Autonomous Ships
Captains, Masters, Pilots, & Software
A Talk with Professor Martin Davies

- What are autonomous ships
  - Levels of autonomy and manning
    - International Maritime Organization (IMO) is a United Nations agency responsible for setting conventions and protocols governing the safety and security of shipping.[1]
    - The IMO has defined four degrees of autonomy in "Maritime Autonomous Surface Ship" (MASS) operations:
      - 1) Majority systems operated by seafarers. Some operations automated.
      - 2) Remotely controlled with seafarers onboard. Operations are controlled from off the ship, but the ship is manned.
      - 3) Remotely controlled without seafarers onboard.
      - 4) Fully autonomous. Ship's operating system able to make decisions and determine actions. No seafarers on board. [2]
  - Current tech development
    - Currently, fully autonomous ships are only in waters within the jurisdiction of individual states, outside of shipping routes. Companies mainly in Scandinavian countries, Japan, and South Korea are also developing fully autonomous bulk carriers and cargo vessels.
    - E.g. Rolls-Royce partnered with Finland's Finferries to develop and demonstrate the world's first fully autonomous ferry in 2018.[3]
- How unmanned vessels may change the shipping industry
  - Benefits of unmanned ships
    - No accommodation space means cost savings in building costs and fuel consumption, and more space for cargo. Also improves ship maneuverability.
    - No need for crew means ships can have quicker turnaround. Less idle time at ports.
      - During the COVID pandemic, with ports, airports, and other facilities closed, seafarers faced extreme difficulty with

[1] International Maritime Organization: https://www.imo.org/
[2] IMO takes first steps to address autonomous ships. March 24, 2018: https://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx
[3] Finferries' Falco world's first fully autonomous ferry. December 3, 2018: https://www.finferries.fi/en/news/press-releases/finferries-falco-worlds-first-fully-autonomous-ferry.html

repatriation and crew changes. The IMO described the situation as a humanitarian and safety crisis.[4]
        - Less room for human error in collisions or other accidents. Some studies indicate that 80-85% of accidents are directly or indirectly caused by human error.[5]
        - More efficient fuel consumption has environmental benefits.
    - Concerns with unmanned ships concerns
        - Seafarer job displacement. Seafarers whose jobs will be displaced tend to be from developing countries, like the Philippines, Myanmar, and Ukraine.
        - Cybersecurity risks
            - Autonomous ships expose shipowners and cargo to a different kind of piracy: cyber piracy. Cyber criminals can cripple or hijack systems for ransom or change the ship's course to steal cargo.
            - Cyber piracy is already an issue in the shipping industry with many components of the ship's operation digitalized.

- International maritime regulations
    - United National Convention on the Law of the Sea (UNCLOS): comprehensive regime governing all uses of the oceans and their resources[6]
    - IMO conventions and protocols. Key related conventions include:
        - International Convention for the Safety of Life at Sea (SOLAS): safety standards in construction, equipment, and operation of merchant ships[7]
        - Convention on the International Regulations for Preventing Collisions at Sea (COLREG): navigational rules on preventing collisions[8]
        - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)[9] and International Convention on

[4] IMO FAQ—Crew changes: A humanitarian, safety and economic crisis: https://www.imo.org/en/MediaCentre/HotTopics/Pages/FAQ-on-crew-changes-and-repatriation-of-seafarers.aspx
[5] Ziarati, R.; Ziarati, M. Review of Accidents with Special References to Vessels with Automated Systems—A Way Forward. Available online: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.665.5802&rep=rep1&type=pdf
[6] United Nations Convention on the Law of the Sea (UNCLOS), 1982: https://www.imo.org/en/OurWork/Legal/Pages/UnitedNationsConventionOnTheLawOfTheSea.aspx
[7] International Convention for the Safety of Life at Sea (SOLAS), 1974: https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx
[8] Convention on the International Regulations for Preventing Collisions at Sea (COLREGs), 1972: https://www.imo.org/en/About/Conventions/Pages/COLREG.aspx
[9] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978: https://www.imo.org/en/About/Conventions/Pages/International-

Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F)[10]
    - International Convention on Maritime Search and Rescue (SAR)[11]
- Interpretational issues with international maritime regulations
    - International maritime laws were drafted at a time when ships were expected to be manned. They were premised on the assumption that a master and crew would be on board. Now that autonomous ships are a near-reality, what are the interpretational issues that arise?
    - Collision regulations and liability
        - Determining when a departure from the rules is necessary in an unmanned/autonomous ship
            - COLREGs[12] Rule 2:
                - (a) *Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.*
                - (b*) In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, **which may make a departure from these Rules necessary** to avoid immediate danger.*
        - Who has primary responsibility in a collision
            - Shipowner
            - Master
            - Ship or software manufacturer
    - Master of the ship duties
        - Master of the ship has primarily responsibility on the ship and broad authority to navigate, jettison cargo, and engage in rescue when necessary among other things.
        - Master's duty to render assistance

Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx

[10] International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995: https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Fishing-Vessel-Personnel-.aspx

[11] International Convention on Maritime Search and Rescue (SAR), 1979: https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Maritime-Search-and-Rescue-(SAR).aspx

[12] COLREGs: https://treaties.un.org/doc/Publication/UNTS/Volume%201050/volume-1050-I-15824-English.pdf

        - Under UNCLOS Article 98, the master has a duty to render assistance to anyone in danger of being lost at sea and to attempt to rescue anyone in distress to the extent it's reasonable.[13]
        - If the ship is operated remotely and there is no master on board, or the ship is fully autonomous, to what extent does the duty apply?
    - Manning levels
        - A ship is required to be safely manned by a broad range of international and domestic regulations.
        - Do the regulations require a crew to be on board or can it include a shore-based team?
    - Look-out requirement
        - COLREGs Rule 5 requires that every vessel "maintains a proper look-out by sight and hearing as well as by all available means appropriate" under the circumstances.
        - Does "sight and hearing" require crew to be on board?
        - May look-out be properly maintained through the sensors and systems available on autonomous ships?
- Pilotage
    - A pilot is a local navigational expert that advises the master in navigating the ship into ports, harbors or around local navigable waters. The master retains overall command.
    - Pilotage rules are not part of IMO regulations. May be hyper-local regulations.
        - E.g. In the United States, pilotage is regulated by the individual states. All states with navigable waters have at least one pilots' association responsible for the waters in its jurisdiction. Some states like Texas and Florida have multiple pilots' associations each responsible for different waters in the state.[14]
    - Pilotage regime may pose a substantial obstacle for autonomous vessels.

[13] UNCLOS Part VII High Seas, see Article 98: https://www.un.org/Depts/los/convention_agreements/texts/unclos/part7.htm
[14] The American Pilots Association Members: http://www.americanpilots.org/members/index.php