

History, State-of-the-arts and Future Trend of Ship Manoeuvrability and Controllability

- Thirty Years Research Review -

Kazuhiko Hasegawa
Osaka University
Japan

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Background and History of the Research

- Ship manoeuvring research in 1970s
- Autopilot for saving energy
- Necessity of the research of man-machine System
 - Developing a ship handling simulator, as one of the oldest ones in the world
- Developing standard mathematical model of ship manoeuvring

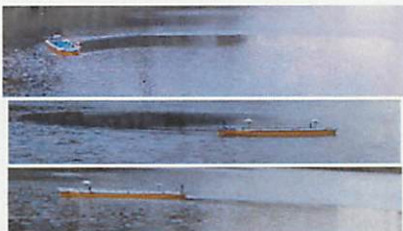
VLCCs



Ship Manoeuvring Model before 1970

- David and Schiff Model
 - Davidson, K.S.M., and L.I. Schiff, Turning and course keeping qualities, Trans. SNAME, Vol.54, 1946
- Abkowitz Model
 - Abkowitz, M.A., Lectures on Ship Hydrodynamics - Steering and Manoeuvrability, Hya Report no. Hy-5, 1964
- Nomoto's K-T Model
 - First order Model
 - Second order model
 - Second order non-linear model
- Necessity to develop a model for new types of ships

Model Ship Experiments



Model Ship Experiments



Ship Manoeuvring Model in 1970s

- David and Schiff Model
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Ship Manoeuvring Model in 1980s

- Necessity to develop a model for new types of ships
 - MMG model (module type mathematical model considering hull, propeller, rudder and their interactions respectively)
- Still now several variation of MMG model exists
- Some extended MMG models applicable for twin-propeller ship, for shallow water etc. exist

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Adaptive Autopilot

- Model Reference Adaptive Control
 - Amerongen, J. van and A.J. Ulbrink ten Cate, Model reference adaptive autopilots for ships, Automatica, Vol. 11, pp 441-445, 1975
- Self-tuning Control
 - Källström, C.G., K.J. Åström, N.E. Thorell, J. Eriksson and L. Sten, Adaptive autopilots for steering of large tankers, Report Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, 1977
- Stochastic Model
 - Ohtsu, K., M. Horigome, G. Kitagawa, A new ships autopilot design through a stochastic model, Automatica, Vol 15, pp. 255-268, 1979
- Adaptive Control
 - Tiano, A., E. Volta, A.W. Brink and T.W. Verbruggen, Adaptive control of large ships in non-stationary conditions - a simulation study, Proceedings Symposium on Ship Steering Automatic Control, Genova, Italy, 1980
- etc

Cost Function of Fuel Consumption

- Koyama's criterion $J = \int |u| dt + A\delta$
 - Koyama, T On the optimum automatic steering system of ships at sea, J.S.N.A., Vol 122, Dec. 1967
- Norrbin, N.H., On the added resistance due to steering on a straight course, 13th ITTC, Berlin, Hamburg, 1972
- Clarke, D., Development of a cost function for autopilot optimization, Proceedings Symposium on Ship Steering Automatic Control, Genova, Italy, 1980
- Blanke, M. and J.C. Nortoft Thompson, Experiment with direct measurement of steering generated propulsion losses, 6th Ship Control Systems Symposium, Ottawa, Canada, 1981
- Hasegawa's criterion
 - K. Hasegawa - On a Performance Criterion of Autopilot Navigation, Journal of the Kansai Society of Naval Architects, Japan (JKSNAJ) 176, pp.93-103, Sep., 1980
- etc

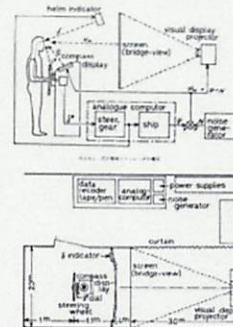
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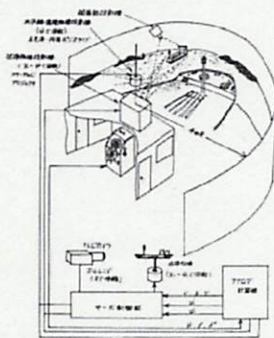
First Generation Ship Handling Simulator (1974)

- Feasibility study on instability criterion of human ability to control a VLCC (SR151, Japan)
 - Nomoto, K., Simulators from the naval architects point of view, Proceedings of MARSIM, Southampton, UK, 1978
 - T. Koyama, K. Kose and K. Hasegawa : A Study on the Instability Criterion of the Manual Steering of Ships (in Japanese), J. of the Society of Naval Architects of Japan (J.SNAJ) 142, pp.119-126, Dec., 1977

First Ship Handling Simulator in the world (Hiroshima University, 1970)



SR151 Ship Handling Simulator (1974)



Full Mission Ship Handling Simulator

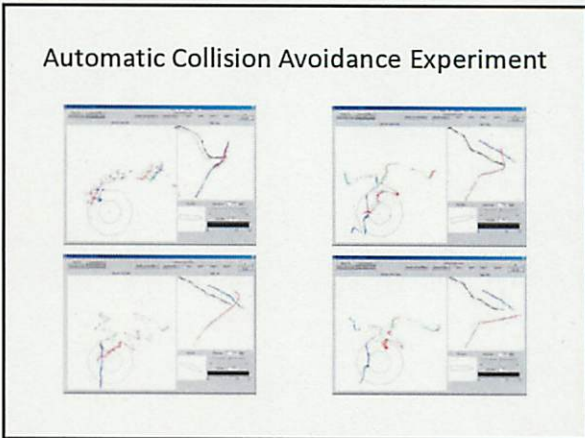
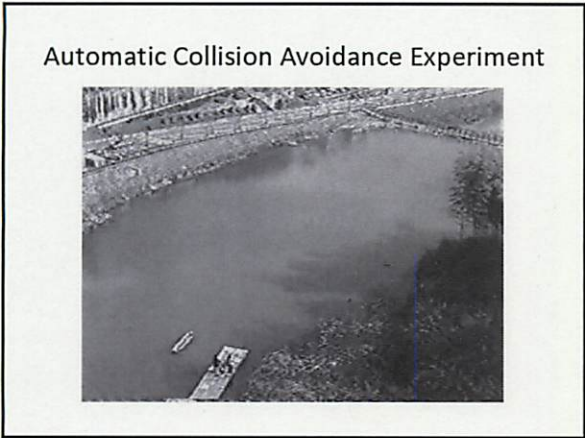


Background and History of the Research (contin'd)

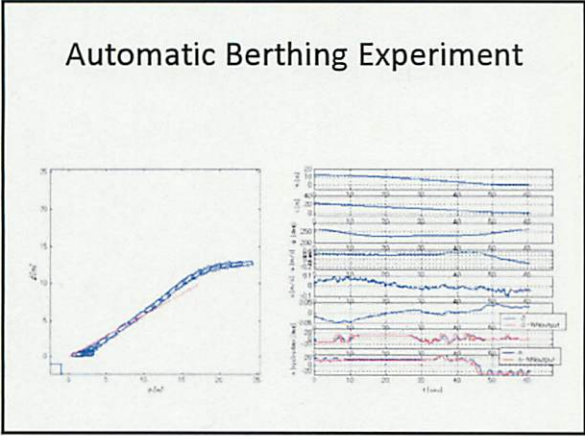
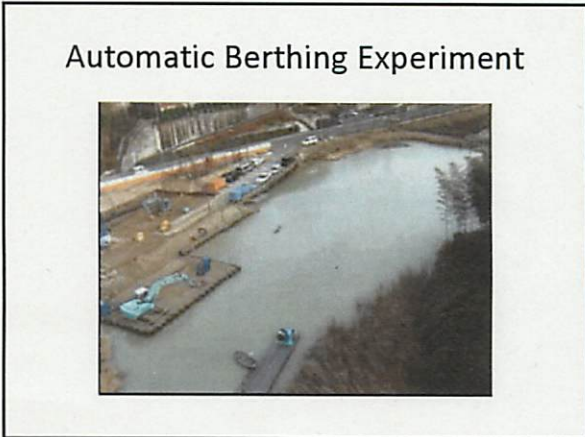
- Developing intelligent ship control systems including
 - collision avoidance
 - berthing/deberthing control
- Developing a tool for safety assessment in congested waterways
- Developing standardisation of mathematical model of ship manoeuvring in low speed and/or in shallow water etc

Automatic Collision Avoidance

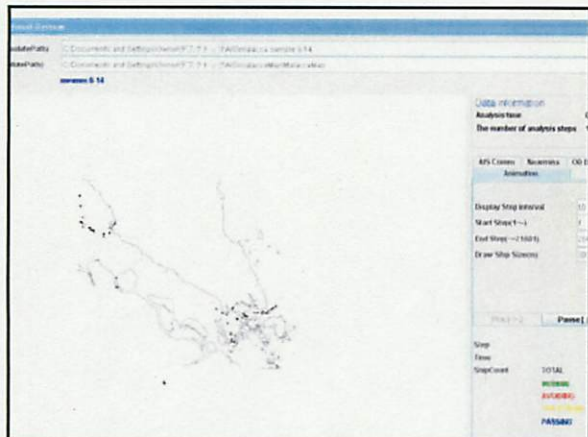
- Fuzzy Reasoning and Control
 - A. Kouzuki and K. Hasegawa : Automatic Collision Avoidance System for Ships Using fuzzy Control (in Japanese), J.KSNAJ 205, pp.1-10, June 1987
 - K. Hasegawa : Fuzzy Modelling of the Behaviours and Decision-Making of Ship Navigators, Proc. of 3rd International Fuzzy Systems Association (IFSA) Congress, pp.663-666, Seattle, Aug. 1989
- Expert System for Multiple Ship Encounter
 - K. Hasegawa, A. Kouzuki, T. Muramatsu, H. Komine and Y. Watabe : Ship Auto-navigation Fuzzy Expert System (SAFES) (in Japanese), J.SNAJ 166, pp.445-452, Dec. 1989



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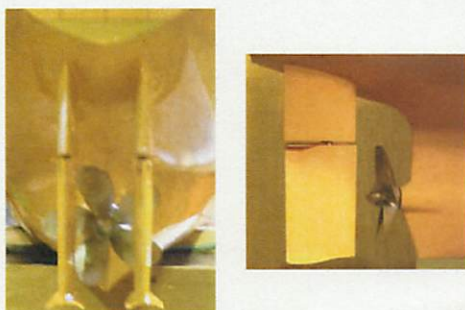
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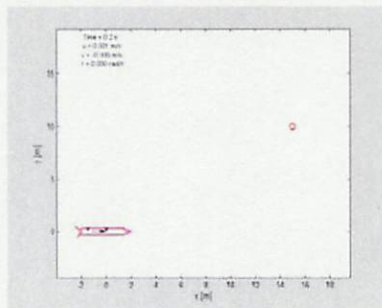
Single-propeller Twin-Rudder Ship



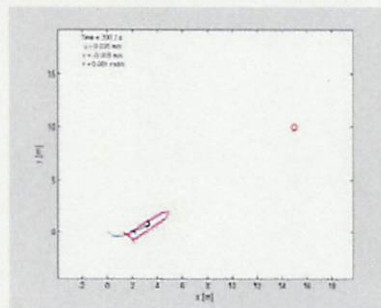
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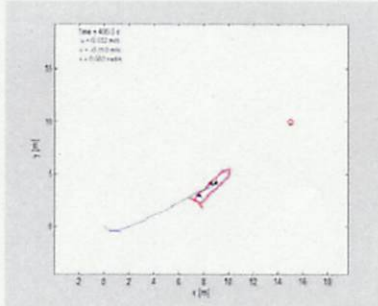
Automatic Navigation in Slow Speed by Single-propeller Twin-rudder Ship



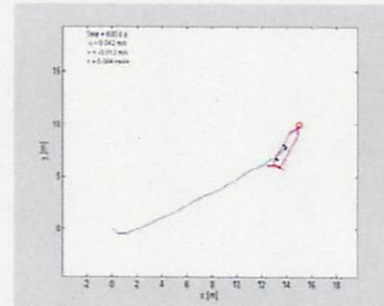
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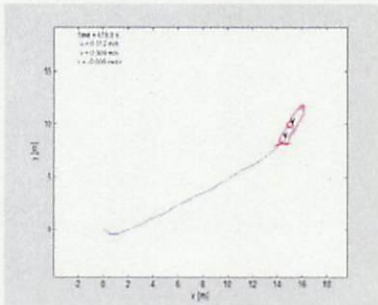
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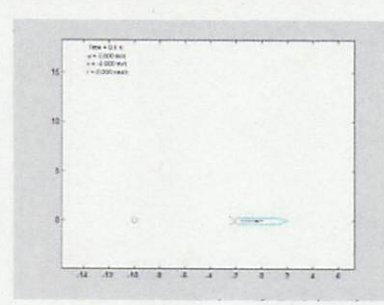
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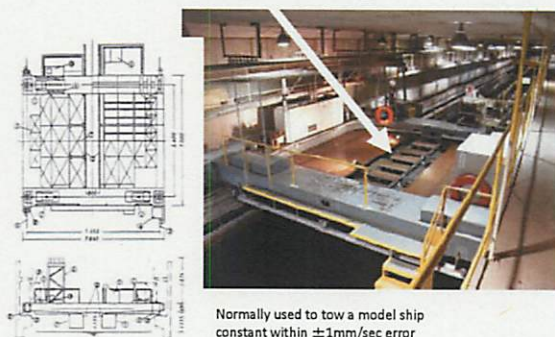
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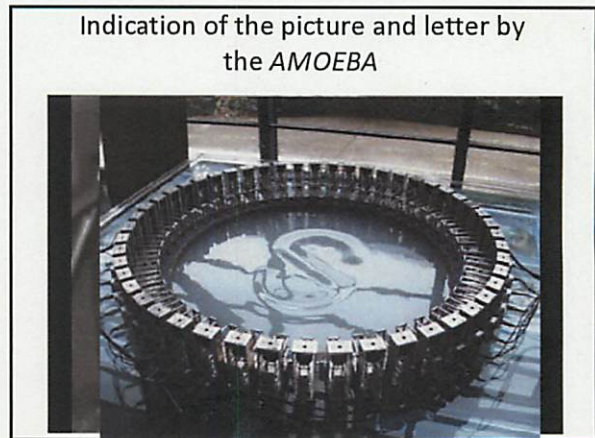
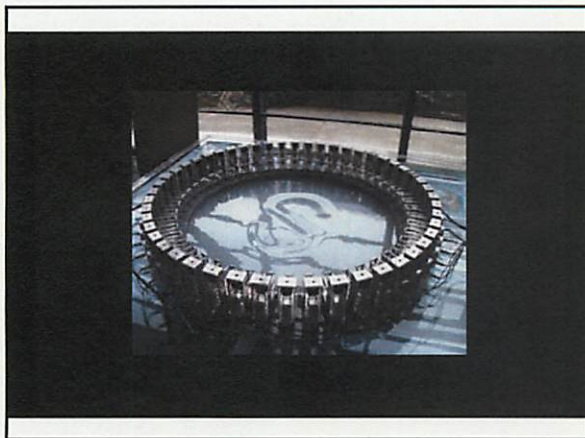
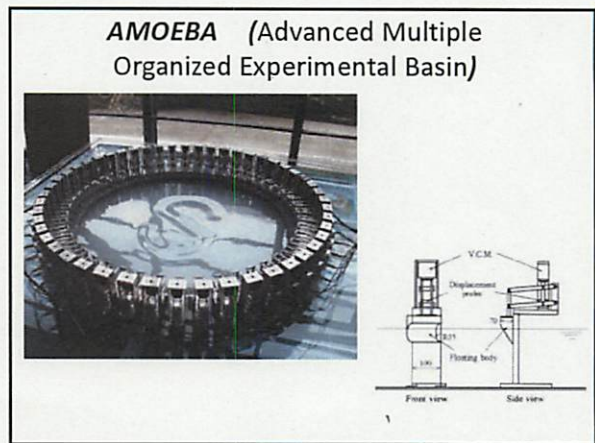
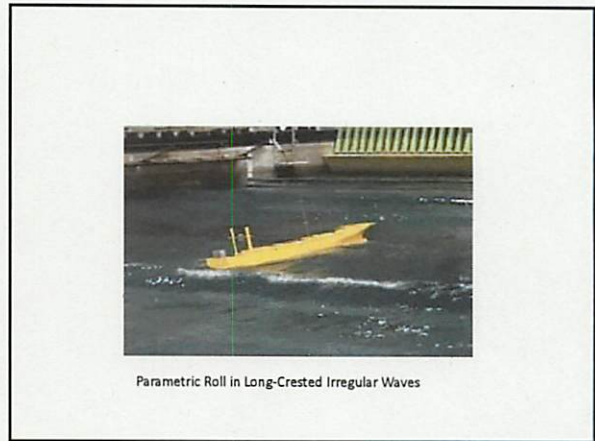
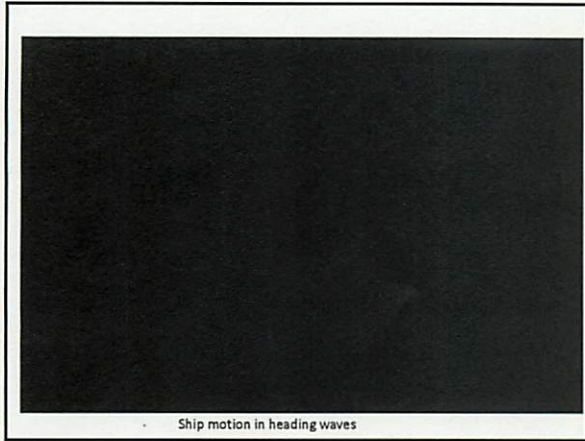


Concluding Remarks

- Ship manoeuvrability and its prediction are long-time subject.
- It cannot be separated with human and autopilot behaviours and with environmental disturbances.
- New devises, new theories and new ideas to overcome these important issues are highly recommended to be searched by younger generation.

Towing Carriage





Invitation to Japan



Invitation to Osaka



Thank you for your attention.