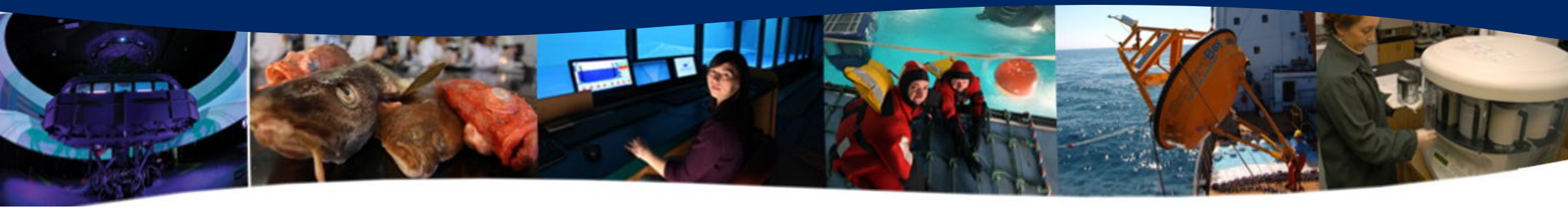

# FROM SAIL TO STEAM TO BITS AND BYTES

John Cross – Faculty Manager – Special Projects.
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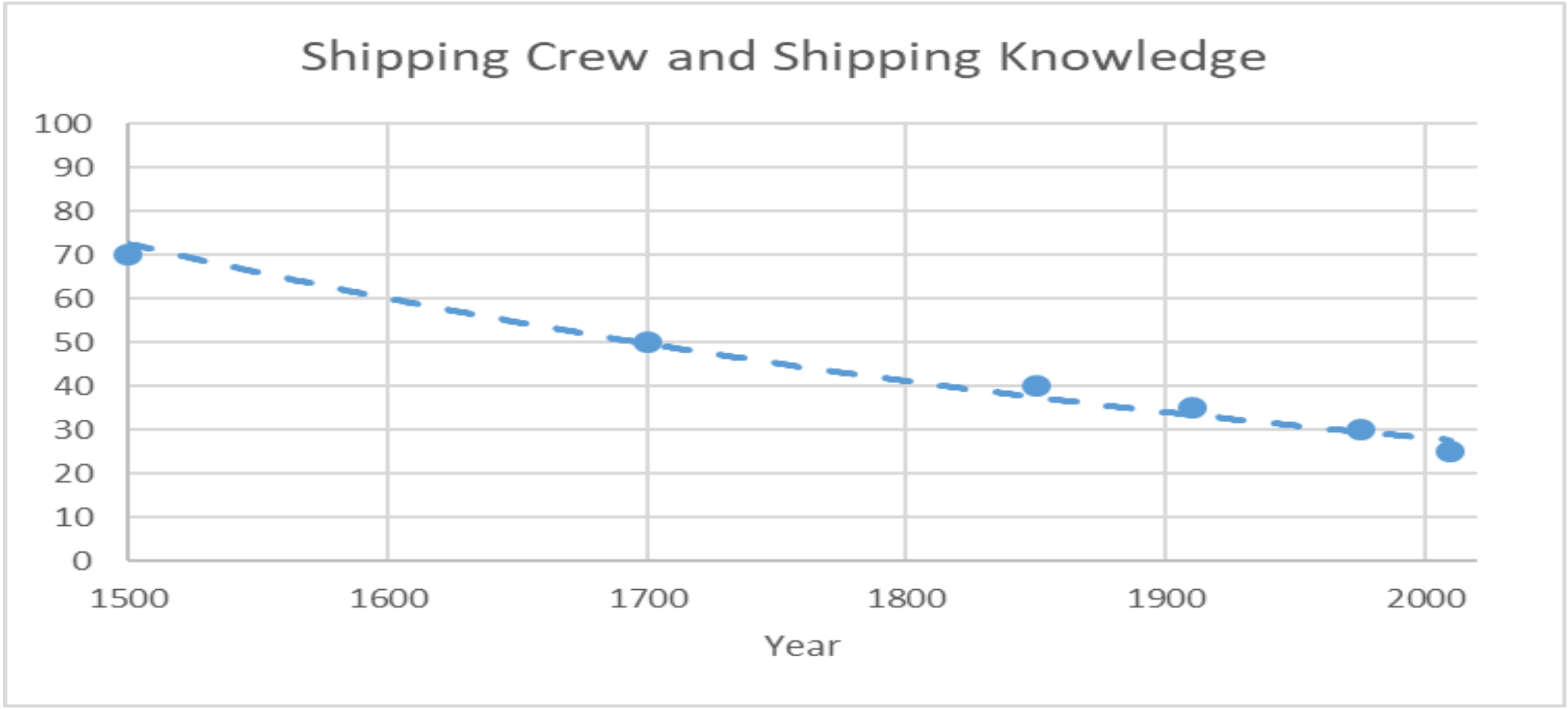
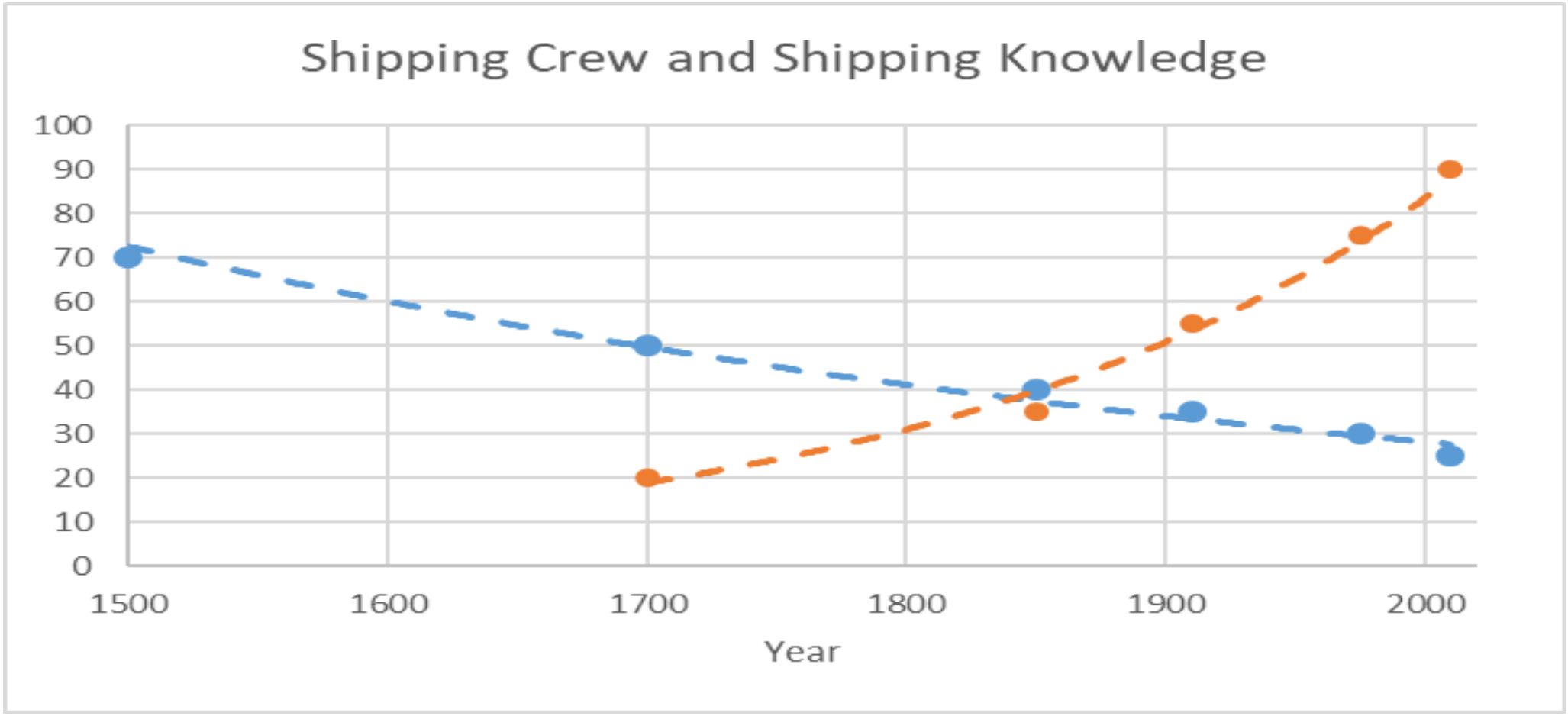
(CMS)

# Shipping Crew and Shipping Knowledge



# Shipping Crew and Shipping Knowledge



# What does a Mariner do?

## ENGINEERING - Roles and Requirements

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **REQUIREMENTS** | **CAPABILITY REQUIREMENT** | **OPERATIONAL REQUIREMENTS** | **SHIP VOYAGE STATUS** | **SITUATIONAL REQUIREMENTS** | **SHORE TO SHIP ASSITANCE** | **ENGINEERING DEPARTMENT STAFF** |
| **A** | Propulsion and all supporting ship systems | Personnel Qualifications | COLD SHIP TO PORT STANDBY | STANDARD OPERATION | CONDITION BASED MONITORING | Superintendent (Technical) |
| **B** | Maintenance | Regulatory / Manning requirements | PORT STANDBY to COMMENCEMENT OF MANOUVERING | PLANNED MAINTENANCE | REPAIR PLANNING | CHIEF ENGINEER |
| **C** | FAILURE DIAGNOSIS | Occupational responsilities defined by the company | MANOUVERING to COMMENCEMENT OF PASSAGE AT SEA | CONDITION BASED MAINTENANCE | FAILURE DIAGNOSIS | 2nd ENGINEER |
| **D** | PERFORMANCE AND EFFICIENCY MONITORING | Survey Requirements | COMMENCEMENT OF PASSAGE-AT SEA (FULL-AWAY) | DRY DOCK | EXPERT ASSITANCE | ETO Electro Technical Officer |
| **E** | PROJECT MANAGEMENT | | EMERGENCY RESPONSE | REPAIR PLANNING | PROJECT MANAGEMENT | 3rd Engineer/Motor Man |
| **F** | SAFE EVACUATIN OF PERSONNEL | | ALONGSIDE / ANCHORED | | COLLABORATIVE DISCUSSION | 3rd ENGINEER/CADET |
| **G** | ADMIN | | DRY DOCK | | PERFORMANCE AND EFFICIENCY MONITORING | MOTOR MAN |

## DECK - Roles and Requirements

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **REQUIREMENTS** | **CAPABILITY REQUIREMENT** | **OPERATIONAL REQUIREMENTS** | **SHIP VOYAGE STATUS** | **SITUATIONAL REQUIREMENTS** | **SHORE TO SHIP ASSITANCE** | **DECK DEPARTMENT STAFF** |
| **A** | PASSAGE PLANNING (APEM) | Personnel Qualifications | BRIDGE DEPARTURE CHECKS | STANDARD OPERATION | CONDITION BASED MONITORING | Superintendent (Marine) |
| **B** | COLLISION AVIODANCE | Regulatory / Manning requirements | BERTHING AND (PILOTAGE) MANOUVERING to COMMENCEMENT OF PASSAGE AT SEA | PLANNED MAINTENANCE | REPAIR PLANNING | MASTER |
| **C** | MANOUVERING to COMMENCEMENT OF PASSAGE AT SEA including MANUAL BERTHING/SECURING ALONGSIDE AND ACHORING | Occupational responsilities defined by the company | MANOUVERING to COMMENCEMENT OF FULL -AWAY | CONDITION BASED MAINTENANCE | FAILURE DIAGNOSIS | CHIEF OFFCIER |
| **D** | LIFE SAVING APPLIANCES | Survey Requirements | COMMENCEMENT OF PASSAGE-AT SEA (FULL-AWAY) | DRY DOCK | EXPERT ASSITANCE | 2ND MATE |
| **E** | CARGO HANDLING | | EMERGENCY RESPONSE | REPAIR PLANNING | PROJECT MANAGEMENT | 3RD MATE |
| **F** | SAFE EVACUATIN OF PERSONNEL | | ALONGSIDE / ANCHORED | | COLLABORATIVE DISCUSSION | 4RD MATE |
| **G** | ADMIN | | DRY DOCK | | PERFORMANCE AND EFFICIENCY MONITORING | AB/Bosun |

# What does a Mariner do?

**Roles and Tasks - LIKELIHOOD OF HUMAN RELIANCE PRESENT DAY TO 2040**

| | | CAPABILITY REQUIREMENT | PERSONNEL QUALIFICATIONS | CARGO HANDING | OCCUPATIONAL RESPONSIBILITIES DEFINED BY THE COMPANY - PERSONEEL SAFETY / CULTURE / ETHICS / CODE OF CONDUCT | MANUAL SECURING OF VESSEL OR ANCHORING | STANDARD OPERTATION | EMERGENCY RESPONSE | PASSAGE PLANNING - APEM | BERTHING | ANCHORING | COLLSION AVOIDANCE | COLD SHIP TO PORT STANDBY | MANOUVERING to COMMENCEMENT OF PASSAGE AT SEA | COMMENCEMENT OF PASSAGE-AT SEA (FULL-AWAY | COMMENCEMENT OF PASSAGE-AT SEA (FULL-AWAY | SAFE EVACUATION OF PERSONNEL | FAILURE DIAGNOSIS | CONDITION BASED MAINTENANCE | REPAIR PLANNING | PROJECT MANAGEMENT | COLLABORATIVE DISCUSSION | SURVEY REQUIREMENTS | PERFORMANCE AND EFFICIENCY MONITORING | DRY DOCK | EXPERT ASSITANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PRESENT DAY UNTIL 2020** | PORT APPROACHES SHIP CONTROL/ MANAGEMENT | SKILLS REQUIRED FROM PRESENT DAY FORCE | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H |
| **YEAR 2020 - 2025** | PORT APPROACHES SHIP CONTROL/ MANAGEMENT | SKILLS REQUIRED FROM PRESNT DAY FORCE | H | A | H | M/A | M/A/AI | H | M-A | M-A | M-A | M-AI | H | M | M | M | H | H | H | H | H | H | M/L | H | H | H |
| **YEAR 2025 - 2030** | INTERNATIONAL / COUNTRY BY COUNTRY SHIP CONTROL MANAGEMENT | SKILLS REQUIRED OF FUTURE WORK FORCE | H | A | H | A | H | M/L | A | AI | L/AI | L/AI | L | L | L | L | A | H | M/L/A | M/L | H | H | L/A | M/L | M/L | H |
| **YEAR 2030 - 2040** | INTERNATIONAL / COUNTRY BY COUNTRY SHIP CONTROL MANAGEMENT | SKILLS REQUIRED OF FUTURE WORK FORCE | H | A | H | A | AI | AI | A | AI | AI | AI | A | A | A | A | A | H/A/AI | L/A/AI | L/A | H | H | L/A | L/A | L/A | H |
| **YEAR 2020 - 2025** | | | MASTER, MARINE ENGINEER, SYSTEMS ENGINEER | EXPERT ASSISTANCE | MASTER, MARINE ENGINEER, SYSTEMS ENGINEER | AB/BOSUN | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER | MASTER / PILOT | MASTER / PILOT | MASTER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | REOL | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | SHOREBASED |
| **YEAR 2025 - 2030** | | | MASTER, MARINE ENGINEER, SYSTEMS ENGINEER | EXPERT ASSISTANCE | MASTER, MARINE ENGINEER, SYSTEMS ENGINEER | REOL | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER AND MARINE ENGINEER/SYSTEMS ENGINEER | MASTER/SYSTEMS ENGINEER | MASTER / PILOT | REOL | REOL | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | REOL | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | MARINE ENGINEER/SYSTEMS ENGINEER | SHOREBASED |
| **YEAR 2030 - 2040** | | | SYSTEMS ENGINEER | REOL | SYSTEMS ENGINEER | REOL | SYSTEMS ENGINEER | SYSTEMS ENGINEER | REOL | REOL | REOL | REOL | SYSTEMS ENGINEER | REOL | REOL | REOL | REOL | SYSTEMS ENGINEER | SYSTEMS ENGINEER | SYSTEMS ENGINEER | SYSTEMS ENGINEER | SYSTEMS ENGINEER | SYSTEMS ENGINEER/ EXPERT ASSISTANCE | SYSTEMS ENGINEER | SYSTEMS ENGINEER | SHOREBASED |

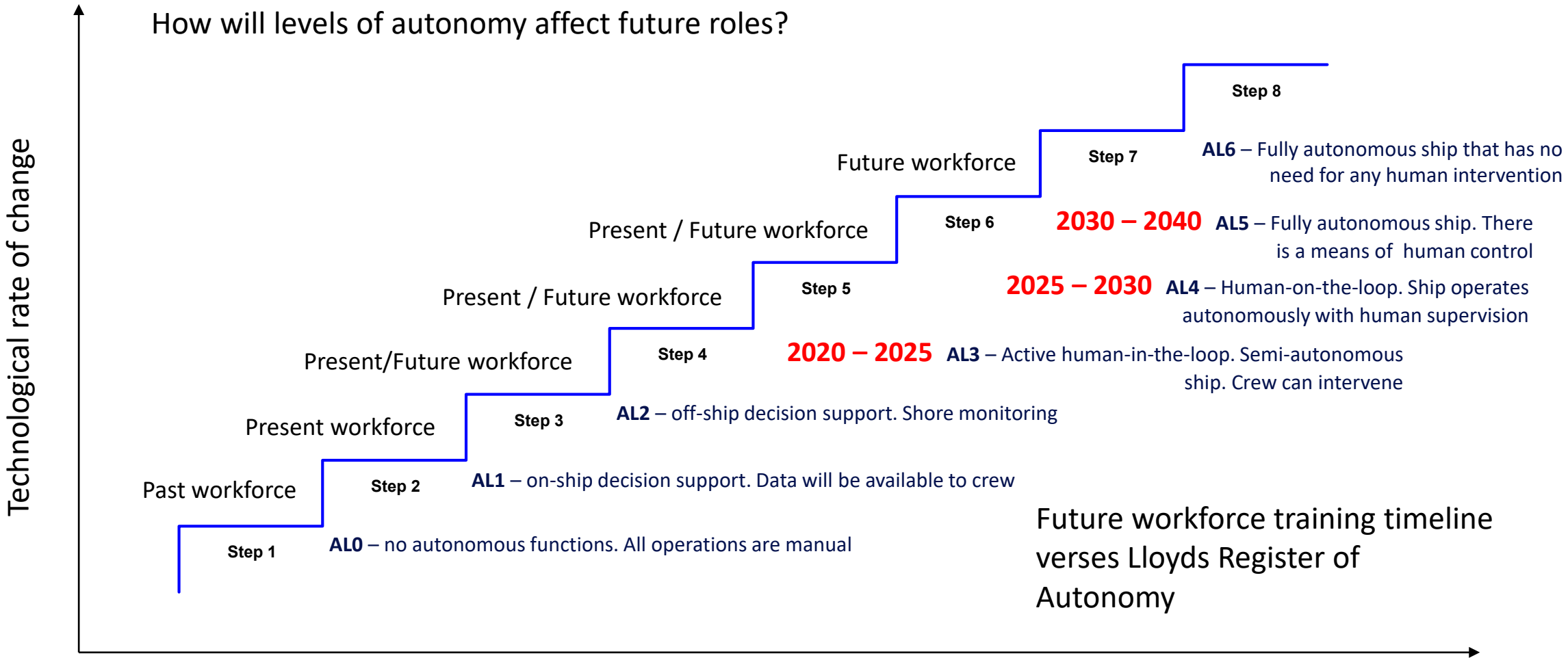
**Only for ships equipped with AI/Non Retrofit**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **RESOURCE** | OIL | SUPERINTENDENT | CHIEF ENGINEER | 2nd ENGINEER | ELECTRO TECHNICAL OFFICER | 3nd ENGINEER | 4th ENGINEER | MOTORMAN | EXPERT ASSITANCE | SURVEY |
| | WATER | SUPERINTENDENT | MASTER | CHIEF OFFICER | 2nd MATE | 3rd MATE | 4th MATE/CADEY | AB/BOSUN | MARINE PILOT | SURVEY |
| | NEW ROLES | AI | SYSTEMS ENGINEER | A | REOL | VIRTUAL ASSIANT | | | | CARGO HANDLING |
| | | ARTIFICIAL INTELLIGENCE | AUTOMATED | REACHING/REACHED END OF LIFE | | | | | | DRY DOCK |

**HUMAN RELIANCE v TECHNOLGY ADVANCE**

| | | |
|---|---|---|
| **KEY** | H | HIGH RELIANCE ON HUMAN SKILLS |
| | M | MEDIUM RELIANCE ON HUMAN SKILLS |
| | L | LOW RELIANCE ON HUMAN SKILLS |
| | A | AUTOMATED |
| | AI | ARTIFICIAL INTELLIGENCE |

# When will a Mariner not do it?



# Looking at the Past

- Paper in 2018 looked at past incidents.
- Used the Transportation Safety Board of Canada accident reports.
  - Non fishing accidents.
  - Recent.
  - No weighting was given to how severe the  accident was.
- Found 22 accident reports.
  - In 18 of those it was anticipated that an autonomous vessel would have been able to mitigate or eliminate the problem.
  - In 4 cases an autonomous ship would have suffered at least as much if not more than what occurred.

# Looking at the Past

| | |
|---|---|
| Mechanical issues | 11 |
| Collisions | 2 |
| Groundings | 8 |
| Stability problems | 3 |
| Loss life | 2 |
| Loss of environment | 1 |

- Somewhat surprising result was that the main benefit was in the engine room.
  - Better standard maintenance.
  - Better predictive maintenance.
  - Better operations.

# IMO Model Courses

- Look at skill sets for an engineer.
- Used IMO Model Courses as a reference.
  - Courses 7.02 and 7.04
  - Identifies the skills / functions that an engineer should have.
    - Engineering Knowledge;
    - Thermodynamics;
    - Applied Mechanics;
    - Etc.

# IMO Model Courses

| COMPETENCE 1.1 | Maintain a Safe Engineering Watch | IMO Reference |
|---|---|---|
| **1.1.1 THOROUGH KNOWLEDGE OF PRINCIPLES TO BE OBSERVED IN KEEPING AN ENGINEERING WATCH (7 hours)** | | STCW Code ch VIII |
| **Textbooks:** | | section A-VIII/1 |
| **Teaching aids:** A1, A3, V1, V2, V9 | | para 10 |
| Required performance: | | section A-VIII/2 |
| – explains principles to be observed in an engineering watch at sea and in port, including the following based on the provisions concerned in the STCW Code, ch VIII, section A-VIII/1, A-VIII/2 and B-VIII/2: | | part 4 para 9-12 |
| – duties associated with taking over a watch and accepting a watch | | part 4-2 para 52-83 |
| – routine duties undertaken during a watch | | part 5 para 90-97 |
| – maintenance of the machinery space logs and the significance of the reading taken | | part 5-2 para 100-101 |
| – duties associated with handing over a watch | | part 5-4 para 103-104 |
| – explains standards/regulations for watchkeeping in a national law if any | | section B-VIII/1 |
| – states the importance, ordinance and arrangements of watchkeeping, and the need to: | | para 6-9 |
| – wear appropriate clothes, safety shoes and a safety helmet | | section B-VIII/2 |
| – carry a torch lamp | | part 4-2 para 6-8 |
| – maintain bodily functions | | |
| – be awake and highly conscious | | |
| **1.1.2 SAFETY AND EMERGENCY PROCEDURES (8 hours)** | | R1 |
| **Textbooks:** | | |
| **Teaching aids:** A1, A3, V1, V2, V9 | | |
| Required performance: | | |
| – states what is meant by emergency in accordance with components of the machinery | | |
| – states that the type of impact of the emergency should be promptly identified and countermeasures conforming to the emergency procedures and contingency plans established beforehand, should be taken | | |
| – states that changeover of remote/automatic control to local operation of all systems has to be almost always done in case of emergency to take actions necessary for maintaining a safe operation | | |
| – states that each component/installation constructing propulsion machinery can be isolated from the entire system and can be run manually | | |
| – explains remedial/emergency procedures and conditions in accordance with components of the machinery in such an event of power failure | | |
| – explains necessary procedures/measures with isolation of the component/ installation of major machinery, taking examples such as arrangements/ managements of piping systems, control systems and other elements concerned | | |
| – states procedures for recovery and malfunctions considered to be likely occurred in steering gears in case of blackout and other causes including procedures for changeover of remote-auto to electric hydraulic driven at machine side and hand pump hydraulic driven at machine side respectively | | |

- states what is meant by emergency in accordance with components of the machinery
- states that the type of impact of the emergency should be promptly identified and countermeasures conforming to the emergency procedures and contingency plans established beforehand, should be taken
- states that changeover of remote/automatic control to local operation of all systems has to be almost always done in case of emergency to take actions necessary for maintaining a safe operation
- states that each component/installation constructing propulsion machinery can be isolated from the entire system and can be run manually

# IMO Model Courses

- Main conclusion was that the IMO model courses were not particularly useful in looking at autonomous systems.
  - Blooms taxonomy is not useful for autonomous systems.
- Interesting take away was that if you look at a ship as a whole, only 40 % of the model courses were required to operate the ship.  The rest:
  - Allow an engineer to move from ship to ship to ship.
  - Allow an engineer to trouble shoot a system.

# Where Will Autonomy Develop

- Autonomy will develop in the Engine Room first.  Several Reasons for this.
  - Technical - Engines lend themselves better to autonomy.
  - Legal – The current IMO regulations deal more with the navigation of a ship as opposed to running engines.
  - Public – At this point in time the  public does not seem to want complete autonomy in “moving” things.

# When Will Autonomy Develop

- Not soon because:
  - Legislation – both national and international.
  - Liabilities and legal responsibility.
  - Public Perception.
  - Cost.
  - New build vs retrofit.

# When Will Autonomy Develop

| Time Frame | Event |
|---|---|
| 2025 | Technology robust |
| 2030 | Transitioning of shipboard personnel to land jobs. Humans still very much in the loop. |
| 2040 | Significant crew reduction, development of specialized shore jobs / teams (operations, supply, repair, etc.). Humans on the loop. |
| 2045 | First International Autonomous Ship (no crew) with shore support. Humans on the loop |
| 2050 | Autonomous fleets. Humans sometimes on the loop. |

# What Will the Workforce Look Like

- Engine-room:
  - General movement from an operator of technology to:
    - Integrator of technology.
    - Increased importance on predictive maintenance.
    - Movement away from prediction related to judgement related skills.
  - Increased role and specialization of the Electro-technical officer.
    - Systems (computer) person critical.
    - Cyber-security.
    - 3-D parts printing.

# What Will the Workforce Look Like

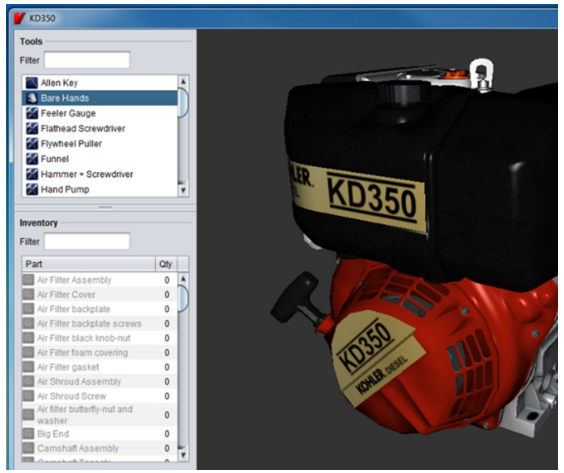
- Deck:
  - General movement from an operator of technology to:
    - Monitor of operations.
    - Coordinator of emergency operations.
    - Increased need for judgement taking into account factors that autonomous systems are not good at (business, human factors).
  - Lack of public trust will keep bridge officers in the loop longer then expected.

# Training for the New Workforce

- Training has continued essentially unchanged for 300 years (perhaps a change might be in order).
- Traditional “University” structures will give way to:
  - Mastery modes of instruction.
  - Movement away from physical location.
  - Delivery anytime, any duration.
- Reworking of IMO Model Courses
  - Introduce information on autonomous systems.
  - Reduce/rework  some of the traditional subjects (e.g. astro-navigation).
  - Increase soft skills.

# Training Tools for New Workforce

- Tools are going to change as well:
  - Heavy use of simulation (is it simulation anymore).
  - Use of low cost VR and AR technologies.
  - More portable instruction technologies.




# Conclusions

- Ship crew will reduce in the future:
  - Reduction in ship-board personnel more than made up for in shore operation jobs.
- Technology will allow changes to take place quickly: regulatory, “culture” and public perception will act to slow down adoption.
- Training will become somewhat specialized and very technical.

# After thoughts


**Industrial Research Chair in Marine Passenger Transportation Technology**

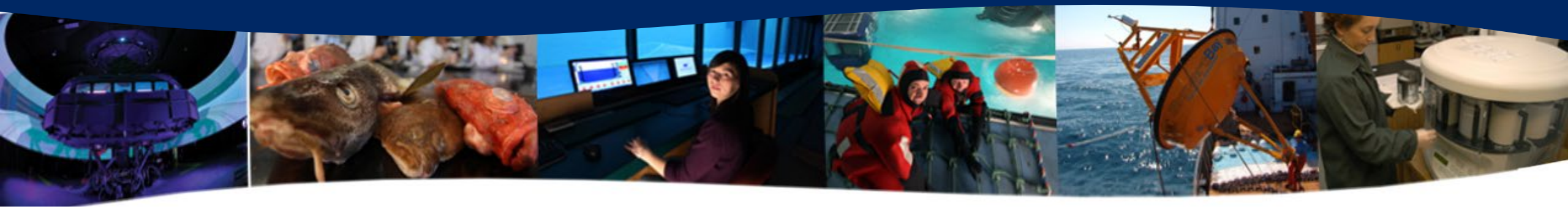
**Marine Institute**
**Memorial University**

The Fisheries and Marine Institute of Memorial University of Newfoundland invites applications for a tenure-track assistant or associate professor faculty position of Industrial Research Chair in Marine Passenger Transportation Technology commencing in January 2020 or shortly thereafter.

The successful candidate will fill a unique and dynamic position at the intersection of technology and marine transportation. Applicants should have a bachelor and PhD degrees in relevant disciplines with an interdisciplinary background, and demonstrated outstanding research in at least one of the following areas: new marine fuels and efficient propulsion, AI & Robotics, Big (marine) Data and/or Autonomous systems. The Chair will work with faculty and stakeholders to provide insights into the future of marine transportation. While a background in marine transportation is an asset it is not considered critical. Applicants should have demonstrated outstanding leadership in research and mentorship as well as a strong record of attracting external funding.

Memorial University is the largest university in Atlantic Canada and its Marine Institute has a long-standing tradition of partnership with all relevant stakeholders including academic, research and development, industry, and regulatory bodies both nationally and internationally. The Marine Institute is committed to the development of a strong research group in marine passenger transportation technology. The incumbent must be willing and able to take a leadership role in this endeavor. They are expected to foster collaboration in cognate fields across the country and internationally, supervise graduate students and postdoctoral scholars, attract external funding, teach graduate and/or undergraduate courses, and help develop a new graduate program in this field. The successful candidate will work with a dedicated technical team at the Marine Institute.

MARINE INSTITUTE
MEMORIAL UNIVERSITY



## FROM SAIL TO STEAM TO BITS AND BYTES

# THANK YOU
# QUESTIONS?

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