# SOMD RECENT ADVANCED TOPICS ON SHIP MANOEUVRABILITY AND ITS ONTROL

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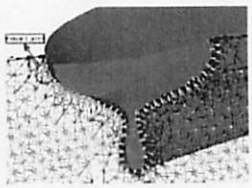
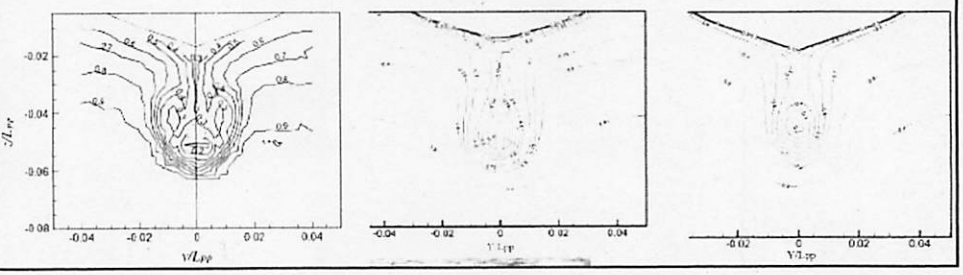
## Why and what do we need for research on ship manoeuvrability?

+ Ship manoeuvrability is the front-line of ship safety in the real world.
+ It is not evaluated only by ship inherent capability, but also by devices, human operator or automation.
+ Ship hydrodynamics in experimentally and theoretically
+ Control theory from classical theory to some advanced theories
+ Human engineering, man-machine system
+ Accident analysis

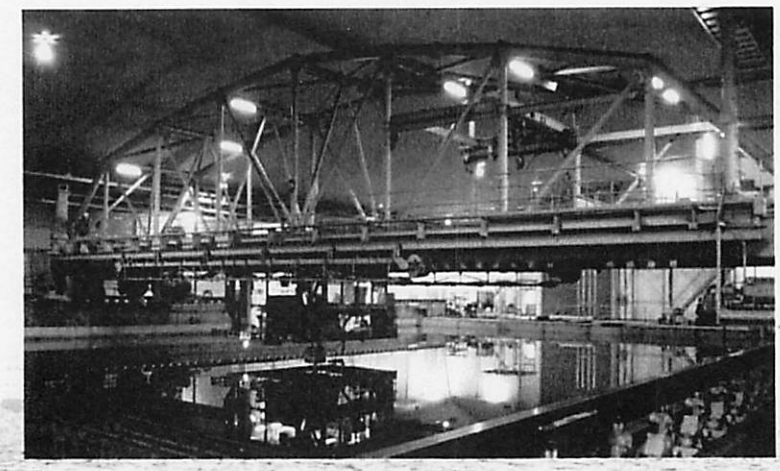
## Ship Hydrodynamics

+ Theoretical approach
  - Wind theory
  - Slender body theory
  - RANS based CFD





## Developping Mathmatical Model



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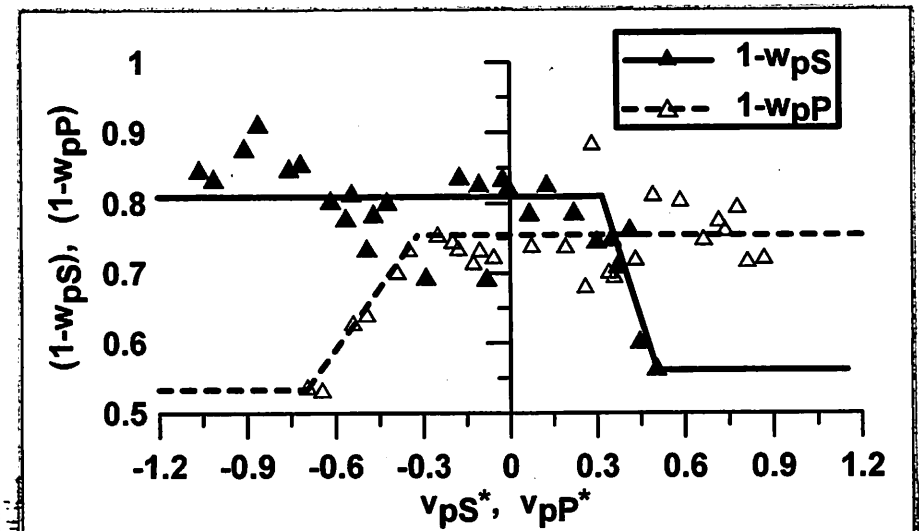
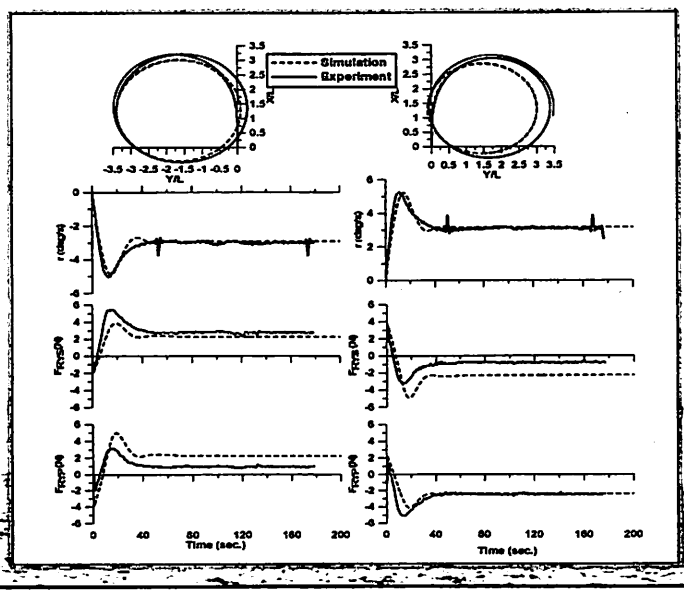



## Prediction by Simulation



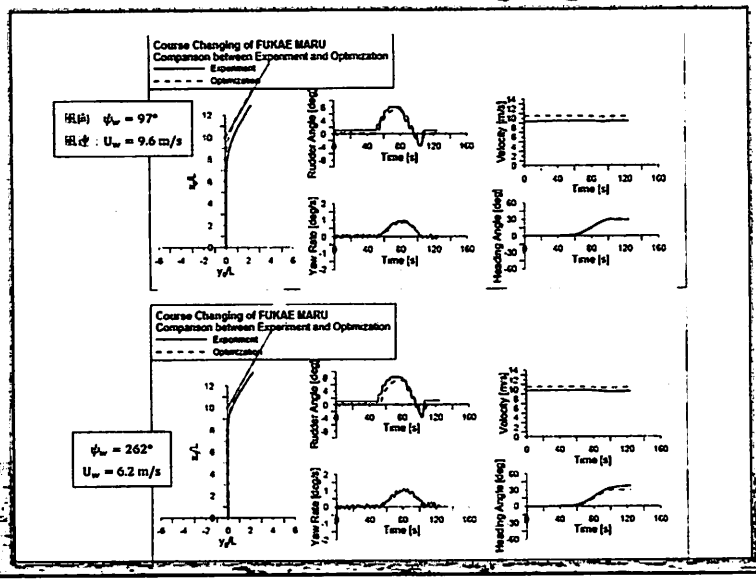
## Fate of Ship Manoeuvring Control

+ Larger non-linearity, non-steadiness than other vehicles such as air plane or automobile
+ Human decision and operation is essential, even if how much the automated or computer-aided system develops.

## Ship Steering by Automation

+ Autopilot
  - Course keeping
  - Energy saving (fuel consumption)
+ Directional stability
  - Autopilot parameter optimisation
  - Human capabiilty
+ Some fundamental research is not yet done before

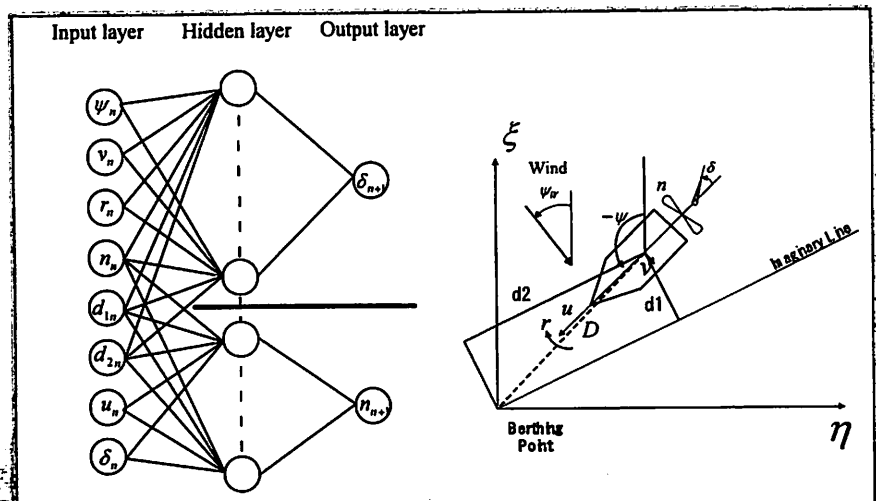
# Optimal Steering using NPL for Course Changing



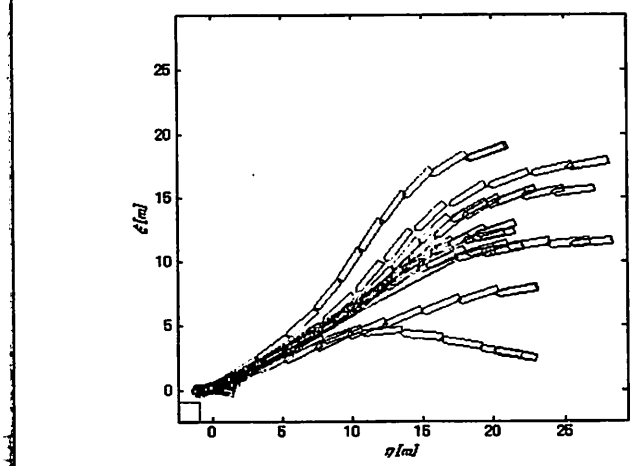

# Automation for Special Manoeuvres

+ Automatic berthing/deberthing
+ Automatic collision avoidance
+ Etc.
+ New control paradigm
  - Fuzzy logics
  - Neural networks
  - Genetic algorithm
  - etc.

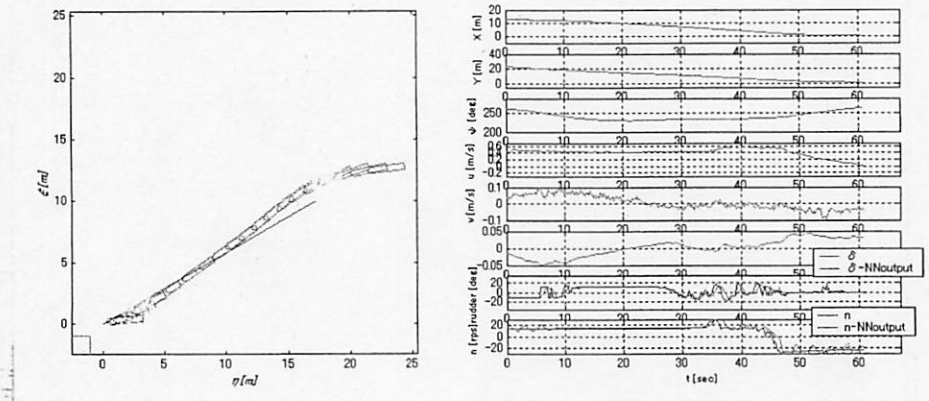
# Automatic Berthing Using Artificial Neural Networks (ANN)



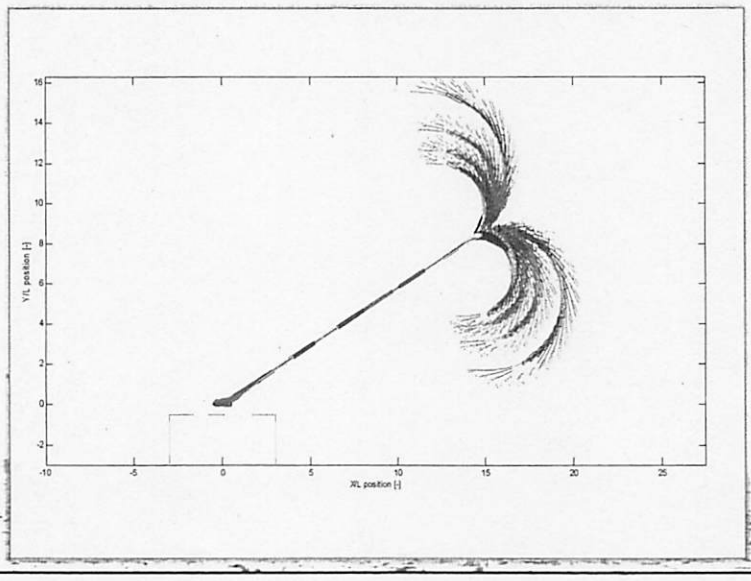

# Manual Berthing Experiment



# Automatic Berthing Using ANN

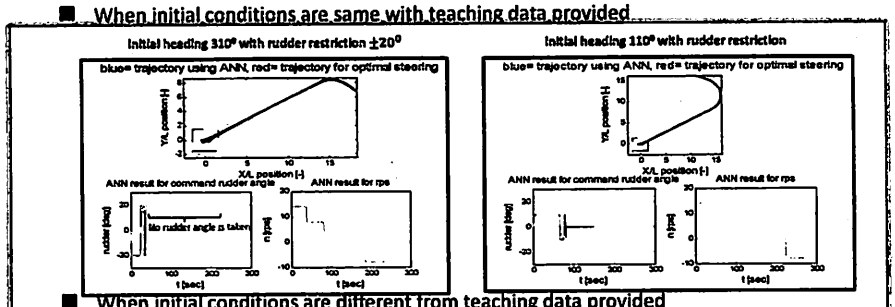



# Using Optimal Steering as Creating Teaching Data of ANN for Automatic Berthing Control

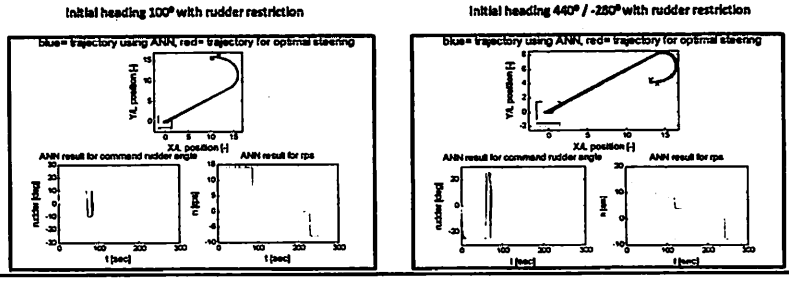


# Revised Automatic Berthing Using ANN

- When initial conditions are same with teaching data provided



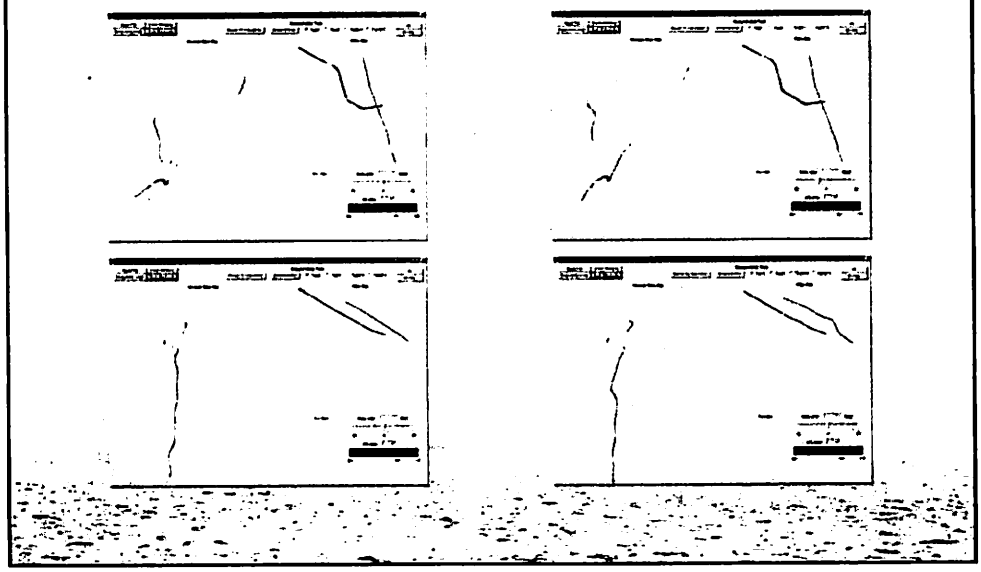

- When initial conditions are different from teaching data provided



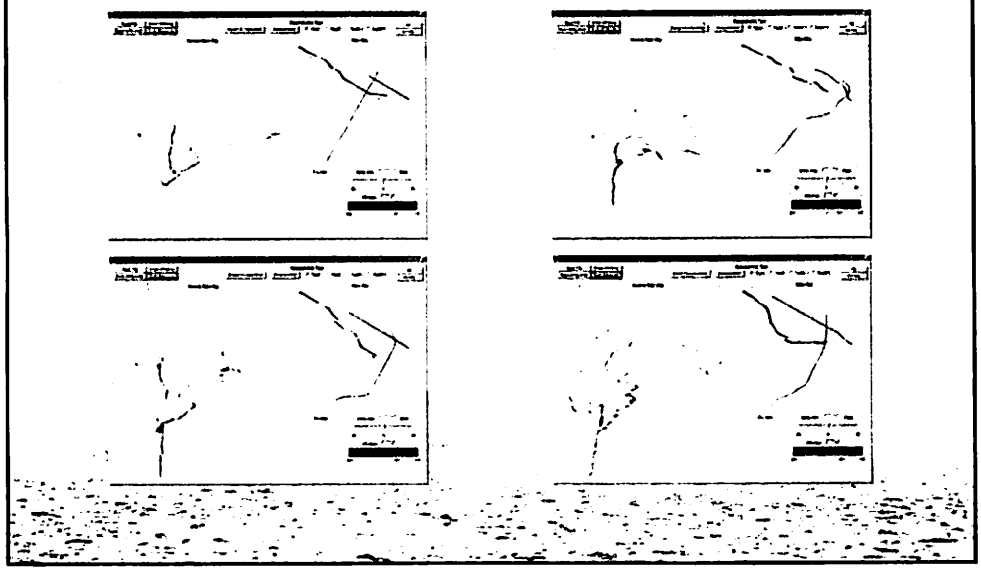

# Automatic Collision Avoidance

+ Fuzzy reasoning for collision risk
+ Fuzzy control for collision avoidance action
+ Expert / knowledge-based system or if-then-based rules for multiple-ship encounter

## Model Experiment for two-ship encounter

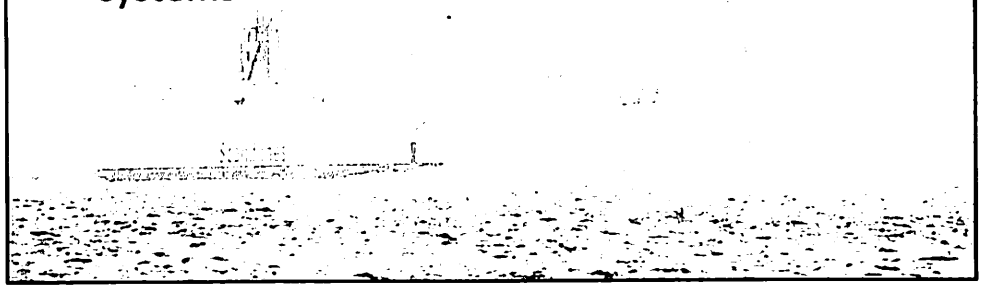


## Model Experiment for multiple-ship encounter

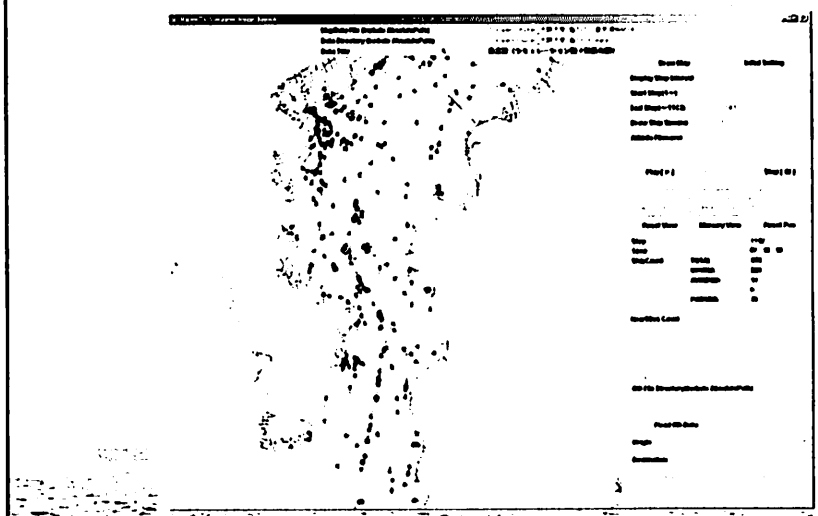


## Marine Traffic Simulation

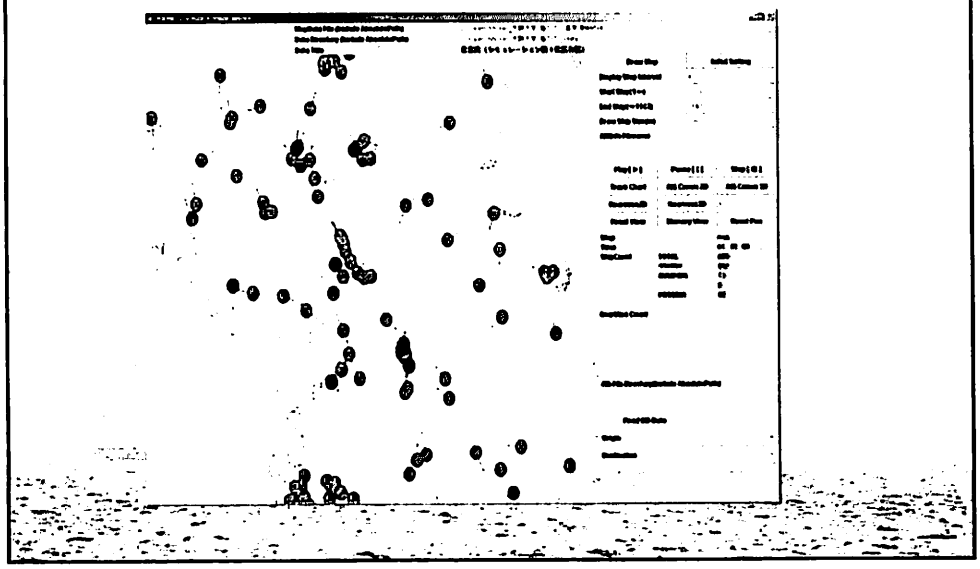
+ An application of automatic collision avoidance
+ For assessment of congested waterways
+ Designing waterways and traffic control systems



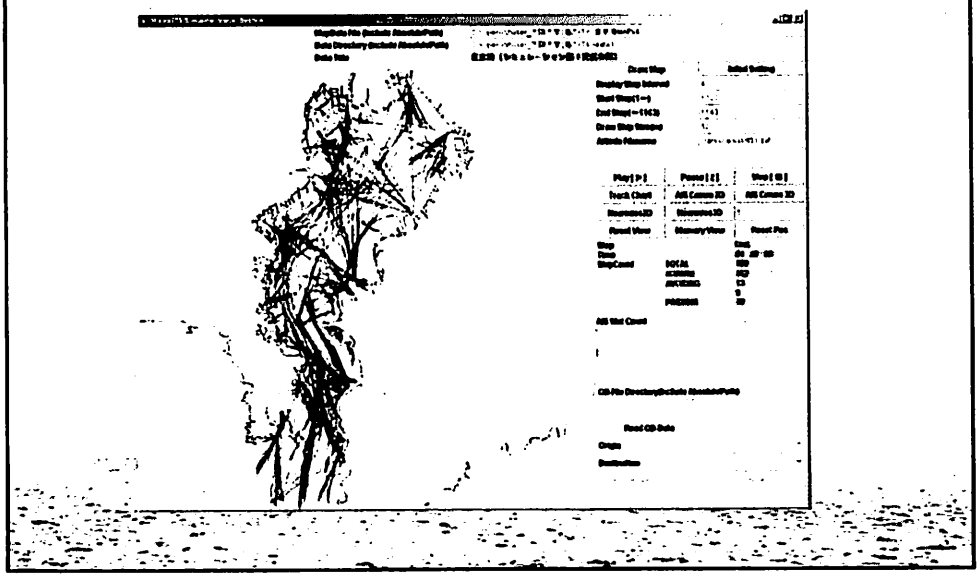
## Marine Traffic Simulation (Tokyo Bay)



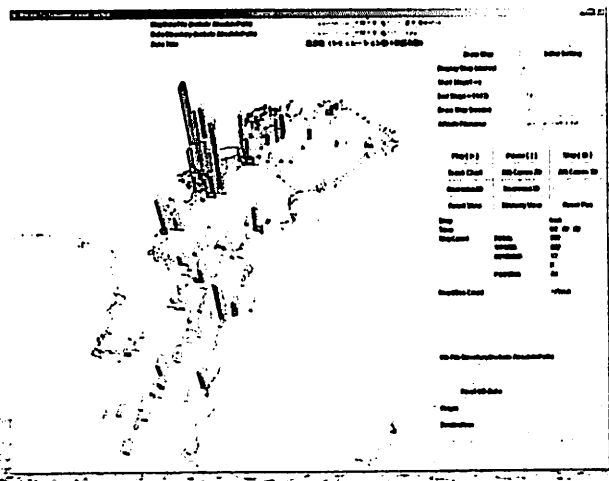
## Marine Traffic Simulation (Tokyo Bay, Enlarged)



## Marine Traffic Simulation (Tokyo Bay, Trajectories)



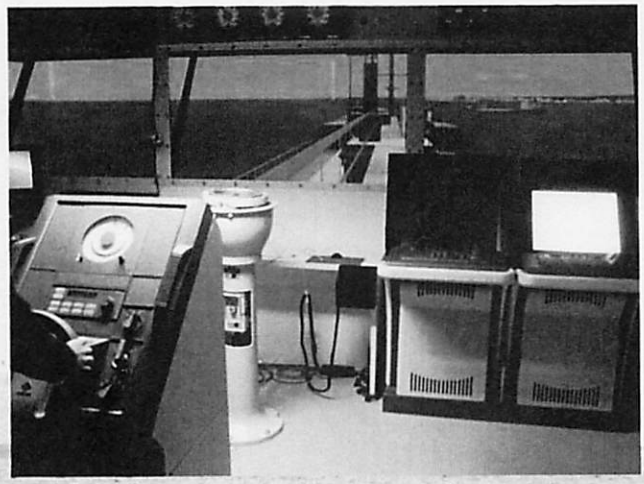
Marine Traffic Simulation (Tokyo Bay, Near-miss Distributions)



## Intelligent Ship Handling Simulator

+ Automatic target ship operation based on waypoint navigation with capability of automatic collision avoidance against own ship and even between other target ships
+ Automatic natural traffic flow generation based on statistics or artificial distribution
+ Accident analysis

## Ship Handling Simulator, NMRI, Japan

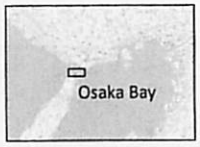


## Accident Analysis

+ Akashi Strait double collision accident (2008)
+ Case study
+ Check by human error or accidental force

# Akashi Strait Double Collision Accident, Japan (2008)

**Date and time**
Around 2:55 p.m., Wednesday, March 5, 2008



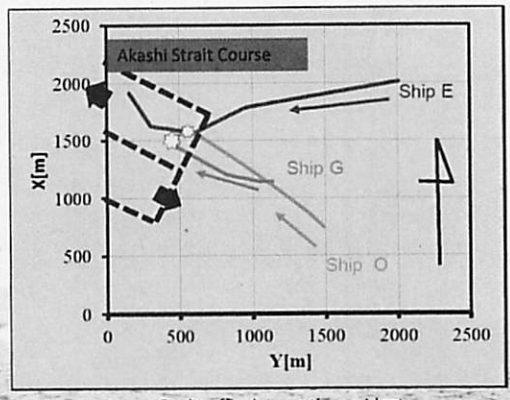

**Outline**

All ships was sailing westward to the Akashi Strait Course

Ship O and Ship E collided.

Ship O and Ship G collided.

Ship G sank.




Real traffic data on the accident

# Experimental result in case 1 (1st exp.)

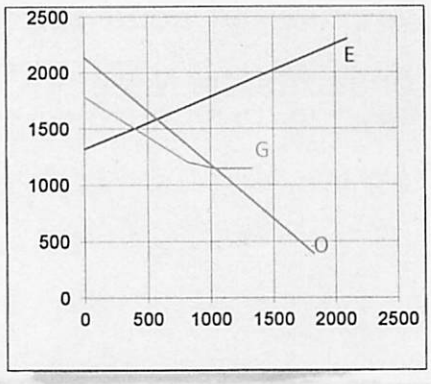
**Case 1**

Own ship: O

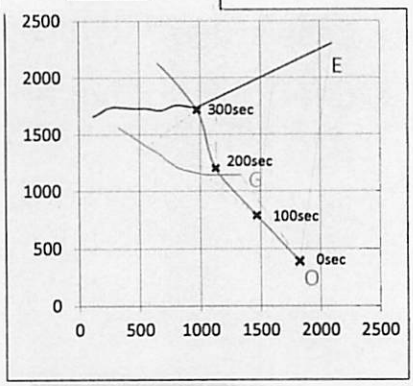
Avoid mode

View In the bridge

Various angle views




Setting route



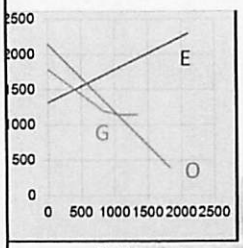

1st experimental result of full track chart

## Experimental result in case 1 (1st -6th exps.)

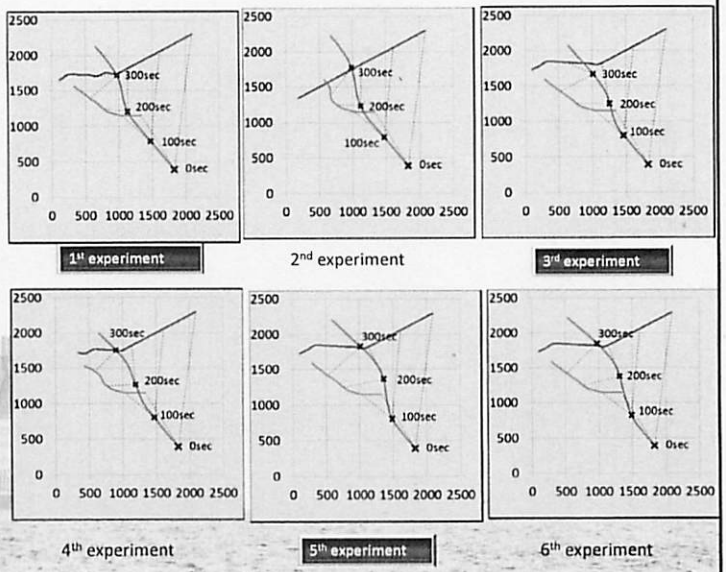
**Case 1**

Own ship: O

Avoid mode




Setting route




1st experiment | 2nd experiment | 3rd experiment

4th experiment | 5th experiment | 6th experiment

## Conclusions

+ Brief introduction of some advanced research topics in ship manoeuvrability and its control
+ However, there are still other subjects to be solved such as shall and confined water problems, low speed manoeuvring and new devices.
+ Future contributions to safer, cleaner and more ecological ship navigation are encouraged.