- *Projects related to ship maneuvering and motions, floating body hydrodynamics – numerical and experimental.*
- *Research guidance in the area of ship maneuvering and motions (PhD – 3 completed and 8 going on; MS – 3 completed and 2 going on)*

- g) Fields of major scientific interest on order of choice:

Ship hydrodynamics - maneuvering, motions, passenger comfort, wave wash, resistance & propulsion; Ocean Wave-structure Interaction.

(More Details about projects, research guidance & publications of PI are given in Appendix-A)

Appendix-A

Previous work done in this or related fields by Principal Investigator (Prof. P. Krishnankutty)

Sponsored Research Projects

1. *Generic Design Methodology for **Underwater Towed Bodies**, NPOL, Cochin*
2. *Study on the **Non-Linear Effects of Free Surface Waves** on Fixed and Floating Marine Structures/ Vehicles, NRB, Ministry of Defense, Govt. of India*
3. *Study of Progressive **Squat of Vessels** Operating in Harbor and Inland Waterways, MHRD, Govt. of India*
4. ***Shipping Quality and Safety** of High Speed Vessels, Terminals and Ports Operations In Nodal Points (SPIN), European Commission, Glasgow University, UK*
5. *Numerical Estimation of **Second Order Wave Forces** on Ships and Ocean Platforms, NRB, Ministry of Defense, Govt. of India*
6. *Tools to Optimize High Speed Craft to **Port Interface Concepts** (TOHPIC), European Commission, Glasgow University, UK*

Consultancy Projects

1. ***Hydro-Mechanical Performance** Estimation of Amphibian Battle Tanks, CVRDE, Ministry of Defense, India*
2. *Development of Software for the Determination of **Motion Derivatives** and Model Test Data Analysis of underwater Bodies, Naval Science and Technological Lab, India*
3. *Stability and **seaworthiness** of fishing vessel – FIBRO Plast, UP*
4. ***Sea keeping** and dynamics of a ships carrier ship – Neilsoft*
5. *Sea keeping and **manoeuvrability** tests/studies on hull 304 – Modest Infrastructure Pvt. Ltd., Mumbai*
6. *Conversion of Schottle Propulsion of a Ferry to Conventional Twin-Screw Propulsion, Kerala Shipp-ing and Inland Navigation Co*
7. *Conversion of a Dry-Cargo Barge to a Tanker Barge, Kerala Shipp-ing and Inland Navigation Co*
8. *Design of Lime Shell Barge, Travancore Cements, Kerala*
9. *Inclining Test and Stability Booklet of Dredgers, Indian Rare Earth Ltd.*
10. *Design of a Passenger Boat (150 Capacity), Steel Industries Ltd, Kerala*
11. *Design of Floating Jetty System, KREMENCO Kuwait*
12. *Seagoing Coastal Vessel Model Testing and Vessel Design, Master Shipyard Ltd., Cochin*
13. *Hydrodynamic Design Evaluation of AHT/Supply Vessel, Keppel Singmarime, Singapore*
14. *Powering and Flow Line Estimation of a Pilot Vessel, Henderson Internl, UAE*
15. *Motion Studies on Workboat-cum-Supply Vessel, Alcock Ashdown, Gujarat*
16. *Hydrodynamic Design Evaluation of AHTS Vessel, Keppel Singmarime, Singapore*
17. *Sea Keeping and Manoeuvrability Tests on Hull 304, Modest Infrast., Mumbai*
18. *Passive Anti-Roll Stabiliser Study for Work Boat, Alcock Ashdown, Gujarat*
19. *Resistance and Sea Keeping Computation for SWATH Hulls, Neilsoft, Maharashtra*
20. *Resistance, Sea Keeping and Anti-Roll Tests for Geotechnical Offshore Vessel, Modest Infrastructure Ltd., Mumbai*

21. Test, Evaluation and Design of Fishing Boat, AshokLeyland, Chennai

Research Guidance

1. Sheeja. J, "Numerical Estimation of Hydrodynamic Derivatives in **Surface Ship Maneuvering**" (PhD completed, 2010)
2. Aswathy.S "Study of Nonlinear Effects of Free Surface Waves on Marine Structures" (PhD completed, 2012)
3. Sunnykumar.P "Non-Linear Time Domain Analysis of **Floating Body Hydrodynamics Using Potential Flow Model**" (PhD ongoing since 2008)
4. Roni Francis "Effect of Fin and Tow Parameters on the Hydrodynamic Stability of an Underwater Towed System" (MS completed 2015)
5. Rajitha, S. "Estimation of **Ship Maneuvering** Hydrodynamic Derivatives Including Roll-Effects Using RANSE based **CFD**" (PhD completed 2015)
6. Krishna, B. "Numerical and Experimental Analysis of the **Shallow Water Hydrodynamics of High Speed Mono Hull and Catamaran Vessels**" (MS completed, 2009)
7. Bharatwaja,S. "Hydrodynamic studies on an Underactuated **Autonomous Underwater Vehicle**" (PhD ongoing since 2010)
8. Praveen "Estimation of hydrodynamic coefficients for a family of **axisymmetric underwater vehicles**" (PhD ongoing since 2011)
9. Ankush, K. "**Experimental and Numerical PMM Simulations to Determine Ship Manoeuvring Coefficients**" (MS completed 2014)
10. Naga Praveen, "Experimental and Computational Study of Lift – Based **Flapping Foil Propulsion System for Ships**" (PhD ongoing since 2012)

List of Publications in Related and Other Areas

International Journals

1. Rajita R.S., Krishnankutty, P. and PanneerSelvam, R. "Study of **Maneuverability of Container Ship** by Static and Dynamic Simulations using RANSE based Solver", JI. Ships and Offshore Structures, 15 Dec 2014 (DOI: 10.1080/ 17445302.2014.987439).
2. Sunny Kumar,P., Vendhan, C.P, and Krishnankutty,P. "A Study of Finite Element Model for Nonlinear Water **Wave-Body Interaction** using the Fully Nonlinear Potential Flow Theory", Journal of Ships and Offshore Structures (under review).
3. Ankush, K. and Krishnankutty, P. "Design Options for Dynamic Captive Ship Model Test Facility", International Journal of Innovative Research and Development(IJIRD), Vol 1 Issue 10 Dec. 2012, 248-263
4. Praveen, P.C. and Krishnankutty, P. "Study on the Effect of Body Length on the Hydrodynamic Performance of an Axi-Symmetric Underwater Vehicle", Indian Journal of Geo-Marine Science (IJMS) August 2013.
5. Senan, A., and P.Krishnankutty (2012), A study on nonlinear wave forces and motion responses of a tri-hull carrier vessel, *Journal of Engineering for the Maritime Environment*, 226, 3-14.
6. Sheeja, J and Krishnankutty, P., "Numerical Estimation of **Non-Linear Hydrodynamic Derivatives** of a Container Ship", *International Shipbuilding Progress* (under review).
7. Sheeja, J and Krishnankutty, P., "Estimation of Sway Velocity-Dependent Hydrodynamic Derivatives in Surface **Ship Manoeuvring** Using RANSE based CFD", International Journal of Ocean and Climate Systems, Sep 2010, Vol.1, Nos. 3&4, pp167-178.

8. B.Krishna* and P.Krishnankutty., “Experimental and Numerical Study on Trim and Sinkage of a High Speed Catamaran Vessel in **Shallow Waterways**”, *International Shipbuilding Progress*, 2009 , Volume 56, Number 3&4, pp159-176..
9. K.S.Varyani and P.Krishnankutty “**Stopping manoeuvre** of high speed vessels fitted with screw and waterjet propulsion”, *Journal of Marine Engineering & Technology (IMarEST, UK)*,No.13, Jan 2009, pp11-19
10. Varyani,K.S., Krishnankutty, P., “Influence of Mooring Rope Characteristics on the Horizontal **Drift Oscillation of a Moored Ship**”, *International Shipbuilding Progress*, 2006 , Volume 53, Number 1, pp55-71.
11. Varyani,K.S., Krishnankutty, P., “Modification of **Ship Hydrodynamic Interaction** Forces and Moment by Underwater Ship Geometry”, *Ocean Engineering*, 2006, 33, 1090-1104
12. Varyani,K.S, Thavalingam, A. and Krishnankutty, P. “New Generic Mathematical Model to Predict **Hydrodynamic Interaction** Effects for Overtaking Manoeuvres in Simulators”, *Journal of Marine Science and Technology, Japan*, Vol.9, No.1, 2004, pp24-31, ISSN 0948-4280
13. Krishnankutty,P. and Varyani, K.S. “Force on the Mooring Lines of a Ship due to the **Hydrodynamic Interaction** Effects of a Passing Ship”, *International Shipbuilding Progress*, Vol. 51, No. 1, 2004, pp33-57
14. Varyani,K.S, McGregor,R, Krishnankutty, P and Thavalingam, A. “New Empirical and Generic Models to Predict Interaction Forces for Several Ships in **Encounter and Overtaking Manoeuvres** in a Channel”, *International Shipbuilding Progress*, Vol. 42, No. 4, 2002, pp237-262
15. Krishnankutty,P. and Vendhan,C.P. “Analysis of Diffraction-Radiation Problem of a Twin-Hull Barge System”, *International Shipbuilding Progress (The Netherlands)*, Vol. 42, No. 432, Dec 1995, pp357-379
16. Krishnankutty,P. and Vendhan,C.P. “Three-Dimensional Finite Element Analysis of Diffraction-Radiation Problem of Hydro dynamically Compact Structures”, *Marine Structures (UK)* Vol.8, 1995,pp 525-542
17. Ignatius,K.K.V. and Krishnankutty,P. “Ship Data Model Using Cell Network”, *Computer Applications in the Automation of Shipyard Operations and Ship Design(ICCAS)*, VII, IFIP Transactions B-5,pp331-341, North Holland, Amsterdam, 1992.

International Conferences/Reports

18. Sai Sanjit, G. and Krishnankutty, P., “Numerical Study of Propeller Effect on the Hydrodynamic Derivatives in **Maneuvering of a Container Ship**”, International Conference on Computational and Experimental Marine Hydrodynamics (MARHY2016), November 24-25, Chennai, India.
19. Rameesha T.V. and Krishnankutty, P. “Numerical Study on the **Maneuvering of a Ship in Waves** based on Unified State Space Model”, Proceedings of the ASME 35th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2016), Busan, South Korea, 19-24 June, 2016
20. Rameesha T.V. and Krishnankutty, P. “Numerical Investigation on the Influence of **Froude Number on the Hydrodynamic Derivatives** of a Container Ship”, Proceedings of the ASME 35th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2016), Busan, South Korea, 19-24 June, 2016
21. Shenoi, R., Krishnankutty, P. and Panneer Selvam, R. “Sensitivity Study of Hydrodynamic Derivative Variations on the **Maneuverability Prediction** of a Container Ship”, Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore

and Arctic Engineering (OMAE 2015), Saint Johns, Canada, June 08-13 May 31 – June 05, 2015

22. Mannam, N.P.B. and Krishnankutty, P. "Numerical Study on **Fish Tail Shaped Rudder** for Improved Ship Maneuvering", Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2015), Saint Johns, Canada, June 08-13 May 31 – June 05, 2015
23. Praveen, K. and Krishnankutty, P. "Numerical Study of Self-Propulsion and **Manoeuvring Characteristics** of 90t AHTS Vessel", International Conference on Computational and Experimental Marine Hydrodynamics, 3-4 Dec 2014.
24. Roni Francis, Sudarsan, K., Krishnankutty, P. and Anantha Subramanian, V. "Numerical and Experimental Determination of **Velocity Dependant Hydrodynamic Derivatives** of an Underwater Towed Body". International Conference on Computational and Experimental Marine Hydrodynamics, 3-4 Dec 2014.
25. Praveen, P.C., Krishnankutty, P. and Panigrahi, P.K "Investigation On The Effect Of Fineness Ratio On **The Hydrodynamic Forces** On An Axisymmetric Underwater Body At Inclined Flow", International Conference on Computational and Experimental Marine Hydrodynamics, 3-4 Dec 2014
26. Kulshrestha, A. and Krishnankutty, P. "Estimating Manoeuvring Coefficients of a Container Ship in **Shallow Water** Using CFD", International Conference on Computational and Experimental Marine Hydrodynamics, 3-4 Dec 2014
27. Naga Praveen Babu, M. and Krishnankutty, P "Experimental and Computational Study of Lift - Based Flapping Foil Propulsion for Ships", International Conference on Computational and Experimental Marine Hydrodynamics, 3-4 Dec 2014
28. Naga Praveen Babu, M., Krishnankutty, P. and Mallikarjuna, J.M"Experimental Study of Flapping foil Propulsion System for Ships and Underwater Vehicles and PIV Study of Caudal Fin Propulsors", Oceanic Engineering Society IEEE AUV 2014 Conference, Oxford, USA, October 2014.
29. Krishnankutty, P., Anantha Subramanian, V., Roni Francis, Prabhasudan Nair, P. and Sudarsan, K. "Experimental and Numerical Studies on an Underwater Towed Body", Proceedings of the ASME 2014 33rd International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2014), San Francisco, CA. June 08-13, 2014
30. Naga Praveen Babu, M. and Krishnankutty, P., "Bio-Mimetic Flapping Foil Propulsion System for Manned Submersibles", UTW 13: Underwater Technology 2013, 21st October 2013, NIOT Chennai, India
31. R Rajita Sheno, P Krishnankutty, R PanneerSelvam and A Kulshrestha "Prediction of **Manoeuvring Coefficients** of a Container Ship by Numerically Simulating HPMM Using RANSE Based Solver", 3rd International Conference on Ship Manoeuvring in Shallow and Confined Water, Ghent, Belgium, June 03-06, 2013.
32. Praveen, P.C. and Krishnankutty, P. "Study on the Effect of Body Length on the Hydrodynamic Performance of an Axi-Symmetric Underwater Vehicle", 4th International Conference on Underwater System Technology, Kuala Lumpur Malaysia, December 4-6, 2012.
33. Krishnankutty, P. "Surface **Ship Maneuvering**, Underwater Towed Bodies and Autonomous Underwater Vehicles", Lecture delivered in the Workshop on AUVs in Ocean Observation Systems at Shah Alam, Kuala Lumpur, Malaysia on 04 December 2012.
34. Ankush, K. and Krishnankutty, P. "Design Options for Dynamic Captive **Ship Model Test Facility**", International Conference on Technology of the Sea (Tech SAMUDRA 2012), Visakhapatnam, India, 6-8 December 2012.
35. Roni Francis, K.Sudarsan, P.Krishnankutty, V Anantha Subramanian, "Design and Analysis of a Towed Submersible System", International Conference on Technology of the Sea (Tech SAMUDRA 2012), Visakhapatnam, India, 6-8 December 2012.
36. VBS Ayyangar, P Krishnankutty, Manu Korulla, PK Panigrahi, "Hydrodynamic Design of a Flat Fish Autonomous Underwater Vehicle", International Conference on Civil,

- Offshore & Environmental Engineering 2012, (ICCOEE2012), Universiti Teknologi Petronas, Malaysia, June 2012
37. Vendhan, C.P., Sunnykumar, P. and Krishnankutty, P. "Finite Element Analysis Of Nonlinear Water **Wave-Body Interaction**- Computational Issues", Proceedings of the ASME 31st International Conference on Ocean, Offshore and Arctic Engineering, OMAE2012, July1-6, 2012
 38. Senan, A., and P.Krishnankutty (2012), Numerical estimation of nonlinear wave forces on a multi-hull barge using finite element method, ASME31st International Conference on Ocean, Offshore and Arctic Engineering (OMAE-2012),Rio de Janeiro, 1-6 July.
 39. Senan, A., and P.Krishnankutty (2012), Estimation of second-order wave forces on marine structures using finite element method, Eighth International Conference on Coastal and Port Engineering in Developing Countries (PIANC-COPEDEC 2012), IITM Chennai, India, 20-24 February.
 40. Senan, A., and P.Krishnankutty (2011), Experimental and Numerical Study of a Multihull Barge, International Conference on Developments in Marine CFD (ICM-CFD-2011), Chennai, India, 18-19 November.
 41. MD.Kareem Khan and P. Krishnankutty, "Hydrodynamic Performance Evaluation of Hull - Waterjet System Using CFD and Experiment", Seventh International Conference on High Performance Marine Vehicles (HIPER'10), Melbourne, Florida, USA, Oct 13-15, 2010.
 42. AswathySenan, P.Krishnankutty and V.Anantha Subramanian, "Experimental and Numerical Study of Motion Characteristics of an Equi-Hull Trimaran", Proc. Ninth International Conference on Hydro-Science Engineering (ICHE 2010), IIT Madras, India, 2-5 Aug 2010
 43. SheejaJanardhanan and Krishnankutty P., "Operational Risks on the **Controllability of a Vessel in Harbour Environment** Due to Shallow Water Effects", *17th Congress of the Asia and Pacific Division of the International Association of Hydraulic Engineering and Research(IAHR-APD) and 7th International Urban Watershed Management Conference*, Auckland, New Zealand, 21- 24 February, 2010
 44. SheejaJanardhanan and P. Krishnankutty, "Prediction of **Ship Manoeuvring** Hydrodynamic Coefficients Using Numerical Towing Tank Model Tests", *12th Numerical Towing Tank Symposium (NuTTS 2009)*, Cortona, Tuscany, Italy, 4-6 October, 2009
 45. SheejaJanardhanan and P. Krishnankutty, " Numerical Estimation of Sway Velocity-Dependent Non-Linear Hydrodynamic Derivatives in **Surface Ship Manoeuvring**", *International Conference in Ocean Engineering (ICOE 2009)* – Feb 1-5, 2009, IIT Madras, India
 46. Baireddy Krishna and P.Krishnankutty, "Study on the Grounding Chances of a High Speed Mono-Hull Vessel Form in **Shallow Waters**", *International Conference in Ocean Engineering (ICOE 2009)* – Feb 1-5, 2009, IIT Madras, India
 47. P.Krishnankutty&SheejaJanardhanan, "A Passing Ship Induced **Hydrodynamic Interaction** Forces on a Ship Moored in a Harbour and the Influence of Mooring Rope Material on its Subsequent Drift Movements",*International Conference on Infrastructure Development in the Ports & Shipping Sector and its Management (IDPM)*" held on 18-20 Jan 07, Chennai
 48. Krishnankutty, P., Varyani, K.S. and Krishnan, D.K. "**Wave Wash** Generated by a High Speed Catamaran Ferry in Deep and Shallow Waterways", *International Conference on Marine Hydrodynamics (MAHY-2006)*, NSTL, Visakhapatnam.
 49. Krishnankutty, P. and Krishnan, D.K. "A Study to Identify the Restrictions Required on a Tanker Operating in Cochin Harbour to Save it from **Grounding due to Squat**",

International Conference on Marine Hydrodynamics (MAHY-2006), NSTL, Visakhapatnam.

50. Varyani, K.S., Krishnankutty, P., Day, A.H, Guevel, M., Vega, J. and Annasanta, "Report on Passenger Comfort on High Speed Vessels", *Report No GRD2/200/30303-SPIN-HSV/4.3*, Jan 2004, European Commission.
51. Krishnankutty, P. and Varyani, K.S. "Ship Form Effects on the Forces and Moment on a Stationary Ship Induced by a Passing Ship", *6th IFAC Conference on Manoeuvring and Control of Marine Crafts (MCMC'2003)*, Spain, 17-19 Sep 2003.
52. Varyani, K.S. Krishnankutty, P. and McGregor, R.C. "Effect of Rudder Size and Location on the **Turning Performance** of a High Speed Swath Ferry", *6th IFAC Conference on Manoeuvring and Control of Marine Crafts (MCMC'2003)*, Spain, 17-19 Sep 2003.
53. Varyani, K.S. Krishnankutty, P. and Vantorre, M. "Prediction of Load on Mooring Ropes of a Container Ship due to the Forces Induced by a Passing Bulk Carrier", *International conference on Marine Simulation and Ship Manoeuvrability (MARSIM'03)*, Kanazawa, Japan, 25-28 Aug 2003
54. Day, A.H., Baltrop, N.D., Varyani, K.S and Krishnankutty, P. "Report on **Route Planning** and Environmental Problems Resulting from Fast Vessel Operations", *Report No GRD2/200/30303-SPIN-HSV/4.2B*, Dec 2003, European Commission.
55. Varyani, K.S and Krishnankutty, P. "Report on High Speed Vessels **Manoeuvrability**", *Report No GRD2/200/30303-SPIN-HSV/4.2A*, Oct 2003, European Commission.
56. Varyani, K.S. and Krishnankutty, P. "**Hydrodynamic Interaction** Between Two Ships", *Report No G3RD-CT-2000-00491/TOHPIC/1.3.08.02*, May 2002, European Commission.
57. Varyani, K.S. and Krishnankutty, P. "**Squat Effects** on Vessels in Restricted Waterways", *Report No G3RD-CT-2000-00491/TOHPIC/1.3.08.01*, Feb 2002, European Commission.
58. Varyani, K.S. and Krishnankutty, P. "**Wave Wash** of INCAT96 in Barcelona", *Report No G3RD-CT-2000-00491/TOHPIC/1.2.08.03*, Jan 2002, European Commission.
59. Varyani, K.S, Krishnankutty, P and McGregor, R. "Report on Current **High Speed Vessels**", *Report No GRD2/200/30303-SPIN-HSV/4.1*, Sep 2002, European Commission.
60. Krishnankutty, P., Pradeep, K.R. and Anilkumar, K.A. "Second-Order Wave Force Estimation Using Three-Dimensional FEM", *International Conference on Ship and Marine Technology (SMART 2000)*, Cochin, Dec 2000, pp165-172
61. Arun, U and Krishnankutty, P. "Integration of Graphical Pre- and Post-Processors for Effective Utilisation and Representation of Diffraction Problem Solutions", *International Conference on Ship and Marine Technology (SMART 2000)*, Cochin, Dec 2000, pp139-148
62. Baiju, M.V, Chandramohan, P.V and Krishnankutty, P. "Analysis and Design of Floating Dock", *International Conference on Ship and Marine Technology (SMART 2000)*, Cochin, Dec 2000, pp21-34
63. Krishnankutty, P. and Vendhan, C.P. "Estimation of Wave Diffraction Effects Around Inclined Cylinders Using 3D-FEM", *Seventh International Conference on Computer Applications in the Automation of Shipyard Operations and Ship Design (ICCAS)*, Brazil, 1991

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PROFESSIONAL BODY MEMBERSHIPS

- **Fellow** of Royal Institution of Naval Architects (**RINA**), UK
- **Member** of Society of Naval Architects and Marine Engineers (**SNAME**)
- **Member** American Society of Mechanical Engineers (**ASME**)
- **Chartered Engineer**, Engineering Council, UK
- **Member**, International Association of Hydraulic Engineering and Research (**IAHR**)
- **Life Member**, Ocean Society of India, Cochin
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POST DOCTORAL RESEARCH

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