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The Swedish policy lab for maritime autonomous surface ships

Håkan Burden[a]*, Susanne Stenberg[a], Lisa Carlgren[a] and Ted Sjöblom[a]

[a]*RISE Research Institutes of Sweden, Gothenburg, Sweden*

Abstract

The Swedish policy lab for maritime autonomous surface ships, or smart ships, explored three use cases for developing policy in practice. The policies regard smart ships on national waters: one short-term written policy identifying the next shared step for two authorities to position remote navigational assistance as a new service, giving the maritime ecosystem one official position to relate to; one informal policy relying on a mutual trust, where information sharing between an operator of small, unmanned ships and the supervisory authority enables critical competence building; and one evolving policy on the process of certifying autonomous or remote operated functions using non-standardized technology. In conclusion, despite shipping being explicitly regulated internationally we found that there is substantial leeway for national policies regarding smart ships on national waters.

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Keywords: MASS; vessels; pilot; unmanned; regulation;

1. Smart ships

During the last fifteen years the shipping industry has faced a number of setbacks – the financial crisis in 2008, the slow recovery of the economy combined with a surplus of shipping capacity and then one of the major companies went bankrupt in 2017. Also, the transition of today towards less fossil dependent energy sources may affect the need for shipping. The industry is looking for new opportunities to increase demand and lessen operational costs. By reducing the costs for manning, autonomous operations could be a way for the industry to recover its positions and find new markets (Munim, 2019). A further incentive is that 70–90% of marine accidents are thought to be caused by human error (Porathe et al., 2018).

In 2017 the International Maritime Organisation, IMO, decided to carry out a regulatory scoping exercise in

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: author@institute.xxx

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relation to the perceived challenges of Maritime Autonomous Surface Ships (MASS, see i.e. Ringbom, 2019). While the exercise is completed there is still substantial work to be done at an international level to define clear regulations for MASS (IMO, 2021), or smart ships as they also are referred to when the focus is on reducing manning and improving operations through digitalistion (Aas et al., 2020). On the IMO list of priorities for future work is coming up with shared definitions for autonomy and levels thereof as well as new meanings of the terms master, crew and remote operator. Another prioritized issue is how smart ships will relate to international instruments for collision avoidance (IMO, 1972) and safety at sea (IMO, 1974).

The need for new international instruments has not hampered initiatives among member states. In Norway the Yara Birkeland has drawn attention as the ambition was for unmanned transportation in the Oslo Fiord (Akbar et al., 2021). The first ever testing area for MASS was opened in 2017 in Finland (Makkonen et al., 2022). And in recognition of the pilgrims and their crossing of the Atlantic in 1621 the Mayflower 400 was set out to recapture the endeavor with an unmanned sailing boat (Hendershot and Marsh, 2020).

In Sweden there are actors with the ambition to explore the possibilities of smart ships. In 2021 the policy lab Smart ships was launched with an aim to detail the possibilities and challenges from a policy perspective. The focus was on two questions

1. What are the possibilities and challenges for remote navigational assistance?
2. What are the possibilities and challenges for operating smart ships?

The outcome of the project were three policies that answered the challenges. In summary, the first policy is a joint statement between two authorities that remote navigational assistance is desirable and further tests are needed. The second policy states that trials with smaller, unmanned vessels do not require registration or certification and are only supervised by the responsible authority if explicitly asked to intervene. Such trials can therefore commence if they do not cause the public inconvenience. The policy might change if the perception of trials changes or a new mandate is formulated. Finally, the third policy regards larger ships and how they can operate novel equipment and functions as long as the gap between proven and novel technologies can be abridged through a safety case approach.

Before we detail how the questions were addressed and under which context, we will define what is meant by policy and policy lab. The contribution then details our results before concluding with relating them to international trends and highlighting future research trajectories.

2. Policy and policy labs

Defining what policy means is not a trivial task. For our purposes we have chosen to adhere to Black's definition of regulation, e.g. the intention to influence the actions of others for a specific purpose (Black, 2002). She further proposes that a regulation can be broken down into five constituent parts;

1. An activity – a process like controlling, monitoring or co-ordinating; an outcome such as norms or culture; a property like self-correcting.
2. An actor – states, NGOs, economic and social forces and technologies.
3. A form – international bodies, associations, firms, networks and communities.
4. An area – economy, family, health, education, transportation and so on.
5. An instrument – binding and non-binding rules, sanctions, compiling statistics etc.

I.e.; Empowering (1) an authority (2) by ordinance (3) to prescribe what to include in an application (5) for trialing autonomous vehicles (4) is a policy. The purpose would be to ensure that trials hold a certain level of safety. This definition is in line with Hood's definition of regulation as the ability to keep a system in a preferred subset of possible states (1986).

As can be seen, following Black's definition enables more actors than governments to create and enforce policies. Baldwin, Scott and Hood discuss the difference and see three ways to define regulation, from direct government intervention to the unintentional influence conducted by civil society (1998). Jordana and Levi-Faur lean towards the first, defining regulation as "a specific form of governance: a set of authoritative rules, some often accompanied by some administrative agency, for monitoring and enforcing compliance" (2004). They list four aspects to consider in a regulatory process;

1. Adjustment flexibility: Will the regulation stand the test of time, i.e., does the regulation detail technology-specific or functional requirements?
2. Capture the problem: Who has relevant information for defining the needs and effects of the regulation and which interests should be considered? This aspect can be seen as how representative is the regulation in relation to the problem and the interests of the relevant stakeholders?
3. Context responsiveness: Does the regulation work for different levels of administration, e.g. from national to local administration or from international to national?
4. Predictability of regulatory outcome: Will the regulation serve its purpose and how can that be assessed?

By combining the five aspects of Black (2002) and Jordana and Levi-Faur (2004) with the notion of 'purpose' we have ten different aspects to consider when describing a regulation. Before we continue by defining policy labs, it is worth emphasizing that policy is more than law and conducted also by other actors than the government. Furthermore, for our purposes we will use the term *policy* instead of regulation since the term *regulation* is the recommended translation for policies issued by Swedish administration (see e.g. section 5 for an example of how the Swedish Transport Agency issues a regulation on domestic shipping).

There are multiple ways to facilitate policy development, such as test beds (Engels et al., 2019), regulatory sandboxes (Zetsche et al., 2017) and labs (Fuller and Lochard, 2016).

According to Fuller and Lochard, a policy lab intends to "approach policy issues through a creative, design, or user-oriented perspective […] strive to organize experiments to test proposed policies […] work for or within a government entity or public administration and contribute to the shaping or implementation public policies" (Fuller and Lochard, 2016).

The lab can take multiple forms, varying from permanent organisations to time-bound projects; be a physical or virtual place or seen as a methodology (Hagy, Morrison and Elfstrand, 2017). What is common is the aim to shape or implement policies using collaborative tools with relevant stakeholders (Hagy, Morrison and Elfstrand, 2017), incrementally and over multiple iterations (Mergel, 2016) as well as drawing on multiple disciplines (Junginger, 2016).

Policy labs can be found across the globe. The European Commission has an EU Policy Lab, as do the Government Offices in the United Kingdom (Fuller and Lochard, 2016). From the USA, the UC Davis Policy Institute and Stanford Change Labs can be mentioned. There are also organizations that have policy lab-like structures such as the Organization for Economic Cooperation and Development (OECD) that has the Observatory of Public Sector Innovation (OPSI). The World Economic Forum also has labs for policy development.

3. Policy lab Smart ships

Policy Lab Smart Ships was a project that ran spring 2021 to spring 2022. The partners were ABB, RISE Research Institutes of Sweden, the Swedish Transport Agency, the Swedish Maritime Administration, Trafikverket's Road Ferries and Saab Kockums. The Swedish Transport Administration financed the project.

While the English names for the agency and the administrations are similar, they differ in their responsibilities;

- the Transport Agency is the supervisory authority for maritime operations and ships,
- the Transport Administration is the public body facilitating road infrastructure, and
- the Maritime Administration is the public body facilitating maritime infrastructure.

Trafikverket's Road Ferries (TRF) is the Transport Administration's shipping company responsible for public transport on water crossings of national interest. ABB and Saab Kockums are technology providers with a wide range of products and services. Finally, RISE is the main Swedish research institute. The motivation for the policy lab was two main challenges;

1. What are the possibilities and challenges for remote navigational assistance?
2. What are the possibilities and challenges for operating smart ships?

Each question was answered in the context of specific cases. The first question was represented by a case involving

the Transport Agency who mandate which waters require piloting, while the Maritime Administration is responsible for providing piloting. This case thus required the cooperation of two public bodies if new navigational services were to be introduced on Swedish waters.

The second question was represented by two cases, involving Saab Kockums, ABB and TRF as well as the Transport Agency. Saab Kockums have developed small vessels intended for dull, dirty or dangerous operations with the explicit ambition that the nature of the operations require the vessels to be unmanned. TRF are also investing in smart ships with autonomous functions but here the ambition is to improve safety by reducing the margin for human errors through systems like auto-docking but also by enabling remote operations of safety functions like lifeboats and fire extinguishers. Automating the configuration between the ships front- and aft-facing propellers should also reduce the energy needed as the ship goes back and forth across a straight in the Stockholm archipelago. ABB is invested as a possible supplier of technology relevant for TRF to procure. The role of the Transport Agency is being the supervisory authority for ships, providing the necessary certificates for passenger ferries and seaworthiness.

To address the two questions the policy lab was organized as monthly workshops with all project partners with meetings between different partners in-between when needed. RISE prepared analyses of existing policies that were discussed during the workshops as well as different exercises that encouraged co-creation of solutions.

4. Remote navigational assistance

To get the collaboration going between the Transport Agency and the Maritime Administration we introduced an exercise inspired by Carpaccio slicing (Cockburn, 2009). The exercise builds on the metaphor that the only way to consume a whole elephant is by slicing it thinly. The way we implemented it was to define a table with the rows representing the steps from current state to wanted state, or the slices, while the columns represented the aspects to consider while slicing (see Table 1). The ambition was both to break the complexity of the task into more manageable tasks while identifying details that would facilitate or hinder the progression across states.

Table 1. A framework for slicing remote navigational assistance into actionable tasks.

Phase	Organisation	Technology	Environment	Policy
Desired state … Intermediate state … Current state	Competences, roles, responsibilities, …	Autonomous functions, physical and digital infrastructure, communication technologies, …	Ports, routes, areas, …	Laws, ordinances, regulations, international instruments, …

The outcome was a detailed roadmap where remote navigational assistance became an intermediate step towards the capability to assist unmanned ships in the future; why should the pilot be on the ship if it is operated from shore in another country? The exercise further detailed which ports have the right infrastructure to facilitate the service and what kind of training the involved personnel need for maintaining safe operations. Regarding piloting there are policies in terms of laws and regulations. An important question to resolve is the relationship between existing services, mandatory and optional, and remote navigational assistance. And importantly, is remote navigational assistance to complement or supersede existing service? As the authorities are yet to decide if the roadmap is to be public we refrain from giving more specific details.

Based on the discussion around the matrix the two authorities identified the option to create a shared statement on the need for remote navigational assistance while also identifying open questions that need to be addressed. The roadmap was thus complemented by a shared statement and a project application to ensure resources for trialing the service in selected ports in Sweden. The ambition behind the trials will be to find the constraints regarding when the service can be offered, who can receive the offer and how the offer stands in relationship to existing services such as piloting and VTS.

5. Operating and certifying smart ships

Since IMO had concluded its regulatory scoping exercise the focus in relationship to operating smart ships was initially on international guidelines for validating novel designs (IMO, 2013) and trialing MASS (IMO, 2019). While

these guidelines support authorities and private enterprises in detailing the challenges involved, they do not prescribe specific solutions or binding requirements. The discussion therefore shifted towards other IMO instruments for safety at sea (SOLAS, 1974) and collision avoidance (COLREG, 1972) as well as how to "wheelmark" novel equipment within the EU (2014).

The international lead turned out to be a red herring. Instead, we shifted focus to a new guideline released by the Transport Agency on trialing smart ships on Swedish waters. While still a guideline, the document lists a few policies that in turn include binding requirements. By back-tracking through the policies we found that the Swedish policies only relate to non-binding international policies, except in one case where the definition of polar area is given by a binding IMO instrument. Among the national policies is regulation TSFS 2017:26 on domestic shipping, see Fig. 1.

An important differentiation between policies in Fig. 1 is that in Sweden laws are decided upon by the parliament, ordinances are issued by the government while regulations are created and updated by authorities. In this specific case it means that if the laws on maritime code and ship safety were to be updated for allowing operations with smarts ships it would require the parliament to act. For the ordinance to change accordingly, the government has to decide that it is a prioritized question among health, international conflicts and everyday business. However, if the changes can be done at the level of regulations, the mandate lies with the Transport Agency.

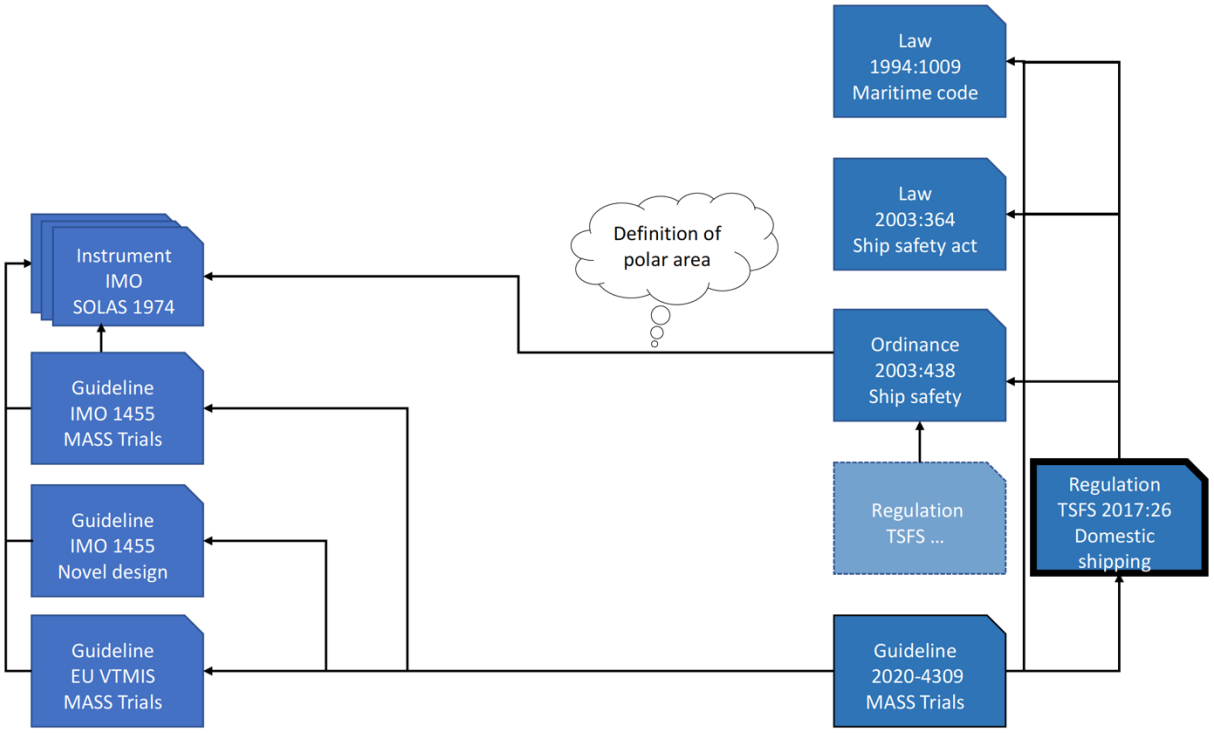

Fig. 1. The relationships between Swedish and international policy regulating safe shipping.

During the workshops we discussed how to interpret regulation TSFS 2017:26 in relation to MASS and smart ships. While it took multiple workshops to come to the core of the issue the outcome was that Saab Kockums declared that they will begin trials with unmanned vessels during 2022 and the agency responded that as long as the ships are shorter than five meters and the trials cause no inconvenience for the public they would not intervene. Since trials with smaller, unmanned vessels are not supervised by the Transport Agency there is an opportunity to commence trials with such vessels if they do not cause public inconvenience and comply with applicable laws and regulations.

When it comes to automated functions on passenger ferries such as road ferries the process for certification will probably be the same as for traditional builds. Since there has yet to be a formal application from TRF the answer might change as new insights or details are unveiled. The main difference is that in the beginning of the process the applicant, TRF, will need to describe the gap between what has been developed according to a cohesive set of

specifications (often provided by class societies) and through innovative design processes. The gap will then need to be analysed in terms of risks and a suitable set of mitigation strategies to ensure that a reasonable level of safety is obtained.

6. Discussion

In relation to the two questions we set out to explore in the policy lab;

1. What are the possibilities and challenges for remote navigational assistance?
2. What are the possibilities and challenges for operating smart ships?

we have identified three policies. The first policy relates to the first question while the second and third policy relates to the second question. Table 2 gives an overview of the policies according to the aspects of policy presented in section 2.

The first policy is a shared document written by representatives of the two involved authorities. The purpose is to define both remote navigational assistance as a service but also the work that lies ahead to establish the service. The statement also serves the purpose to tell the maritime sector that the authorities will act towards a common goal, making it more probable that other actors will want to participate in the work that lies ahead. The nature of the policy means that the probability of reaching the intended purpose is high. The flexibility of the policy is low since it is a one-time initiative for a short-term purpose, representing a first step towards the desired state. It should be applicable at both national and local levels but have no bearing internationally.

The second policy is a self-correcting and mutual agreement between the Transport Agency and Saab Kockums regarding operating unmanned, small vessels. It takes the form of a culture or a norm and relies on trust. The flexibility is low since it does not represent either party's interests and will most probably be replaced through an explicit policy change. Just as for the first policy the second policy will cover national and local levels but not hold in an international context, while the probability that it will obtain its purpose is high – Saab Kockums will trial unmanned ships during 2022 and the agency will not intervene if not explicitly asked to by a third party.

Table 2. An overview of the identified policies.

Reference	Aspect	Q1 Policy	Q2 Policy	Q2 Policy
Black (2002)	Activity	Outcome	Self-correction	Outcome
	Actor	Maritime Agency & Transport Administration	Transport Administration & Saab Kockums	Transport Administration
	Form	National authorities	Culture / Norm	Authority
	Area	Navigational assistance	MASS operations	MASS certification
	Instrument	Document	Trust	Market supervision
	Purpose	Involve maritime sector through joint statement	Enable trials with small ships and information sharing	Evolve current process to include safety cases for novel designs
Jordana & Levi-Faur (2004)	Flexibility	One-time initiative	Low	High
	Representativity	Authorities	No	Authority
	Responsiveness	National and local	National and local	International, national and local
	Probability	High	High	?

Finally, the third policy is a process under development. It builds on an existing policy for certifying ships and will be adjusted to manage novel technologies through a safety case approach. How well this will work is an open question since it relies on both the agency and the technology developers to find a common way of understanding the relevant risks and suitable mitigation strategies. That said, it is still the agency that owns the process as part of their market supervisory role while it should reflect the interests of all involved parties, including other sea users who will share

the waters with the innovative ship. The third policy resonates with international attempts in the UK (MCA, 2022) and the IMO guidelines for approving novel designs (2013), even if the national process is less detailed than the one proposed by IMO.

As can be seen, the three policies all have an authority as the actor, while in one case a private enterprise is also involved. Neither is the chosen instrument a law in any of our cases. Instead, the policies are implemented in different ways so that the mandate to act is with the actor. This emphasizes the point that from a policy lab perspective, policy is more than law and can be developed by others than authorities.

On the other hand, the second policy relies on an assumption that smaller vessels do not impose risks severe enough to motivate the costs of supervision. The rapid technological development could lead to a reassessment of such a stance. It is not impossible that new policies will be needed if remote operating vessels from shore becomes a leisure activity or if there is a severe incident involving smaller vessels. This brings us to the notion of flexibility as two of the policies are deliberately designed to fill the existing gap between more long-standing policies. Inevitably, they will either be amended or superseded in order to create a more stable situation.

7. Conclusions

Shipping has a long history with deep and embedded traditions. That is reflected in the international policies that govern the trade. IMO is currently working on how to introduce new instruments and update their legacy for safe operations with MASS and smart ships. However, we found that the way forward is not to wait for clarifications from the international community but to explore the possibilities given for national authorities to govern what happens on national waters. This is in line with ongoing work in the UK on sea worthiness (MCA, 2022).

From a policy perspective it also means that national governments and authorities have the mandate to act and regulate MASS according to their own purposes as long as they don't interfere with international policies. Limiting the policies to what can be done on national waters is one way, another is to define policies that apply for ships built and operated in the own jurisdiction.

In terms of future research trajectories, we want to explore the possibilities for remote operations in relation to national policies. The outcome would be relevant for both our questions as remote navigational assistance and smart ships rely on detaching the acts of navigation, docking and evacuation from the ship itself.

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