Activities for Realization of Autonomous vessels

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AKISHIMA LABORATORIES (MITSUI ZOSEN) INC.
MITSUI E&S


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   “R&D on Autonomous System Concept for Sea-Transport”

2. R&D on Autonomous Maneuver Control System

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The 1st automated ship (1961)

Kinkazan-maru
Japanese Government’s program
“R&D on Autonomous System Concept for Sea-Transport”

A research theme
of
“Program for Promoting Technological Development of Transportation”
by MLIT

MLIT: Japan’s Ministry of Land, Infrastructure, Transportation and Tourism
Aim of R&D project

Output

- Concepts of autonomous vessels
- Road map to develop autonomous vessels and technologies

Aim

Early realization of autonomous systems for sea transportation

Promotion to develop related technologies

Gathering momentum of employing autonomous Vessel for practical shipping

Promotion to maintain infrastructures, legal systems and regulation

The vision which maritime industry can share
Research Consortium

- Consortium is composed of 7 members covering the Maritime Sector of Japan

**Shipbuilder**
Mitsui E&S Shipbuilding Co., Ltd.

**Academia**
Tokyo University of Marine Science and Technology

**Shipping Company**
Mitsui O.S.K. Lines, Ltd.

**Classification Society**
ClassNK (Nippon Kaiji Kyokai)

**Maritime Research Institute**
National Maritime Research Institute (NMRI)

**Coordinator of R&D project**
Japan Ship Technology Research Association

Akishima Laboratories (Mitsui Zosen) Inc.
Research Flow

Analysis for Onboard Work

Function Classification of Onboard Works

Identification of Required Functions for Autonomization

List of Required Technologies

Investigation into Required Technologies

Grasp of Core Technologies

Assessment Technologies

Verification Test of Core Technologies

R&D Road-Map for Autonomous Vessels

Concept of Autonomous Vessels
Analysis for Onboard Work

Onboard Work
- 4 categories over 200 works
  - Ocean Navigation
    - 26 works
      - Lookout
      - Info. acquisition
      - Maneuver
      - Response
      - Record / Report
      - RADAR, AIS, etc.: 8 works
      - ECDIS, etc.: 7 works
      - Steering, etc.: 6 works
      - Rescue, etc.: 4 works
  - Harbor Navigation
    - 62 works
      - Lookout
      - Info. acquisition
      - Maneuver
      - Prepare
      - Mooring
      - Anchoring
      - Record / Report
      - Pilot, etc.: 13 works
      - Tag boat, etc.: 14 works
      - Thruster, etc.: 11 works
      - Trial, etc.: 15 works
      - Winch, etc.: 6 works
      - Casting, etc.: 2 works

Cargo Handling
## Autonomous Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Roles of Human / System</th>
</tr>
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<tbody>
<tr>
<td></td>
<td><strong>Situation Awareness</strong></td>
<td><strong>Decision</strong></td>
</tr>
<tr>
<td>5</td>
<td>Fully Autonomous vessel</td>
<td>The vessel recognizes situation autonomously in every conditions.</td>
</tr>
<tr>
<td>4</td>
<td>Autonomous vessel</td>
<td>The vessel recognizes situation autonomously until it requests human assistance.</td>
</tr>
<tr>
<td>3</td>
<td>Conditionally Autonomous vessel</td>
<td>The vessel recognizes situation autonomously in limited conditions.</td>
</tr>
<tr>
<td>2</td>
<td>Highly supported vessel</td>
<td>Human recognizes situation with system supports.</td>
</tr>
<tr>
<td>1</td>
<td>Advanced vessel (as of 2017)</td>
<td>Human recognizes situation with integrated information.</td>
</tr>
<tr>
<td>0</td>
<td>Conventional vessel</td>
<td>Human recognizes situation with individual information</td>
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R&D on
Autonomous Maneuver Control System
Our basis for Autonomous vessels

- Mitsui E&S have been developing automatic/autonomous vessels.
- Our current focus is on **autonomous maneuver control system**.
- We have **basic technologies and products** for autonomous vessels.

**Related Products**
- Mitsui Ship Maneuver Control System “MMS”
- Monitoring System “Fleet Transfer” & “Fleet Monitor”

**Related technologies**
- **Accurate estimation**
  - Hydrodynamic characteristics of hull and maneuvering device
  - Forces due to wind, wave and current
  - Maneuvering behavior of an total ship
- Maneuver control technologies
Mitsui Ship Maneuver Control System “MMS”

- MMS is the basis for autonomous maneuver control system.
- MMS enables “Auto Tracking”, “Dynamic Positioning”, “Auto Heading” and “Joystick operation” etc.
- MMS automatically performs a complicated maneuvering that needs to control engine, thruster, rudder etc. at the same time.

Auto Heading  Dynamic Positioning  Auto Tracking  Joystick operation  Control Mode  Console
History of developing “MMS”

1985  Submarine Rescue Tender “Chiyoda”
      Research vessel “Kaiyo”
      1st generation DPS

1988  Training ship “Osyoro-maru”

1991  Patrol ship “Erimo”
      1st generation MMS

2005  Deep Sea Drilling Vessel “Chikyu”
      Class-2 DPS

2013  Fireboat “Miyakodori”
      DPS using Water Jet System

2016  Class-3 DPS
      Designed on ABS, LR, NK and DNV-GL regulation

2017  Integrated system (MMS+DPS)
Monitoring system “Fleet Transfer”

- “Fleet Transfer” is a collection and monitoring system for operation data of vessels in service.
- The system enables to share operation data with offices on shore.

Support for Ship management
- Soundness of Vessel
- Effective maintenance

Support for Navigation
- Energy-saving
- Safe operation

Grasp of Engine/Equipment status

Grasp of Voyage situation

Navigation data

Engine/Equipment data

Data Center

Fleet Transfer

Vessel in service
Autonomous maneuver system will be realized by adding Autonomous functions & Monitoring function to existing system “MMS”.

**Configuration of Autonomous system**

- **Conventional Vessel**
- **Existing products “MMS”**
- **Autonomous functions**
- **Monitoring function**
- **Under development**
- **Existing products “Fleet Transfer”**

**Maneuver control system**

**Autonomous maneuver control system**

**Autonomous Vessel**
The aim of adding functions is to reduce human-error, work-load and operation time.

Examples of adding functions

Auto Collision Avoidance【Preventive for Human error】
- Suggestion of a safe course depending on surrounding situations by system

Auto Berthing【Reduction of Work load & operation time】
- Automatic control berthing speed & heading with high accuracy under wind

Auto Watch【Preventive for Human error & Work load】
- Automatic detection for Floating Object
- Risk evaluation & warning
**Monitoring function**

- Autonomous system’s **reliability and usability** will be enhanced by adding monitoring functions “Fleet Transfer.

Autonomy system failures can cause serious accidents.

**Grasping status and Predicting failure** are indispensable.

Required for grasping & prediction

Monitoring system is expected to be a key component for automated control system.
Achievements to Autonomous vessel (1)

  - This function is demonstrated with “SINEI-MARU”, cement carrier, by Ube Shipping & Logistics, Ltd., Tokyo University of Marine Science & Technology, Akishima Laboratories etc.
  - Approaching navigation was controlled automatically to minimize the approaching time in harbor.

Virtual Quay was supposed. For the safety, this demonstration was carried out under Crew monitoring.

| LENGTH | 152.5 m |
| BREADTH | 24.2 m |
| DEPTH | 9.0 m |
| GROSS TONNAGE | 13,787 ton |
| PROPELLER | CPP |
| RUDDER | SCHILLING TYPE |
| THRUSTER | BOW |

Example of Trajectory

Condition at Start Point; Spd. 10knot, Head. 20deg.

Condition in Passage; Spd. 5knot, Head. 35deg.

Condition at End Point; Spd. 3knot, Head. 0deg.

Berthing Demo.
Achievements to Autonomous vessel (2)

Highly Automated Control System (2007)

- National project to study for saving energy and labor load in operation was demonstrated with “SHIGE-MARU”, domestic product oil carrier, by EIYU KAIUN co., Ltd., NMRI, Mitsui etc..
- MMS was installed in “SHIGE-MARU” to realize the automatic berthing operation without anchor operation or tug-boat assist.
- It was confirmed that the necessary time for harbor operation can be shortened to 50～70% comparing with conventional ship.

<table>
<thead>
<tr>
<th>Dimensions</th>
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<tbody>
<tr>
<td>Length (Lpp)</td>
<td>98.0 (m)</td>
</tr>
<tr>
<td>Breadth</td>
<td>16.0 (m)</td>
</tr>
<tr>
<td>Draft</td>
<td>6.4 (m)</td>
</tr>
<tr>
<td>Dead Weight</td>
<td>4999 (ton)</td>
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**Example of Trajectory**

**SHIGE-MARU**
Full-Scale Test of Autonomous Vessel
Full-Scale Test

- **Full-Scale Tests are planed** for autonomous maneuver control system

- **Aim of test**
  - Verification & demonstration of autonomous maneuver control system applying for actual ships

- **Vessel for full-scale test**
  - A ship is in a domestic ferry service, with abt. 200m length.
  - Under discussing with a shipowner

- **Maneuver function**
  - Auto Collision Avoidance
  - Auto Berthing & Un-Berthing

*OZT: Obstacle Zone by Target*
Schedule of Full-Scale Test

- Preparation of the algorithm (2018)
  - Verification of the algorithm for autonomous operation using simulators and a small ship

- Equipping with the system (2019)
  - Equipping with maneuver control system to an actual ship
  - Adjustment of control system in an actual ship on the open and safe sea

- Full-scale test (2020)
  - Full-scale test under situations resembling actual ship’s operation
Thank you
for your kind attention

From this ship
Kinkazan-maru