Discussing COLREGs adaption for fully Autonomous Surface Vessels

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Introduction

- Unmanned ships have been becoming more and more popular over the past few years
- Several projects around the world are focusing in large Maritime Autonomous Surface Ships (MASS)
- Great interest in regulation of unmanned ships including IMO MSC, LEGAL and other committees
- Less interest in small Autonomous Surface Vessels (ASVs)

Introduction

- ASVs have been used in Research & Development (R&D) for decades
- Useful for environmental monitoring, border protection, seabed mapping, oceanography, etc
- Typically small (no space for crew), recent developments include larger ASVs (above 12 meters)
- Less regulatory attention due to small size

Introduction

- Need to regulate as these are the most mature autonomous vessels (when compared to large ships)
- Some Code of Practices initiatives coming from industry but formal regulations are lacking
- The first ASV has been registered in the UK ship register
- One of the most urgent topics to address is collision avoidance, i.e. COLREGs treaty

State of the art

- First legal issue is the uncertainty in the definition of vessel/ship
- COLREGs “includes every description of water craft, including non-displacement craft, WIG craft and seaplanes, used or capable of being used as a means of transportation on water“

- Small/medium ASVs are not used to transport cargo or people. Some authors believe that by transporting sensors, they fulfil the requirement.

State of the art

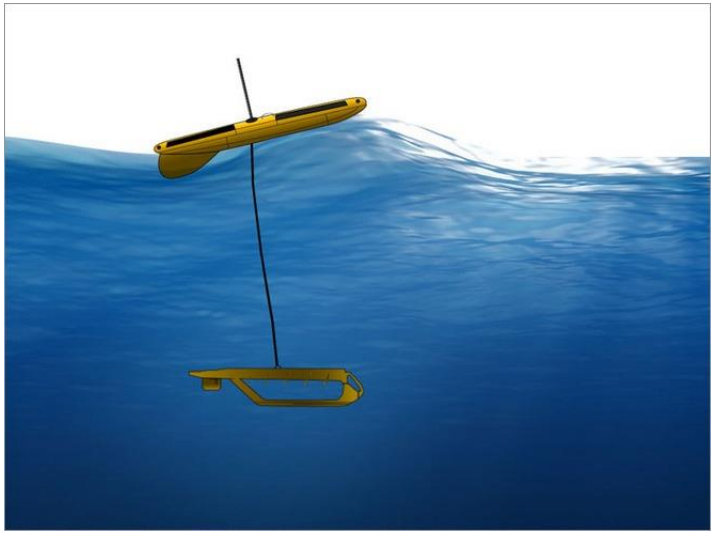
- Other propose to consider them as devices or equipment
- Some works propose that the good seamanship principle still apply (even if COLREGs would not apply)
- Regardless of this, many authors in the literature claim their ASVs compliance with COLREGs both in simulation and in real tests.

State of the art

- Some questions remain:
  - What does compliance for ASVs means?
  - What kind of quantitative tests should be used?
  - Is it fair to use quantitative evaluation when for manned vessels a qualitative evaluation is used?
- Compliance verification is out of the scope of this work

Use case

- Some ASVs can be fully autonomous (remotely monitored only for emergencies)
- Wave Gliders crossed the Pacific in a trip of over 9000 nautical miles
- Use case: small, fully autonomous ASV



Use case

- Some authors argue that fully autonomous can be more reliable than remotely controlled
- Addressing the extreme case (fully autonomous) prepare us for the future
- Current technology is able to detect other vessels
- Advances needed for synthetic voice and sound sensors

Use case

- Several companies sell small/medium ASVs and claim COLREGs compliance
- Larger unmanned ships will take more time to get to the market as the performance requirements are higher
- Regulatory framework should be ready for when these ASVs flood the market.
- We address COLREGs as safety is of utmost importance.

COLREGs

- Need to adapt COLREGs as they were written taking into account the human element (no autonomy).

- Different approaches can be used in order to regulate ASVs:
  - Formal approach for treaties not allowing the use of equivalents (e.g. COLREGs)
  - Introduce one annex to COLREGs just for ASVs
  - Full new code (goal-based) for Unmanned Ships
  - Flexible non-binding solutions

COLREGs

- Having separate rules may create confusion and inefficiency

- Our approach:
  - Suggest amendments and clarifications
  - Leave technical details for self-regulation industry led initiatives

- Flexible non-binding approach that leaves the definition of operational conditions and certification for classification societies and flag states

Proposal

- Hardest challenges of adapting COLREGs for ASVs:
  - Ensure the same level of safety as in manned vessels
  - Translate principles as good seamanship or ordinary practice of seamen into algorithms
  - Define “ample time”, “large enough”, “early action”, “safe speed”

- Hard to pre-program good seamanship, many unexpected situations but
- Simulation and use of historical data can train Artificial Intelligence (AI) to implement this principle.

Proposal

- The use of simulation and substantial training data can also help algorithms to be ready to decide which action to take when other vessels are not compliant.
- Several works in the literature have shown this is possible.
- Situational awareness of an ASV can be superior to human pilot due to the amount of data it can collect and process in real time
- More and better sensors are within the spirit of Rule 5

Proposal

- Rule 1 – no need for amendement

- Rule 2 – needs a clarification.
  - for ASVs, the ordinary practice of seaman shall be translated to algorithms as much as possible by gathering input from experienced captains through simulation, historical data and machine learning.

- Rule 3.a de jure, ASVs are using COLREGs even if they don’t transport cargo or people. – no need to amend

Proposal

- Rule 3.k – needs an amendment.
  - Vessels shall be deemed to be in sight of one another only when one can be observed visually from the other. ***For ASVs, the farthest range sensor will be considered to deem a vessel in sight of one another.***
- A new Rule 3.n
  - ***Autonomous Surface Vessels (ASVs) are vessels for which the operating system of the vessel is able to make decisions and determine actions by itself.***
- Rule 4 – no need to clarify, i.e. establish the conditions of operation (as it is for manned vessels)

Proposal

- Rule 5 – needs an amendment, the most debated rule.

- Our proposal is to simply amend
  - Every vessel shall at all times maintain a proper look-out by ***artificial*** *or* human sight and hearing
- The definition of artificial is left for the compliance process

- Rule 6 needs a new paragraph similar to 6.b for other sensors besides Radar.

- Rule 7 is a corollary of Rule 5 and speaks about all available means – no need to amend

Proposal

- Rule 8 – no need to amend. Case law and best practices can inform on the exact meaning of close quarters, safe distance, etc

- Rule 9 and 10 – no need to amend.

- Rule 11 needs to be amended as Rule 3.k
  - Rules in this Section apply to vessels in sight or artificial sight of one another. ***Artificial sight is defined by the farthest range sensor used by the ASV.***

Proposal

- Rule 12 and 13 – no need to amend.
- Rule 14 – This rule and all others should follow Rule 11 definition of artificial sight without amending 1-by-1.
- Rule 15 – same as Rule 14
- Rule 16, 17 – no references to human senses, no need to amend.

Proposal

- Rule 18 – no need to amend. Some works proposed to use this rule (vessels not under command) for all operations of ASVs. This is impractical and should be avoided.

- Rule 19 – same point as Rule 14 for Rule 19.a

- Rule 19.b – as in Rule 8, case law and best practices can inform us about safe speed.

- Rule 19.d needs an amendment to include other sensors:
  - A vessel which detects by radar ***or other sensors*** the presence of another vessel...

Proposal

- Part C of COLREGs deals with Lights and Shapes
- Part D presents Sound and Light Signals
- These technical rules need consensus from industry so we will only refer to some proposals in the literature
- Some works propose to use the “closest compliance possible” for “vessels of special construction” clause
- Other works propose to have a different set of lights or exemptions for smaller vessels

Proposal

- Part E deals with exemptions – to be defined depending on performance tests
- Part F is about compliance: need to define first the certification and compliance verification authority
- Technical annexes need to be amend accordingly with new amendments in Part C and D, in particular to include digital distress signals
- Several works recommend the usage of AIS for ASVs

Conclusion

- Interdisciplinary study looking at COLREGs from the legal and technical perspectives
- Small fully autonomous ASVs can be found in the market
- Manufacturers claim compliance but there is a need to adapt the rules
- Our goal is to contribute to the debate on how to regulate ASVs
- Future work will address remotely piloted vessels

Thank you

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