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Significance of the Requirements for High-Risk AI Systems in the EU AI Act in an Autonomus Shipping Context

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Preface

This thesis was submitted in April 2025, marking the completion of my Master's degree in Law at the University of Oslo. The version published here is identical to the version originally submitted, aside from a few minor terminological adjustments.

The implementation of artificial intelligence across a wide range of societal functions is well underway – and the shipping industry will be no exception. This development calls for new regulation.

The topic of this thesis is the significance of the requirements for high-risk AI systems in the new EU AI Act in the context of autonomous navigation systems (ANS). I consider whether the requirements may apply to such systems deployed in commercial cargo shipping, and whether the requirements may have an indirect impact on regulations governing ANS via the Marine Equipment Directive or the "Brussels Effect". Finally, I provide reflections on possible approaches that the EU may adopt with respect to regulating ANS in the near future.

All these issues are closely linked to the interplay between EU law and the regulatory framework established by the International Maritime Organization (IMO), which receives considerable attention throughout the thesis. Please note that all references made to the draft of the upcoming "MASS Code" from the IMO are based on the version adopted at MSC 109 (December 2024). Although the draft was brought close to its final form at MSC 110 (June 2025), these developments do not affect the central arguments presented here.

I am sincerely grateful for the generous guidance and valuable contributions from Professors Erik Røsæg and Trond Solvang at the Faculty of Law, my colleagues at Kvale, and Sifis Papageorgiou at the Norwegian Maritime Authority.

Thank you to my clever, kind, and relentlessly funny friend Simon for every discussion and every bit of help – with law, and with things that were, frankly, far more important – from the very first week at university to the last.

Finally, to my family, and to my dear Julie – thank you for cheering me on, even through my many meaningless monologues about big boats.

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Sebastian Søyland

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1 Introduction

1.1 Thesis Topic, Research Questions, and Overview

As the technological developments of Maritime Autonomous Surface Ships (MASS) and artificial intelligence (AI) in shipping continue, the need to address new legal issues arises. Issues regarding liability in future accidents involving MASS have been frequently discussed in international legal literature in recent years.[1] Meanwhile, there has been less discussion on operational and regulatory requirements for these ships.

The Artificial Intelligence Act (AIA) was adopted by the EU in August 2024.[2] Its requirements for "high-risk AI systems" address issues such as transparency, human oversight measures, and cybersecurity.[3] These are central considerations in the development of MASS, particularly in relation to autonomous navigation systems (ANS).[4]

Against this background, the topic of this thesis is the significance of the requirements for high-risk AI systems in the AIA in the context of ANS. The topic will be examined through the lens of two research questions. First, in Chapter 3, I examine the substantive scope of the requirements and consider whether they may apply to ANS deployed in commercial cargo shipping. Second, in Chapter 4, I presume that the requirements do not apply to such ANS and consider whether the requirements may nevertheless have an impact on other regulations governing ANS. For the purpose of this thesis, I refer to this as the requirements having an "indirect impact".

Before I address these research questions, Chapter 2 sets out their actual and legal premises. This includes a conceptual clarification of ANS, and an introduction to the interplay between the EU and the International Maritime Organization (IMO) in the context of regulating MASS and ANS. Finally, in Chapter 5, I present conclusions to the research questions, and reflect on possible approaches that the EU may adopt with respect to regulating ANS in the near future.

1.2 The Need for Legal Clarity in Autonomous Shipping

Private stakeholders involved in financing, building, insuring and operation of MASS need to understand the standards that they must comply with. These standards have contractual implications regarding the construction of the ships and their equipment. They also affect the training and education of seafarers,[5] and

1 Inter alia in Béatrice Schütte, 'Damage caused by autonomous ships: towards regulation for civil liability in EU waters?' in Ellen J Eftestøl, Anu Bask and Maximilian Huemers (eds), *Towards a Zero-Emissions and Digitalized Transport Sector: Law, Regulation, and Logistics* (1st edn, Edward Elgar Publishing 2024); Bariş Soyer and Andrew Tettenborn, 'Autonomous Ships and Private Law Issues' in Bariş Soyer and Andrew Tettenborn (eds), *Artificial Intelligence and Autonomous Shipping: Developing the International Legal Framework* (1st edn, Hart Publishing 2021); Henrik Ringbom, Erik Røsæg and Trond Solvang (eds), *Autonomous Ships and the Law* (1st edn, Routledge 2021) Part III.

2 Regulation (EU) 2024/1689 (AIA).

3 The AIA Articles 13, 14 and 15, respectively.

4 Regarding transparency, see Andreas Nygard Madsen and Tae Eun Kim, 'A state-of-the-art review of AI decision transparency for autonomous shipping' (2024) 8 J. int. marit. saf. Regarding human oversight measures, see J (Hans) van den Broek, J R (Jaco) Griffioen and M (Monique) van der Drift, 'Meaningful Human Control in Autonomous Shipping: An Overview' (2020) 929 Mater. Sci. Eng. 012008, Section 3. Regarding cybersecurity, see Nimra Tabish and Tsai Chaur-Luh, 'Maritime Autonomous Surface Ships: A Review of Cybersecurity Challenges, Countermeasures, and Future Perspectives' (2024) 12 IEEE 17114.

5 Illustrated by the discussions in Gholam Reza Emad, Hossein Enshaei and Samrat Ghosh, 'Identifying seafarer training needs for operating future autonomous ships: a systematic literature review' (2021) 14 AJMOA 114.

they are likely to influence the determination of liability following accidents.[6] Furthermore, national maritime authorities need legal clarity, as they must know the standards that they are expected to enforce, who they are obligated to report to, and when and what to report.[7]

As of now, the only MASS-specific rules at the international level are interim guidelines for MASS trials.[8] So far, these guidelines have arguably provided sufficient regulatory coverage. However, if MASS are to become a meaningful part of global shipping, a clear, comprehensive and permanent international legal framework must be established.[9] The IMO is scheduled to introduce such a framework in May 2026, commonly referred to as the "MASS Code", with its final and mandatory version scheduled for adoption in 2030, and coming into effect in 2032.[10] Meanwhile, the requirements for high-risk AI systems in the AIA are set to come into effect in stages between 2025 and 2027, creating a need to clarify the relationship between the AIA and the MASS Code.

6 Felix Collin, 'Unmanned ships and fault as the basis of shipowner's liability' in Henrik Ringbom, Erik Røsæg and Trond Solvangs (eds), *Autonomous Ships and the Law* (1st ed, Routledge 2021) 91-93.

7 Hazel Sivori and Lauren Brunton, *Out of the Box. Implementing autonomy and assuring artificial intelligence in the maritime industry* (Lloyd's Register 2023) 29.

8 Thesis Sections 2.3.2 and 2.4 concerning the guidelines adopted by the IMO and the EU, respectively.

9 Henrik Ringbom, 'Developments, challenges, and prospects at the IMO' in Henrik Ringbom, Erik Røsæg and Trond Solvangs (eds), *Autonomous Ships and the Law* (1st ed, Routledge 2021) 57.

10 Maritime Safety Committee Session 109 Agenda item 5, *Development of a Goal-Based Instrument for Maritime Autonomous Surface Ships (MASS)* (5 December 2024) Annex II, *Revised Road Map for Developing a Goal-Based Code for Maritime Autonomous Surface Ships (MASS).*

2 The Actual and Legal Premises of the Research Questions

2.1 Autonomous Shipping

2.1.1 The global leap towards autonomous commercial shipping

The IMO refers to the developments in autonomous shipping as "rapidly evolving".[11] Furthermore, the maritime autonomy market has been expected to almost double in value from 2023 to 2028.[12] Certain MASS are already operating with full autonomy within national waters, like the MV Yara Birkeland in Norway.[13] A broader commercial deployment of MASS is likely in the future, including, eventually, on the high seas. Since MASS are expected to reduce the total costs of the shipowners, it is plausible that, once the technology and legal framework are established, many shipowners will need to adopt MASS and autonomous systems into their fleets to remain competitive.[14] In recent years, the global shipping community has observed significant breakthroughs in extensive, interdisciplinary projects such as the AUTOSHIP in Norway,[15] the MEGURI2040 in Japan,[16] and the KASS in South Korea.[17]

2.1.2 The concept of autonomous navigation systems (ANS)

For the purpose of this thesis, I define the concept of ANS inspired by the latest draft of the MASS Code from the IMO.[18] This refers to ANS as systems "which has the functionalities of situational awareness, route planning and determination for collision and grounding risk avoidance, ship's heading, speed and track control".[19] This definition distinguishes ANS from integrated navigation systems (INS), which feature complex *automatic* functions, but lack *autonomous* qualities.[20] INS are currently deployed by shipowners operating "conventional ships",[21] and have been regulated by IMO law for many years.[22]

Furthermore, this definition of ANS considers the systems as a whole, acknowledging that not all components of the systems must necessarily be located *on board* the ships. Hardware components such as cameras, lidars and radars will, of

11 The International Maritime Organization, *Autonomous shipping* (2025).

12 Sivori and Brunton (n 7) 14.

13 The maiden voyage as fully autonomous took place in March 2023. See Yara, *Yara Birkeland, two years on* (April 28 2024).

14 Lloyd's Register and Mitsui O.S.K. Lines, *Maritime Autonomous Surface Ships (MASS). Creating a framework for efficiency, safety and compliance* (Lloyd's Register 2024) 34.

15 SINTEF, *Breakthrough for autonomous ships* (2023).

16 Jasmina Ovcina Mandra, 'Japan takes its autonomous shipping to the next level' *Offshore Energy* (21 July 2023).

17 Kuehne+Nagel, *South Korea sets sights on fully autonomous ships by 2030* (8 July 2024); Korea Autonomous Surface Ship Project (2025).

18 Maritime Safety Committee Session 109 Agenda item 5, *Development of a Goal-Based Instrument for Maritime Autonomous Surface Ships (MASS)* (5 th of December 2024) (The draft MASS Code).

19 The draft MASS Code Section 4.7

20 ANS and INS are further differentiated in light of the AIA in Section 3.2.1 below.

21 Melih Akdağ, Petter Solnør and Tor Arne Johansen, 'Collaborative collision avoidance for Maritime Autonomous SurfaceShips: A review' (2022) 250 Ocean Eng. 110920, p. 1109234.

22 The Maritime Safety Committee Resolution 252(83), *Adoption of the Revised Performance Standards for Integrated Navigation Systems (INS)* (8 October 2007).

course, be on board.[23] However, certain hardware components providing input for the software systems may, for instance, be located on flying drones.[24]

Similar to the hardware, it is possible that essential software components may also not be located on board. A key issue addressed in both research questions of this thesis is where the autonomous qualities of the systems – metaphorically, the "brain" – will be located. This ultimately concerns the designs of the ANS, which are difficult to predict at this stage.

For instance, it is conceivable that the software that in fact independently makes the navigational decisions based on input from land, other ships, and its own equipment, is solely located on board the ship. That would place the autonomous qualities of the system on board the ship, leaving humans resuming control of navigation, either on board or in a Remote Operations Centre (ROC),[25] as the navigational alternative.[26]

However, one can also envision technical solutions where there are only *automatic* functions in the software on board the ships that, presumably via satellite, collect, organize and send raw data about the surroundings of the ship to *autonomous* software located in a ROC on land. Based on input from the ship, the autonomous software on land can then make navigational decisions that it sends back to the software on board the ship, which simply executes the commands it receives. One could even imagine a scenario in which multiple ships are connected to the *same* autonomous software system on shore. This system could coordinate input from all vessels, make navigational decisions on their behalf, and transmit these back to the ships.[27]

2.1.3 Thesis delimitation – focus on commercial cargo shipping

The scope of the research questions are limited to focus on ANS used in *commercial cargo shipping*. This excludes, for instance, ANS used in private or military settings. The purpose of this delimitation is to avoid unnecessary complexity in addressing the boundaries of the general scope of the AIA.[28]

2.2 The AIA and Its Requirements for "High-Risk AI Systems"

Regulating AI across various sectors in European society, the AIA is the first comprehensive regulation of its kind in the world.[29] The AIA currently applies within the EU member states.[30] However, the EU has marked the Act as EEA-relevant, and it will likely be implemented in the EEA Agreement. Norway, for example,

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23 DNV GL, *Study of the risks and regulatory issues of specific cases of MASS – Part 2* (European Maritime Safety Agency 25 March 2020) 23.

24 Zbigniew Pietrzykowski, Piotr Wołejsza, Łukasz Nozdrzykowski, Piotr Borkowski, Paweł Banaś, Ja-nusz Magaj, Jarosław Chomski, Marcin Mąka, Sylwia Mielniczuk, Anna Pańka, Paulina Hatłas-Sowińska, Eric Kulbiej and Magdalena Nozdrzykowska, 'The autonomous navigation system of a sea-going vessel' (2022) 261 Ocean Eng. 112104, 112108-112110.

25 I base my understanding of a ROC on the definition provided in the draft MASS Code Section 4.39.

26 Such designs of MASS and ANS are seemingly presumed by Oskar Levander in 'Autonomous ships on the high seas' *IEEE Spectrum Magazine* (Vol. 54, no. 2, pp. 26-31, February 2017) on page 29.

27 Such a design could be a natural answer to the requirement in the draft MASS Code that an autonomous navigation system "should effectively integrate and coordinate with other ship systems to prevent conflicting operational commands". See the draft MASS Code Section 17.3.1 EP3.

28 Thesis Section 3.2.

29 Council of the EU, *Artificial intelligence act: Council and Parliament strike a deal on the first rules for AI in the world* (2 February 2024).

30 The AIA Article 113.

has already stated its intention to promptly incorporate the Act into Norwegian legislation following its implementation.[31]

The AIA adopts a risk-based approach where an AI system is classified according to its level of risk. Some provisions in the AIA are general, while others are conditional upon the risk classification. AI systems can be deemed to pose minimal risk (not regulated), limited risk (certain requirements, primarily regarding transparency), "high-risk" (wide range of requirements), and unacceptable risk ("prohibited AI systems").

Both research questions of this thesis focus solely on the requirements for "high-risk AI systems". These are the requirements in Chapter III Sections 2-5 of the AIA. The focus on these specific requirements is due to their particular relevance for ANS, as illustrated in the introductory chapter of the thesis.

Pursuant to the AIA Article 113, the requirements apply from 2 August 2026. However, certain rules concerning notification come into effect on the 2 August 2025, and the obligations triggered by high-risk classification under the specific classification rule in Article 6(1) applies from 2 August 2027.[32]

2.3 Essential Aspects of IMO Law

2.3.1 The IMO – drafting the law of the sea

The IMO is an UN agency. Among its primary functions is the drafting of international legislation aimed at ensuring safety and security in global shipping.[33] The broad international support of the IMO is evidenced by the near-universal ratification of its core conventions.[34] The International Convention for the Safety of Life at Sea (SOLAS)[35] is undoubtedly the most important global convention for ship safety and equipment. It is ratified by 167 states, representing 99% of the commercial fleet of the world.[36] Similar to other IMO conventions, SOLAS requires its contracting parties to give the convention "full and complete effect" through domestic legislation.[37] The conventions of the IMO lack practical effect unless they are incorporated into national legislation and domestically enforced.[38]

Because IMO law is incorporated into domestic law, the formal authority to interpret its provisions rests with the respective states. However, the IMO issues non-binding circulars that specify how the conventions should be interpreted and implemented in practice.[39]

2.3.2 Existing regulations of ANS under IMO law

As stated in a 2023 report published by Lloyd's Register, the development of legal frameworks regulating AI in the shipping industry is likely to progress at a signifi-

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31 Government of Norway, Ministry of Local Government and Modernisation, *Forordning om kunstig intelligens (KI-forordningen)* (2025).

32 This is, however, impractical in the case of ANS. See Section 3.3.3 of the thesis.

33 Barbara Stępień, 'Navigating New Waters: IMO's Efforts to Regulate Autonomous Shipping' (2024) 23 Chin. J. Int. Law. 599, 602.

34 The International Maritime Organization, *Status of Conventions* (2025); Simon Baughen and Andrew Tettenborn, 'International Regulation of Shipping and Unmanned Vessels' in Bariş Soyer and Andrew Tettenborns (eds), *Artificial Intelligence and Autonomous Shipping: Developing the International Legal Framework* (Hart Publishing 2021) 7.

35 International Convention for the Safety of Life at Sea (adopted 1 November 1974, entered into force 25 May 1980) 1184 UNTS 278 (SOLAS).

36 Andreas Osnes, *SOLAS-konvensjonen* (Store Norske Leksikon 2 October 2024).

37 SOLAS Article I b).

38 International Chamber of Shipping, *Imo Conventions: Effective Implementation* (International Chamber of Shipping 2014).

39 International Chamber of Shipping, *Imo Conventions: Effective Implementation* (International Chamber of Shipping 2014).

cantly slower pace than the development of the technology itself.[40] Consistent with this, there is no comprehensive MASS-specific regulations in IMO law today.[41] The IMO issued MASS-specific guidelines in 2019.[42] However, these are brief, regard only *trials* with MASS, and were issued in a circular, which means that they, as a starting point, function as international soft law.[43]

Meanwhile, the existing conventions of the IMO apply to MASS. Some requirements currently pose clear obstacles to fully autonomous operations, for example in relation to watchkeeping standards.[44] However, most of the current requirements do not, in themselves, prohibit MASS operations. The real issue is the significant uncertainty around what it means for autonomous ships to actually comply with the requirements, as the IMO had only conventional ships in mind when drafting the conventions.[45] This uncertainty is openly acknowledged by the IMO, and constituted a central element of the underlying rationale for the MASS Code initiative.[46]

2.3.3 The upcoming MASS Code and its regulation of ANS

The MASS Code, together with any relevant circulars, will specify how the existing conventions are to be understood when applied to MASS. The current draft of the Code establishes requirements for ANS specifically,[47] complemented by general requirements regarding system design, software principles and alert functions that will also be of relevance to ANS.[48] Predictably, several of these requirements have no corresponding requirements in the current conventions.[49]

The MASS Code is scheduled for adoption at the IMO in a non-mandatory version in May 2026.[50] Being non-mandatory, IMO member states do not need to implement it in domestic law right away, although they are welcome to. The IMO will then enter an "experience-building phase" with a view to revise the non-mandatory Code in 2028. The finalized and mandatory version of the Code is scheduled for adoption at the IMO in July 2030, entering into force in January 2032. It is not yet clear how the IMO will implement the mandatory Code within the conventional framework, but a new chapter in SOLAS is currently being considered.[51] This will, in practice, require the 167 states that have ratified SOLAS to give the Code effect within their national legislation.[52]

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40 Sivori and Brunton (n 7) 28.

41 Barbara Stępień, 'Navigating New Waters: IMO's Efforts to Regulate Autonomous Shipping' (2024) 23 Chin. J. Int. Law. 599, 627-629.

42 The International Maritime Organization, *Interim Guidelines for Mass Trials*, MSC.1/Circ.1604 (14 June 2019).

43 Referred to as "informal law" in Anna Petrig, 'Unconventional Law for Unconventional Ships? The Role of Informal Law in the International Maritime Organization's Quest to Regulate Maritime Autonomous Surface Ships' Vessels' in Natalie Kleins (ed), *Unconventional Lawmaking in the Law of the Sea* (Oxford University Press 2022), Section 7.5.

44 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (adopted 7 July 1978, entered into force 28 April 1984) 1361 UNTS 190 (STCW), Chapter VIII Regulation 2(2)(1) regarding constant physical presence of on-watch officers at the bridge of the ship.

45 Lloyd's Register and Mitsui O.S.K. Lines (n 14) Section 4.4.

46 The draft MASS Code Preamble, para. 3.

47 The draft MASS Code Chapter 17.

48 The draft MASS Code Chapters 9, 10 and 14, respectively.

49 Seungje Jin and Kwangil Lee, 'Gap analysis and harmonization of International Standards for Maritime Autonomous Surface Ships' (2024) 2867 J. Phys. 012051.

50 The draft MASS Code Annex II.

51 The draft MASS Code Annex II

52 SOLAS Articles I and VI.

2.4 The Relationship Between IMO Law and EU Law in the Context of ANS – Introduction to the Marine Equipment Directive (MED)

Since ANS will be regulated under the MASS Code, both research questions in this thesis touch upon the relationship between EU law and IMO law. Therefore, in this section, I will briefly introduce key aspects of this relationship in the context of ANS, which will serve as premises for the discussions in the following chapters.

All members of the EU are members of the IMO, but the EU itself is not a member.[53] The European Commission holds an observatory status, but this does not come with obligations to regard IMO law in general.[54] Nevertheless, the legal work of the IMO enjoys great respect with the EU, which has traditionally taken active steps to give effect to and enforce IMO standards within EU law.[55] In this way, the EU ensures harmonized rules within the Union, while at the same time avoiding its member states facing potentially conflicting regulations from the EU and the IMO.

The EU has already demonstrated its commitment to IMO standards when it adopted its own guidelines for MASS trials, which largely referred to the guidelines previously issued by the IMO.[56] More importantly, when the IMO adopts the MASS Code, the Code may, to a certain extent, take effect within EU law through the Marine Equipment Directive (MED).[57]

The MED gives effect to certain requirements for "marine equipment" in the IMO conventions SOLAS, COLREGs and MARPOL,[58] including their "codes of mandatory application" that have entered into force.[59] Accordingly, if the mandatory version of the MASS Code is incorporated into SOLAS, the relevant provisions of the Code, including their relevant circulars, would be given effect within EU law via the MED. Conversely, the MED does not automatically give effect to the non-mandatory version of the Code. However, this version may arguably attain relevance as a form of provisional *de lege lata* in current interpretations of the conventions.[60]

The MED only gives effect to requirements for "marine equipment" that is to be "placed on board" an EU ship and "for which the approval of the flag State administration is required" by the conventional framework.[61] Therefore, an important question in the context of ANS is whether these systems constitute "marine equipment" that is to be "placed on board" ships, particularly in light of the fact that essential components of ANS may be land-based,[62] and that certain on-board components could be argued to constitute integrated structures of the MASS them-

53 The International Maritime Organization, *Member States* (2025). Note that three of the EFTA-states, Norway, Iceland and Switzerland, are also IMO members.

54 The International Maritime Organization, *Intergovernmental Organizations which have concluded agreements of cooperation with IMO* (2025).

55 Judith van Leeuwen and Kristine Kern, 'The External Dimension of European Union Marine Governance: Institutional Interplay between the EU and the International Maritime Organization' (2013) 13 GEP 69, 82-83.

56 *EU Operational Guidelines on trials of Maritime Autonomous Surface Ships (MASS)* (Version 1, October 2020)

57 Directive 2014/90/EU (MED).

58 Convention on the International Regulations for Preventing Collisions at Sea (adopted 20 October 1972, entered into force 15 July 1977) 1050 UNTS 16 (COLREGs); International Convention for the Prevention of Pollution from Ships (adopted 2 November 1973, modified by Protocol of 1978, entered into force 2 October 1983) 1340 UNTS 184 (MARPOL).

59 The MED Article 2(3).

60 Thesis Section 3.4.2.2.

61 The MED Article 3(1).

62 Thesis Section 2.1.2.

selves rather than equipment "placed" on board. I will discuss these issues in Chapter 3.[63]

63 Thesis Sections 3.4.2.2 and 3.4.2.3.

3 May the Requirements for High-Risk AI Systems Apply to Autonomous Navigation Systems?

3.1 Chapter Overview

In this chapter, I consider whether the requirements for high-risk AI systems in the AIA may apply to ANS deployed in commercial cargo shipping. The AIA sets out two main conditions that must be met for this to be the case. First, the ANS must fall within the general scope of the Act.[64] Second, the ANS must be classified as "high-risk AI systems".[65]

However, even if these conditions are met, the requirements may still not apply, as there are certain potential barriers that must be considered. I will briefly discuss one such barrier within the AIA itself, namely Article 2(2).[66] I will also, in greater detail, discuss whether the MED functions as *lex specialis* to the AIA and its requirements in the context of ANS, and thereby taking precedence.[67]

3.2 Are ANS Within the General Scope of the AIA?

3.2.1 Are ANS "AI systems"?

The AIA applies only to "AI systems", a term legally defined in Article 3(1) of the Act. The European Commission has approved guidelines on how to interpret this definition in practice.[68] The guidelines explicitly state that they are non-binding, and that the authority to interpret the AIA ultimately lies with the European Court of Justice (CJEU).[69] However, the very delegation of authority to issue the guidelines implies that they should carry decisive interpretative weight, unless superseded by interpretations from the CJEU or by other binding instruments of EU law.

The European Commission understands Article 3(1) to contain seven elements, although the elements do not necessarily need to be apparent at the same time in the "life" of an AI system.[70] Pursuant to the guidelines, an AI system is:

> "(1) a machine-based system; (2) that is designed to operate with varying levels of autonomy; (3) that may exhibit adaptiveness after deployment; (4) and that, for explicit or implicit objectives; (5) infers, from the input it receives, how to generate outputs (6) such as predictions, content, recommendations, or decisions (7) that can influence physical or virtual environments".[71]

64 Thesis Section 3.2.

65 Thesis Section 3.3.

66 Thesis Sections 3.3.1 (introduction) and 3.3.3 (demonstration of significance).

67 Thesis Section 3.4.

68 The European Commission, 'Approval of the content of the draft Communication from the Commission - Commission Guidelines on the definition of an artificial intelligence system established by Regulation (EU) 2024/1689 (AI Act)' COM (02 February 2025) 924 final (The Guidelines on the Definition of an AI system). Note that the guidelines are only approved and not formally adopted of the Commission as of April 2025.

69 The Guidelines on the Definition of an AI system, para. 7.

70 The Guidelines on the Definition of an AI system, para. 10.

71 The Guidelines on the Definition of an AI system, para. 9.

Requiring the system to be "machine-based" (1), the guidelines recognize a wide range of software and hardware components as being part of the AI system, which will undoubtedly encompass all necessary components of ANS.[72]

The elements 2 to 7 in the guidelines all refer to the autonomous qualities of the AI system. The general condition of autonomous operation (2) simply refers to the system having "some degree of independence of action", meaning being independent of human leadership.[73] This will be the case for ANS, for instance due to the ability of "determination for collision and grounding risk avoidance, ship's heading, speed and track control".[74] Essentially, ANS will function as the *brain* of the traditional navigating seafarer, making independent evaluations and decisions based on its existing knowledge or available data.[75]

Certain ANS will likely be able to adapt and evolve after deployment (3), and the systems will have explicit objectives (4). Please note that the third element is, in any case, not decisive for considering ANS as AI systems.[76]

The ANS must be able to infer from the input that they receive (5). Defining ANS as systems with "situational awareness", reacting to what they learn about the surroundings of MASS, they will satisfy the interference element.[77] As the reaction of the systems will take the form of navigational output, such as decisions on change of heading and speed,[78] element number 6 will be satisfied.[79] Finally, ANS will, of course, be able to influence physical environments (7).

In conclusion, ANS will likely be considered "AI systems" under the AIA. In particular, it is the aspects of autonomy, adaptiveness, and interference that will distinguish ANS from INS, which would not be classified as AI systems. Considering the recitals of the AIA, INS will likely be regarded as "simpler traditional software systems" that are "based on the rules defined solely by natural persons to automatically execute operations".[80]

3.2.2 The requirement for a responsible entity – illustrated by a shipowner

Requirements in the AIA only apply to legal subjects as defined in Article 2(1) of the Act. This provision outlines the roles such subjects must occupy within the AI value chain, such as "providers" or "deployers" of AI systems, and the connection that they must have to the EU in their capacity of those roles.

Since the research question at hand is limited to focus on the substantive scope of the requirements for high-risk AI systems in the *general context* of commercial cargo shipping, I will not provide discussions on all specific scenarios in which legal subjects may fulfill the criteria set out in Article 2(1). I will limit myself to pointing out that it appears realistic that certain stakeholders in commercial cargo shipping will satisfy these criteria. This can be illustrated through an example of a shipowner.[81]

First, a shipowner using an autonomous navigation system in commercial cargo shipping would qualify as a "deployer" of an AI system pursuant to the AIA Article

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72 The Guidelines on the Definition of an AI system, para. 11.

73 The Guidelines on the Definition of an AI system, para. 14, referring to the AIA Recitals para. 12.

74 The draft MASS Code Section 4.7.

75 Sivori and Brunton (n 7) 16.

76 The Guidelines on the Definition of an AI system, para. 23.

77 The draft MASS Code Section 4.7.

78 The draft MASS Code Section 4.7.

79 The Guidelines on the Definition of an AI system, paras. 58 and 59.

80 The AIA Recitals para. 12.

81 When I refer to a "shipowner", I refer to a legal subject within the Scandinavian concept of a "reder", as described in Thor Falkanger, Hans Jacob Bull and Lasse Brautaset, *Scandinavian Maritime Law* (4th edn, Universitetsforlaget 2017) Chapter 7.1.

3(4). Second, the shipowner will have the required connection to the EU if it has its "place of establishment or are located within the Union".[82] Furthermore, non-EU-based shipowners will also have sufficient connection if "the output produced" by the AI system is "used in the Union".[83] The output, being for instance decisions on navigation, will naturally be considered as used in the Union if it is employed in the steering of ships within EU territorial waters or ports,[84] in contrast to sailing the high seas.[85] Nonetheless, one may argue that output used in navigation on the high seas should be considered as used within the Union in the case of EU-flagged vessels, by analogy with the principle of flag state jurisdiction.[86]

3.3 Are ANS "High-Risk AI Systems"?

3.3.1 Two high-risk classification provisions – one with a potential barrier

An AI system can be classified as "high-risk" pursuant to the AIA Articles 6(1) or (2). As a starting point, the requirements for high-risk AI systems apply to systems that are classified as high-risk pursuant to Article 6(2). Under Article 6 (1), this is somewhat more complicated.

One of the conditions for high-risk classification under Article 6(1) is that the AI system is "covered by the Union harmonisation legislation listed in Annex I".[87] Annex I is divided into Sections A and B. In the Explanatory Memorandum to the AIA, this is referred to as a division of "New Legislative Framework" and "Old Approach legislation", respectively.[88] If the AI system is covered by the New Legislative Framework in Section A, and the conditions of Article 6(1) are otherwise met, the requirements for high-risk AI systems apply. Conversely, Article 2(2) decides that if an AI system is classified as high-risk under Article 6(1) on the basis of being covered by the Old Approach legislation in Section B, the requirements do *not* apply. Hence, classification under Article 6(1) may establish Article 2(2) as a barrier to applying the specific requirements for high-risk AI systems.

3.3.2 Legal value of current understandings due to pending clarifications

3.3.2.1 The starting point: a matter of interpretation

To determine whether ANS must be classified as "high-risk AI systems" under Articles 6(1) or (2), an interpretation of the provisions and their respective conditions is necessary. Interpretations of the AIA must be carried out in accordance with the method set out by the CJEU, being the supreme authority in all EU legal matters.[89] This essentially involves starting with a natural understanding of the wording in the context in which it stands, and in light of the objectives that the provision is

82 The AIA Article 2 (1) b).

83 The AIA Article 2 (1) c).

84 The United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 3 (UNCLOS) constitutes no barrier to the AIA regulating ANS in territorial waters, cf. UNCLOS Article 21(1) a).

85 UNCLOS Article 87.

86 UNCLOS Article 92.

87 Thesis Sections 3.3.3 (conditions) and 3.4.2.2 (assessment).

88 European Commission, 'Explanatory Memorandum to the Proposal for a Regulation laying down harmonized rules on artificial intelligence (Artificial Intelligence Act)' COM (2021) 206 final (The AIA Act Proposal Explanatory Memorandum) Section 1.2.

89 Treaty on European Union (TEU), (1992) OJ C 191/1, Article 19;Lorna Woods, Philippa Watson and Marios Costa, *Steiner & Woods EU law* (13th edn, Oxford University Press 2017) 46.

intended to achieve.[90] The AIA Article 1(1) sets out the "purpose" of the Act, and is therefore of great interest when interpreting Article 6. In contrast to Article 1(1), the Recitals and Explanatory Memorandum of the AIA are not binding, but they are still relevant, as they provide context.

3.3.2.2 Significance of the pending clarifications from the European Commission

However, conducting interpretations with a goal to find *de lege lata* in questions of high-risk classification may be premature as of April 2025. According to the AIA Article 6(5), the European Commission has an obligation to consult the European Artificial Intelligence Board, and then "provide guidelines specifying the practical implementation" of Article 6, as well as providing "a comprehensive list of practical examples of use cases of AI systems that are high-risk and not high-risk". The Commission has until 2 February 2026 to do so.

Given the broad language of Article 6(5), it can be assumed that the Commission has the authority to clarify whether ANS are "high-risk" or not. It is less certain whether the Commission is *obligated* to provide this clarification. Nonetheless, the primary concern for stakeholders in autonomous shipping must naturally be whether the Commission does or does not clarify this. Although it is difficult to predict with certainty what the Commission will address, it seems unlikely that it will bypass the practical question of ANS.

Article 6(5) does not specify whether the guidelines and the list of practical examples shall be considered legally binding for later interpretation. However, the European Commission has already approved guidelines on how to correctly understand both the concepts of "AI systems" and "prohibited AI systems".[91] Both sets of guidelines explicitly state that they are not to be considered binding, and that they do not affect the authority of the CJEU.[92] Accordingly, it is unlikely that the guidelines and the list regarding high-risk classification will be considered binding either. However, the very delegation of authority to issue the guidelines and the list implies that they should carry decisive weight when interpreting Article 6 (1) and (2), unless superseded by the CJEU or other EU law. Therefore, clarifications from the Commission on whether ANS are high-risk AI systems will likely be of significant practical importance.

3.3.2.3 Legal relevance of current interpretations

Despite the pending clarifications from the European Commission, current interpretations of the AIA Articles 6(1) and (2) are not necessarily without value. On the contrary, they may even offer insights into what the Commission can – and arguably should – clarify.

Harmony within EU law is important when adopting and understanding new EU legislation. This has a bearing on both the principle of creating legal

certainty in EU law, and the function of removing barriers on the internal market through successfully harmonizing rules of law within the Union.[93] This suggests that the Commission should recognize the benefit of their understandings of the AIA upholding conformity with and indirectly promoting the interpretive method of EU law, as set out by the CJEU. Furthermore, though the CJEU will likely

90 Sorina Doroga and Alexandra Mercescu, 'A Call to Impossibility: The Methodology of Interpretation at the European Court of Justice and the PSPP Ruling' (2021) 13 EJLS 87, 95-96.

91 Pursuant to the AIA Articles 96(1) f) and b), respectively.

92 The Guidelines on the Definition of an AI system para. 7; The European Commission, 'Approval of the content of the draft Communication from the Commission – Commission Guidelines on prohibited artificial intelligence system practices established by Regulation (EU) 2024/1689 (AI Act)' COM (04 February 2025) 884 final (The Guidelines on Prohibited Artificial Intelligence Practices) para. 5.

93 Woods, Watson, and Costa, *Steiner & Woods EU Law,* pages 171 and 335, respectively.

respect the clarifications, it still has the authority to overturn them, as recognized by the Commission in the previously adopted guidelines.[94] This also suggests that the Commission should set out understandings that could have emerged from plausible interpretations of the AIA.

In the following sections, I interpret Articles 6(1) and (2), considering whether ANS can be classified as "high-risk AI systems" under the current provisions. In section 3.3.5, I address how the European Commission can change the interpretive premises by altering the text of the AIA.

3.3.3 An interpretation of the AIA Article 6(1)

For an AI system to be classified as "high-risk" under Article 6(1), two cumulative conditions must be met. First, the AI system must be "covered by the Union harmonisation legislation listed in Annex I", or be a "safety component" of a product that is covered.[95] The Recitals clarify that being "covered" by legislation refers to falling within the substantive scope of that legislation.[96] Second, the AI system, or the product it is a safety component of, must be "required to undergo a third-party conformity assessment" pursuant to the same legislation.[97]

Annex I lists 20 alternatives of Union harmonisation legislation. Reviewing their scopes of application, I find that some of these may cover certain situations with autonomous systems and activities at sea.[98] However, the MED is essentially the only piece of listed legislation that may regulate ANS in commercial cargo shipping.

Reflecting the shifting regulatory paradigms in EU maritime law, the first version of the MED was recognized as a so-called "New Approach Directive",[99] while the current version is listed as "Old Approach Legislation" in the AIA Annex I Section B.[100] This means that the AIA Article 2(2) excludes ANS from the substantive scope of the requirements for high-risk AI-systems on the basis of being classified as high-risk under Article 6(1).[101] Hence, the decisive interpretive question is whether ANS may be classified as high-risk pursuant to Article 6(2).

3.3.4 An interpretation of the AIA Article 6(2)

3.3.4.1 High-risk classification pursuant to Article 6(2) – an overview

"In addition" to the systems that are high-risk under Article 6(1), Article 6(2) decides that "AI systems referred to in Annex III shall be considered to be high-risk". Annex III recognizes AI systems in any of eight listed "areas" as high-risk. One of these areas are "critical infrastructure", which is the only alternative standing out as relevant to consider in the case of ANS deployed in commercial cargo shipping. Article 6(3) sets out exceptions to Article 6(2), establishing criteria for when "an AI system referred to in Annex III shall not be considered to be high-risk".

94 The Guidelines on the Definition of an AI system para. 7, The Guidelines on Prohibited Artificial Intelligence Practises para. 5.

95 The AIA Article 6(1) litra a).

96 The AIA Recitals para. 49.

97 The AIA Article 6(1) litra b).

98 In particular Directive 2013/53/EU and Directive 2014/34/EU.

99 Helen Delaney and Rene van de Zande, *A Guide to EU Standards and Conformity Assessment* (1st edn, National Institute of Standards and Technology (U.S.) 2000) 2, referring to Directive 96/98/EC.

100 The AIA Act Proposal Explanatory Memorandum, Section 1.2.

101 Thesis Section 3.3.1.

3.3.4.2 Annex III, Section 2, "critical infrastructure" – what are the conditions?

In the area of critical infrastructure, Section 2 of Annex III recognizes AI systems "intended to be used as safety components in the management and operation of critical digital infrastructure, road traffic, or in the supply of water, gas, heating or electricity" as high-risk.

The general concept of "safety components" is legally defined in the AIA Article 3(14). However, the Recitals also provide a definition aimed specifically at Annex III, Section 2. This recognizes that "safety components" of the designated critical infrastructures in Annex III "are systems used to directly protect the physical integrity of critical infrastructure or the health and safety of persons and property but which are not necessary in order for the system to function".[102] The use of the word "system" twice is clearly unfortunate. The Recitals must logically be interpreted to refer to the AI system (the "safety component") the first time, and the relevant critical infrastructure entity the second time. This understanding is supported in legal literature.[103]

Read in light of the Recitals, Annex III, Section 2 sets out three conditions that must be met for an AI system to be considered as high-risk pursuant to Article 6(2). First, the AI system must fulfill a function related to protecting the physical integrity of infrastructure. Second, the system must not be necessary for the functioning of that infrastructure. Third, the infrastructure must be a type of "critical infrastructure" within the scope of Annex III, Section 2. In the following, I will apply these conditions to ANS.

3.3.4.3 Applying the conditions of infrastructure protection and non-necessity

First, the ANS must "directly protect the physical integrity" of critical infrastructure.[104] This will undoubtedly be the case, for instance through collision and grounding avoidance.

Second, the ANS must not be "necessary" for the critical infrastructure to "function".[105] Essentially, the ANS must only add qualities to already functioning critical infrastructure entities, and these qualities must essentially be intended to ensure or enhance safety.

On the one hand, MASS depend on ANS to function once the systems are put into use during a voyage, as they are making the decisions that navigate the ship safely from point A to point B. This may indicate that, when in use, ANS could be considered "necessary".

On the other hand, one could argue that ANS, in many cases, simply represent an *opportunity* for shipowners to enhance the safety of their vessels and voyages. Using ANS is not "necessary" in commercial cargo shipping as such, since the conventional ships of today only use INS, or other systems for navigation. Furthermore, ANS will arguably not be "necessary" in the operation of the MASS of the future either, as these will allow for the Master to switch back to human-based navigation at any time during a voyage.[106] This must be seen in connection with one of the main ideas of autonomous shipping development, which is safety enhancement and reduction of accidents. This is illustrated both by the focus

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102 The AIA Recitals para. 55.

103 Paul Voigt and Nils Hullen, *The EU AI Act: answers to Frequently Asked Questions* (1st edition, Springer 2024) Sub-Chapter 3.1.2.2.

104 The AIA Recitals para. 55.

105 The AIA Recitals para. 55.

106 Which will certainly be required by the MASS Code, see the draft MASS Code Section 17.5.

areas of specific MASS projects,[107] and by the broader rationale underpinning the development of the MASS Code.[108] These arguments strongly support that ANS fall within the category of safety-enhancing but non-necessary AI systems. Accordingly, the most plausible interpretation is that ANS satisfy the second condition.

3.3.4.4 Applying the third condition – is autonomous shipping covered critical infrastructure under Annex III, Section 2?

The question is whether ANS qualify as safety components of the critical infrastructures listed in Annex III, Section 2. Essentially, the question is whether autonomous ships and shipping are covered infrastructures.

Pursuant to the wording, the Annex only recognizes "critical digital infrastructure, road traffic" and "the supply of water, gas, heating or electricity" as covered critical infrastructures. In its position paper to the AIA proposal from the European Commission, Norway advocated that "AI systems for autonomous shipping" should be covered.[109] Although this was not reflected in the final wording, the question remains whether one of the specifically listed categories in Annex III nonetheless encompasses autonomous shipping.

ANS are not safety components in "road traffic", nor are they likely to be considered safety components in "critical digital infrastructure". The latter concept is not defined in the AIA, but the Recitals refer to "critical digital infrastructure as listed in point (8)" of the Annex to the Critical Entities Resilience Directive (CER).[110] The CER refers to legal entities responsible for "digital infrastructure" in the Directive (EU) 2022/2555 (NIS2) Article 6. This may give an indication of what such infrastructure may be.[111]

The NIS2 Article 6 concerns physical infrastructures in digital services.[112] Within MASS operations, the closest analogue is likely to be ROCs. Although ROCs will depend on the physical infrastructures in NIS2 to remotely operate and monitor MASS, the ROCs will likely not qualify as such infrastructures themselves. However, even if they did, ANS would then no longer be considered their "safety components".[113]

Therefore, the decisive question is whether ANS can be considered safety components in the "supply of water, gas, heating, or electricity". The alternative of interest is gas suppliance, as it raises the question of whether the shipping of liquefied natural gas (LNG) and liquefied petroleum gas (LPG) constitute such.

In order to reduce costs and improve safety, LNG and LPG carriers of the future may be equipped with ANS. For instance, Kongsberg Maritime in Norway and Samsung Heavy Industries in South Korea are currently collaborating on a design for an autonomous LNG carrier,[114] and Polish researchers have performed collision

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107 T. Porathe, Å. Hoem, Ø. Rødseth, K. Fjørtoft and S. Johnsen, *At least as safe as manned shipping? Autonomous shipping, safety and "human error"* (SINTEF and NTNU 2018);Jiri de Vos, Robert G. Hekkenberg and Osiris A. Valdez Banda, 'The Impact of Autonomous Ships on Safety at Sea – A Statistical Analysis' (2021) 210 Ocean Eng. 107558, Section 5.

108 The draft MASS Code Preamble para. 3.

109 Government of Norway, Ministry of Local Government and Modernisation 'Norwegian Position Paper on the European Commission's Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts (COM(2021) 206)' (2021) Section 5.

110 The AIA Recitals para. 55, referring to the Directive (EU) 2022/2557 (CER).

111 Voigt and Hullen (n 103) Sub-Chapter 3.1.2.2.

112 These are infrastructures such as internet exchange points, domain name systems, and cloud computing systems.

113 Systems providing fire alarm control, or similar, are more likely to qualify as safety components of the ROCs, as exemplified with cloud computing systems in the AIA Recitals para 55.

114 Ship Technology, *SHI and Kongsberg partner on autonomous LNG carrier design* (21 March 2023).

avoidance tests with positive results with an autonomous LNG carrier model in quasi-real conditions.[115]

The concept of *supplying gas* is neither defined nor exemplified in the text of the AIA, the Recitals, or the Explanatory Memorandum. However, the AIA defines the general concept of "critical infrastructure" in Article 3(62). It does so by referring to Article 2(4) of the CER. The CER may therefore shed light on how to correctly interpret the more specific critical infrastructures of the AIA Annex III, such as gas suppliance. Legal authors are of the same impression.[116]

Article 2(4) of the CER generally defines "critical infrastructure" as "an asset, a facility, equipment, a network or a system", or a part of such, "which is necessary for the provision of an essential service". Through a delegated act from the European Commission in 2023, the CER generally recognizes freight transport at sea as an "essential service" under Article 2(4).[117] Consequently, LNG and LPG shipping qualify within the *general category* of "critical infrastructure" in both the CER and the AIA. One may argue that considering LNG and LPG shipping as "critical infrastructure" under the specific *gas suppliance* alternative in the AIA Annex III will simply respect the conceptual link that the AIA Article 3(62) sets out between the AIA and the CER.

In the specific gas subsector, the Annex of the CER refers to critical infrastructures by pointing to certain definitions in Article 2 of the Directive 2009/73/EC (Gas Directive). This directive was repealed and replaced by the Directive (EU) 2024/1788 in August 2024. However, there are no decisive differences between the two Gas Directives with regard to the question at hand. Although both concern, for instance, the "supply" of LNG in the EU, this does not encompass LNG *shipping*. At the same time, this does not necessarily exclude LNG and LPG shipping from being considered gas suppliance under the AIA Annex III, Section 2. The positive examples of critical infrastructures in the gas subsector set out in the Gas Directives must be understood as just that – examples of what *is* critical infrastructure, and not necessarily a basis to conclude what it is *not* under the AIA.

In contrast, the Recitals of the AIA specify that "critical digital infrastructure" should be considered "as listed" in the CER Annex, leaving little room for extensive interpretation.[118] The Recitals do not refer to the CER in this way when it comes to gas suppliance. This suggests that there is room to perform a broader interpretation of the gas suppliance concept. Such an interpretation, however, must arguably align with the objectives of the AIA.

The AIA is intended to ensure a "high level of protection" for health and safety.[119] Consistent with this, the Recitals focus on how the significance of critical infrastructure becomes evident in society if the safety components of the infrastructure fail or malfunction. According to the Recitals, such failure or malfunctioning may lead to "appreciable disruptions in the ordinary conduct of social and economic activities".[120] More importantly, it can result in "serious harm to the provision of basic supplies to the population", which may lead to "an imminent threat to life or the physical safety of a person".[121]

Several European countries import large amounts of gas for heating and production of electricity. The gas is most commonly transported through pipelines,

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115 Zbigniew Pietrzykowski, Piotr Wołejsza, Łukasz Nozdrzykowski, Piotr Borkowski, Paweł Banaś, Janusz Magaj, Jarosław Chomski, Marcin Mąka, Sylwia Mielniczuk, Anna Pańka, Paulina Hatłas-Sowińska, Eric Kulbiej and Magdalena Nozdrzykowska, 'The autonomous navigation system of a sea-going vessel' (2022) 261 Ocean Eng. 112104, Section 3.2.

116 Voigt and Hullen (n 103) Sub-Chapter 3.1.2.2.

117 Commission Delegated Regulation (EU) 2023/2450.

118 The AIA Recitals para. 55.

119 The AIA Article 1(1).

120 The AIA Recitals para. 55.

121 The AIA Recitals para. 33.

but in some supply chains, it is also transported as LNG and LPG at sea.[122] The failure of ANS in LNG and LPG shipping can lead to accidents with severe damage to the MASS, crew, and other ships, in addition to serious environmental damage. Furthermore, malfunctions in ANS could affect and delay multiple LNG and LPG carriers simultaneously, which may prevent significant amounts of gas from reaching its destinations on time.[123] Such delays may have immediate disruptive effects on European societies. Illustrated by the European challenges following the Russian invasion of Ukraine, the International Energy Agency (IEA) emphasized that "reliance on imported natural gas for electricity can lead to painful price spikes when supplies are disrupted".[124]

In conclusion, an interpretation of Annex III, Section 2, suggests that ANS may be regarded as safety components in critical infrastructure when that infrastructure is LNG or LPG shipping. In such a scenario, the ANS would qualify as high-risk AI systems under Article 6(2).

3.3.4.5 The exception to Article 6(2) – can the European Commission rule out ANS as high-risk AI systems under Article 6(3)?

The chapeau of the AIA Article 6(3) decides that when an AI system "does not pose a significant risk of harm to the health, safety, or fundamental rights of natural persons, including by not materially influencing the outcome of decision making", it shall not be considered high-risk under Article 6(2). The provision further identifies four situations in which this condition is presumed to be fulfilled. As it is summarized in legal literature, the systems in the four listed cases should only support human decision or activity.[125] In such cases, *de facto* decision-making power remains with humans, while the AI systems merely assist the humans as a tool.

For the purpose of this thesis, ANS are capable of making navigational decisions independently, without necessarily requiring approval from a human being.[126] Accordingly, ANS are unlikely to qualify for an exception from Article 6(2) pursuant to Article 6(3).

3.3.5 Can the European Commission make changes to the current provisions?

The European Commission might ultimately prefer for the AIA to not apply within the shipping industry, and could therefore, pursuant to Article 6(5), clarify that ANS do not constitute high-risk AI systems. Such a position may be driven by political considerations, or stem from the *lex specialis* concerns discussed below.[127] However, a plausible interpretation of the current Article 6(2) suggests that ANS in LNG and LPG shipping may be considered as high-risk AI systems.[128] Therefore, a clarification contradicting this would arguably be unfortunate, as it would not promote the interpretive method in EU law.[129] Conversely, the European Commission might instead prefer the AIA to regulate autonomous navigation *beyond* LNG and LPG shipping, which there is not much support for in current interpretations either.

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122 The International Energy Agency, *Gas imports and exports* (2025).

123 Such simultaneous failure may, for instance, be due to many ships, with different shipowners, being connected to the same autonomous navigation system or ROC, where there is an error, or is subject to a successful cyberattack. See Section 2.4 of the thesis regarding designs of ANS.

124 The International Energy Agency, *Natural gas in electricity generation* (2025).

125 Voigt and Hullen (n 103) Sub-Chapter 3.1.2.10.

126 Thesis Section 2.1.2 and the Draft MASS Code Section 4.7.

127 Thesis Section 3.4.

128 Thesis Section 3.3.4.

129 Thesis Section 3.3.2.3.

A pragmatic solution for the Commission in these scenarios would simply be to amend the text of AIA. Although the Commission is not one of the legislative bodies of the EU,[130] it can, if authority is correctly provided, adopt delegated acts.[131] In contrast to clarifications under the AIA Article 6(5), delegated acts are legally binding.

The AIA Articles 6(6), 6(7), 7(1) and 7(3) empower the Commission to amend or remove the text of Article 6(3) and Annex III, and hence alter the premises for high-risk classification under Article 6(2). It is important to note that the Commission, pursuant to all these provisions, must be able to justify that certain conditions are met.[132] I will not discuss all these conditions, but limit myself to outlining a practical example in Article 7(1). If an AI system meets certain risk-related criteria,[133] the provision grants the Commission the authority to amend Annex III to include that system, provided that the system is "intended to be used in any of the areas listed" in the Annex.[134] Since freight transport at sea is generally recognized as falling within the scope of "critical infrastructure" in Annex III,[135] the Commission could include "AI systems for autonomous shipping" in the wording of Annex III, as proposed by the Government of Norway in 2021.[136]

3.4 Is the MED *Lex Specialis* to the AIA in the Context of ANS?

3.4.1 Legal grounds to establish the MED as *lex specialis*

I will now consider whether the MED precludes applying the requirements for high-risk AI systems to ANS, on the basis that the MED is *lex specialis* to the AIA in this context.

It is not necessary for an EU legal act to explicitly state that it takes precedence over another in order to be considered *lex specialis*. It is a general principle of EU law that "special provisions prevail over general rules in situations which they specifically seek to regulate".[137] However, in the case of the MED, Article 3(2) explicitly provides that:

"Notwithstanding the fact that the equipment referred to in paragraph 1 may also fall within the scope of instruments of Union law other than this Directive, that equipment shall, for the purpose set out in Article 1, be subject only to this Directive."

The Recitals of the MED confirm that the provision serves to designate the Directive as *lex specialis* in certain situations.[138]

130 TEU Article 17.

131 Treaty on the Functioning of the European Union (TFEU), (2012) OJ C 326/47 Article 290.

132 Treaty on the Functioning of the European Union (TFEU), (2012) OJ C 326/47 Article 290.

133 The AIA Article 7(1) litra b).

134 The AIA Article 7(1) litra a).

135 Pursuant to the AIA Art 3(62), referring to the CER Art 2(4), read in light of Commission Delegated Regulation (EU) 2023/2450.

136 Government of Norway, 'Norwegian Position Paper' (n 109) Section 5.

137 Joined Cases T 60/06 RENV II and T 62/06 RENV II, *Italian Republic and Eurallumina SpA v European Commission* (2016) ECLI:EU:T:2016:233, para. 81.

138 The MED Recitals para. 4.

3.4.2 Significance of the MED Article 3(2) in relation to the AIA and ANS

3.4.2.1 The two conditions – parallel application and overlapping purposes

For the MED to be regarded as *lex specialis* to the AIA in the context of ANS, Article 3(2) indicates that two cumulative conditions must be fulfilled.

First, the ANS must "fall within the scope" of application of both the AIA and the MED. This chapter proceeds on the assumption that the requirements for high-risk AI systems may be applied to ANS, at least in certain situations, pursuant to the conditions in the AIA. The remaining issue is whether ANS also fall within the scope of the MED, creating a possible parallel application of the AIA and the MED.

Second, the *lex specialis* effect of the MED is limited to "the purpose set out in Article 1" of the Directive. Consequently, for the MED to override the AIA, the AIA must pursue a regulatory purpose that overlaps with the one of the MED.

3.4.2.2 The first condition – are ANS regulated by the MED?

As previously outlined, the question of whether the MED covers ANS gives raise to two principal issues – namely the role of the MASS Code in the MED, and the geographical location and design of an autonomous navigation system in relation to the scope of the MED.[139]

First, the MED only gives effect to requirements set out in SOLAS, COLREGs, and MARPOL. None of these currently provide comprehensive regulation of ANS or its components. This regulatory gap will be filled by the upcoming MASS Code.[140] Once the mandatory version of the MASS Code is adopted under the conventions, likely under SOLAS, and enters into force, its requirements will be given effect through the MED. This is scheduled for 2032.[141] Nonetheless, I assume that the non-mandatory version of the MASS Code will serve as a form of provisional *de lege lata* when interpreting the conventions in a MASS context, in the absence of any mandatory MASS-specific regulations from the IMO. Furthermore, several member states of the EU might adopt the non-mandatory MASS Code. Consequently, it is reasonable to assume that the MASS Code will, in practice, have to be taken into account under the MED already from the time of its adoption in 2026.

Second, the MED only gives effect to requirements for "marine equipment" that is to be "placed on board" an EU-flagged ship and "for which the approval of the flag State administration is required by the international instruments".[142] I presume that the IMO, as a continuation of its work on the MASS Code, will ensure that both ANS as a whole and its components will need flag state approval under the current conventional framework. The legally contentious question is whether ANS are "marine equipment" that is to be "placed on board" ships.

While the MED applies to equipment, and not systems, it differs from both the AIA and the MASS Code. However, Annex I of the AIA appears to presume that the MED can in fact cover "AI systems".[143] This implies that the MED must be capable of covering AI systems, such as ANS, by encompassing the specific components ("equipment") that together constitute the "AI system" under the AIA.

The fact that the equipment must be "placed" on board may suggest that it should be easily removable too. However, this should arguably not be interpreted

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139 Thesis Section 2.4.

140 Seungje Jin and Kwangil Lee, 'Gap analysis and harmonization of International Standards for Maritime Autonomous Surface Ships' (2024) 2867 J. Phys. 012051.

141 The draft MASS Code Annex II.

142 The MED Article 3(1).

143 Thesis Section 3.3.3.

too strictly. INS are currently covered by the MED, and many of their components are deeply integrated into the core structures of the vessel.[144]

A natural interpretation of the condition that the equipment must be placed "on board" suggests that, in order to fall within the scope of the MED, the equipment must be *physically located* on board the ship. However, not all components of ANS will necessarily be situated on board.[145] Autonomous software components located on shore will, as a starting point, fall outside the scope of the MED.

This raises the question of whether the phrase "on board" can be interpreted broadly so as to include all necessary components of ANS, regardless of their physical location. Pursuant to the interpretive method set out by the CJEU, provisions of EU law must be interpreted in light of their purpose.[146] At the same time, the CJEU is exceptionally reluctant to depart from the natural understanding of a clear wording.[147]

The MED is a dynamic instrument of nature. It explicitly acknowledges the "constant evolution" of international marine equipment standards, and it is designed to align EU law with these developments – partly to ensure legal harmonisation, and partly to facilitate the free movement of such equipment within the Union.[148] The Directive was originally drafted with conventional ships in mind, where INS would be physically located on board.[149] With the upcoming MASS Code, the IMO implicitly recognizes that some marine equipment essential to navigation of MASS may not be located on board the ships.

Against this background, it may be argued that all components recognized as part of ANS under the MASS Code should fall within the scope of the MED as well, even if located on shore. Nonetheless, it is my understanding that this interpretive approach pushes the limits of what is permissible under the current, quite clear wording. It would likely be more appropriate to address this through an amendment of the MED, rather than by stretching its current scope.[150]

In conclusion, pursuant to an interpretation of the MED, the Directive only covers components of ANS that are physically located on board EU ships.

3.4.2.3 Implications for the substantive scope of the AIA that land-based components of ANS fall outside the scope of the MED

Since the MED only covers marine equipment that is physically placed on board ships, it cannot be *lex specialis* to the AIA in cases where the latter regulates purely land-based AI systems. If this were to be the case, a question is whether the land-based components of an autonomous navigation system in isolation can qualify as an "AI system".[151] This would, of course, require the autonomous software components of the system to be located on shore.[152] However, even if this were to be the case, it appears unlikely, as an AI system includes all software and hardware components that "enable the AI system to function".[153] That said, it

144 Regulation (EU) 2024/1975, MED/4.59.

145 Thesis Section 2.1.2.

146 As arguably set out originally in Case C-77/83 *Srl CILFIT and others and Lanificio di Gavardo SpA v Ministero della sanità* (1984) EU:C:1984:91, cf. Sorina Doroga and Alexandra Mercescu, 'A Call to Impossibility: The Methodology of Interpretation at the European Court of Justice and the PSPP Ruling' (2021) 13 EJLS 87, 95-96.

147 Koen Lenaerts and José A Gutiérrez-Fons, *To Say What the Law of the EU Is: Methods of Interpretation and the European Court of Justice* (Academy of European Law, September 2013) 7.

148 The MED Article 1 and Recitals para. 4.

149 Regulation (EU) 2024/1975, MED/4.59.

150 Thesis Section 5.3.2.

151 Pursuant to the definition in the AIA Article 3(1), see Section 3.2.1 of the thesis.

152 Which is not inconceivable, see thesis Section 2.4.

153 Guidelines on the Definition of an AI system, para. 11.

remains difficult to reach a definitive conclusion on this issue without insight into how ANS will ultimately be designed and operate.

3.4.2.4 The second condition – do the purposes of the AIA and the MED overlap?

The AIA Article 1(1) outlines the "purpose" of the Act, while the Recitals and the Explanatory Memorandum provide further elaboration and context. This provides for a natural basis of comparison with the purpose set out in the MED Article 1.

As a starting point, the purpose of the AIA is significantly broader than that of the MED. Certain elements in the purpose of the AIA, such as ensuring democracy and supporting innovation, is not reflected within the purpose of the MED. Therefore, it is necessary to consider whether the MED Article 3(2) requires a *complete* overlap in purposes.

When describing the legislation that the MED will be *lex specialis* to, the Recitals refer to "other instruments of Union law which lay down requirements and conditions, inter alia, in order to ensure" certain elements of the purpose in its Article 1.[154] The phrase "inter alia" arguably acknowledges that the *lex specialis* function will apply despite the fact that the relevant EU instruments pursue other elements within its purposes as well. This is quite logical. Extensive *lex generalis* instruments will often have more detailed and multifaceted purposes than the MED has in its field of marine equipment regulation. Therefore, I interpret the MED Article 3(2) to not require a complete overlap in purposes – it is sufficient that there *is* an overlap.

As long as any overlap is sufficient, this condition appears to be met in the case of the AIA and the MED. First, the MED seeks to "ensure the free movement" of marine equipment within the EU.[155] Similarly, the AIA aims to "improve the functioning of the internal market"[156] and ensure "the free movement, cross-border, of AI-based goods and services."[157] In the context of AI-based navigational equipment, these purposes must be considered to overlap.

Second, the MED seeks to "enhance safety at sea and to prevent marine pollution through the uniform application" of international instruments like SOLAS, COLREGs and MARPOL.[158] When comparing the objective of marine pollution prevention with purposes in other EU legislation, it follows from the Recitals that this can be equated with the more general concept of "environmental purposes".[159] The AIA shall "ensure a high level" of safety and environmental protection. The AIA differs from the MED in that it aims to ensure such protection "against the harmful effects of AI systems." At the same time, the essence is that the AIA, like the MED, is intended to address fundamental safety and environmental concerns.

In conclusion, it appears to be an overlap between the purposes of the AIA and the MED. This suggests that the MED is *lex specialis* to the AIA in the context of ANS. It may also be argued that the AIA implicitly supports this conclusion. Article 2(2) of the AIA prevents the requirements for high-risk AI systems from being applied to systems covered by the MED.[160] This exclusion may be interpreted as an acknowledgment that the AIA pursues regulatory objectives similar to those of the MED, thereby activating the *lex specialis* principle. However, this is not explicitly stated in the AIA, nor in its Recitals or the Explanatory Memorandum.

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154 The MED Recitals para. 4.

155 The MED Article 1.

156 The AIA Article 1(1).

157 The AIA Recitals para.1.

158 The MED Article 1, referring to the "international instruments" in Article 2.

159 The MED Recitals para. 4.

160 High-risk classification pursuant to the AIA Article 6(1), see Sections 3.3.1. and 3.3.3 of the thesis.

3.4.2.5 Significance of the lex specialis function only applying to "EU ships"

The *lex specialis* function of the MED will only extend to components of ANS that are physically on board an "EU-ship". An "EU ship" is defined as a vessel "flying the flag of Member State" of the EU.[161] Just as non-EU shipowners may fall within the general scope of the AIA,[162] ANS on board non-EU-flagged ships may be regulated by the AIA. The *lex specialis* function of the MED does not apply to components of ANS on board such vessels.

3.4.3 Significance of the pending clarifications from the European Commission

The pending clarifications from the European Commission regarding high-risk classification may prove significant in clarifying the relationship between the AIA and the MED.[163] The AIA Article 6(5) provides that these clarifications shall concern the practical implementation of the high-risk classification provisions "in line with Article 96." Article 96(1) litra e) states that the guidelines shall contain "detailed information" on the relationship between the AIA and Union harmonisation legislation listed in Annex I, such as the MED, "including as regards consistency in their enforcement". In order to fulfil this mandate, the Commission must arguably clarify to what extent the MED constitutes *lex specialis* in relation to the AIA – for instance in the case of ANS.

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161 The MED Article 2(2). This includes the EFTA states, such as the coastal states Iceland and Norway, since the MED is incorporated into the EEA agreement.

162 Thesis Section 3.2.2.

163 Thesis Section 3.3.2.

4 The Question of Indirect Impact

4.1 Chapter Overview and the Concept of "Indirect Impact"

In this chapter, I consider whether the requirements for high-risk AI systems in the AIA may have an impact on other regulations governing ANS even if the requirements in the AIA do not apply. In the following, when I refer to this as "indirect impact", I am not referring to the concept of "indirect effect", which essentially is a principle of interpreting domestic law in the spirit of EU law when the latter suffers from unintentional gaps or is not successfully implemented in domestic law.[164]

First, I consider whether the requirements may have an indirect impact within EU law through the AIA Articles 2(2) and 105. Then, I look beyond EU law, considering whether the requirements can have an impact on domestic regulations of ANS through the "Brussels Effect".

4.2 Impact Within EU Law

4.2.1 The mechanism in the AIA Article 2(2), and the new MED Article 8(5)

If ANS are classified as high-risk AI systems under the AIA Article 6(1) on the basis that they are covered by the MED, Article 2(2) prevents the requirements for high-risk AI systems to apply via Article 6(1).[165] However, Article 2(2) decides that other provisions of the AIA apply in these situations. For ANS, Article 105 is the provision of relevance.

The AIA Article 105 amends the MED Article 8 with a new (fifth) paragraph. The new paragraph requires the European Commission to "take into account" the system-oriented requirements for high-risk AI systems in the AIA Chapter III, Section 2, when performing its activities pursuant to the MED Article 8(1), and when exercising its authority pursuant to the MED Articles 8(2) and (3). The two latter provisions are discussed below.[166] The MED Article 8(1) does not directly concern EU-regulation of ANS, but I will touch upon the provision when considering the "Brussels Effect".[167]

As determined by the AIA Article 2(2), Article 8(5) of the MED applies only to AI systems that are classified as high-risk pursuant to the AIA Article 6(1).[168] Also, Article 8(5) limits its scope to AI systems that are "safety components within the meaning" of the AIA.[169]

4.2.2 The ANS must be classified as high-risk pursuant to the AIA Article 6(1)

Pending clarification from the European Commission, the question of whether ANS constitute high-risk AI systems under the AIA Article 6(1) remains a matter of interpretation.[170] The provision demands that ANS are "covered" and "required to undergo a third-party conformity assessment" by the MED.[171]

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164 Also referred to as the "doctrine of consistent interpretation" in legal literature, see Robert Schütze, *An Introduction to European Law* (4th edn, Oxford University Press 2023) 129.

165 Thesis Section 3.3.3.

166 Thesis Section 4.2.4.

167 Thesis Section 4.3.4.

168 Considered with respect to ANS in Section 4.2.2 below.

169 Considered with respect to ANS in Section 4.2.3 below.

170 Thesis Section 3.3.2.

171 Thesis Section 3.3.3.

The question of whether ANS fall within the scope of the MED has already been addressed in this thesis.[172] Here, however, the potential geographical allocation of components of ANS in different locations is brought into focus from a slightly different angle.[173] In order for the requirements for high-risk AI systems to apply to ANS, this presupposes that a sufficient number of components are located either on non-EU-ships or on shore, such that those components constitute an "AI system" escaping the *lex specialis* function of the MED.[174] Conversely, the premise for a potential *indirect* impact via the MED Article 8(5) is that a sufficient portion of components from an autonomous navigation system are located *on board* an EU-ship, such that they collectively constitute an "AI system" under the AIA that can be "covered" under the MED pursuant to the AIA Article 6(1). Given that most elements of the definition of an AI system relate to the autonomous capabilities of the AI system, the decisive factor will likely be whether the "brain" of the autonomous navigation system is situated on board the ship.[175]

If an autonomous navigation system is already covered by the MED, this would already imply a recognition that the components of the system require flag State approval pursuant to Article 3(1) of the MED. Such approval would certainly constitute a "third-party conformity assessment" within the meaning of Article 6(1) of the AIA. The relevant flag State authorities will certainly perform "assessment activities, including testing, certification and inspection", aligned with the definition of a "conformity assessment body" in the AIA Article 3(21).

4.2.3 The ANS must be "safety components" within the meaning of the AIA

A "safety component" is legally defined in the AIA Article 3(14) as a component of a "product". The component must either fulfill "a safety function" for that product or "the failure or malfunctioning of which endangers the health and safety of persons or property".

It does not seem problematic to consider an autonomous ship as a "product" that an autonomous navigation system can be a component of. Nothing in the AIA suggests otherwise, and the concept of a product remains vague throughout the Recitals and Explanatory Memorandum.[176] It might be intentionally vague, designed to encompass a wide range of items in which AI systems can become a component. Moreover, it does not seem problematic that components of ANS might be partially situated outside of the products (the MASS) themselves.[177] The Recitals emphasize that it is not of definitional significance whether AI systems are "embedded" or "non-embedded" in the products.[178]

Furthermore, ANS will fulfil safety-enhancing functions for MASS, while their failure or malfunction may endanger the surroundings of the ships, and even disrupt supply chains.[179] In summary, ANS are likely "safety components within the meaning" of the AIA, as required by the MED Article 8(5).

172 Thesis Section 3.4.2.2.

173 Thesis Sections 2.1.2 (actual premises), 3.4.2.2 and 3.4.2.3 (significant in the research question of whether the requirements for high-risk AI systems apply to ANS).

174 Thesis Section 3.4.2.

175 Thesis Section 3.2.1.

176 Well demonstrated by the AIA Recitals para. 12.

177 Thesis Section 2.1.2.

178 The AIA Recitals para. 12.

179 Thesis Section 3.3.4.3.

4.2.4 Grounds to believe that the AIA will in fact have an impact through the new MED Article 8(5)

4.2.4.1 How practical is the authority of the European Commission under the MED Articles 8(2) and (3)?

The MED Article 8(5) stipulates that the European Commission shall "take into account" the specific requirements for high-risk AI systems in the AIA Chapter III, Section 2, when "adopting technical specifications and testing standards" pursuant to the authority set out in the same Article, paragraphs (2) and (3). These provisions allow the Commission to draft and adopt standards for marine equipment on board EU-ships, in contrast to the primary function of the MED, which is to give effect to international standards. It may be regarded as a legislative safeguard, applicable in situations where the EU finds that the IMO has not adopted, or will not adopt, standards for marine equipment that the Union considers acceptable.

Since the Commission does not hold general legislative competence, such standards must be adopted in delegated acts.[180] Articles 8(2) and (3) set out conditions that must be fulfilled for the Commission to legally exercise its authority.

Article 8(2) applies in situations where there is an "absence" of an international standard for an item of marine equipment, resulting in "a serious and unacceptable threat to maritime safety, to health or to the environment". The MASS Code will set out international standards for ANS.[181] However, the Code will be non-mandatory in its initial years, which is also the reason that it will not be given immediate effect through the MED.[182] Nevertheless, this will likely not suffice to conclude that there is an "absence" of a standard within the meaning of Article 8(2). This is particularly the case given that the provision expressly requires the Commission to take into account any ongoing work at the IMO, such as with the development of the MASS Code.

Article 8(3) applies to situations where the Commission observes a "weakness or anomaly in an existing standard" and that a temporary standard adopted by the Commission is "necessary to remove an identified unacceptable threat to maritime safety, health, or the environment". Like with Article 8(2), the Commission must take into account ongoing work at the IMO.

In theory, the EU might be inclined to apply stricter regional standards to AI in the maritime sector as an extension of its new and ambitious approach to AI regulation. As Lloyd's Register has pointed out, the IMO faces a significant challenge in drafting the MASS Code, as it should be acceptable to all member states of the IMO.[183] To illustrate, the EU has adopted significantly more ambitious regulatory goals and standards for GHG emissions in shipping than the IMO.[184]

However, practically speaking, it must be considered unlikely that the Commission will conclude that regulations of ANS from the IMO are so insufficient that the conditions of Article 8(3) are met. This is due to a number of reasons. First, and most importantly, this could create a challenging situation for EU member states collaborating with non-EU member states in MASS operations, where the latter are only bound by the IMO obligations. Second, the wording of the provision itself indicates a high threshold. Third, it appears that the Commission has never before

180 Pursuant to the MED Article 37, in accordance with the TFEU Article 290.

181 The draft MASS Code, Chapters 17 (ANS-specific), 9, 10 and 14 (general).

182 The MED Articles 2(3) and 3(1).

183 Lloyd's Register and Mitsui O.S.K. Lines (n 14) 10.

184 Regarding these goals, see Erik Røsæg, 'A status report on the greening of shipping from a legal viewpoint' in Ellen J. Eftestøl, Anu Bask and Maximilian Huemers (eds), *Towards a Zero-Emissions and Digitalized Transport Sector: Law, Regulation, and Logistics* (Edward Elgar Publishing 2024) 16. Regarding the standards, see Section 4.3.2 of the thesis.

exercised this authority.[185] Fourth, the EU has considerable trust in and respect for IMO standards regarding marine equipment.[186] Fifth, this respect extends specifically to the context of MASS.[187]

In conclusion, it must be considered unlikely that the European Commission can and will exercise its authority under Articles 8(2) or 8(3) of the MED for the purpose of regulating ANS. Accordingly, it is unlikely that the requirements for high-risk AI systems set out in the AIA will have any meaningful impact through the new Article 8(5) of the MED.

4.2.4.2 Significance of the requirements of the AIA by taking them "into account"

If the European Commission were in fact to exercise its authority under the MED Articles 8(2) or (3), the Commission is obliged to "take into account" the requirements for high-risk AI systems the AIA Chapter III, Section 2. Neither the AIA nor the MED legally defines what it entails to take something "into account". It is not specified how much weight the requirements must carry. This allows the Commission discretion and flexibility.

4.3 Impact on Domestic Regulations Through the "Brussels Effect"

4.3.1 The "Brussels Effect" and the AIA – starting points

EU law may exert influence even when it does not formally apply, a phenomenon commonly referred to as the "Brussels Effect". It can be distinguished into two forms: a *de jure* and *de facto* Brussels Effect. A *de jure* Brussels Effect arises when non-EU/EEA member states voluntarily adopt EU legislation, despite not being obligated to do so. By contrast, a *de facto* Brussels Effect occurs when companies choose to align their operations with EU law, even in markets where they are not legally required to comply with it.[188]

Perhaps the most prominent example of the Brussels Effect in practice is the global response following the adoption of the EU General Data Protection Regulation (GDPR) in 2016.[189] Influential American tech companies such as Facebook, Google and Twitter adapted their practices to comply with the GDPR in order to retain access to the European market. However, many of these companies extended the same practices to other jurisdictions as well, thereby contributing to a *de facto* Brussels Effect.[190] In response to these companies, several countries around the world began aligning their domestic legislation with the GDPR, giving rise to a *de jure* Brussels Effect as well.[191]

Recent literature presents compelling arguments that the AIA is likely to exert both a *de jure* and *de facto* Brussels Effect in the coming years, similar to the

185 I find that the authority has only been exercised in minor regulatory issues pursuant to Article 8(2), for instance in Regulation (EU) 2024/1295.

186 Thesis Section 2.4.

187 Thesis Section 2.4

188 Anu Bradford, *The Brussels Effect: How the European Union Rules the World* (1st edn, Oxford University Press 2020) Front Matter.

189 Regulation (EU) 2016/679.

190 Bradford (n 188) Chapter 5 Section 4.

191 Bradford (n 188) Chapter 5 Section 4.

GDPR.[192] The question, however, remains whether this will hold true in the context of regulating ANS.

4.3.2 Potential of a *de jure* Brussels Effect – lessons from GHG regulations?

As a starting point, the members of the IMO will certainly prioritize ensuring that their domestic regulation complies with the MASS Code and other IMO obligations. However, the AIA may achieve a *de jure* Brussels Effect by influencing the drafting of the finalized MASS Code at the IMO, because the Code in turn will influence domestic regulations of ANS.[193]

Although the legislation of the IMO traditionally enjoys significant respect with the EU once it is finalized and adopted,[194] the EU is not necessarily reluctant to influence ongoing processes – such as with the MASS Code, which will not be finalized before 2030. The MED Article 8(1) demands the EU to "pursue the development by the IMO" of "appropriate" international standards for marine equipment. When carrying out these activities, the new MED Article 8(5) specifies that the European Commission shall "take into account" the requirements for high-risk AI systems of the AIA Chapter III, Section 2.

Although *direct* influence through the observer status of the European Commission is not possible, there are arguably other ways in which the EU may exert influence over the IMO. Within the concept of the Brussels Effect lies the recognition of the capacity of the EU to shape global regulatory standards by acting early in emerging policy areas. The GDPR in the area of data protection stands as a well-established example,[195] but more recent instances can arguably be identified – even within the maritime sector. A particularly illustrative example is the parallel regulatory developments regarding GHG emissions from ships by the EU and the IMO.

The Deputy Director General and Deputy CEO of Danish Shipping has argued that the regulatory frameworks of the EU for reducing GHG emissions in the shipping industry, namely the EU ETS and FuelEU Maritime,[196] have been instrumental in prompting the IMO to adopt its global climate agreement for shipping in 2023.[197] The relevance of this assertion was renewed in April 2025 when the IMO announced its intention to adopt an amendment to MARPOL Annex VI in October 2025 that arguably resembles an "IMO version" of the EU regulations that are already in force.[198]

In the case of the regulation of AI in shipping, it is particularly noteworthy that the EU stands as a global pioneer in the field of AI regulation. The EU has established a large and highly specialized apparatus directly related to the practical implementation of the Act, with bodies such as the European AI Office.[199] Lessons learned and guidelines developed by the EU in the coming years may serve as a

192 Agnidipto Tarafder and Aniruddh Vadlamani, 'Will the EU AI Regulations Give Rise to Another 'Brussels Effect'? Lessons from the GDPR.' (2025) 10 JDPP 45; Marco Almada and Anca Radu, 'The Brussels Side-Effect: How the AI Act Can Reduce the Global Reach of EU Policy' (2024) 25 Ger. Law J. 646, Section B; Siegmann and Anderljung, *The Brussels Effect and Artificial Intelligence: How EU regulation will impact the global AI market* (August 2022) 59 and 69.

193 Siegmann and Anderljung (n 192) 66-67.

194 Thesis Sections 2.4 and 4.2.4.1.

195 Bradford (n 188) Chapter 5, Section 1.

196 Commission Implementing Regulation (EU) 2023/2599 (ETS) and Regulation (EU) 2023/1805 (FuelEU Maritime).

197 Danish Shipping, *EU achieves ambitious climate regulations for shipping* (25 July 2023).

198 The International Maritime Organization, *IMO approves net-zero regulations for global shipping* (11 April 2025).

199 The European Commission, *European AI Office* (2025).

source of inspiration for others with less experience in AI regulation, such as the IMO.

4.3.3 Potential of a *de facto* Brussels Effect

As stated in a 2023 report published by Lloyd's Register, stakeholders in autonomous shipping should develop internal frameworks concerning appropriate use of AI systems.[200] Just as the EU may influence the drafting of AI-related legislation at the IMO, it may likewise serve as a source of inspiration for private stakeholders when developing their internal frameworks. The stakeholders will of course primarily consider legally binding sources of law drafted by the IMO. However, specialized EU bodies, such as the European AI Office, will likely offer comprehensive guidelines, recommendations, and advisory services, rooted in the AIA, to companies developing, providing, and deploying AI systems.[201] Such services may offer valuable support to, for instance, shipowners considering implementing AI in their operations, irrespective of their formal legal obligations.

200 Sivori and Brunton (n 7) 32.

201 See for instance the European Commission, *European AI Office* (2025).

5 Conclusions and Reflections

5.1 Conclusion on Whether the Requirements May Apply to ANS

It is currently uncertain whether the requirements for high-risk AI systems in the AIA may apply to ANS deployed in commercial cargo shipping. The uncertainty relates to interpretive issues both within and beyond the AIA. First, although ANS are "AI systems", it is unclear whether they are "high-risk" under Article 6(2). Second, the question of whether the MED is *lex specialis* to the AIA in the context of ANS remains unresolved.

Current interpretations suggest that ANS may be classified as high-risk AI systems under Article 6(2) when deployed in LNG or LPG shipping.[202] At the same time, the MED appears to function as *lex specialis* to the AIA with regard to ANS, but only in relation to components of the systems located on board EU-flagged ships.[203] That said, the European Commission may, practically speaking, clarify these issues by February 2026.[204]

5.2 Conclusion to the Question of Indirect Impact

I have considered whether the requirements for high-risk AI systems in the AIA may have an impact on ANS regulations even if the requirements for high-risk AI systems in the AIA do not apply.

With regard to EU law, the AIA Articles 2(2) and 105 set out a mechanism that could allow the requirements to have an impact on standards for marine equipment on board EU ships that are drafted and adopted by the European Commission pursuant to Articles 8(2) and (3) of the MED. However, it seems unlikely that the Commission will adopt such standards for ANS.[205]

As for the potential of the AIA having a "Brussels Effect" on domestic regulations of ANS, this remains uncertain and will only materialize – or not – over time. States are, however, likely to prioritize their existing and forthcoming obligations under IMO law, particularly with regard to the implementation of the MASS Code. Nevertheless, the practical experience gained by the EU when implementing the AIA may prove valuable to the IMO in its ongoing efforts toward a finalized and mandatory version of the MASS Code by 2030, potentially facilitating a *de jure* Brussels Effect of requirements for high-risk AI systems in the AIA.[206] Similarly, private stakeholders in the emerging autonomous shipping industry may adopt practices suggested by specialized EU-bodies. This may give rise to a *de facto* Brussels Effect.[207]

5.3 Reflections on Possible Approaches That the EU May Adopt

5.3.1 Two possible regulatory approaches

The EU needs to determine its regulatory approach to ANS, and to AI in shipping more generally. In the case of ANS, two approaches may be envisaged: one in which the Union places continued trust in the IMO, and another in which it adopts

202 Thesis Section 3.3.4.

203 Thesis Section 3.4.

204 Thesis Sections 3.3.2 and 3.4.3.

205 Thesis Section 4.2.4.1.

206 Thesis Section 4.3.2.

207 Thesis Section 4.3.3.

a more active role. Based on the findings of this thesis, I will briefly reflect on these approaches and consider the legal amendments that each would require.

5.3.2 The first approach – trusting the IMO

To delegate the regulation of ANS to the IMO may entail either a fully passive stance from the EU, or that IMO law and ANS regulation are given effect within the EU legal framework. Assuming that the latter is the most likely scenario, I offer certain reflections on its implications.

First and foremost, this approach presupposes that the AIA and its requirements for high-risk AI systems do not apply to ANS. It appears that the *lex specialis* function of the MED can ensure this outcome for ANS located on board EU-flagged ships.[208] However, in order to avoid the creation of loopholes whereby the AIA could apply to primarily land-based ANS,[209] or ANS installed on board non-EU ships,[210] the most straightforward course of action would be to determine that ANS do not meet the conditions for applying the AIA directly, as set out within the Act. An effective legislative course of action would be for the European Commission to clarify that ANS are not high-risk AI systems.[211] With respect to the interpretive method in EU law, the Commission could also consider amendments to the AIA that explicitly clarify that LNG and LPG shipping does not constitute *supplying* gas within the meaning of Annex III.[212]

Furthermore, in order to ensure an implementation of IMO requirements in the spirit of the MED, the scope of the Directive should be amended to explicitly cover ANS *in their entirety*, like the MASS Code will. The current version of the MED, from 2014, was drafted for conventional ships, in which INS are physically located on board.[213] The Directive will only cover components of ANS that are physically placed on board EU-ships, whereas land-based components will not be covered.[214] This distinction may create unintended regulatory incentives in system designs. Furthermore, the MED is a dynamic instrument of nature, designed to respect the "constant evolution" of international standards for marine equipment.[215] This evolution, particularly in light of the upcoming MASS Code, currently calls for an expansion of the scope of the MED to encompass all components of ANS.

An alternative approach could be to retain the MED with its current scope, while establishing a complementary Directive or Regulation that governs certain land-based components that are covered by the MASS Code. Like the MED, such a regulation can give effect to relevant IMO requirements, thereby ensuring consistency and coherence in the implementation of IMO standards for MASS within EU law.

To enhance legal certainty during the period of the non-mandatory MASS Code, the EU could also consider expressly recognizing this version of the Code via the MED. The mandatory version will inevitably be given effect, and the non-mandatory Code might have interpretive relevance for current requirements.[216]

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208 Thesis Section 3.4.

209 Thesis Section 3.4.2.3.

210 Thesis Section 3.4.2.5.

211 Thesis Section 3.3.2.

212 Thesis Section 3.3.5.

213 Regulation (EU) 2024/1975, MED/4.59.

214 Thesis Sections 3.4.2.2 and 3.4.2.3.

215 The MED Recitals para. 4.

216 Thesis Section 3.4.2.2.

5.3.3 The second approach – a more active role for the EU

The Explanatory Memorandum to the AIA acknowledges AI as a "fast-evolving family of technologies".[217] Against this background, the EU may have an interest in bringing AI in shipping within the scope of the AIA, as a unified regulatory framework. Furthermore, freight transport at sea is generally recognized as "critical infrastructure" under the AIA.[218] The question thus also becomes one of how much confidence the EU places in the IMO as a drafter of law in areas that are important to European safety.

Of course, there is no need for conflicting regulations between the AIA and the MASS Code, should both apply to ANS. However, the EU has already demonstrated, particularly in the context of regulating GHG emissions, that it is not opposed to adopting stricter requirements within the Union than those provided by the IMO.[219]

From a legal perspective, this approach from the EU would require amendments to the MED to ensure that it does not operate as *lex specialis* with respect to the AIA. It would also require a clarification of which ANS are to fall under the scope of the AIA and why – for instance, through the adoption of delegated acts expanding Annex III to designate "AI systems for autonomous shipping" as high-risk, in line with the proposal from Norway in 2021.[220]

5.3.4 Is there a preferable approach?

The approach chosen by the EU will, naturally, have strong political connotations, particularly in light of the aforementioned safety concerns. However, from a legal standpoint, it is my view that the most appropriate course of action would be for the EU to entrust the regulation of ANS to the IMO, while ensuring that such regulation is given effect within EU law for EU-flagged ships – for instance through the MED.

First, this approach would be consistent with the long-standing tradition of the EU respecting and supporting operational and regulatory standards established by the IMO.[221] Second, it would uphold the legal rationale of the MED by ensuring uniform regulation of ANS across the Union, while also facilitating EU member states in meeting their IMO obligations.[222] This is arguably important in the implementation of new maritime technologies, such as ANS, which require international coordination. Finally, this approach would not pose significant regulatory risks, as the MED contains a legislative safeguard in Articles 8(2) and (3).[223]

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217 The AIA Act Proposal Explanatory Memorandum, Section 1.1.

218 Pursuant to the AIA Art 3(62), referring to the CER Art 2(4), read in light of Commission Delegated Regulation (EU) 2023/2450.

219 Thesis Section 4.3.2.

220 Government of Norway, 'Norwegian Position Paper' (n 109) Section 5.

221 Thesis Section 2.4.

222 Thesis Sections 2.4 and 3.4.2.2.

223 Thesis Sections 4.2.1 and 4.2.4.1.

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