Title: Maritime autonomy and Remote Operations **IA No: DfT00430** **RPC Reference No:** N/A **Lead department or agency:** Department for Transport **Other departments or agencies:** Maritime and Coastguard Agency	**Impact Assessment (IA)** **Date: 09/08/12** **Stage:** Consultation **Source of intervention:** Domestic **Type of measure:** Primary Legislation **Contact for enquiries:** Maritimeengagement@dft.gov.uk

Summary: Intervention and Options

RPC Opinion: N/A

Cost of Preferred (or more likely) Option (in 2019 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
NQ	NQ	NQ	Qualifying Provision

What is the problem under consideration? Why is Government intervention necessary?

A number of issues and areas for clarification for maritime autonomy in the Merchant Shipping Act 1995 (MSA) and related legislation have been identified. Although, at present, the UK market for autonomous shipping is small, it is expected to grow as shipping technology develops both in the UK and abroad and have a huge impact on the maritime industry and labour market. Government intervention is needed to put in place high level powers to develop Regulations needed to enable autonomous shipping and manage risks.

What are the policy objectives and the intended effects?

Maritime 2050 and the Technology and Innovation in UK Maritime Route Map set out Government's ambition for the future of shipping. The primary objective of this policy is to lead the development of legislation to support and enable the introduction of autonomous shipping technologies, whilst maintaining health, safety, security and environmental standards and fairly distributing liabilities between stakeholders. It will prepare the UK domestic law framework for future changes in international law, allowing the UK to provide an active and informed position in international discussions. It will maintain and improve regulatory standards and efficiency, enabling investment, innovation, growth and job creation in the maritime sector.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Option 0: Do minimum (baseline) – Maritime and Coastguard Agency continue to utilise Merchant Shipping (Load Line) Regulations 1998 exemption to allow autonomous shipping in UK. The Workboat Code is due to be updated and will include new regulatory provisions for remotely operated unmanned vessels under 24 metres in length on an exemption basis.

Option 1: Wait for International Maritime Organisation (IMO) – This is the same as option 0 (do minimum) until a new regulatory instrument is agreed at the IMO, which is not expected to be before 2028.

Option 2: Legislate in advance of the IMO (preferred) – Amend the current primary legislation framework such as the MSA, Harbours Act 1964 and Aviation and Maritime Security Act 1990 (AMSA) to provide the powers to regulate all autonomous maritime craft regardless of size or degree of autonomous operation, including submersible apparatus. This is the preferred option because it supports the objective for the UK to be a leader in maritime autonomy, enabling innovation, growth and jobs in the UK maritime sector whilst managing the possible risks and adverse or unequitable outcomes.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** TBC

Does implementation go beyond minimum EU requirements?		N/A		
Is this measure likely to impact on international trade and investment?		Yes		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** NQ	**Non-traded:** NQ	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: ..... Date: .....

Summary: Analysis & Evidence

Policy Option 1

Description: Wait for IMO to develop an instrument on autonomous shipping

FULL ECONOMIC ASSESSMENT

Price Base Year 2021	PV Base Year 2022	Time Period 10 years	Net Benefit (Present Value (PV)) (£m)		
			Low: NQ	**High:** NQ	**Best Estimate:** NQ

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	NQ		NQ	**NQ**
High	NQ		NQ	**NQ**
Best Estimate	**NQ**		**NQ**	**NQ**

Description and scale of key monetised costs by 'main affected groups'

This proposal will wait for the IMO to develop autonomous shipping legislation before aligning domestic legislation to further enable autonomous shipping in the UK. Given the early stage of development of IMO recommendations, a robust estimation of costs such as compliance, engagement and familiarisation cannot be made. That analysis will be carried out in the IAs done at consultation and final stage for the secondary legislation and certification requirements, with illustrative evidence shown in this IA.

Other key non-monetised costs by 'main affected groups'

This option is not expected to deliver significantly different impacts from 2022 to 2027 compared to option 0 (do minimum), except for some transition costs of continuing to work with the IMO. From 2028 onwards, there are expected to be higher transition costs compared to option 0 (do minimum), as HMG, regulators and the UK maritime sector look to implement legislative changes. Consultation and final stage IAs for final Regulations and restrictions will fully appraise the costs. Net cost are unlikely exceed zero as new firms will voluntarily take on the regulatory costs.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	NQ		NQ	**NQ**
High	NQ		NQ	**NQ**
Best Estimate	**NQ**		**NQ**	**NQ**

Description and scale of key monetised benefits by 'main affected groups'

This is a permissive measure as the ultimate result of an international regulatory framework will be to enable autonomous shipping in the UK. Beyond 2028, there are expected to be some ongoing (regulatory) cost savings compared to the option 0 (do minimum), higher benefits, particularly for vessels over 24 metres in length, and improved outcomes for wider economic impacts, risks and unintended consequences. These assumptions will be tested through consultation.

Other key non-monetised benefits by 'main affected groups'

At this stage none of the benefits are monetised, but they could be monetised in the future depending on which aspects of autonomous shipping are enabled through secondary legislation, including: investment and revenue from technology sales for autonomous ship manufacturers; operational and labour cost savings for shipping companies; growth in the wider maritime sector and economy; increased/improved jobs; lower shipping costs for businesses/consumers; higher tax revenue and improved public services.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

The current approach (until at least 2028) may present a barrier to growth, particularly as industry develops larger and more complex autonomous shipping, inhibiting the development of maritime autonomy in the UK, including investment, jobs, and growth. Safety, security, health, and environmental impacts may not be properly defined, accounted for or mitigated by HMG, regulators, and industry. UK domestic legislation would not be ready for future changes in international law and there is a reputational risk if the UK falls behind.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m: NQ
Costs: NQ	**Benefits:** NQ	**Net:** NQ	

Summary: Analysis & Evidence

Policy Option 2

Description: Legislate for maritime autonomous surface ships of all sizes and submersible apparatus **in advance of the IMO** (preferred)

FULL ECONOMIC ASSESSMENT

Price Base Year 2021	PV Base Year 2022	Time Period 10 years	Net Benefit (Present Value (PV)) (£m)		
			Low: NQ	**High:** NQ	**Best Estimate:** NQ

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	NQ		NQ	**NQ**
High	NQ		NQ	**NQ**
Best Estimate	**NQ**		**NQ**	**NQ**

Description and scale of key monetised costs by 'main affected groups'

Option 2 is a scaled up version of option 1 (wait for IMO), with transition costs brought forwards as the UK develops and implements domestic legislation and regulation for autonomous shipping earlier. Therefore in the main, the impacts in terms of magnitude, direction and affected stakeholders are as described for option 1 (wait for IMO), except the impacts will be realised earlier under this option and are therefore subject to less discounting, because people generally prefer value now rather than later.

Other key non-monetised costs by 'main affected groups'

There will likely be significantly higher up front (2022 to 2027) transition costs compared to option 0 (do minimum) associated with developing the legislation, familiarisation by industry and associated training etc., but these will likely decrease from 2028 onwards. Consultation and final stage IAs for final Regulations and restrictions will fully appraise the costs. Net costs are unlikely exceed zero as new firms will take on the regulatory costs voluntarily.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	NQ		NQ	**NQ**
High	NQ		NQ	**NQ**
Best Estimate	**NQ**		**NQ**	**NQ**

Description and scale of key monetised benefits by 'main affected groups'

As with option 1 (wait for IMO), this is a permissive measure. Compared to option 0 (do minimum), legislating now is expected to deliver significantly higher net benefits across the appraisal period, particularly for vessels over 24 metres in length, and improved outcomes for wider economic impacts, risks and unintended consequences from 2022 to 2027 and 2028 onwards. There are also expected to be ongoing (regulatory) cost savings over the same period. These assumptions will be tested through consultation.

Other key non-monetised benefits by 'main affected groups'

At this stage none of the benefits are monetised. Benefit categories and stakeholders are expected as in option 1 (wait for IMO). However, on balance option 2 (legislate in advance of the IMO) is expected to deliver higher net benefits than option 0 (do minimum) and option 1 (wait for IMO) given the fact that benefits (and costs) would be brought forwards to 2022 from 2028, and these would also be higher in present value terms because of discounting (3.5%). These assumptions will be tested through consultation.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

The primary risk in developing the domestic legal framework now is that the UK could diverge from international standards as they develop in the future, but the UK may be able to take its experience on the regulation of autonoumous vessels to the international discussions to shape them and reduce this risk. Additionally, where permitted, flexibility within the proposed legislative changes could also ensure that the UK is able to align with the international position as it develops. In addition, there could be a disproportionate effort compared to technology development.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m: NQ
Costs: NQ	**Benefits:** NQ	**Net:** NQ	

1.0 Policy Rationale

Policy background

The proposed changes to legislation is a cross-cutting piece of transport legislation that aims to address a number of issues at the interface of transport and technology. This impact assessment (IA) relates to the maritime autonomy aspects of the proposed legislative changes. For the purposes of the consultation document we refer to all of these types of vessels as 'MASS' (Maritime Autonomous Surface Ships). In this IA, maritime autonomy is defined in a broad sense, including ships, vessels, or craft with or without crew onboard, that are either remotely operated[1] or autonomous.[2] The United Nation's International Maritime Organization (IMO) has identified four degrees of ship autonomy:[3]

- **Degree 1** – a ship has automated processes and algorithmic decision support, but onboard crew members are still needed to operate the systems (albeit with less supervision).
- **Degree 2** – ships are controlled remotely, but still with onboard crew members.
- **Degree 3** – ships are controlled remotely with no seafarers on board.
- **Degree 4** – the ship is fully autonomous, but with shore-based emergency over-ride.

The Government has promoted an ambitious agenda for maritime autonomy, as set out in Maritime 2050 and the Technology and Innovation in UK Maritime (TIUK) route-map.[4] The Maritime 2050 vision is for smart shipping and autonomy to make the maritime sector a cleaner, safer and more efficient place to work, and for this to be achieved through working collaboratively with industry to encourage a culture of innovation. The Maritime TIUK route-map also sets the ambition for the UK to be at the heart of a global maritime autonomy industry and the destination of choice for industry leaders pursuing innovative maritime technologies.

The Maritime and Coastguard Agency's (MCA) Maritime Autonomy Regulation Lab (MARLab), initially funded by the Regulators' Pioneer Fund, was created to fulfil several Maritime 2050 objectives: for the Government to lead efforts to establish a proactive international regulatory framework for autonomous vessels and to work with industry to understand benefits, find use cases and develop proof of concepts for new technologies.

MARLab undertook a review of the regulatory landscape with regards to: i) enabling the safe testing of autonomous technologies; and, ii) promoting regulatory innovation in maritime technologies. MARLab concluded its work in September 2020, with responsibility for continuing the development of maritime autonomy passing to the Maritime Future Technologies team within MCA.[5] In addition, the Department for Transport (DfT) funded smart shipping research in partnership with Maritime Research and Innovation UK (MarRI-UK), delivered by London Economics, NLA International, Marine South East and glass.ai. The findings of this research have been used to inform the proposed legislation and this IA.[6]

The MARLab review focused on smaller vessels (under 24 metres) operating in the UK, because there is a regulatory cut off (the Workboat Code[7]) and all companies who had approached the MCA at that time had vessels under 24m. In the last 2 years the MCA and DfT have been approached by industry regarding 4 international trials and a number of domestic trials. Two projects include vessels over 24m and some involve new concepts such as fleet operation. As vessels get larger and operate in new ways (remotely, or as a fleet) they present new policy and regulatory challenges that need to be addressed, in an expansion from MARLab's original scope.

MARLab identified a number of issues that would benefit from clarification in the Merchant Shipping Act 1995 (MSA) that ought to be addressed to facilitate and enable the operation of autonomous and/or

[1] Remotely operated vessels, for the purposes of this impact assessment, refer to vessels where there is a human element involved in the control or operation of the vessel, but that human element is not located onboard the vessel; or to a vessel that carries crew but some functions of the vessel are controlled from a location remote from the vessel.
[2] Autonomous vessels, for the purposes of this impact assessment, refers to vessels that are capable of decision making and operating without human input.
[3] IMO 'Autonomous shipping', accessed 21 July 2021, available at: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx
[4] HMG 'Maritime 2050: navigating the future', 24 January 2019, available at: https://www.gov.uk/government/publications/maritime-2050-navigating-the-future
[5] MARLab 'Maritime Autonomy Regulation Lab (MARLab) Report', 11 November 2020, available at: https://www.gov.uk/government/publications/maritime-autonomy-regulation-lab-marlab-report/maritime-autonomy-regulation-lab-marlab-report
[6] DFT funded smart shipping research in partnership with MarRI-UK, London Economics, NLA International, Marine South East and glass.ai, 2020 (unpublished)
[7] A Code of Practice for small workboats in commercial use to sea and all pilot boats, MCA, 5 February 2021, available at: https://www.gov.uk/government/publications/workboat-code

unmanned maritime ships and vessels (see Section 2). The recommendations from this report have formed the basis for the maritime autonomy proposals in the proposed changes to legislation.[5]

The proposed legislation would apply to all vessels and craft regardless of size, including very small craft which might not traditionally be considered as 'ships'. It will be designed to align with other legislation, such as the Harbours Act 1964, the Aviation and Maritime Security Act 1990 (AMSA), regulations under the MSA, and international conventions (e.g. Safety of Life at Sea, International Regulations for Preventing Collisions at Sea etc.). It will apply to devolved administrations.

This proposed legislative approach sits alongside Government investment in maritime autonomy, and updates to the Workboat Code for vessels under 24 metres in length.[7] It is expected to indirectly impact the autonomous shipping industry, including shipping companies and seafarers, with more indirect impacts for wider maritime sector and the UK. The details of any secondary legislation will be determined at a later stage but are expected to cover specific segments or aspects of the autonomous shipping market.

Problem under consideration

Opportunities

Before COVID-19, the maritime sector accounted for 95% of UK trade (imports and exports) and a strong maritime industry is a strategic asset to the UK, particularly now we have left the EU, which can be used to boost exports and influence around the world.[8] The sector employed 220,000 people in 2019 and was worth £17 billion Gross Value added (GVA) to the UK economy each year.[9] The structure of the maritime sector, with low margins and long asset life-cycles, means that the sector can be slow to adopt new technologies, with potentially significant gains for countries/organisations able to identify and implement transformational technologies first.

Although, at present, the UK market for autonomous shipping is small, it is expected to grow as shipping technology develops both in the UK and abroad and have a huge impact on the shipping industry, as in many other sectors.[10] In 2018 several flagship projects were underway in Scandinavia and the Far East, and in the UK our smart and autonomous shipping industries were developing at pace. For example, UK companies such as L3 Harris export their Maritime Autonomous Surface Ships (MASS) internationally,[11] and Essex-based Sea-Kit recently won the prestigious Shell X Prize, a US$4 million global competition.[12]

The global autonomous ships market size is estimated to be valued at US$88 billion in 2020, and is projected to reach US$135 billion by 2030, registering a CAGR of 4.4% from 2020 to 2030.[13] The global, wider ship technology market is estimated to grow by over 170% to US$278 billion by 2030[14] and the Government Office for Science predicts that the global 'ocean economy', as defined by the OECD including all maritime, fishing and offshore oil and gas, will double to US$3 trillion by 2030.[15]

The Government is encouraging the commercialisation of maritime technologies, through initiatives such as those announced in the Ten Point Plan for a Green Industrial Revolution[16], MARLab, Maritime Research UK (MarRI-UK)[17] and Innovation UK[18], with investments worth over £20 million.

Autonomous vessels have the potential to reduce operating costs in the shipping sector. It is estimated that the present value of the cost of owning an autonomous vessel is US$4.3 million lower than a manned ship over a 25-year period due to savings on fuel consumption, crew supplies and salaries, making it cheaper to transport people and goods.[19] This could also contribute to reducing shipping emissions. The benefits could also impact the supply-chain (e.g. upstream manufacturing and ancillary services), other

[8] HMG 'Promoting the UK's world-class global maritime offer: Trade and Investment 5-year plan 2019', 2019, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/964144/maritime-5-year-plan-digital-a4-revised-feb-2021.pdf
[9] CEBR on behalf of Maritime UK 'State of the Maritime Nation 2019', 11 September 2019, available at: https://www.maritimeuk.org/media-centre/publications/state-maritime-nation-report-2019/
[10] Lloyd's Register 'Global Marine Technology Trends 2030 Autonomous Systems', August 2017, available at: https://www.lr.org/en/insights/global-marine-trends-2030/technology-trends/
[11] L3Harris, available at: https://www.l3harris.com/en-gb/united-kingdom?regional_redirect=en-gb
[12] Bloomberg 'England's Sea-Kit Leads Rivals in Race to Map Earth's Seabed', 20 October 2020, available at: https://www.bloomberg.com/news/articles/2020-10-20/england-s-sea-kit-wants-to-be-the-first-to-map-the-earth-s-entire-seabed
[13] Allied Market Research 'Autonomous Ships Market', December 2020, available at: https://www.alliedmarketresearch.com/autonomous-ships-market
[14] Chubb, N., Zangrando, L. on behalf of Inmarsat 'Trade 2.0: How startups are driving the next generation of maritime trade', September 2019, available at: https://www.inmarsat.com/en/insights/maritime/2019/trade-report.html
[15] HMG 'Foresight Future of the Sea', 21 March 2018, available at: https://www.gov.uk/government/publications/future-of-the-sea--2
[16] HMG 'Ten Point Plan for a Green Industrial Revolution', 18 November 2020. Available at: https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[17] MarRI-UK 'Technology and Innovation in UK Maritime Call', 2020. Available at: https://www.marri-uk.org/funding-opportunities/technology-and-innovation-in-uk-maritime-call
[18] UK Research and Innovation 'Search results for 'maritime'', accessed 9 July 2021. Available at: https://www.ukri.org/?s=maritime
[19] Kretschmann, L., Burmeister, H. and Jahn, C. 'Analysing the economic benefit of unmanned autonomous ships: An exploratory cost-comparison between an autonomous and a conventional bulk carrier' 2017, *Research in Transportation Business & Management*, 25.10.1016/j.rtbm.2017.06.002.

sectors (e.g. from growth or knowledge spillovers) and end users of shipping (e.g. from higher quality services and/or lower prices).

Technology could reduce the need for certain jobs, replacing labour that is currently employed. For example, according to the ONS, 27,000 jobs in the water transport sector are at risk of automation.[20] At the same time, technology also creates new types of employment, to which labour is better suited than capital i.e. more complex and less repeatable tasks.[21] The overall net impact on employment will depend on which of the two effects will dominate. Comprehensive evidence on which effect is stronger is currently limited. However, recent evidence on 28 industries for 18 OECD countries since 1970 suggests that automation has not been employment-displacing, although it has reduced labour's share in value added to economic output.[22]

Indirect and induced employment is another potential benefit of investing in smart shipping technology. In 2017, 177,000 jobs were supported by the Marine Scientific and Engineering industry. Of those 177,000 jobs, 61,000 were through indirect employment (in the supply chain) and 34,000 jobs were induced employment (jobs generated in the wider economy due to growth by direct and indirect employees).[23]

In addition, new shipping technology could increase safety, health and security standards; the MCA has recognised that a consistently occurring factor throughout almost all accidents, incidents and errors is the human element.[24] Maritime workers face a far higher risk of fatality than the average worker.[25] Between 2011 and 2018, 65.8% of EU Member State flagged shipping accidents were attributed to human action with shipboard operation being the main contributor.[26] In 2018, 1,227 accidents involving 1,339 vessels were reported to UK vessels or in UK coastal waters.[27] Seafarers on shipping vessels spend between four and six months at sea on average, leaving their family and friends onshore while they work 10 to 12-hour days.[28] Autonomous vessels could reduce the need for humans to do dangerous jobs, reduce the risk of human error and the negative social impact of shipping by reducing the number of personnel at sea.[29]

Uncertainty

However, a lack of certainty in the regulation of autonomous vessels is potentially impeding investment and innovation. In addition, changes to international legislative instruments to accommodate MASS, (agreed through the IMO) are unlikely to be completed before 2028 based on IMO's Maritime Safety Committee 103rd session in May 2021.[30] From an industry perspective, gaps in the regulatory framework are slowing innovation and industry are asking for interim regulation and guidance to allow the on-water testing and even operation of autonomous vessels in UK waters, as well as access to data to support their developments. From a regulator's perspective HMG's approach to autonomous shipping has been ad-hoc.[31]

Existing UK legislation only accounts for manned shipping, setting out roles and responsibilities for the people and organisations involved in shipping operations. Commercial ships are regulated through the MSA, which has been drafted around several assumptions, including that a ship has crew onboard to operate it. Maritime autonomy challenges many of these assumptions, meaning barriers may exist for autonomous shipping to be readily compliant with the required legislation.

To date, autonomous shipping in the UK has been addressed through exemptions, exceptions, and equivalences to the existing regulations. Every time a trial of an autonomous vessel is organised, the operator must prove the safety case and obtain exemptions from national and international maritime safety requirements for each voyage (e.g. Load Line, Safety of Life at Sea, Convention on the International

[20] ONS 'Which occupations are at highest risk of being autonomated', 25 March 2019, available at: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/whichoccupationsareathighestriskofbeingautomated/2019-03-25
[21] UK Commission for Employment and Skills 'The Future of Work Jobs and Skills In 2030', 2020, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/303335/the_future_of_work_key_findings_edit.pdf.
[22] Autor, D. and Salomons, A. 'Is Automation Labor-Displacing?', 2018, Productivity Growth, Employment, and the Labor Share. BPEA Conference Drafts
[23] CEBR 'The economic contribution of the UK Marine Engineering and Scientific industry', 2019, available at: https://www.maritimeuk.org/cebr-economic-impact-studies-2019/
[24] MCA 'Human Element Guidance – Part 2 The Deadly Dozen – 12 Significant People Factors in Maritime Safety', 2016, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/837844/MGN_520_Final.pdf
[25] Roberts, S., Nielsen, D., Kotowski, A. and Jaremin, B., 2014. Fatal accidents and injuries among merchant seafarers worldwide. Occupational Medicine, 64(4), pp.259-266.
[26] The data includes ships flying a flag of an EU Member State, accidents in territorial sea and internal waters of Member States or wherever there are interests of Member States involved, as reported in EMCIP. [EMSA (2020). Annual Overview Of Marine Casualties And Incidents 2019. Available at: http://www.emsa.europa.eu/accident-investigation-publications/annual-overview.html
[27] Marine Accident Investigation Branch 'Annual Report 2018', 2019, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/817106/2019-AnnualReport2018.pdf.
[28] IMO 'FAQ On Crew Changes And Repatriation Of Seafarers', 2020, available at: http://www.imo.org/en/MediaCentre/HotTopics/Pages/FAQ-on-crew-changes-and-repatriation-of-seafarers.aspx
[29] de Vos et al. 'The Impact of Autonomous Ships on Safety at Sea – A Statistical Analysis', Reliability Engineering & System Safety, Volume 210, 2021, 107558, ISSN 0951-8320, https://doi.org/10.1016/j.ress.2021.107558.
[30] IMO MSC 'Autonomous ships: regulatory scoping exercise completed', May 2021, available at: https://www.imo.org/en/MediaCentre/PressBriefings/pages/MASSRSE2021.aspx
[31] MARLab workshops, February 2018

Regulations for Preventing Collisions at Sea and Safe Manning). In addition, trials are normally conducted using a manned escort vessel, or a Notice to Mariners warning sea users of the existence of autonomous trials. Classification Societies and Insurers also need to make special arrangements to assure themselves that the relevant risks are covered. The larger the vessel, and the higher the level of autonomy proposed, the more complex this burden becomes because, the more Regulations must be accommodated through "equivalence" or "exemption".[32] Where exemptions are used by default, this infers that a tailored approach is required.

While this approach has enabled autonomous shipping to operate in a limited capacity, it is expected to become increasingly unsustainable as the market grows, as levels of autonomy increase, and more complex regulatory issues need to be addressed. This could represent a potential barrier to growth. Specific areas for consideration include the regulation of the autonomous ships' control location, known as the Remote Operation Centre (ROC), from which the waterbourne vessel is controlled, the roles of the personnel employed to operate autonomous ships and Port, Flag and Coastal state obligations, safety, security and environmental considerations, and liabilities and insurance.

Risks

Without establishing UK legislation for autonomous and/or unmanned shipping, there is a potential missed opportunity to use our knowledge and experience to shape and influence standards across the globe as other countries and multilateral organisations, such as the IMO, set their own standards. There is a risk the UK falls behind global market leaders such as Norway, Denmark, Singapore and is unable to capture some or all of the benefits as autonomous and/or unmanned shipping companies may choose to domicile outside of the UK. Belgium, Russia, and Finland are also leading the development of their own autonomous shipping legislation.[5]

In addition, existing international conventions were created under the assumption that a crew would be onboard, so conventions may need to be updated to reflect the presence of autonomous vessels. Without clearly defined roles and responsibilities, there is an increasing risk of accidents as we transition to a world with more autonomous and/or unmanned operating alongside each other, manned vessels, and other hazards. From 2012 to 2014, 31% of marine accidents were associated with technology in the UK.[33] In the aviation sector, small unmanned aircraft (drones) were involved in around 125 'Airprox' incidents in 2019 (there was a dip in 2020 and 2021 due to reduced flight traffic).[34] For example, Gatwick airport had to be closed for and there have been a number of police reports about drone incursions at prisons and critical national infrastructure.[35]

Ethical considerations will also need to be addressed in the development of autonomous vessels. When autonomous vessels are put in a position to make a decision where all options have a bad outcome it is important to understand how the machine decides on which option to choose. Government, industry, and the wider public should be involved in agreeing how autonomous vessels are programmed to make decisions, to minimise risk to uninvolved third parties and ensure liabilities are appropriately distributed between stakeholders.

Conclusions

The existing regulatory framework needs to be amended to enable autonomous shipping to operate safely and with legal certainty in the UK. Amendments are needed to enable autonomous shipping to operate on the UK flag and within UK waters and ensure an equivalent level of oversight is given to both manned, unmanned, autonomous and non-autonomous ships and vessels. To do this, it is proposed that legislative changes will be used to amend or provide the powers to amend the MSA (and other related legislation, such as Harbours Act 1964 and AMSA), to ensure that autonomous shipping can be regulated effectively.

The broad definition of maritime autonomy coupled with the fast pace of technology development will require sufficiently flexible powers to allow the regulation of all degrees and levels of maritime autonomy, for both iterative and step-changes in technological developments. These developments must be compatible with the framework of international conventions and provisions which govern non-autonomous ships. In this primary legislation we intend to set key definitions and take the powers necessary to put in

[32] Evidence from interviews in smart shipping research funded by DFT, 2020 (unpublished)
[33] Bielic, T. et al. 'Preventing marine accidents caused by technology-induced human error', 2017, Pomorstvo. 31. 33-37
[34] An Airprox is a situation in which, in the opinion of a pilot or air traffic services personnel, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved may have been compromised. UK Airprox Board 'Monthly Airprox Reviews', 2019, available at: https://www.airproxboard.org.uk/Reports-and-analysis/Monthly-summaries/Monthly-Airprox-reviews/
[35] BBC News 'Gatwick drone policing costs 'shocking'', 25 March 2019, available at: https://www.bbc.co.uk/news/uk-england-47696499

place a regulatory framework through secondary legislation. The detail of the final regime will be established through secondary legislation and guidance, in consultation with stakeholders.

Rationale for intervention

Regulation can both be a driver and a barrier to adoption. Government and regulators should therefore seek to create regulatory certainty while ensuring that they develop regulation that is conducive to innovation without creating additional barriers. At present, autonomous shipping is a relatively small market in the UK, with a handful of companies in R&D phases. These are legally permitted to operate on an exemption basis. This approach is expected to represent a barrier to innovation and growth as the market develops, and therefore a potential Government failure.

Therefore, Government intervention is needed to put in place high level powers to develop a comprehensive regulatory framework and guidance to further enable a broad range of potential autonomous operations from and into the UK. This will give existing and potential future autonomous shipping manufacturers and operators the regulatory certainty they need to enter the UK market. Only Government can put in place the powers and subsequent detailed regulations and guidance. In addition, legislation and a regulatory structure is needed to address the following market failures for autonomous and/or unmanned shipping:

- **Uncertainty** – The long lead time and uncertainty around success of technology development can dampen the incentives to invest in new technology.[36] In addition, recent interviews found a lack of joined-up thinking and working to encourage the development and adoption of smart shipping technologies in the UK.[6] These upfront development costs and uncertainty can lead market players to delay investment or under-invest, potentially hoping to benefit from the others' investment. The UK has typically seen lower levels of industry investment in R&D compared to other developed economies, something that the Government's announcement to increase R&D spending to £22 billion each year attempts to address.[37] The proposed powers to regulate autonomous shipping, along with Government investment, could signal to the industry that the Government is willing to bridge the gap between action today and positive outcomes in the future.
- **Spillovers** – R&D often comes with spillover benefits or unexpected outcomes that are not captured by the initial developers and/or investors.[38] This knowledge may be transmitted by the movement of labour between sectors; knowledge exchange between workers via conferences, publications and informal exchanges at meetings or networking events;[39] cross-sector collaborations and diversification strategies for suppliers of technology.[40] In the space sector, research by London Economics (for the UK Space Agency) found that private benefits of R&D to innovators (i.e. ripple effects) appear to be approximately £3-4 in impact for each £1 of public expenditure, with the spillover impacts to the broader public being significantly larger.[41] This can mean developers and/or investors underinvest in R&D projects.[42] This problem applies to maritime autonomy given the emerging nature of these technologies. The proposed powers to regulate autonomous shipping, along with Government investment, could signal to the industry that the Government recognises the spillover benefits that these new technologies will bring to the UK.
- **Externalities** – Private sector investment in and operation of autonomous shipping technology may fail to fully take account of the impact on third parties i.e. positive or negative externalities. Government legislation can better account for these externalities and spillover benefits, unlocking or dissuading investment and activities which the private sector may not support without incentives to do so. Clear legislation that enables secondary legislation and guidance could ensure opportunities and risks are properly managed and mitigated. For example, accidents between autonomous ships and other vessels, people or objects could be reduced or avoided altogether.
- **Moral hazard** – Creating legislation without clear roles and responsibilities, a robust monitoring and enforcement regime, and adequate penalties, runs the risk that the regulatory regime would be, or would be perceived to be, impotent. In addition, licence holders may take unnecessary risks

[36] House of Commons 'Bridging the valley of death: improving the commercialisation of research', 13 March 2013, available at: https://publications.parliament.uk/pa/cm201213/cmselect/cmsctech/348/348.pdf
[37] HMG 'New plans to put uk a front of global innovation race', 22 July 2021, available at: https://www.gov.uk/government/news/new-plans-to-put-uk-at-front-of-global-innovation-race
[38] It should be noted that the level of transmission depends on the transmission mechanism. For example, investment in proprietary R&D that is kept secret will yield lower spillover impacts than R&D that is subsequently shared with others, e.g. via publication.
[39] UK Space 'Spillovers In the Space Sector', 2019, available at: https://www.ukspace.org/wp-content/uploads/2019/04/Spillovers-in-the-space-sector_March2019.pdf
[40] Nessie project 'Cross-Sector Knowledge Transfer: North Sea Solutions For Innovation In Corrosion For Energy', 2018, available at: http://www.nessieproject.com/library/reports-and-researches/nessie-report-cross-sector-knowledge-transfer
[41] London Economics 'Spillovers in the space sector', 2018, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/788725/LE-UKSA-Spillovers_in_the_space_sector-FINAL_FOR_PUBLICATION_050319.pdf
[42] Aghion, P. and Jaravel, X. 'Knowledge Spillovers, Innovation and Growth', 2015, The Economic Journal, 125(583), pp.533–573.

if they believe Government will cover the costs of accidents. This is a situation known as "moral hazard": because there is low or no risk of their being held responsible, and because they will not bear all the costs of non-compliance or offences, licence holders might not take (costly) action to reduce risks. A monitoring regime and appropriate enforcement, liability and insurance measures will require organisations to comply with regulations and reduce risks to socially acceptable levels.

Policy objectives

Maritime 2050 and the Technology and the Innovation in UK Maritime (TIUK) Route Map set out HMG's ambition for the future of shipping:[4]

"*The UK is determined to be world leading in the design, manufacture, uptake, and use of smart shipping technologies. To achieve this, we will develop a UK legislative framework for autonomous vessels and lead efforts to establish an international regulatory framework. We will support industry in developing and testing new technologies by funding flagship projects and learning from other sectors like the automotive industry. The UK will be a vibrant hub of research and development. Shipping companies will benefit from a highly competitive register for technologically advanced and autonomous vessels."*

In addition, proposals by the Taskforce for Innovation, Growth and Regulatory Reform included one on maritime:[43]

"Proposal 10.1 Create a world leading regulatory framework for autonomous vehicle and other disruptive mobility solutions: Modernise maritime law to support safe testing and deployment for Marine Autonomous Surface Ships"

Changes to legislation to enable autonomous shipping supports the delivery of Government and Departmental priorities, including the development of new transport technologies that benefit transport users, growing and levelling up coastal communities, reducing environmental impacts and increasing the UK's global impacts. The primary objective of this policy is to lead the development of legislation to support and enable the introduction of autonomous shipping technologies, whilst maintaining health, safety, security and environmental standards and fairly distributing liabilities (legal responsibilities) between stakeholders. From the problem under consideration, these objectives can be summarised as follows:

- Give the UK the powers to ensure the new and growing sector of autonomous shipping is appropriately regulated and supported
- Ensure there is a cohesive approach to maritime operations and regulatory oversight as between autonomous and non-autonomous shipping
- Ensure that all vessels in the UK fleet and operating in UK waters are built, surveyed, operated and inspected to ensure they do not cause harm to other maritime users, the environment, human health, property or resources
- Allow the UK to provide an active and informed position in international discussions that will shape the regulation of autonomous shipping internationally and the development of an IMO instrument
- Prepare the UK domestic law framework for future changes in international law

The specific outcomes that are intended to flow from these objectives are shown in Figure 1 below:

Figure 1 Intended outcomes for policy objectives

Outcome	
1)	Maintain/improve regulatory standards, including safety, security and environment
2)	Reduce regulatory uncertainty for maritime autonomy industry
3)	Develop efficient regulation of maritime autonomous vessels
4)	Encourage investment in maritime autonomy
5)	Facilitate innovation in the maritime sector and associated knowledge spillovers
6)	Encourage growth in the maritime sector and wider economy
7)	Enable creation and diversification of jobs in the maritime sector
8)	Facilitate improved welfare and safety for the maritime sector

[43] HMG 'Taskforce on Innovation, Growth and Regulatory Reform independent report', 16 June 2021, available at: https://www.gov.uk/government/publications/taskforce-on-innovation-growth-and-regulatory-reform-independent-report

9) Lead the development of maritime autonomy internationally
10) Enable the UK to meet future autonomy related IMO obligations
11) Facilitate the fair and equitable distribution of benefits, costs, and risks among stakeholders

Options considered

The options outlined here cover the legislative options only (highlighted green, Figure 1). There are other interventions that are happening in parallel, including Government investment and R&D, to meet the policy objectives set out in Maritime 2050 and TIUK. These other options are not explicitly appraised in this IA but should be considered as part of the wider maritime autonomy context.

Figure 2 Intervention options for smart shipping [6]

Intervention options	
Funding	Providing R&D funding and de-risking innovation investments
Collaboration	Facilitating collaborations and partnerships
Skills development	Supporting education and skills development
Policy & regulation	Policy and regulatory frameworks that foster innovation

The purpose of the maritime autonomy aspects of the proposed legislative changes is continued and increasing support for autonomous shipping technologies as the market develops. Therefore, banning autonomous shipping was not considered as an option since it does not meet the policy objectives.

Through the MARLab and MCA Maritime Future Technologies team review, Government and industry have discussed the implications of regulating different types of operations (e.g. pleasure vs. commercial) and levels of autonomy (e.g. remotely piloted vs fully autonomous). The MCA is already updating The Workboat Code to include provision for the safe operation of remotely operated unmanned surface vessels under 24 metres, but this excludes fully autonomous vessels, vessels above 24 metres in length and underwater apparatus.[44]

The proposed legislation would apply to all vessels and craft regardless of size, including very small craft which might not traditionally be considered as 'ships'. It will be designed to align with other legislation, such as the Harbours Act 1964, the Aviation and Maritime Security Act 1990 (AMSA), regulations under the MSA, and international conventions (e.g. Safety of Life at Sea, International Regulations for Preventing Collisions at Sea etc.). It will apply to devolved administrations.

This proposed legislative approach sits alongside Government investment in maritime autonomy, and updates to the Workboat Code for vessels under 24 metres in length.[7] It is expected to directly impact the autonomous shipping industry, including shipping companies and seafarers, with more indirect impacts for wider maritime sector and the UK. The details of any secondary legislation will be determined at a later stage, but are expected to cover specific segments or aspects of the autonomous shipping market.

We are not proposing to designate test areas for maritime autonomy trials. As long as appropriate certification through the current exemption processes can be obtained there are methods by which autonomous vessels can be trialled in all UK waters. Allowing the trialling of autonomous vessels across the UK provides a wide variety of environments for them to be tested, including in real-life scenarios. We consider that the powers proposed in the preferred option for legslative change would render designated test areas unnecessary because the powers would create a safe, secure and environmentally-sound regulatory framework for the development of these vessels.

In addition, we consider that primary legislation in the following areas will not require amendment to allow the operation of autonomous vessels in UK waters:

- Search and Rescue (SAR) obligations on vessels – covered by the IMO's International Convention for the Safety of Life at Sea (SOLAS) and SAR Convention

[44] HMG 'Workboat Code', 5 February 2021, available at: https://www.gov.uk/government/publications/workboat-code

- Wreck and salvage requirements – wreck includes jetsam, flotsam, lagan, and derelict found in or on the shores of the sea or any tidal water, and salvage includes all expenses, properly incurred by the salvor in the performance of the salvage services.
- Port State Control within domestic legislation - the MCA is responsible for checking that ships visiting UK ports and anchorages meet UK and international safety rules.

The options below reflect the current structure of UK and international shipping legislation and are not intended to provide granular, prescriptive regulations at this stage given the emerging nature of maritime autonomy in the UK and abroad. The preferred option is designed to provide the UK with powers to regulate maritime autonomy as the market develops via secondary legislation under the proposed changes to legislation. The proposed legislation would apply to all vessels and craft regardless of size, including very small craft which might not traditionally be considered as 'ships'. The details of any secondary legislation will be determined at a later stage but are expected to cover specific segments or aspects of the autonomous shipping market.

Option 0 – Do minimum (baseline)

The MCA would continue to utilise the exemption that is available through the Merchant Shipping (Load Line) Regulations 1998, to allow autonomous shipping to continue to operate within UK waters and under the UK Flag. Autonomous vessels would continue to be obliged to comply with all other regulations. The Workboat Code would be updated for remotely operated unmanned vessels under 24 metres in length, but their regulation would be limited to the current powers of the MSA and related primary legislation.

The practical benefits of retaining the existing process are that: (i) industry are aware of the requirements; (ii) the MCA can continue to use a safety-case approach to ensure these vessels are thoroughly assessed to support their safe operation within UK waters; and, (iii) there is no need to amend legislation.

There are a number of risks involved in continuing with the current approach: (i) Reputationally, there is a perception that the industry is being held back by existing legislation and Government is not doing enough to support emerging technologies; (ii) the Load Line Exemption Certificate was not originally designed for the regulation of autonomous shipping and it would be preferable to have a bespoke regime for this; (iii) gaps in powers (for example around training and Remote Operation Centres) would remain, which could limit the safe operation of these vessels; (iv) exemptions and equivalences may not be available or suitable as industry develops larger and more complex autonomous shipping which could limit operations in UK waters; and, (v) the UK domestic legal framework would not be ready for future international discussions and changes in international law.

In addition, there is a reputational risk, where in the absence of UK legislation on autonomous shipping, the UK may lose its reputation as a leader in maritime autonomy. This could also potentially reduce the UK's effectiveness to direct the development of new instruments and the practical implementation of the safety requirements of autonomous shipping as part of discussions at the IMO.

This option does not support the Ministerial priorities and Government position to be a leader in maritime autonomy as it does not consider the full range of autonomous shipping or build on existing legislation to improve the regulatory process for maritime autonomy, which may limit the benefits and increase the risks associated with the autonomous shipping in the UK.

Option 1 – Wait for IMO to develop an instrument on autonomous shipping

This option is the same as option 0 (do minimum) until a new regulatory instrument is agreed at the IMO. The most recent discussion at IMO indicated that following a Regulatory Scoping Exercise further work is needed to identify how to regulate in order to allow the safe operation of autonomous shipping internationally.[45] Based on current workloads, IMO has signalled that a new instrument could be developed but not before 2028.

The practical benefits of this option are that: (i) it would guarantee consistency between the domestic and international regulatory framework for the safe operation of autonomous ships; (ii) industry are aware of the current process to get an autonomous ship on the water in the UK; and, (iii) the MCA can continue to

[45] IMO Maritime Safety Committee 'Outcome of the regulatory scoping exercise for the use of maritime autonomous surface ships (MASS)', 3 June 2021, available at: https://wwwcdn.imo.org/localresources/en/MediaCentre/HotTopics/Documents/MSC.1-Circ.1638%20-%20Outcome%20Of%20The%20Regulatory%20Scoping%20ExerciseFor%20The%20Use%20Of%20Maritime%20Autonomous%20Surface%20Ships...%20(Secretariat).pdf

use a safety-case approach to ensure these vessels are thoroughly assessed to support their safe operation within UK waters. The risks with this approach are the same as for the baseline option above.

This option does not support the Ministerial priorities and Government position to be a leader in maritime autonomy given the likely timeframes for a new IMO regulatory instrument, which may mean higher costs and risks and lower benefits in the interim period, and delayed future benefits associated with autonomous shipping in the UK.

Option 2 – Legislate for maritime autonomous surface ships of all sizes and autonomous/unmanned submersible apparatus in advance of the IMO (preferred)

This is the preferred option. The UK would amend the current framework of the MSA, Harbours Act 1964 and AMSA and supporting secondary legislation to provide the powers to regulate all autonomous ships regardless of size or degree of autonomous operation. These amendments would also cover submersible apparatus, to ensure there is a consistent application of autonomy within the maritime domain in the future. This approach meets the policy objectives sets out above.

Our aim is to allow flexibility to develop appropriate definitions, or allow for the amendment of existing definitions, in secondary legislation as the autonomous shipping industry and international law evolve. Further details of such requirements would be developed in secondary legislation, in consultation with industry and operators.

Our proposal includes four key elements:

1) To identify and determine key definitions and roles for the operation of remotely operated and autonomous vessels.
2) Ensuring that the MCA can regulate autonomous vessels of any size, including craft that might not traditionally be considered as 'ships'.
3) To grant the MCA new powers to develop Regulations for Remote Operation Centres (ROCs) to ensure the safe operation and management of remotely operated or autonomous vessels.
4) Ensuring that the MCA and DfT and ports and harbours have sufficient powers to regulate health and safety, security, and the environmental aspects of autonomous vessels and ROCs

We may need to provide MCA with powers to define and clarify terms and roles for the operation of autonomous vessels, in addition to those defined in the primary legislation, as set out below. This would allow flexibility to develop appropriate definitions in secondary legislation as the maritime autonomy industry evolves. There is no current consensus on what these terms and roles should be, but these powers should provide the flexibility to change the definitions as experience of maritime autonomy develops and the international legal framework evolves.

To ensure parity across the industry and ensure safety, security and the protection of the marine environment we are seeking to ensure that the MCA has the powers to apply and perform their current statutory responsibilities (survey, inspection, certification, and enforcement) on UK-flagged autonomous vessels, their operations in UK waters, and their associated ROCs.

The primary risk in developing the domestic legal framework now is that the UK could diverge from international standards as they develop in the future, for example when defining terms and definitions of autonomous vessels. However, the UK should be able to take its experience on the regulation of autonomous vessels to the international discussions to shape that discussion to reduce this risk.

This option is the preferred choice. It supports the Ministerial priorities and Government position to be a leader in maritime autonomy, by enabling HMG to support innovation, growth and jobs in the UK maritime sector whilst managing the possible risks and adverse or unequitable outcomes.

Definitions and responsibilities

We propose the following key terms be contained in primary legislation (except note that term (v) is for the purpose of this document and could potentially be defined in secondary legislation):

i. ***"Maritime Autonomous Surface Ships" or "MASS**" includes every description of vessel or craft used in navigation that can for any part of its voyage, fully or in part navigate or operate autonomously or through remote operations.* We propose that this definition of MASS would apply to all vessels and craft regardless of size including very small craft which might not be considered to be 'ships'.

ii. *"**Remote operations**" means controlling the functioning of an operation on a MASS from a different place or location from that MASS.*

iii. *"**MASS master**" includes a person (except a pilot) having command or charge of a MASS".*

iv. *"**Remote Operator**" includes every person, including a MASS master, who is employed or engaged in any capacity to undertake remote operations of a MASS.*

v. *"**Remote Operations Centre" or "ROCs"** – is a location from which a MASS may be operated, which is not situated on board the vessel.*

A variety of terms are used across industry to describe remotely operated and autonomous vessels. Having considered terms used by industry, other countries, and developments at the International Maritime Organisation (IMO), we propose that this definition of MASS would apply to all vessels and craft regardless of size including very small craft which might not be considered to be 'ships'. The proposed changes to legislation will not provide definitions for degrees or types of autonomy, but for clarity, the following are included within the scope of the legislation:

- Remotely operated vessels or craft that have no persons on board;
- Remotely operated vessels or craft that may have persons onboard (e.g. crew, personnel and/or passengers); and
- Vessels or craft operating fully autonomously (currently no distinction as to whether persons are on board or not).

To ensure the continued safe regulation of the maritime space and a consistent approach to the use of autonomous and remotely operated systems we propose to introduce powers to regulate autonomous/unmanned submersible apparatus in a manner consistent with manned submersible apparatus to be exercised at a future date through secondary legislation when these concepts mature. We also propose that there should be an entity that, or person who, is accountable and responsible for a remotely operated or autonomous vessel at all times, including in the event of an emergency or accident (a MASS Master). In current legislation the Master performs a key role and holds significant responsibilities in regard to the vessel they are onboard, having overall responsibility for the vessel, crew, cargo, passengers and regulatory compliance. With the growth and adoption of remotely operated and autonomous vessels we propose that a similar arrangement is mirrored in the new legislation for the person having command of a MASS. The proposed definition is based on the following principles:

- A Master does not need to be onboard a MASS;
- the definition of a Master should focus on their roles and responsibilities, removing any reference to their physical location in relation to a vessel, or the characteristics of the vessel (e.g. manned or unmanned). The legislation would need to ensure that all responsibilities are enforceable against a Master not on board a vessel;
- The definition must not change the need for the Master to be onboard a non-MASS vessel.

We also propose that Remote Operator is defined in primary legislation, but the principles and details of certification and training requirements for a Remote Operator including hours of rest for watchkeeping, will be developed in secondary legislation. Current powers allow the MCA to ensure vessels are safely manned and we need to ensure this is applicable to MASS as well. MASS may be manned remotely with vessels being operated by person called a Remote Operator.

We also propose that additional powers are needed to ensure safe manning considerations can be applied to MASS, including from the ROCs from which these vessels are remotely operated. The regulation of ROCs is not straightforward under the MSA. the proposed changes to legislation would provide the MCA

with these powers, including powers to ensure safe manning principles can be applied to vessels, which are operated remotely, or autonomous. The ROC is a location from which a MASS may be operated, which is not situated on board the vessel. The details of the requirements for ROCs will be developed in secondary legislation.

Ports and Harbours

As with other legislation, including the MSA, we would use any changes to legislation to ensure that definitions in harbours legislation (both general and local Acts) are broad enough to cover MASS, for example the definitions of 'ship' and 'master'. In addition, we propose that thelegislative changes contains a power similar to that in section 60 of the Harbours Act 1964 to allow the Secretary of State to repeal or amend any provision relating to a harbour which is contained in an existing local Act or order, where that provision appears inconsistent with, or has become unnecessary in consequence of any provision in legslative change. The aim of this would be to address the complexity of local harbours legislation whilst reflecting the fact that local harbour authorities are best placed to understand the legislation that governs their own harbour. As with s.60 of the Harbours Act 1964 we propose that this power would be subject to safeguards including that the Secretary of State would not exercise the power save on application of a harbour authority and would only do so following consultation.
Otherwise, we do not consider that new powers in harbours legislation are required to enable harbours to regulate MASS operations within their jurisdictions.

Marine equipment

The overall system for type approval of marine equipment is believed to be appropriate for MASS and ROCs and we propose to apply it to them. We will ensure that the MCA has the necessary powers to regulate equipment fitted to MASS and ROCs relevant to safety, security and pollution prevention. It is acknowledged that the equipment that is currently covered by the 2016 Regulations under the MSA and the standards which are applied may need to be amended to include new types of equipment. In particular, the regulation and type approval of software systems/algorithms may need to be considered independently of the (variety of) hardware they may ultimately be used with.

Security

Maritime security is currently governed by a range of different legislative instruments including international conventions such as SOLAS and the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA), primary legislation such as the Aviation and Maritime Security Act 1990 (AMSA 1990) and further secondary legislation, including the Port Security Regulations 2009. We propose that certain changes may be necessary to the legislative framework governing maritime security to support our preferred approach to regulating MASS for a number of reasons:

i. To resolve definitional issues such as 'ship' and 'master' which appear in the AMSA, in a similar way to the definitional issues with the MSA, which were explored earlier in the Impact Assessment;
ii. To ensure that the offences in Part II of the AMSA 1990 against the safety of ships and fixed platforms are appropriately applied to MASS and ROCs. For example, we wish to ensure that it is an offence to seize control of an unmanned ship through remote operation even where the ship then does not present a danger to navigation;
iii. To ensure that Part III of the AMSA 1990, which contains provisions giving the Secretary of State (SoS) powers to issue directions to harbour owners and ship owners for the purpose of protecting ships, persons, property and harbour areas 'against acts violence', also extends to cover ROCs.
iv. To ensure that we have the power to implement international requirements for maritime security on MASS or ROCs.
v. To ensure we have the powers to set standards for cyber security for MASS and ROCs.

Liabilities and insurance

Existing international conventions developed under the auspices of the IMO govern liability, compensation, and compulsory insurance requirements for most shipowners. These conventions cover such things as oil pollution damage caused by ships; damage suffered by passengers on seagoing ships (including death and personal injury claims); and wreck removal. Specific provision is also made to uphold a shipowner's right to limit their liability. At present, for insurance purposes, the thirteen Protection & Indemnity (P&I)

Clubs which comprise the International Group (IGP&I Clubs) between them provide marine liability cover for approximately 90% of the world's ocean-going tonnage.

The IMO Legal Committee, which primarily deals with liability and compensation issues related to the operation of ships, including damage, pollution, passenger claims and wreck removal, met in July 2021 and concluded that, in general, MASS can be accommodated within the existing regulatory framework of the international conventions under the purview of the Legal Committee.

2.0 Costs and Benefits

Methodology

This IA covers the primary legislation to take powers to regulate autonomous shipping in the UK, that in itself will not impose direct costs to business or society, nor directly lead to benefits. The secondary legislation and accompanying guidance that is expected create those impacts is not yet determined. Whilst the proposed legislation is aimed at liberalising and increasing business activity in the UK maritime autonomy sector, these effects are not expected to be immediate as the legislation is a first step in enabling this activity.[46] It would therefore be disproportionate to, at this stage, attempt to monetise the costs and benefits coming from the secondary legislation for which this primary legislation sets the groundwork.

The proposed legislation would apply to all vessels and craft regardless of size, including very small craft which might not traditionally be considered as 'ships'. The details of any secondary legislation will be determined at a later stage but are expected to cover specific segments or aspects of the autonomous shipping market.

This IA therefore qualitatively describes the potential indirect impacts of primary legislation, without making speculative forecasts about the total impacts of both the primary legislation and any future secondary legislation that is yet to be determined.[47] Analysis and the quantification of benefits and costs will be carried out when secondary legislation is proposed using the powers set out in the recommended primary legislative changes.

However, this IA sets out the best available evidence for informing both the current and future legislative policies for maritime autonomy in the UK. The consultation will be used to test this evidence and gather information about both the relevant stakeholders for this legislation, in particular any businesses that may be directly or indirectly impacted, and the associated impacts for these stakeholders. The approach to the consultation and questions are summarised at the end of this IA.

Finally, this IA follows the standard 10-year appraisal period (from 2022 to 2031 inclusive) and 3.5% social discount rate to convert future costs and benefits to be comparable in present value terms to the year when the policy is expected to be implemented (i.e 2022), as per HMT Green Book guidance.[48] Prices are shown in nominal, current values given the illustrative nature of this IA i.e. they have not been converted to the same price year by adjusting for inflation. It should be noted that, as maritime autonomy technology is still in early stages of development, there are expected to be high upfront investment and R&D costs relative to long-lived benefits. This could justify a longer appraisal period. However, there is significant uncertainty in how the market for autonomous shipping will develop, even within a 10-year appraisal period, so it would not be proportionate to consider a longer appraisal period.

Evidence from MARLab review [5]

The MARLab review of the MSA concluded that no provisions in the legislation expressly prohibit MASS operations. However, several provisions in the MSA were ambiguous in nature and is therefore unclear if they raise compliance issues for MASS.

The review confirmed that gaps in the regulatory framework exist as it was written with no foresight of MASS. These issues, although not directly impeding MASS, do provide practical difficulties for the UK's enforcement of its applicable Coastal State law when autonomous ships are being operated in the UK's maritime zones. However, it is argued that they are potential barriers to MASS trials in UK waters. This is because of the lack of clarity for both MASS operators and State regulators since it makes any authorisation process and the policing of compliance more arduous and ad hoc. The aspects of the MSA that would benefit from clarification fit broadly in the following general areas:

- Roles and Responsibilities,
- Safety (and, in particular, Manning Levels)
- Training, and

[46] Regulatory Policy Committee 'Business Impact Target specific issues: direct versus indirect impacts', March 2019, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790016/RPC_case_histories_-_direct_and_indirect_impacts__March_2019__1_.pdf
[47] Regulatory Policy Committee 'RPC case histories: assessment and scoring of primary legislation measures', August 2019, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/827907/RPC_case_histories_-_Primary_legislation__August_2019.pdf
[48] HMG 'The Green Book: appraisal and evaluation in central government', 3 December 2020, available at: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

- Remote Operations.

As part of the MARLab work, the Cabinet Office's Policy Lab conducted stakeholder analysis of the UK MASS industry. Policy Lab conducted over 40 interviews with MASS related individuals from industry, ports, academia, UK Government bodies, and international Government organisations. Interviews focused on current experiences of MASS regulations, the MCA, and broader trends within MASS research and testing. A snapshot of these interviews is presented anonymously here (Figure 3), as well as a Stakeholder Network Map (Figure 4).

The initial realisation was how complex and large the MASS industry was in the UK, and that there were areas we were not aware of or in regular contact with, such as University Strathclyde or smaller sensor developers (out of 210 links made, 78 were new to the MCA). This was a useful exercise that identified the broad range of stakeholders we needed to access, alongside the vessel developers and users of MASS.

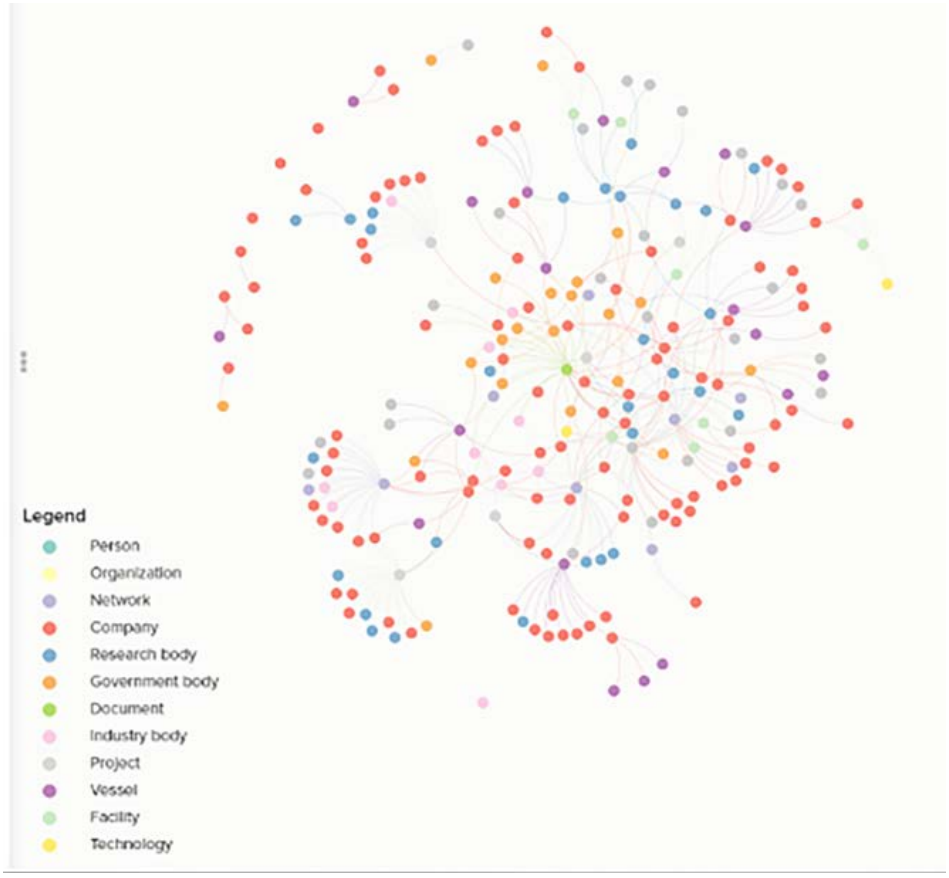
Figure 3 Anonymised MASS interview extracts, Policy Lab [5]

"if the MCA was to put a flag in the ground and declare its position, I think you would see business flock to this country because would know where they stand."

"To actually get them to find a way of giving thumbs up, was by giving the vessel effectively a Loadline Exemption Certificate. Which is not ideal at all … it a very expensive and painful method"

"Goal-focused regulation, something that's flexible which allows industry to interpret the way in which its going to meet a safety goal other than being very prescribed in the regulations about specifically how everything's got to be done. The challenge for industry and the MCA then is to create the evidence base which allows those flexible solutions to be brought forward and approved as being likely to achieve those safety goals."

Figure 4 Stakeholder network map for MASS (using Kumu) [5]



MARLab recommendations

From the MARLab review of the MSA, the following recommendations were made:

1. To remove any doubt that the "Master" of a MASS does not need to be on board it, clarification would be beneficial that an individual who is the equivalent of the master will (probably) not be on board a MASS. Clarification needs to ensure that there is a nominated individual who has the equivalent responsibilities.
2. Terms such as "crew", "seaman" which appear in the Act imply that these individuals are on board their vessel. Clarification and alternative terminology for onshore personnel would be beneficial.
3. The Act stipulates that a vessel shall have a minimum manning level. Although there is no express requirement for a minimum number of attending personnel, there is a risk that it is not legitimate to interpret this as zero. In such a case, Section 49 could be an impediment to MASS trials. Clarity on this point is therefore a necessity.
4. The clarification of Health and Safety laws – what apply on board, what on shore, and do on-board laws apply to personnel with on-shore duties? Is the onshore safety legislation sufficient to address all the relevant requirements that are applicable to personnel on a vessel?
5. The training of the MASS equivalent of a "Master" should include both the minimum standards of training as for the Master of a conventional vessel, and specific, recognised training on the MASS platform and the statutory basis to prescribe such standards should be clarified.
6. The MSA requires that certain documentation is displayed or carried on the vessel, or that documents can be served to that vessel. Clarification is necessary to the effect that the documentation may be elsewhere provided it is easy to locate and that there is a clear and obvious location where documents can be served.
7. To geographic boundaries for the operation of MASS require defining (is it permissible for a MASS to be operated from outside the UK and if so what contractual or other constraints should be applied).
8. To the extent the traditional means of law enforcement such as boarding and inspection of ships may not be viable in the MASS context, consideration should be given as to viable alternatives.

Summary of stakeholders and impacts

Stakeholders

All the options considered will impact on the same group of stakeholders but to differing degrees and with differing outcomes. The stakeholders include:

- **Autonomous shipping manufacturers** – Companies in the upstream R&D and manufacturing part of the supply-chain that provide shipping companies with autonomous vessels. At the moment autonomous vessel manufacturers are the same as operators. Increased developmental opportunities are facilitated through the new regulations, increased market activity as the uptake of MASS increases.
- **Autonomous shipping companies** – Companies providing autonomous shipping operations are the most directly affected by regulations, in terms of familiarisation, training, engagement with the MCA, Certifying Authorities (CA) and Responsible Organisations (RO) and other compliance requirements. However, these companies are expected to have the most to gain from regulation too, in terms of the opportunity to enter the market and associated investment, operational efficiencies, reduced labour costs etc.
- **Seafarers** – Mixed impact on seafarers, with some expected short-term displacement of current sea-based roles (with potential for long-term structural unemployment), but potential augmentation of roles and increased land-based opportunities with higher wages. May be impacted by increased training needs as new technology makes it way onboard. May also improve working conditions by increasing safety onboard and a reduction in the need for crew to undertake dangerous tasks.
- **Ports and Harbour Authorities** – Impacted by autonomous shipping operations within their jurisdiction and potential needs for understanding the legislation, train, and make operational and capital changes to comply, but could also benefit from efficiencies, market growth and knowledge spillovers.
- **Wider maritime sector** – This include non-autonomous shipping companies, pleasure craft and other users of waters, and maritime professional business services. These companies and individuals may want to understand the legislation and develop training. In addition, existing non-autonomous shipping companies may be impacted by increased competition from autonomous shipping companies. However, the wider maritime sector may also benefit from efficiencies, market growth, knowledge spillovers and a reduction in externalities and adverse outcomes.
- **HMG and regulators** – This includes central government, devolved administrations, and regulators, such as the MCA, CAs, ROs and Maritime Accident Investigation Branch (MAIB). Costs may include the implementation of the legislation i.e. actually regulating the autonomous shipping industry, engaging with industry, other countries and the IMO, and any potential liabilities in the event of accidents/claims. However, HMG and regulators could benefit from autonomous shipping itself (e.g. public services such as Search and Rescue), increased tax revenue from market growth and a reputation as a market leader.
- **Businesses and consumers** – These include companies and individuals in the downstream part of the autonomous shipping supply-chain as well as companies in parallel and unrelated sectors of the UK economy. These stakeholders could benefit from increased efficiencies, market growth and knowledge spillovers.
- **Non-seafarers** – Autonomous shipping may impact the wider, land-based jobs market in the UK, opening up new opportunities in autonomous vessel R&D and manufacturing, as well as autonomous shipping operations. It may also open up ‘seafaring’ careers to those that had not previously considered a career in maritime.

Costs

The following costs have been identified for all the options, but these will impact stakeholders differently and vary across options too:

- **Familiarisation** costs/time for industry
- **Training** costs/time for HMG, regulators, and industry
- **Capital** expenditure for compliance by industry, including mitigation of impacts, and development of regulator
- **Operational** expenditure for compliance by industry, including mitigation of impacts
- **Engagement** between HMG, regulators, industry, other countries, and IMO
    - Time spent surveying and certifying ships for registration
    - Time spent monitoring & enforcing e.g. inspections
- **Certification** costs
- **Safety, security, health, and environmental** impacts, which may be negative if not regulated effectively
- **Accidents investigation** costs for industry and the accident investigator, including wreckage and salvage costs
- **Insurance** for industry and associated claims outcomes depending on liabilities
- **Unemployment** in short-term from displacement and long-term structural changes

Benefits

The following benefits have been identified for all the options, but these will impact stakeholders differently and vary across options too:

- **Investment** and activity in autonomous vessel and shipping sectors following regulatory certainty and associated **knowledge spillovers** from R&D to the scientific community and academia, as well as other sectors
- **Economic growth** from autonomous shipping technology development, adoption and sales by shipping companies and associated **operational efficiencies**, driven both by the autonomous shipping technology itself and competition between autonomous and incumbent shipping companies. These may be passed through to businesses and consumers through **lower shipping costs/prices** too.
- **Growth effects** for the maritime supply-chain (indirect, Type I multiplier) and wider economy (induced, Type II multiplier) related to new market opportunities
- **Labour** requirements and costs lower from adopting autonomous shipping technologies (positive productivity shock), but there may also be new **job opportunities** in autonomous shipping labour market, including augmented and new roles e.g. engineering, data processing, coding, remote operations etc.
- **Safety, security, health, and environmental** impacts, which may be positive if regulated effectively
- **Public services** improvement from autonomous shipping e.g. Search and Rescue
- **Tax revenue** from market growth
- **Reputational** i.e. leadership in regulation at IMO

Figure 5 Summary of stakeholders and impacts

Stakeholders	Illustrative costs	Illustrative benefits
Autonomous shipping manufacturers	• Familiarisation costs/time • Training costs/time • Capital expenditure for compliance	• Investment and activity in autonomous vessel sector • Revenue from technology sales to autonomous shipping companies
Autonomous shipping companies	• Familiarisation costs/time • Training costs/time • Pre-engagement with regulator • Capital expenditure for compliance, including mitigation of potential impacts • Operational expenditure for compliance, including mitigation of impacts • Certification costs • Insurance & claims • Monitoring & enforcement e.g. inspections	• Increased investment and activity following regulatory certainty • Operational efficiencies from adopting autonomous shipping technologies • Lower labour requirements and costs from adopting autonomous shipping technologies
Seafarers	• Short-term displacement of jobs • Training costs/time • Short-term adverse safety impacts • Long-term structural unemployment	• New/augmented roles e.g. engineering, data processing, coding, remote operations etc. • Long-term safety and welfare improvements
Ports and Harbour Authorities	• Familiarisation costs/time • Training costs/time • Capital expenditure for compliance • Operation expenditure for compliance • Insurance	• Growth by maritime autonomy market (indirect, Type I multiplier) • Efficiencies and pass through of lower shipping costs • New market opportunities (growth effects)
Wider maritime sector e.g. non-autonomous shipping companies pleasure craft, users of waterways, insurance	• Familiarisation costs/time • Training costs/time e.g. training colleges • Increased competition from autonomous shipping companies	• Growth by maritime autonomy market benefits supply-chain e.g. professional services (indirect, Type I multiplier) • New market opportunities (growth effects) • Knowledge spillovers • Improved safety, security, health, and environment
HMG and regulators	• Increased regulatory activity for MCA (including Certifying Authorities and Responsible Organisations), MAIB and other regulators o Training costs/time o Capital expenditure for compliance o Certification o Monitoring & enforcement e.g. inspections o Accidents investigation • Co-operation within HMG and with industry, other countries, and the IMO • Potential liabilities in the event of accidents/claims	• Public services improvement from autonomous shipping e.g. Search and Rescue • Increased tax revenue from market growth • Reputational i.e. leadership in regulation at IMO
Businesses and consumers		• Growth by maritime autonomy benefits other sectors e.g. wages on retail (induced, Type II multiplier) • Efficiencies and pass through of lower shipping costs (catalytic multiplier) • Knowledge spillovers to the scientific community and academia, as well as other sectors
Non-seafarers		• Increase in opportunities in autonomous shipping labour market

Option 0 – Do minimum (baseline)

This section sets out the baseline (or counterfactual) for maritime autonomy in the UK, including the current and expected future state of the UK shipping and labour markets, which the autonomous shipping sector will either be a subset of or additional to.

To facilitate comparisons with the other options, Figure 6 groups these more detailed costs, benefits, WEI, risks and unintended consequences into broad categories, split across the time periods 2022 to 2027 and 2028 onwards based on the expected timings of option 1 (wait for IMO), and shows our assumptions about the direction and absolute size of these impacts for the do minimum option (these will be tested through consultation):

- **Benefits** are separated out for vessels above and below 24 metres in length based on the current differential treatment of vessels above and below 24 metres in option 0 (do minimum) compared to the alternative options, and include economic growth (direct, indirect and induced), investment tax revenue, public service improvements, knowledge spillovers and positive labour markets impacts.
- Costs are split into –
    - **Transition costs**, including development, investment, capital expenditure, training, time spent surveying ships for registration and associated certification costs/fees, and
    - **Ongoing costs**, including operational expenditure, time spent monitoring and enforcing e.g. inspections, accident investigation and insurance.
- **Risks and WEI** include safety, security, health, environmental, labour market, competition, and reputational impacts are captured by the risks and WEI grouping.

Figure 6 Aggregated impact assumptions for option 0 (do minimum), in absolute terms

Impact over time	2022 to 2027	2028 to 2031	2032+
Benefits <24 metres	Positive, medium	Positive, medium	
Benefits >= 24 metres	Positive, low	Positive, low	
Transition costs	Negative, low	Negative, low	
Ongoing costs	Negative, medium	Negative, medium	
Wider impacts (WEI)	Negative, medium	Negative, medium	

The follow sections describe the expected (illustrative) costs and benefits, wider economic impacts (WEI), risks and unintended consequences for the current approach to regulating autonomous shipping, building on the stakeholders, costs and benefits identified in the previous section. These are used to inform the assessment above (Figure 6) and will be tested through consultation.

Current and expected future number of UK shipping companies

Every merchant ship must be registered in a country (the 'flag state') and ship registration can, in part, be considered an indicator of the overall health of a country's maritime sector.[49] In HMG published maritime and shipping statistics, the following, overlapping definitions of the UK fleet are used:

- **UK registered:** the vessel is UK registered
- **UK direct owned:** the registered owner of the vessel is a company registered in the UK
- **UK parent owned:** the company having the controlling interest in the direct owner is a UK
- company
- **UK managed:** the company managing the ship is a UK company

This IA only focuses on the UK stakeholders and impacts, as per HMT Green Book guidance. Therefore, registered ships and companies need to be segmented to identify UK shipping companies, to estimate the potential impact of these legislative changes. Whilst the flag of ships is important for determining the number of UK registered ships, UK shipping companies operating UK flagged ships will help us determine

[49] HMG 'Shipping Fleet Statistics: 2020', 11 March 2021, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/967763/shipping-fleet-statistics-2020.pdf

the impact on UK companies as a result of the proposed legislative changes. Ships registered under other flags are excluded from this analysis.

In addition, the UK Ship Register (part of the MCA) and IHS Markit Ship and Port Data contains useful information for segmenting the UK shipping market, including vessel length. To reflect the difference between option 0 (do minimum) and the alternative options, this IA has segmented registered ships into vessels shorter and longer than 24 metres in length. In total in by the end of Q1 2021, there were over 100,000 ships in the global fleet, with over 50,000 ship owner companies and over 30,000 ship manager companies. These were heavily skewed towards ships over 24 metres (Figure 7 and Figure 8). [50]

As of Q1 2020, there were 32 ship owner and 28 ship manager companies for the UK flagged ships under 24 metres where the UK was the country of economic benefit for the shipping activities (Figure 7). For UK flagged ships over 24 metres, there were 359 ship owner and 267 ship manager companies where the UK was the country of economic benefit for the shipping activities (Figure 8).

Figure 7 UK and non-UK ships under 24 metres and associated companies [50]

Registered flag	Country of economic benefit	Number of ships	Ship owner companies	Ship manager companies
UK	UK	52	32	28
UK	Other	9	7	9
Other	UK	12	10	10
Other	Other	4,292	2,292	2,249
Sub-total		**4,365**	**2,341**	**2,296**

Figure 8 UK and non-UK ships over 24 metres and associated companies [50]

Registered flag	Country of economic benefit	Number of ships	Ship owner companies	Ship manager companies
UK	UK	787	359	267
UK	Other	362	249	195
Other	UK	1,080	928	419
Other	Other	97,924	51,166	29,275
Sub-total		**100,153**	**52,702**	**30,156**

When looking at the number of activite enterprises by ONS Standard Industrial Classifications (SIC2007) for water transport and ship and boat manufacturing sectors, the number of enterprises remained roughly the same from 2014 to 2019 (Figure 9). For sea and coastal passenger and freight water transport companies, the number of enterprises is also higher than the number of ship owner and manager companies for UK flagged ships (regardless of country of economic benefit), suggesting that the number of UK shipping companies could be almost c.1,500 in 2019.

Figure 9 Business demography, UK, Table 3.2 – Count of active enterprises by SIC2007, 2014 to 2019 [51]

Standard Industrial Classification (SIC2007)	2014	2015	2016	2017	2018	2019
301: Building of ships and boats	1,080	1,095	1,140	1,110	1,080	1,055
30: Manufacture of other transport equipment	**2,405**	**2,520**	**2,700**	**2,840**	**2,825**	**2,695**
501: Sea and coastal passenger water transport	605	620	630	625	635	650
502: Sea and coastal freight water transport	820	830	800	795	790	825
503: Inland passenger water transport	230	235	225	230	225	215
504: Inland freight water transport	80	85	75	75	70	65
50: Water transport	**1,735**	**1,770**	**1,730**	**1,725**	**1,720**	**1,755**

Assuming the rate of change similar over the next 10 years, the number of UK shipping companies is expected to broadly stay the same or increase slightly. This IA therefore assumes the latest available data from the UK Ship Register, IHS Global (Q1 2020) and ONS (2019) is a suitable proxy to estimate the number of UK shipping companies over the 10-year appraisal period i.e. the number of UK shipping companies stays constant over time 10-year appraisal period.

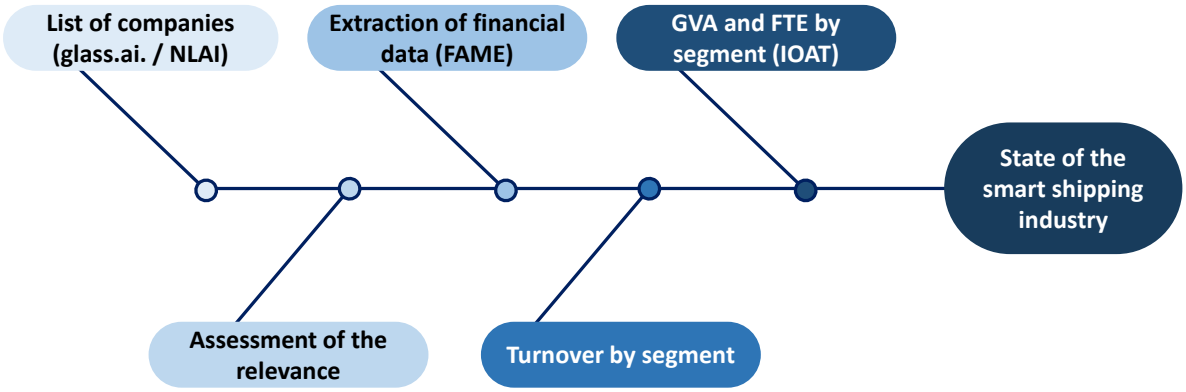
[50] DfT analysis of UK Ship Register and IHS data, July 2021 (unpublished)
[51] ONS 'Business demography, UK', 17 November 2020, available at:
https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/businessdemographyreferencetable

Current and expected future number of UK autonomous shipping companies [6]

UK autonomous shipping companies are either a subset of or additional to the current and expected future number of UK shipping and ship manufacturing companies. Based on smart shipping research funded by DfT in partnership with MarRI-UK, NLA International (NLAI) provided an initial list of smart shipping companies. These were then consolidated by London Economics using *glass.ai*, an ongoing artificial intelligence (AI) discovery process or "web crawler" that reads websites and classifies websites as a company website if it detects certain criteria around content. As a result, more than 450 companies were analysed in this research. For each company, London Economics manually investigated publicly available information (website, companies house, LinkedIn) to determine the relevance of the company, using FAME data. (Figure 10)

This research identified 215 relevant smart shipping companies that split between four market segments. **38 companies were identified as active in the autonomous vessel segment**, with others in the smart ports, on-board technologies, and professional and business services segments. Note that companies can be active in multiple segments, and that autonomous vessel manufacturers and operators currently overlap as the vessels are trialled by the developers and manufacturers.

Figure 10 Method for identifying UK smart shipping companies, including autonomous vessels [6]



n.b. GVA = Gross Value Added; FTE = Full-Time Equivalent; IOAT = Input-Output Analytical Tables

There is significant uncertainty in the expected future number of autonomous shipping companies, therefore this IA does not attempt to forecast them. However, the smart shipping research outlined an approach using a "Bass Diffusion Model" to estimate the adoption and benefits of autonomous shipping. For any given time in this model, there are levels of innovators who are the first to seek out and adopt the technology, levels of imitators who wait to see the experiences of others until choosing whether to adopt the technology or not, and the ultimate market potential.

As more and more organisations adopt the new technology, more and more organisations are tempted to adopt, and more of those tempted do actually adopt. Therefore, the number of imitators increases over time while the number of innovators decreases. The ultimate market potential imposes an upper limit on the potential number of adopters (adoption rate).

Based on the current number of UK autonomous vessel companies (38) and current number of UK shipping companies (up to c.1,500 if using ONS data, Figure 9), the expected future number of UK autonomous shipping companies could be expected to be in the tens or hundreds by the end of the 10-year appraisal period, based on the current number of autonomous vessel companies (38), their early stage of development and assuming the market structure does not fundamentally change (i.e. up to c.1,500 UK companies). By way of comparison to another technology change in shipping over the past few decades, the global Liquified Natural Gas (LNG) shipping fleet is expected to grow from 138 ships in operation in 2021 to 174 ships in operation by 2028 (after reaching its market saturation point in 2024), according to a research report by DNV, and we would expect there to be fewer owner and manager companies than ships.[52]

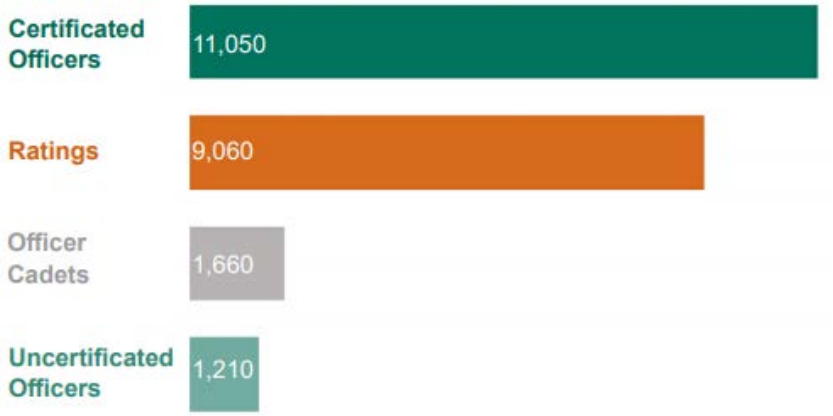
[52] DNV 'Alternative fuel technologies', accessed 22 July 2021, available at: https://www.dnv.com/maritime/alternative-fuels-and-technologies-in-shipping/index.html

Current and expected future number of UK seafarers [53]

Based on the MCA Seafarer Documentation System and Chamber of Shipping Seafarer Employment Survey, an estimated 22,970 UK seafarers were active at sea in 2020, with overall numbers being broadly stable in recent years (Figure 11). There has been an overall downward trend in the number of UK seafarers over the past 15 years. However, between 2012 and 2020 numbers have been broadly stable with the exception of 2018, due to a large increase in Ratings explained by changes in the data coverage of the Chamber of Shipping data.

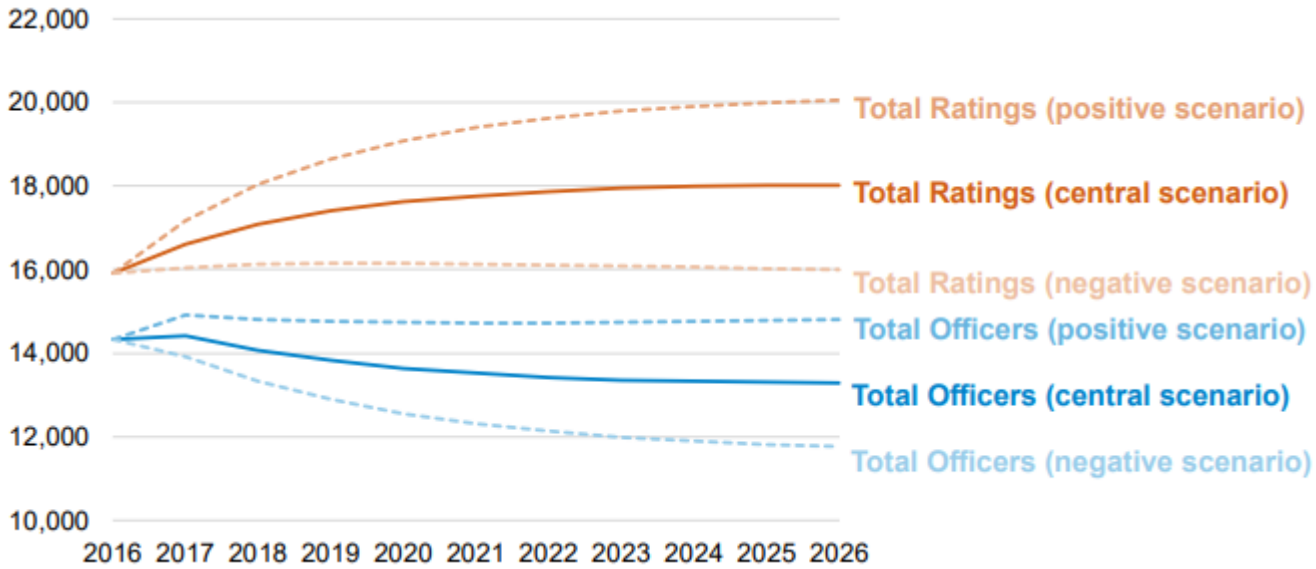
There were 42,920 certificates to work on UK vessels issued by the Maritime and Coastguard Agency in 2020, 15,370 of these were UK nationals. These figures have been broadly stable since 2010. The majority of UK seafarers active at sea were male (83%), with larger female representation in Uncertificated Officers and Ratings.

Figure 11 UK seafarers active at sea by type 2020 [53]



The latest DFT seafarer projections were delivered by Oxford Economics and published in 2016. Although based on the same underlying data as presented in these statistics, numbers were the results of a modelling approach which made several adjustments and assumptions, and so are not directly comparable. The figures projected an increase in the supply of UK Ratings, and a decrease in the supply of total UK Officers - though sensitivity scenarios were also produced (Figure 12). These projections were published before the coronavirus pandemic and so do not reflect any impact of the pandemic.

Figure 12 Sensitivity scenarios for the supply of UK seafarers, 2016 to 2026 [53]



Based on the above evidence, the number of UK seafarers may slightly increase (+15%) or decrease (-10%) by the end of the 10-year appraisal period. This IA therefore assumes a range of possible outcomes and impacts for UK seafarers by the end of appraisal period.

[53] HMG 'Seafarers in the UK shipping industry: 2020', 24 February 2021, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/964225/seafarers-in-the-uk-shipping-industry-2020.pdf

Illustrative benefits

The practical benefits of retaining option 0 (do minimum) are that: (i) industry are aware of the requirements; (ii) the MCA can continue to use a safety-case approach to ensure these vessels are thoroughly assessed to support their safe operation within UK waters; and, (iii) there is no need to amend legislation.

However, the economic benefits of option 0 (do minimum) are likely to be weighted towards shipping operations vessels under 24 metres categories, given the current differential treatment of vessels above and below 24 metres in option 0 (do minimum) compared to the alternative options. The benefits are also expected to be either lower or delayed compared to additional Government legislative intervention (Figure 6). That said, maintaining the current approach will allow the maritime autonomous industry to mature and stabilise, with learning being gathered from the projects currently allowed under the exemption process. Growth of maritime autonomy may also occur, allowing for data and evidence to be gathered to inform the development of future legislation if required.

Illustrative costs

Any ship, whether new-build or transferring from another flag, must be surveyed before it can be registered on the UK Ship Register. Retaining the current approach will ensure that no additional costs are imposed on the maritime autonomous industry in ensuring compliance. However, these costs are expected to be higher per ship given the current, ad-hoc nature of ensuring compliance, which may cause delays in waiting to gain exemptions for autonomous shipping, and current powers do not enable the authorities to survey or inspect all of the operations involved in autonomous shipping. The current approach can be resource intensive for the MCA, and exemptions and equivalences may not be available or suitable as industry develops larger and more complex autonomous shipping. This may present a barrier to growth as the market develops.

Surveys and inspections

Surveys can be carried out by MCA surveyors or, in certain cases, by MCA-approved Class surveyors through the Alternative Compliance Scheme (ACS) or Enhanced Authorisation Scheme (EAS).[54] MCA authorise six Recognised Organisations (ROs), which are members of the International Association of Classification Societies (IACS), to carry out a proportion of their statutory survey work. For smaller vessels that operate under the UK Codes of Practice, MCA have authorised 10 Certifying Authorities (CAs) to survey and issue certificates on their behalf.[55]

MCA's standard hourly survey rate are £147 per hour Monday to Friday between 8am and 6pm, £221 per hour Monday to Friday between 6pm and 8am and all day Saturday, and £294 per hour all day Sunday,[56] but actual times taken to survey and therefore total costs per vessel may vary e.g. bigger ships with more complex designs may take longer, and different ROs and CAs may be quicker or slower.

MCA undertook 2,895 surveys and 2,472 inspections of UK ships during the 2019-20 Financial Year. In the same period, MCA also carried out 1,387 Port State Control inspections on 1,318 individual ships to ensure they were meeting the required standards during which they identified 3,446 deficiencies with 33 ships being detained in the period. In 2019-20, MCA investigated 171 new cases and conducted 10 prosecutions.[55]

Registration

In addition, the registration of a ship (excluding fishing vessels), including registration of a ship whose registration has expired, is £153 or £333 for the Premium Service. The renewal of a registration under regulation 42 of the Merchant Shipping (Registration of Ships) Regulations 1993(a) is £72 or £172 for the Premium Service. The registration of fishing vessels, including registration of a vessel whose registration has expired, is £159 for a simple registration, £196 for a full registration or £376 for a full registration with

[54] UK Ship Register 'Survey', accessed 22 July 2021, available at: https://www.ukshipregister.co.uk/other-services/survey/

[55] MCA ' Annual Report and Accounts 2019-2020', 2020, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928608/MCA_Annual_report_and_accounts_2019_-_2020.pdf

[56] MCA 'Application for Survey or Inspection Marine Offices South', accessed 22 July 2021, available at: https://products.payments.service.gov.uk/pay/reference/5e8ddca91b3c42699c1aa3c33643a6bd

the Premium Service. The renewal of a registration under regulation 42 of the Merchant Shipping (Registration of Ships) Regulations 1993 is £70 or £170 for the Premium Service.[57]

MCA expenditure and income

MCA's total expenditure has risen by £14.4 million to £371.8 million in FY 2019-20. The main elements of the increase were staff costs £3.5 million, Search and Rescue Helicopters (SAR-H) £3.6 million, pollution response £4.4 million and Telecommunications and IT £4.4 million (Figure 13). Total MCA income increased by £0.5 million to £15.4 million in FY 2019-20, reflecting higher revenue from contracts with customers mainly due to a rise in marine surveys income (£5.9 million). Registration of ships generated £1.1 million in income in FY 2019-29 (Figure 14, excludes commercial and other income).[55]

Therefore, it is likely that this policy would generate costs to MCA in relation to autonomous shipping, passed through to companies through fees and charges, well below the +/-£5 million expected annual net direct cost to business (EANDCB) threshold for IAs,[58] given the total surveys and registrations income and expenses were around £6-7 million each year in the past 2 financial years. In addition, it may well save costs associated with examining and certifying seafarers if the number of seafarers is reduced by autonomous shipping. To provide another sense of scale to help justify this, the MARLab team was set up with £1 million funding from the UK Government's Department for Business, Energy, and Industrial Strategy's (BEIS) Regulators' Pioneer Fund. The regulatory cost to business will be tested through consultation.

Figure 13 MCA Statement of Comprehensive Net Expenditure, for the year ended 31 March 2020 [55]

	Note	2019-20 £000	2018-19 £000
Revenue from contracts with customers	[3]	(13,601)	(13,076)
Other income	[3]	(1,843)	(1,793)
Total income		**(15,444)**	**(14,869)**
Staff costs	[2]	56,279	52,773
Purchase of goods and services	[2]	253,308	289,326
Depreciation and impairment charges	[2]	60,432	15,618
Other operating expenditure	[2]	(4,592)	(60)
Net provision (release)/expense	[2]	464	(249)
Total operating expenditure		**365,891**	**357,408**
Net operating expenditure for the year		**350,447**	**342,539**
Finance expense	[13]	5,913	-
Net expenditure for the year		**356,360**	**342,539**
Other comprehensive net expenditure			
Items which will not be reclassified to net operating expenditure:			
Net (gain)/loss on:			
Revaluation of property, plant and equipment		(109)	(902)
Revaluation of intangible assets		(130)	(22)
Revaluation of inventories		(420)	62
Total net revaluation (gains) and losses		**(659)**	**(862)**
Comprehensive net expenditure for the year		**355,701**	**341,677**

[57] MCA 'Maritime & Coastguard Agency quick guide to fees – November 2018', 12 December 2018, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/749572/Maritime___Coastguard_Agency_fees_2018.pdf

[58] HMG 'Better Regulation Framework', March 2020, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/916918/better-regulation-guidance.pdf

Figure 14 MCA Fees and Charges, direct income and expenditure (excluding overheads) [55]

	2019-20			2018-19		
	Income	Expense	Net	Income	Expense	Net
	£000	£000	£000	£000	£000	£000
Statutory services						
Marine surveys	5,866	5,902	(36)	5,106	5,150	(44)
Registration of ships	1,084	1,162	(78)	1,068	824	244
Seafarers' examinations and certification	2,152	2,446	(294)	2,447	2,257	190
Other statutory services	202	286	(84)	450	361	89
Total	**9,304**	**9,796**	**(492)**	**9,071**	**8,592**	**479**

Illustrative WEI, risks, and unintended consequences

There are several potential wider economic impacts and unintended consequences involved in continuing with the current approach:

- The costs associated with ad-hoc exemptions and the focus of the Workboat Code updates on vessels under 24 metres in length may present a barrier to growth, inhibiting the development of maritime autonomy in the UK, including investment, jobs, and growth.
- Safety, security, health, and environmental impacts may not be properly defined, accounted for and mitigated by HMG, regulators, and industry. For example, the distinction between vessels under and over 24 metres in length may present a barrier to integrated autonomous vessels with existing manned shipping operations.

There are a number of risks involved in continuing with the current approach:

(i) Reputationally, there is a perception that the industry is being held back by existing legislation and Government are not doing enough to support emerging technologies;
(ii) the Load Line Exemption Certificate was not originally designed for the regulation of autonomous shipping and it would be preferable to have a bespoke regime for this;
(iii) gaps in powers (for example around training and ROCs) would remain, which could limit the safe operation of these vessels;
(iv) exemptions and equivalences may not be available or suitable as industry develops larger and more complex autonomous shipping which could limit operations in UK waters; and,
(v) the UK domestic legal framework would not be ready for future international discussions and changes in international law.

In addition, there is a reputational risk, where in the absence of UK legislation on autonomous shipping, the UK may lose its reputation as a leader in maritime autonomy. This could also potentially reduce the UK's effectiveness to direct the development of new instruments and the practical implementation of the safety requirements of autonomous shippingas part of discussions at the IMO.

Option 1 – Wait for IMO to develop an instrument on autonomous shipping

This section sets out the expected impacts of waiting for the IMO to develop an instrument on autonomous shipping, compared to option 0 (do minimum) using the same grouped categories of impacts split across the time periods 2022 to 2027 and 2028 onwards.

Figure 15 illustrates that, compared to option 0 (do minimum), waiting for the IMO is not expected to deliver significantly different impacts from 2022 to 2027, except for some transition costs of continuing to work with the IMO. From 2028 onwards, that are expected to be higher transition costs compared to option 0

(do minimum), as HMG, regulators and the UK maritime sector look to implement legislative changes. As a result, there are expected to be some ongoing (regulatory) cost savings compared to the option 0 (do minimum), higher benefits, particularly for vessels over 24 metres in length, and improved outcomes for wider economic impacts, risks and unintended consequences beyond 2028. These assumptions will be tested through consultation.

On balance, option 1 (wait for IMO) is expected to deliver higher net benefits than option 0 (do minimum), but lower net benefits that option 2 (legislatein advance of the IMO) given the delayed benefits (and costs), which would be significant reduced in present value terms because of discounting (3.5%) and would likely be limited by the cut off of the 10-year appraisal period.

Figure 15 Aggregated impact assumptions for option 1 (wait for IMO), relative to option 0 (do minimum)

Impact over time	2022 to 2027	2028 to 2031	2032+
Benefits <24 metres	Zero	Positive, low	
Benefits >= 24 metres	Zero	Positive, high	
Transition costs	Negative, low	Negative, medium	
Ongoing costs	Zero	Positive, medium	
Wider impacts (WEI)	Zero	Positive, medium	

n.b "positive" for "ongoing costs" means cost savings

Illustrative benefits, costs and WEI

The practical benefits of option 1 (wait for IMO) are that: (i) it would guarantee consistency between the domestic and international regulatory framework for the safe operation of autonomous ships (reflected by expected positive WEI of this option compared to option 0); (ii) industry are aware of the current process to get a autonomous ship on the water in the UK; and, (iii) the MCA can continue to use a safety-case approach to ensure these vessels are thoroughly assessed to support their safe operation within UK waters. The risks with this approach are the same as for the baseline option above.

From 2022 to 2027, the economic benefits of option 1 (wait for IMO) are likely to be the same as option 0 (do minimum). Beyond 2028, the benefits are expected to be higher than option 0 (do minimum), particularly for autonomous vessels over 24 metres in length. This is the main additional benefit of option, but given it does not occur until at least 2028, it will likely be limited compared to option 2 (legislate in advance of the IMO)

In waiting for the developments to mature in the IMO, the UK could benefit from a wider spectrum of experience achieved in other nations, which might not be available to the UK e.g. certain environments or types of vessel, reflected by negative but low transition costs from 2022 to 2027. This may help to ensure a more complete introduction of legislation at the point of defining it, reflected by negative, transition costs beyond 2028 compared to option 0 (do minimum), but these are expected to lower in absolute term than option 2 (legislate now).

As a result, compared to option 0 (do minimum), option 1 (wait for IMO) is expected to have ongoing (regulatory) cost savings, given the ad-hoc nature of the current exemption process. These savings are not expected to be realised until at least 2028.

Illustrative risks and unintended consequences

The risks and unintended consequences with this approach are the same as for the option 0 (do minimum) until 2028, and thereafter are expected to be reduced.

Option 2 – Legislate for maritime autonomous surface ships of all sizes and autonomous submersible apparatus in advance of the IMO (preferred)

This section sets out the expected impacts of legislating in advance of the IMO for maritime autonomous and remotely operated surface ships of all sizes and autonomous submersible apparatus (option 2, preferred) compared to option 0 (do minimum), using the same grouped categories of impacts split across the time periods 2022 to 2027 and 2028 onwards.

Figure 16 illustrates that, compared to option 0 (do minimum), legislating in advance of the IMO is expected to deliver significantly higher net benefits across the appraisal period, from 2022 to 2027 and 2028 onwards. However, there will likely be significantly higher up front (2022 to 2027) transition costs compared to option 0 (do minimum) associated with developing the legislation, familiarisation by industry and associated training etc., but these will likely decrease from 2028 onwards. As a result, there are expected to be some ongoing (regulatory) cost savings compared to the option 0 (do minimum), higher benefits, particularly for vessels over 24 metres in length, and improved outcomes for wider economic impacts, risks and unintended consequences across both 2022 to 2027 and 2028 onwards. These assumptions will be tested through consultation.

On balance, option 2 (legislate in advance of the IMO) is expected to deliver higher net benefits than option 0 (do minimum) and option 1 (wait for IMO) given the fact that benefits (and costs) would be brought forwards to 2022 to 2028, and these would also be higher in present value terms because of discounting (3.5%).

Figure 16 Aggregated impact assumptions for option 2 (legislate now), relative to option 0 (do minimum)

Impact over time	2022 to 2027	2028 to 2031	2032+
Benefits <24 metres	Positive, low	Positive, low	
Benefits >= 24 metres	Positive, high	Positive, high	
Transition costs	Negative, high	Negative, low	
Ongoing costs	Positive, medium	Positive, medium	
Wider impacts (WEI)	Positive, medium	Positive, medium	

n.b "positive" for "ongoing costs" means cost savings

Illustrative costs, benefits and WEI

The practical benefits of option 2 (legislate in advance of the IMO) are to: i) give the UK the powers to ensure the new and growing sector of autonomous shipping is appropriately regulated and supported; ii) ensure there is a cohesive approach to maritime operations and regulatory oversight as between autonomous and non-autonomous shipping (reflected by expected positive WEI of this option compared to option 0); iii) ensure that all vessels in the UK fleet and operating in UK waters are built, surveyed, operated and inspected to ensure they do not cause harm to other maritime users, the environment, human health, property or resources; iv) allow the UK to provide an active and informed position in international discussions that will shape the regulation of autonomous shipping internationally and the development of an IMO instrument; and, v) prepare the UK domestic law framework for future changes in international law.

The economic benefits of option 2 (legislate in advance of the IMO) are likely to be the significantly higher than option 0 (do minimum), because it will enable autonomous shipping regardless of vessel length, particularly for autonomous vessels over 24 metres in length, and across the time period from 2022 to 2027 and 2028 onwards. This is the main additional benefit of this option, and it is expected to be higher than option 1 (wait for IMO) as the benefits are brought forwards to 2022 from 2028.

However, there are expected to be higher up front (2022 to 2027) transition costs compared to option 0 (do minimum) associated with developing the legislation, familiarisation by industry and associated training etc., but these will likely decrease from 2028 onwards. This is the opposite to option 1 (wait for IMO), where the bulk transition costs are expected from 2028 onwards, and they are also expected to be slightly lower for option 1 compared to option 2 given the work by other Member States, which HMG, regulators and UK maritime sector could lean on.

As a result, compared to option 0 (do minimum), option 2 (legislate in advance of the IMO) is expected to have ongoing (regulatory) cost savings, given the ad-hoc nature of the current exemption process. These savings are expected to be realised across both 2022 to 2027 and 2028 onwards, which represents greater savings than option 1 (wait for IMO).

Illustrative WEI, risks, and unintended consequences

The primary risk in developing the domestic legal framework now is that the UK could diverge from international standards as they develop in the future, for example when defining terms and definitions of MASS. However, the UK will be able to take its experience on the regulation of MASS to the international discussions to shape that discussion to reduce this risk. Flexibility within the proposed changes to legislation will also ensure the domestic regulations can be amended to ensure they are in line with

international instruments and guidance as they are developed. There are also the following risks and unintended consequences:

- There is a risk relating to the public/industry perception of the level of detail and regulation the proposed changes to legislation would deliver. There will still need to be the development of secondary legislation and consultation on its contents which may disappoint or frustrate some within industry. This will need to be managed through careful communication with key stakeholders.
- An unintended consequence of removing the uncertainty around the use and development of autonomy is that the adoption of the technology might be greater than expected. This could potentially outstrip the supply of suitably qualified personnel or education of those operating in the maritime space. Either stifling the growth of maritime autonomy or leading to operators, masters and regulators not being able to react with full understanding of the situation.
- There is an uncertainty in how widely and to what extent maritime autonomy will be adopted in relation to surface vessels or how the growth of subsurface might change. This could result in a disproportionate effort to regulate a section of the maritime industry that could fail to deliver the expected returns to the UK economy.
- Without careful review and consideration of the amendments that are expected to be made to secondary legislation there is the danger of unintended consequences on the regulation of non-autonomous ships. Although all care will be taken and due diligence will be demonstrated, this risk should be acknowledged.
- By not waiting for international discussions and regulation to be finalised there is a danger that the UK may implement much more rigorous requirements than the IMO later introduce. This may put the UK autonomous industry and UK shipping at a competitive disadvantage with its international competitors. This may also impact on the ability of foreign flagged autonomous shipping being able to operate in UK waters, as it may be designed and operated to a lower standard than would be accepted in UK waters.

4.0 Wider impacts

Innovation Test

The emerging nature of autonomous shipping means that it is inherently innovative, and the proposed primary legislation is designed to enable HMG to better regulate the market and reduce barriers to entry. Without the legislation, there is a risk that other countries will benefit from this innovation to the detriment of the UK and therefore that we will not achieve the policy objectives.

At present, autonomous shipping is a relatively small market in the UK, with a handful of companies in R&D phases. These are legally permitted to operate on an exemption basis. This approach is expected to represent a barrier to innovation and growth as the market develops, and therefore a potential Government failure. Therefore, Government intervention is needed to put in place high level powers to develop a comprehensive regulatory framework and guidance to further enable a broad range of potential autonomous operations from and into the UK.

The options in this IA reflect the current structure of UK and international shipping legislation and are not intended to provide granular, prescriptive regulations at this stage given the emerging nature of maritime autonomy in the UK and abroad. The preferred option is designed to provide the UK with powers to regulate maritime autonomy as the market develops via secondary legislation under the proposed changes to primary legislation. The proposed legislation would apply to all vessels and craft regardless of size, including very small craft which might not traditionally be considered as 'ships'. The details of any secondary legislation will be determined at a later stage but are expected to cover specific segments or aspects of the autonomous shipping market.

Whilst the expected costs to business of subsequent secondary legislation, guidance and regulation may have adverse impacts on innovation, by virtue of it being more specific, the primary legislation as a whole is designed to enable innovation in the UK maritime sector by reducing barriers to entry for autonomous shipping. The approach considers a wide possible definition of maritime autonomy and therefore should not preclude any possible future types of autonomous shipping and as a result permit a wide range of innovation. It also mitigates the risk of designing a narrow legislative and regulatory framework that could become outdated quickly if the market moves at a different speed or direction than set out in legislation.

Small and Micro Business Assessment and Competition Assessment (SaMBA)

Small and Micro Businesses are classified as companies with 49 or fewer employees. This proposed legislation will apply to all businesses, regardless of size. However, it is not expected adversely impact competition. It is enabling legislation to cater for the emerging autonomous shipping market, and any business will be able to enter the market, provided they meet the conditions for vessel certification and registry.

The proposed legislation is expected to increase competition in the UK ship manufacturing, operation, and labour markets, and improve the UK's global competitiveness in these markets. Existing (incumbent) non-autonomous ship manufacturers, operators, and labours (Figure 7, Figure 8 and Figure 9) may be subject increased competition from autonomous ship manufacturers, operators, and the technology itself. For example, lower labour and operational costs for autonomous ships may allow autonomous shipping companies to offer lower prices than non-autonomous shipping companies, incentivising these companies to cut costs, potentially through adoption of autonomous shipping technology, and lower prices to compete.

Recently, there has been a growth in vertical and horizontal market integration in the global maritime transport sector, indicating a potential trend towards market shares being concentrated to a few businesses.[59] The minimum efficient scale for providing shipping services is large, which presents a natural barrier to smaller firms entering the market.[60] For example, there has been a trend towards larger container ships in recent decades, with Ultra Large Container Vessels (ULCVs) able to carry over 10,000 Twenty-foot Equivalent Unit (TEU) containers and the largest ship, HMM Algeciras (Panama), able to carry 24,000 TEU.[61]

[59] UNCTAD (2019b). Review of maritime transport 2019. Available at: https://unctad.org/en/PublicationsLibrary/rmt2019_en.pdf [Accessed 15/09/2020].
[60] The minimum efficient scale is the minimum level of output a firm needs to produce so that the cost per unit of output Is decreasing with increasing scale. If the minimum efficient scale is large, firms must produce a high level of output relative to the total industry output to operate efficiently and competitively in the market.
[61] Marine Insight 'Top 10 World's Largest Container Ships In 2021', 5 March 2021, available at: https://www.marineinsight.com/know-more/top-10-worlds-largest-container-ships-in-2019/

In addition, large capital requirements may act as a barrier to entry in the marine technology sector. To compete in the market entrants are required to invest a large amount of capital in both research and development as well as product development,[62] with increasing development costs the closer to market technologies get.[63]

In the UK water transport sector, the vast majority of businesses are Small and Micro-sized e.g. 94.7% of sea and coastal freight water transport companies have 49 or fewer employees. The same is true for the building of ships and boats sector, where 94.3% of companies have 49 or fewer employees (Figure 17). Whilst the companies may be impacted by the proposed legislation, in terms of familiarising themselves with the legislation and experiencing increased competition from autonomous ship manufacturers and operators, they could also gain from manufacturing and adopting autonomous shipping technology.

Figure 17 Business Population Estimates for the UK and regions 2020, Table 7 [64]

	Micro (1-9)	Small (10-49)	Medium (50-249)	Large (250+)
301 Building of ships and boats	80.0%	14.3%	3.8%	1.9%
501 Sea and coastal passenger water transport	78.7%	14.9%	4.3%	2.1%
502 Sea and coastal freight water transport	76.3%	18.4%	5.3%	0.0%
503 Inland passenger water transport	69.6%	26.1%	4.3%	0.0%
504 Inland freight water transport	85.7%	14.3%	0.0%	0.0%

For companies currently involved in autonomous vessel development in the UK (38) based on the smart shipping research, almost all that are solely focused on developing autonomous vessels (11) are classified as SMEs. The remaining companies that are involved in both developing autonomous vessels and other activities are skewed towards larger numbers of employees, with the largest of these, IBM, classified as a large enterprise (250+ employees).

The proposed legislation provides broad powers to permit increased business activity, which will provide new potential benefits to all businesses, regardless of size, as it is designed to improve access to the UK autonomous shipping market. The specifics of how this are implemented, which will determine any disproportionate impacts or barriers felt by SMBs, will be defined through secondary legislation. Any future SaMBA assessments will focus on the fixed costs and barriers to entry for SMBs e.g. standard rates for certification or legal fees.

Therefore, whilst the proposed legislation is not expected to disproportionately and adversely impact small companies, it has been designed to be flexible in order to both provide HMG with powers to regulate a range of maritime autonomy activities in the UK, but also reduce barriers to entry for SMEs and increase competition. This will be tested through consultation and the SaMBA and Competition Assessment will be considered for any further secondary legislation under the proposed changes to legislation.

Equalities Impact Assessment, Health Impact Assessment and Human Rights

There is a statutory duty to consider the effects of policies on those with protected characteristics under the Public Sector Equality Duty set out in the Equality Act 2010.

As set out in our evidence-based Equality Impact Assessment (unpublished), we consider that the approach to the safe operation, certification and inspection of autonomous shipping will not have a clear adverse or disproportionately negative impact on people who share a protected characteristic. Responses from the consultation will be used further to aid the assessment of the impact on groups of people with protected characteristics.

We also consider that the approach to powers to regulate and survey 'Remote Operation Centres' (ROCs) will not have a clear adverse or disproportionately negative impact on people who share a protected characteristic. Regulating the hours of work (or rest) for watchkeeping in a ROC will not have any significant impacts on people who share a protected characteristic.

[62] Port Technology International 'Successful Delivery Of Terminal Infrastructure', 2017, available at: https://www.porttechnology.org/technical-papers/successful_delivery/
[63] John Hopkins Applied Physics Laboratory 'Parametric Cost and Schedule Modeling for Early Technology Development', 2018, available at: https://www.jhuapl.edu/Content/documents/ParametricCostScheduleModeling.pdf
[64] HMG 'Business population estimates', 8 October 2020, available at: https://www.gov.uk/government/collections/business-population-estimates

We additionally consider that the approach to the requirement for an autonomous ship to have an entity or person who is accountable will not have any significant impacts on people who share a protected characteristic.

Evidence from the Seafarers in the UK Shipping Industry: 2020 report, summarises that most UK seafarers active at sea in 2020 were male (83%). Changes to legislation to enable autonomous shipping will therefore have a greater impact on the males. Impacts on the sexes may vary as the proposed changes to legislation could offer a stronger position for women in the industry.[53]

Seafarer statistics highlight that changes to legislation may have a bigger impact on the age groups 40–61-year-olds. Proportionally deck (70%) and engine (64%) ratings tended to be in this age range. As autonomous and remotely operated vessels would impact the amount of crew needed to operate a vessel 40–61-year-olds would likely be affected more significantly.[53]

Updating primary legislation to enable the operation of autonomous ships should offer opportunities to all groups active in the field. Further Equality Impact Assessments may be completed during the remaining decision-making process, and/or when secondary legislation is considered.

We do expect the proposal to affect or impact upon existing health inequalities. Updating primary legislation to enable to operation of remotely operated and autonomous vessels is expected to impact employment levels and skills within maritime. Evidence suggests there could be job losses, however, the development of automation could also create new types of employment within the sector.[6] Feedback from the consultation will also be used to aid the assessment on the impact on seafarers health.

The policy does not affect or contravene any measures contained in the Human Rights Act 1998.

Justice Impact Test – N/A

The final set of sanctions will depend on the outcome of consultation and the final set of autonomous shipping policies in the proposed changes to legislation, so it is too early to estimate the cost for the Criminal Justice System of non-compliance.

Trade Impact – N/A

Rural Proofing and Sustainable Development – N/A

Greenhouse Gases Impact Test/Wider Environmental – N/A

5.0 Consultation questions

The consultation will be used to test the evidence in this IA and gather information about both the relevant stakeholders for this legislation, in particular any businesses that may be directly or indirectly impacted, and the associated impacts for these stakeholders. Figure 18 shows the consultation questions for the IA.

Figure 18 Consultation questions for the impact assessment

Q1	Are there any stakeholders that are missing?
Q2	Are there any impacts that are either mispresented and/or missing?
Q3	What is the cost to businesses of the current approach to surveying, inspecting and registering autonomous ships in the UK?
Q4	Do you have any further evidence to support the baseline (or counterfactual) for maritime autonomy in the UK?
Q5	Are there any alternative options (including non-legislative options) that could achieve the same policy objectives? If so, please provide details, including costs, benefits and risks
Q6	Are there any regulatory costs or savings to businesses associated with preferred option 2 (legislate in advance of the IMO)? Please provide a qualitative description and monetary values in £ if possible

Q7	Do you agree or disagree with our assumptions about the timing, direction and scale of expected impacts for option 0 (do minimum)? If you disagree, please explain why
Q8	Do you agree or disagree with our assumptions about the timing, direction and scale of impacts expected impacts for option 1 (wait for IMO)? If not, please explain why
Q9	Do you agree or disagree with our assumptions about the timing, direction and scale of impacts expected impacts for option 2 (legislate in advance of the IMO)? If not, please explain why
Q10	Will Small and Micro Businesses (up to 49 employees) be disproportionately adversely affected by the proposed legislation? If yes, please explain why