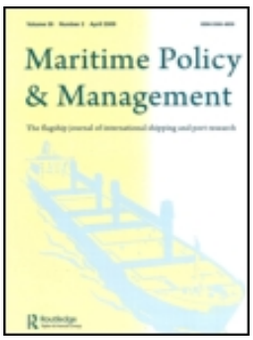

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Maritime human factors and IMO policy

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The development of human factor- (HF) related regulations of the International Maritime Organization (IMO) has often been the result of responses to maritime accidents. The typical reaction to an accident has been a combination of (mainly technical) regulations, changing of procedures and training. Systemic evaluations and changes have rarely been done. Statements made by IMO in recent years claim a shift towards a proactive approach in maritime safety. Key documents, like the IMO Human Element vision, would confirm such statements. This article reviews documents submitted to IMO's Maritime Safety Committee (MSC) in order to evaluate the 'mechanisms' of decision-making and the priorities for setting the agenda in MSC regarding maritime human factors. The review confirms that the IMO work related to HF was reactive in the 1990s. There are a number of examples of more recent regulations that can be considered proactive. However, it is too early to fully confirm a proactive policy in the IMO rule-making process.

1. Introduction

The history of maritime safety is characterized by maritime accidents followed by regulatory responses. The Code of Hammurabi established regulations about liability in case of losses in ancient Babylon almost 3800 years ago (Mukherjee 2002). Load line regulations were probably introduced even earlier in Crete in an attempt to reduce losses resulting from overloaded ships. Load line requirements can be found in a number of legal instruments throughout history—from ancient Rome to the Hanseatic League and further on. In contrast to that, the commercial incentives to avoid the cargo capacity limitations set by the regulations have always been high. Already 150 years ago, Samuel Plimsoll succeeded to draw public attention in the United Kingdom to the intolerable loss of life at sea due to missing effective controls of the maximal allowed cargo to be carried by ships. He managed successfully to introduce more effective national load line rules in the United Kingdom. However, this was only a national approach and applied to the United Kingdom only.

The foundering of the *Titanic* in 1912 marked the beginning of a new era in maritime safety regulations and ended the national attempts to govern maritime safety alone. The resulting Safety at Sea Convention of 1914 was the first international treaty related to maritime safety (International Conference on Safety at Sea 1914). It nevertheless still took some time until the International Maritime Organization (IMO) was given the mandate to safeguard the further development of maritime safety and marine environmental protection standards on a global

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level. The achievements of the IMO related to maritime safety and marine environmental protection are impressive. However, almost all important IMO instruments have been linked to specific maritime accidents. The former Secretary General of the IMO, William O'Neil, described the IMO as swift and decisive in response to accidents (O'Neil 2011). He also referred to a proactive policy that has helped to create a comprehensive regulatory infrastructure aiming at the prevention of accidents on the one hand, and a minimization of damage on the other hand if an accident occurs despite all precautions.

While such a statement sounds reassuring, the question must be asked what the word 'proactive' means in an IMO context (Psaraftis 2002)? It is certainly important to discuss how the member states in IMO identify issues for further action. In a recent publication about the foundering of the *Costa Concordia* in 2012, it was argued that many maritime accidents often involve combinations of similar contributing factors (Schröder-Hinrichs, Hollnagel, and Baldauf 2012). This applies specifically to the human factor- (HF) related aspects of those accidents. This insight is not new in the maritime domain. In fact, more than 30 years ago, similar concerns were raised in this journal because HF problems contributing to maritime accidents seemed to persist despite technological progress made in shipping (King 1979). An obvious question is therefore why it has not been possible to address those factors more effectively. A number of publications about maritime accident investigation or accident investigations offer some general explanations. Frequently reappearing arguments relate to the methodologies used in accident investigations (Lundberg, Rollenhagen, and Hollnagel 2009; Schröder-Hinrichs, Baldauf, and Ghirxi 2011) or the focus of maritime accident investigation (Schröder 2003, 2004a). The fact that a number of HF-related issues have not been addressed in IMO instruments therefore challenges the claim made above about a proactive policy of IMO.

An evaluation made of how proactive the discussions in IMO are should not only focus on the quality of and follow-up to maritime accident investigations. While accident investigation reports are a valuable source of information regarding maritime HFs, other sources should also be considered. The authors of this article understand the word 'proactive' to mean that an entity should try to identify safety problems and discuss possible solutions on the basis of existing knowledge, without waiting for accidents to happen. We would therefore expect to see both papers about HF-related aspects and their influence on maritime operations and regulations in different IMO instruments based on the evaluation and discussion of such papers.

This article will try to analyse the maritime HF-related documents handed in to IMO and compare the content of these documents with the content published in two scientific journals focusing on maritime issues in the last 40 years. The comparison of the two datasets should show if the HF-related decisions in IMO are still accident driven, that is, reactive, or if they have become proactive.

2. Historical developments of human factors (HFs)

As pointed out above, accidents have been important for the development of maritime safety regulations. The maritime sector has also considered HFs as a main contributing factor to accidents, in common with other industrial sectors. But this was not always so. Frederick Taylor's work from 1882 is a good example of how early HF research focused on work itself. Taylor was convinced that there was 'one best way' to carry out a task to maximize performance, and studied the selection and training of industrial workers using

time and motion studies (Badge-Schaub, Lauche, and Hofinger 2012). Following technological developments after World War II, the capabilities of machines started to exceed the control capabilities of human operator, which created a demand-capacity gap. The industrial workplace also started to become complex with tightly coupled interactions between subsystems (Perrow 1984). Accidents like *Three Mile Island* in 1979 demonstrated that HFs had become a critical part of plant safety and made clear that the conditions for successful functioning were created by a combination of social and technical factors. Socio-technical systems today are often non-linear and outcomes are often intractable. Resilience engineering has therefore recently been introduced as an approach to safety management. Resilience is here understood as the intrinsic ability of a system to adjust its functioning prior to, during or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions (Hollnagel et al. 2011).

Maritime transport today is an industry with tight couplings between the different subsystems. Even so, the overall system is perceived as linear rather than complex. This may explain why discussions about maritime safety differ from other domains, such as aviation and offshore. The fact that accidents in other industries typically lead to more casualties and attract more public interest and concerns than the shipping business may also play a role. David Moreby (1975) published one of the early dedicated attempts to look into specific maritime HFs. He described organizational and technical changes that took place in seafaring as well as the seafarer as an individual, the work on board a ship and the economic system that influences it all. However, such examples of academic work dedicated to seafarers are rare. Hetherington, Flin, and Mearns (2006) confirmed the remarks made by Moreby in 1975 since they could not find many specific studies focusing on the seafarer. It therefore seems that maritime HFs is a discipline that still requires efforts to shape it up and define an agenda for future research. There are a number of publications in more recent years that allow being optimistic that this work is on its way. Grech, Horberry, and Koester (2008) can be used as an example of the more recent publications.

3. IMO and human factors

The IMO—formerly known as IMCO—was established in 1948 to work as a technical agency for the improvement of maritime safety and related aspects (United Nations 1958). The setting up of the IMO was not easy, and the only common denominator for the member states was the agreement that an international forum to discuss technical standards for ship construction and equipment was desirable. As the interest of the global shipping community was limited, it took almost 10 years before the IMO met for the first time. This also explains why the IMO kept a rather low profile in the beginning. It was not until 1967 that the IMO was given a chance to develop a comprehensive profile. The foundering of the *Torrey Canyon* in that year highlighted loopholes in the international legislative framework, which prevented the IMO member states involved from reacting effectively to the accident. As a result, a number of new treaties were suggested to address issues related to marine environmental protection, civil liability, the circumstances allowing an intervention at the seas as well as maritime education and training. In the following years, whenever another significant accident occurred, similar responses followed and further treaties were added or the existing ones extended.

The reactions listed in Table 1 focused on technical regulations while the human operator—the ship officer, the marine engineer or the rating—generally was ignored. The

Table 1. Selected accidents and the reactive follow-up in IMO (based on Schröder 2004b).

Year of accident	Ship name	Resulting measure/instrument	In force since
1912	*Titanic*	SOLAS, 1914[a]	
1967	*Torrey Canyon*	Intervention Convention, 1969	1975
		Civil Liability Convention, 1969	1975
		MARPOL Convention, 1973	1983
		STCW Convention, 1978	1984
1976	*Argo Merchant*	MARPOL Convention, Protocol of 1978	1983
1987	*Herald of Free Enterprise*	ISM Code, 1994	1998
1989	*Exxon Valdez*	OPRC Convention, 1990	1995
		MARPOL Convention, 1992 amendments (double hull)	1995
1994	*Estonia*	SAR Convention, 1998 amendments (improvement of cooperation)	2000
1999	*Erika*	Res. 949(23) Guidelines on places of refuge for ships in need of assistance	2003[b]
2002	*Prestige*		

Notes: [a]The first SOLAS never entered into force as a result of World War I. The convention was revised in 1929 and 1948, and the fourth version of 1960 was the first version adopted in IMO.
[b]IMO resolutions, if not specifically referred to in IMO mandatory instruments, are of advisory nature and not legally binding.

only exception was the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW Convention) (United Nations 1984). The *Torrey Canyon* accident raised doubts about the previously practised system of nationally defined criteria for maritime education and training as well as certification, which meant that all IMO member states had different interpretations about what was required before a certificate of competence could be issued. The adoption of the STCW Convention, which replaced the old International Labour Organization (ILO) Officers' Competency Certificates Convention (No. 53) of 1936, was therefore a major step towards global standards in this area (Morrison 1997). Nevertheless, it was not until the capsizing of the *Herald of Free Enterprise* in 1987 that the IMO started looking at human and organizational factors in a different light. The developments in IMO between 1991 and 1997, when HF-related issues were discussed in more detail, led to a more holistic approach to HFs and a recognition of the impact that HFs make on maritime safety.

4. Review of human factor-related publications

In order to discuss how the IMO addresses HF-related issues, an analysis of the contents of documents submitted to IMO's Maritime Safety Committee (MSC) was carried out and discussed in relation to papers published in two academic journals specialized in maritime affairs. The two selected journals—*Maritime Policy & Management* and the *Journal of Navigation*—have a history of more than 40 years. It is therefore expected that the published papers reflect issues of concern in the maritime community over this time span. The comparison of the content of the two journals and the content of the documents submitted to MSC should enable a discussion how the IMO selects issues for further consideration and how decisions are made regarding those issues. The main question for this survey is when and how certain topics are considered relevant to be included to the

agenda of MSC. It was assumed that a special interest in topics during certain years might be linked to papers published in academic journals. It was furthermore assumed that the comparison of the journal and the IMO document contents could help to determine how proactive the IMO has been over the years.

4.1. *Methodology and data used in the study*

4.1.1. *Model and taxonomy for the review of HF-related publications.* In a recent review of HF-related studies in the maritime domain, Hetherington, Flin, and Mearns (2006) used an onion model and a related taxonomy based on earlier publications by HSE (1997), Jørgensen (2002) and Stanton (1996) for the classification of the studies reviewed in their article. Since this model has similarities with the model suggested for formal safety assessment (FSA) in the IMO context (IMO 2002), it was used as a basis for the development of a model and a related taxonomy in the current study. Hetherington, Fin, and Mearns (2006) have used three layers in their model (design, personnel, organization and management). Following the ideas of Reason (1990) about latent and active conditions, a distinction is made between immediate (personnel) and underlying (organization and management) causes leading to accidents. Since the IMO has adopted an approach that is also based on ideas of Reason (1990), as well as Edwards (1972) and Hawkins (1987) as guidance for accident investigation (IMO 1999), it was considered appropriate to expand and revise the model and the taxonomy used by Hetherington, Flin, and Mearns (2006). A fourth layer was therefore added to consider environmental issues (physical, economic and regulatory). In addition, the taxonomy used was brought in line with the philosophy of the Human Factors Analysis and Classification System (HFACS) by Shapell and Wiegmann (2001), a tool that is often used when Reasons model is the basis for a review (Schröder-Hinrichs, Baldauf, and Ghirxi 2011). The taxonomy developed for this study provides for a three-level coding and allows for a more in-depth discussion of the reviewed content. The model and taxonomy are shown in Figure 1 and Table 2.

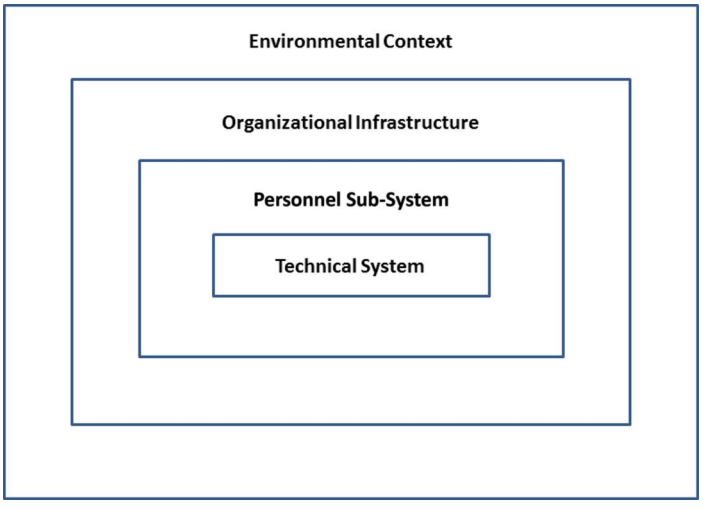

Figure 1. Taxonomy used in this study based on IMO's FSA approach (IMO 2002).

Table 2. Detailed overview about the taxonomy used for the coding of documents in this study.

Level 1	Level 2	Level 3
Environmental Context	Physical environment	Weather conditions
		Ergonomics
	Economic environment	Financial situation of owner
		Market situation
	Regulatory environment	Flag state regulation
		International standards
		Port state regulations
Organizational Infrastructure	Resources	Human resources
		Technical resources
	Organizational climate	Organizational structure
		Organizational policies
		Organizational culture
	Organizational processes	Operations
		Procedures
		Supervision
Personnel Sub-System	Crew condition	Cognitive factors
		Physiological state
	Personnel factors	Crew interaction
		Personal readiness
Technical System	Usability	Automation
		Design
	Availability	Shortage of equipment
		Unsuitable equipment
		Non-existence of good equipment

4.1.2. *Data sources for the review of HF-related publications.* In order to carry out a review of the content of HF-related publications and to compare them with submitted documents to the IMO, two appropriate academic journals were selected as described above. There are other journals with a publication history similar to *Marine Policy.* However, the papers published are more related to marine environmental issues rather than to maritime HFs. There are also a couple of more recent maritime journals, such as the *WMU Journal of Maritime Affairs*. However, they have only published for about 10 years, which does not allow for a study that covers the active HF-related IMO times following the floundering of the *Herald of Free Enterprise* in 1987.

As far as IMO documents were concerned, all documents submitted to the IMO's MSC were analysed in this study. MSC is one of the parent bodies of the technical subcommittees. It was therefore assumed that the documents submitted to MSC would automatically reflect discussions in the other subcommittees, whether an issue of interest was discussed under standards, training and watch-keeping, flag state implementation or a more technical agenda point. Since all subcommittees report back to MSC, relevant discussion items in the different subcommittees will be visible in the documents coming from the subcommittees to MSC.

4.1.3. *Methodology applied in the study.* Two HF experts reviewed the contents of the *Journal of Navigation* and *Maritime Policy & Management* from 1973 to 2012 and coded all HF-related manuscripts according to the taxonomy introduced above. A manuscript could be linked to several items of the taxonomy if it covered several HF-related aspects. In order to increase the reliability of the coding process, the experts worked independently. The results of the coding were subsequently compared, and in case of different coding results, the different opinions were resolved through mutual discussions.

The same methodology was used for the coding of the documents submitted to IMO's MSC. Since the agenda item Human Element shows up in 1991 for the first time, it was decided that a full review of 40 years of IMO documents would not be necessary. The coding was therefore only done for MSC documents between 1985 and 2012. It was furthermore decided that a review of documents submitted before 1985 would only be undertaken, if the review of the first 27 years left room for speculation.

4.2. *Results of the review*

The review of the HF-related content of the two journals identified 380 manuscripts from the *Journal of Navigation*. They were coded and tabulated as 626 entries in the taxonomy. The identified 133 manuscripts from *Maritime Policy & Management* resulted into 238 entries in the taxonomy. The review of the MSC documents identified 2158 HF-related documents, which resulted into 6646 individual entries in the taxonomy. The problem with the MSC documents was that there are years with two meetings and years with only one meeting. While the alteration was more regular in recent years, there were periods earlier without a regular meeting alteration. In order to allow a comparison with the annually published content of the academic journals, it was decided to use average figures in the years with more than one MSC meeting. As a result the original number of 6646 records in the taxonomy reduced to 4555 entries. The reduced number forms the basis for the further analysis.

Table 3 shows the focus of HF-related publications and documents in the three data sources. It should be kept in mind that the MSC documents cover a period of 27 years only, while the journal review covers a 40-year period. Before the journal content is commented on in more detail, some general comments about the MSC documents should be made.

As shown in Figure 2, the review identified that HF-related documents in MSC have a first peak in the years between 1991 and 1997. This is the period when MSC introduced the term Human Element (HE) for the first time to its agenda and started a follow-up to the *Herald of Free Enterprise* accident. The discussion in MSC resulted in a number of previously mentioned instruments that were adopted by the IMO assemblies in the years 1991 (17), 1993 (18), 1995 (19) and 1997 (20) (for an overview about the discussions in the different committees and subcommittees and the adopted instruments, see Eriksson and Mejia (2000)). Apart from the International Safety Management (ISM) Code addressing important organizational conditions for safe shipboard operations, the IMO HE vision was developed (IMO 1997, 2003a). The HE vision in its revised form of 2003 is an ambitious document. It provides some kind of a definition for the term HE in the principles section of the resolution. The HE is referred to as a 'complex multi-dimensional issue', involving 'the entire spectrum of human activities performed by ships crews, shore-based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all

Table 3. Summary of the coding results of the MSC documents and the journal manuscripts.

		Journal of Navigation		*Maritime Policy & Management*		IMO MSC	
No	Taxonomy	No.	%	No.	%	No.	%
E000	**Environmental Context**	**158**	**25.2**	**85**	**35.8**	**1716**	**37.7**
E101	Weather conditions	37	5.8	4	1.7	78	1.7
E102	Ergonomics	2	0.3	0	0	50	1.1
E201	Financial situation of owner	6	1.0	28	11.8	5.5	0.1
E202	Market situation	1	0.2	5	2.1	0.5	0
E301	Flag state regulation	4	0.6	19	8.0	120.5	2.6
E302	International standards	102	16.3	23	9.7	1365.5	30.1
E 303	Port state regulations	6	1.0	6	2.5	96.5	2.1
O000	**Organizational Infrastructure**	**31**	**5.0**	**62**	**26.1**	**1400.5**	**30.7**
O101	Human resources	19	2.8	35	14.7	453	9.9
O102	Technical resources	1	0.2	5	2.1	356	7.8
O201	Organizational culture	1	0.2	0	0	27.5	0.6
O202	Organizational policies	2	0.4	13	5.5	105.5	2.3
O203	Organizational culture	1	0.2	1	0.4	65	1.4
O301	Operations	3	0.5	3	1.3	182.5	4.0
O302	Procedures	3	0.5	4	1.7	199	4.4
O303	Supervision	1	0.2	1	0.4	12	0.3
P000	**Personnel Sub-System**	**106**	**16.9**	**67**	**28.1**	**518.5**	**11.4**
P101	Cognitive factors	46	7.3	22	9.2	98.5	2.2
P102	Physiological state	22	3.5	9	3.8	147.5	3.2
P201	Crew interaction	10	1.6	21	8.8	93.5	2.1
P202	Personal readiness	28	4.5	15	6.3	179	3.9
T000	**Technical System**	**331**	**52.9**	**24**	**10.0**	**920.5**	**20.2**
T101	Automation	207	33.2	12	5.0	409	9.0
T102	Design	24	3.8	4	1.7	326.5	7.2
T201	Shortage of equipment	0	0	0	0	1	0
T202	Unsuitable equipment	71	11.3	7	2.9	168.5	3.7
T203	Non-existence of good equipment	29	4.6	1	0.4	15.5	0.3
	Total	**626**	**100**	**238**	**100**	**4555.5**	**100**

of whom need to co-operate to address human element issues effectively'. This can be seen as an indicator for the recognition of the socio-technical context of HFs. The goals section of the same resolution defines the need to 'conduct a comprehensive review of selected existing IMO instruments from the human element perspective'. It also refers to the promotion of safety culture and the provision of a 'framework to encourage the development of non-regulatory solutions and their assessment, on the basis of human element principles'. In this respect, it should be recognized, for example, that the discussions about the so-called large passenger vessels between 2000 (IMO 2000) and 2006 (IMO 2006a), as well as the review of the STCW Convention in 2010 (IMO 2010a) were not accident driven. Whether this is a confirmation of the new proactive way of addressing HF issues in IMO is difficult to say at this point in time. The last accidents that had significant HF implications were probably the tanker accidents of the *Erika* in 1999 and the *Prestige* in 2002, which caused a review of the policies for granting places of refuge (IMO 2003b).

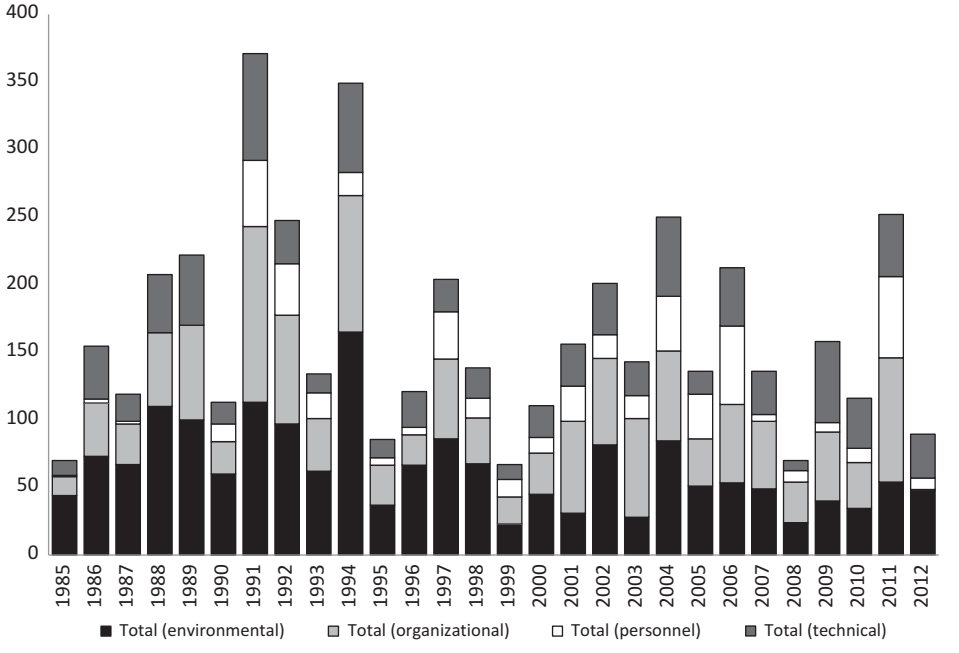

Figure 2. Overview of the coding results of the MSC documents.

However, this was more a consideration of organizational rather than individual HFs. Other accidents like the capsize of the ferry *Le Joola* off Gambia in 2002 or fire on the ferry *al-Salam Boccaccio 98* in the Red Sea in 2006 did not cause a major reaction in IMO. This highlights the dilemma of the IMO Secretariat. The IMO Secretariat has no influence on the agenda of a meeting. This depends on the member states and the topics that they are willing to discuss. In the case of the *Herald of Free Enterprise*, the UK recognized the importance of this accident and could convince the other member states to carry out a systemic change of shipping operations through the ISM Code. In case of other accidents, no such fundamental change happened at later occasions if only maritime safety-related issues are concerned.

Other peaks in HF-related discussions can be seen in 2002, 2004, 2006 and 2011. The discussions from 2002 to 2006 reflect another busy period of HF considerations. The revised HE vision of the IMO is a significant outcome. This later on led to the IMO strategy to address the HE (IMO 2006b). In 2005 and 2006, a number of interesting documents were submitted to MSC targeting near misses (IMO 2006c), human-machine interfaces (IMO 2006d), organizational factors (IMO 2006e) and leadership (IMO 2005). However, the interest in HF has suddenly decreased afterwards. It is noteworthy that a consultation proposal made by the ILO in 2008 on issues related to training, hours of work and rest, manning levels, seafarer fatigue, carrier and skill development and opportunities for seafarers' employment was rejected (IMO 2008). The Joint MSC/Marine Environment Protection Committee (MEPC) Working Group on HE in IMO saw no need to establish a working group with the ILO as the issues are partly covered by the Standards of Training and Watchkeeping (STW) Sub-Committee in IMO. In

addition, the suggested terms of reference for such a working group were considered as too 'wide and open-ended'. HF considerations have not been on a very high level since 2008, even though interesting studies on human behaviour (IMO 2010b) and just culture (IMO 2010c) were submitted for discussion. There is a peak in 2011. This mainly relates to the implementation of the 2010 Manila Amendments to the STCW Convention. HE was not an agenda item for MSC 89 (November 2011) and 91 (November 2012).

Figures 3 and 4 provide more information on organizational and personnel factors that were coded during the MSC document review.

In addition, Figure 5 shows the number of submitted papers under the agenda item HE in the MSC. It illustrates the decreasing focus on HF-related items in recent years.

The IMO in its strategy (IMO 2006b) suggests in Section 5 feedback and continuous improvement to periodically consider current information related to research in the field of human factors and ergonomics. This is one of the reasons why the content analysis of the manuscripts published in the two journals was made. The coding results are given in Figures 6 and 7.

The content in the *Journal of Navigation* shows an expected pattern with dominating technical issues in relation to HF issues. The content assigned to the Technical System part of the taxonomy represents the majority (331 out of the total of 626 taxonomy entries) and mainly relates to automation (207 taxonomy entries) and design (24 taxonomy entries). The Technical System articles show an even distribution over the whole considered period of 40 years. What has changed is the focus of the manuscripts over the years from design (ergonomics—such as the display of information on a radar screen) to automation (human-machine interfaces—such as accidents with an automatic navigation system on

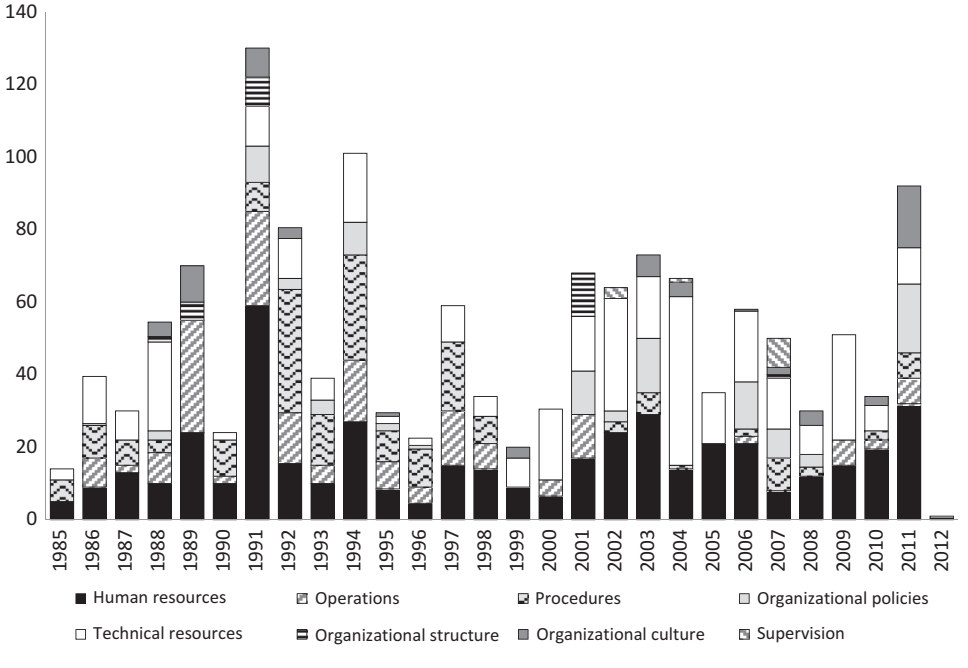

Figure 3. Content of the MSC documents in the sub-category Organizational Infrastructure.

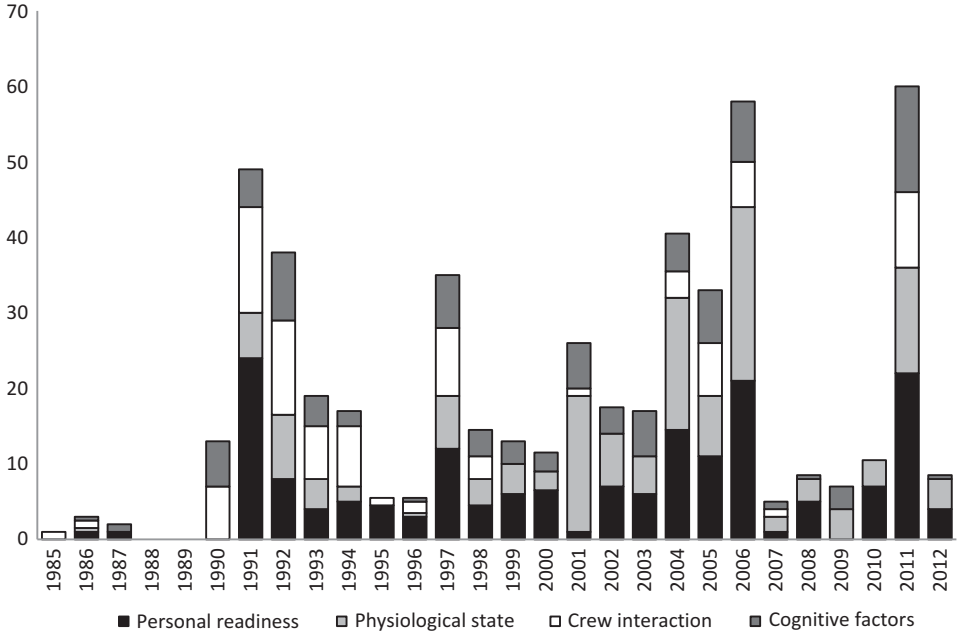

Figure 4. Content of the MSC documents in the sub-category Personnel Sub-System.

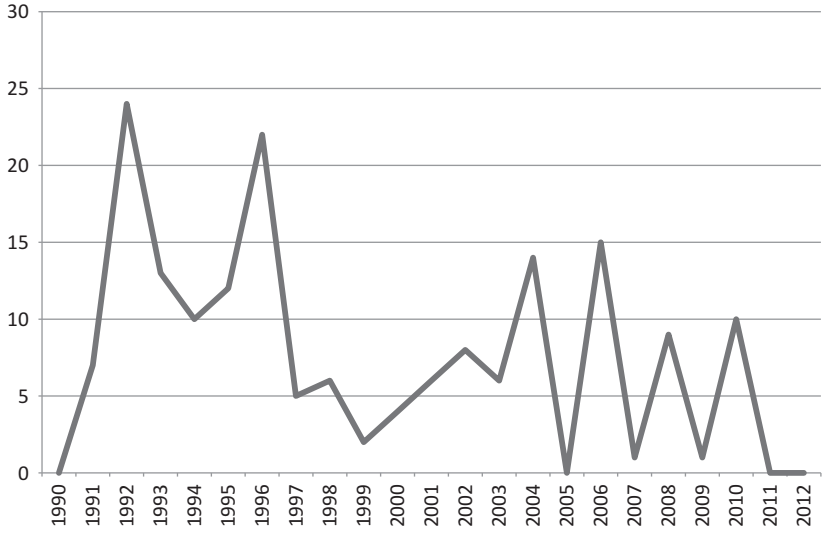

Figure 5. Average number of documents submitted to MSC under the agenda item Human Element.

board a passenger ship). The other main categories of the taxonomy are represented to a lesser degree. The second largest main category is Environmental Context (158 taxonomy entries). The articles here mainly relate to international standards. There are not many articles about personnel or organizational factors. In the beginning of the 1970s, the issue

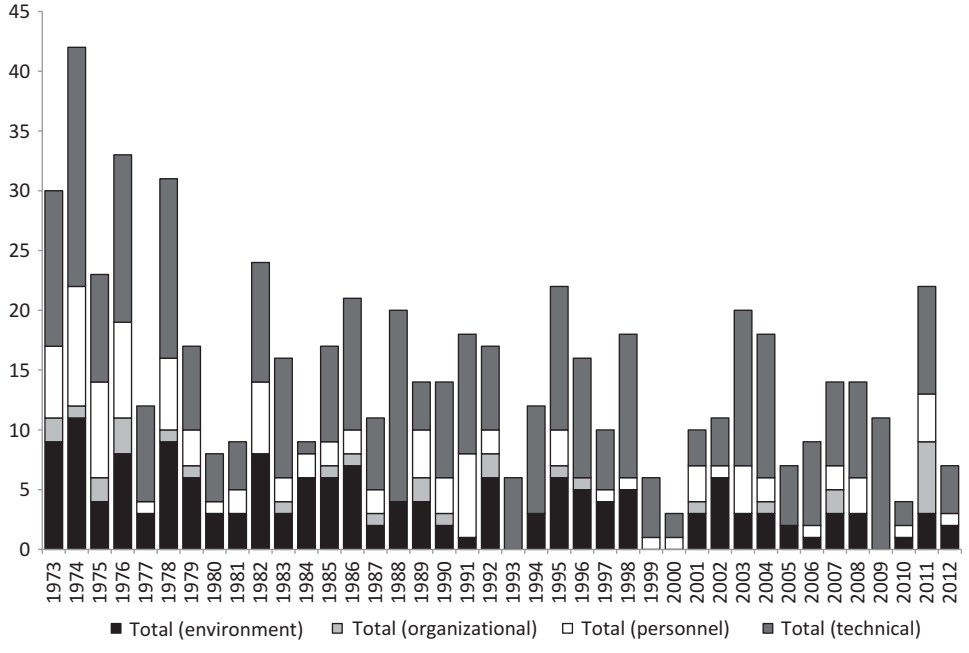

Figure 6. Overview about the coding results of manuscripts published in the *Journal of Navigation*.

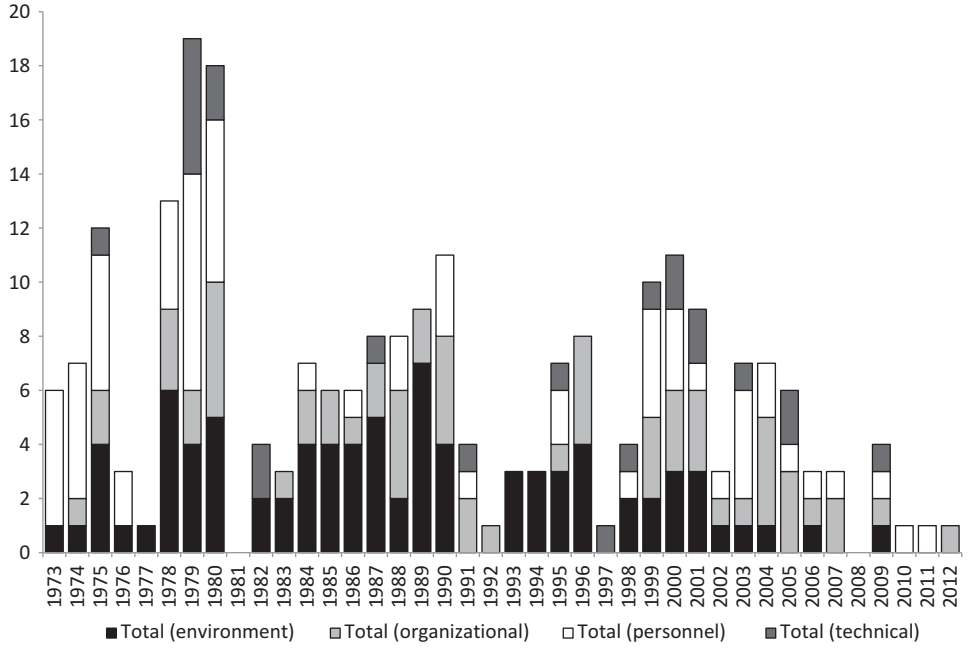

Figure 7. Overview about the coding results of manuscripts published in *Maritime Policy & Management*.

of collisions and groundings was discussed in detail. However, these were mere observations of the trends and areas where collisions and groundings happened. The manuscripts did not address the human involvement in the collisions and groundings. Manuscripts focusing on these issues, such as the already-mentioned bridge automation system (Lützhöft and Dekker 2002), represent exemptions in the content reviewed.

The analysis of the *Maritime Policy & Management* journal reveals no overall focus either on the Environmental Context, the Organizational Infrastructure or the Personnel Sub-System, but the journal pays less attention to the Technical System, which is to be expected. The *Maritime Policy & Management* journal shows a decline in the coverage of maritime HFs in the beginning of the 1980s and then again after a peak in 2000. The majority of the articles focus on the Environmental Context (85 out of the total of 238 taxonomy entries). In the early years, most of those articles focus on the 'financial situation of owners', and subsequently the focus shifts to legal issues. The Environmental Context is not evenly distributed over the years but has significant peaks in 1978, to 1980 as well as from 1984 till 1990. After 1990, the Environmental Context is still mentioned in articles but does not get the same attention as before. The Organizational Infrastructure and the Personnel Sub-System receive comparable attention with 67 and 62 articles, respectively, from a total of 238. Even with similar numbers, these topics are not evenly distributed over the years but are concentrated in peaks. The articles about Organizational Infrastructure peak in 1978–1980, 1989–1990, 1996, 1999–2001 and 2004–2005. The main topics within the Organizational Infrastructure are 'human resources' and 'organizational policies'. The Personnel Sub-System focuses primarily on 'cognitive factors' and 'crew interaction' and has three peaks in the years 1973–1975, 1978–1980 as well as 1999 and 2000. After the year 2000, the Personnel Sub-System is not prominent anymore. The Technical System is not the main focus of the *Maritime Policy & Management* journal with only 24 out of 238 articles. Articles on technical issues depict a more or less equal distribution with only two major peaks in 1979 and 1980 as well as 2000 and 2001. The focus of those articles lies on 'automation' and 'unsuitable equipment'. It is worth noting that within the technical issues, the focus of the articles shifts from 'automation' to 'design' to 'unsuitable equipment' from 1973 to 1996 and thereafter the focus is on both 'unsuitable equipment' and 'automation'. The content analysis of the *Maritime Policy & Management* journal reveals an overall decline in the coverage of maritime HFs.

4.3. *Validity of the study*

With regard to the validity of the data, a number of factors influenced the coding of the IMO documents. When major IMO events occur, a number of submissions are made related to these events. An example highlighting the consequences is the implementation of the 2010 Manila Amendments to the STCW Convention. The interest in HF was relatively low in the years the amendments were adopted. In 2011, however, a large number of documents were submitted considering implementation issues related to those amendments. If one only looks into the coding results without this information, it may seem as if renewed interest for HF could be concluded from this peak. However, no HF-related documents were otherwise submitted to MSC under the agenda item HE. In fact, HE was not an agenda item in MSC 89 and 91. Despite this artificial peak, it is still possible to look at the overall development of HF considerations at IMO.

4.4. *General trends identified*

Given the remarks regarding the validity of the study, a couple of trends were identified during the content analysis of the HF manuscripts and documents:

(1) **It was not possible to establish a relationship between the journal publications and the IMO documents.**
The topics of the papers published in the journals reviewed are independent from the discussions in IMO. There are only a few instances where comments on IMO discussions in the journals can be found. Research results are submitted to MSC. However, they often refer to research in non-maritime domains or were not published in journals.

(2) **The work in IMO in the 1990s was mainly accident driven.**
The HF discussions started following the foundering of the *Herald of Free Enterprise* in 1987. It took until 1991 for the term Human Element to be added to the MSC agenda. In light of the findings of the *Herald of Free Enterprise* accident investigation, a thorough review of potential HF-related implications was carried out by different subcommittees working under MSC. The reviews were finalized in 1997 and resulted in a number of revised regulations and recommendations as well as a number of new resolutions. The HF-related discussions have afterwards not continued on a similar high level.

(3) **The majority of work related to HF at IMO was done between 1991 and 1997 and reflects mainly the state of the art at that time.**
As stated before, the majority of HF-related discussions were carried out between 1991 and 1997. In this phase, academic work related to HF has been taken into consideration. However, it reflects the state of the art of the early 1990s. The IMO resolutions about casualty investigation refer to models of Reason (1990) or Hawkins (1987). This represents the epidemiological view of accident causation. Today, other approaches are available, but it does not look as if the casualty guidance will be revised. On the contrary, it seems that no specific guidance is given anymore in order to avoid that it becomes obsolete at one time in the future. The accident investigation guidelines are only one example for HF-related discussions. The ISM Code, for example, has not seen a major review following its introduction in 1993, although the tanker industry has recently adopted the Tanker Management and Self Assessment (TMSA) scheme (OCIMF 2008), where compliance with the ISM Code is only considered level 1 out of four possible levels to maintain safe operations on-board tankers. Other examples could be quoted in this context.

(4) **IMO follows an own routine in dealing with HF-related issues.**
Once an agenda item is introduced in an IMO committee, it develops its own dynamic. Committees only meet once or twice a year and refer items under discussion to subcommittees for further analysis. This lowers the speed of decision-making. In order to deliver the facts that allow for the formulation of decisions at the highest level, that is, during the assembly every second year, concentrated and coordinated efforts are needed. This may be one explanation why topics treated by academics are not considered in an appropriate way. Academic work is mainly taken into consideration, when the discussions in IMO come to a point where academic backing is considered helpful. It is only

then that a targeted search for information is carried out and member states present samples of national research for further discussion and consideration in IMO meetings.

(5) **It was not possible to determine if the IMO has truly become proactive in HF-related issues.**
Recent years have fortunately not seen major accidents that required a HF-related response at IMO. The 2010 Manila amendments of the STCW Convention cannot be fully related to accidents. This could be seen as a positive sign. It will nevertheless require a few more years of evidence before it can be confirmed that the IMO is now becoming truly proactive. It is slightly worrying that documents related to leadership, just culture, etc., submitted in recent years have not received the attention they should. One critical step to evaluate how proactive IMO is will certainly be the follow-up to the *Costa Concordia* accident last year.

Another comment should be made with respect to maritime HFs and related academic publications. From the review of the journal content, the conclusion was drawn that they only became 'popular' as a subject for publication more recently. The number of studies and manuscripts related to maritime HFs in earlier years was not significant. This confirms comments made by Moreby (1975), King (1979) or Hetherington, Flin, and Mearns (2006). A search for the keyword 'maritime human factors' in ScienceDirect produces hits mainly after 2000. Maybe, this is a trend where more academics realize that results from other HF domains, such as aviation, cannot be transferred to the maritime context without careful adaptations.

5. Discussion and conclusions

Decision-making, whether for regulations, safety, design, etc., must be based on a conceptualization of the system for which the decisions are made. This is indeed a prerequisite to move from reactive to proactive regulation.

The current premise is that a system can be described in terms of its parts, and that their functioning can be explained in terms of causes or factors. While this thinking has been immensely successful and helped us to design, build and operate even very large and complicated technological systems (with the possible exception of some cruise liners), it does not work well to explain how humans and organizations interact, or indeed to explain how complex socio-technical systems work. Despite that, nearly all industries and domains continue to use design methods that reflect the conditions of the 1970s and 1980s, even though these are no longer valid. Whereas it was defensible 30–40 years ago to focus on individual 'components', factors and functions, the nature of systems has changed beyond recognition. Rather than being orderly and decomposable, systems are now a 'blooming, buzzing confusion' made up of countless, interconnected systems. This not only taxes each system's ability to persevere but also challenges the appropriateness of our design methods.

Thinking in terms of layered models, such as the onion model, will be inadequate for future maritime activities (and may even be so for some today). It is a positive sign that IMO recognizes the state of the art, even though changes could be faster. Good system design and good regulations require the ability to 'think big' while 'thinking small' (Hollnagel 2006). They must at the same time ensure the stable functioning of the local

system and the persistence and survival of the larger, global system. This requires not only a revision of many commonly held design ideals, but also the development of methods that do not have decomposition as their main principle. Humans are essential to make a system work, but not just as a factor among other factors. Regulation and design instead require a perspective that emphasizes the intrinsic ability of joint systems and organizations to adjust their functioning prior to, during or following changes and disturbances, so that they can sustain required operations under both expected and unexpected conditions. The role of human factors in maritime policy must go beyond the classical human factor, as in the Människa-Teknik-Organisation (MTO; swedish meaning Human-Technology-Organization) thinking (Hollnagel 2010), and recognize that humans are necessary to ensure that systems work and that things go right. Only in this way can we become genuinely proactive and think of wholes rather than of parts.

The *Herald of Free Enterprise* was in many ways a turning point in the maritime safety regulations as discussed in IMO. Prior to this accident, the related follow-up to an accident was mainly done by new technical requirements hoping to cover the identified safety problem. It seems, however, that this accident made clear that such an approach only had a limited potential. Instead, a focus on the human operator and a consideration of the human and organizational factors was needed. This realization was manifested by the adoption of the ISM Code (IMO 1993), the introduction of formal safety assessment (FSA) as part of the IMO rule-making process (IMO 2002) or the provision of guidelines for the investigation of HF aspects in maritime accidents (IMO 1999). IMO went even a step further and introduced a Human Element (HE) vision for the work of the organization (IMO 1997, 2003a). This acknowledges the importance of this issue vis-à-vis maritime safety and clearly addresses the complexity of human and organizational factors in a maritime context. As such, it could be seen as a starting point where IMO may identify HF-related safety issues in a more proactive way. In fact, it could be argued that a reactive approach was unavoidable at the beginning of the IMO activities as there was no adequate system of international treaties dealing with all relevant aspects of maritime safety. With the full spectrum of IMO instruments now at hand, it should be easier to be proactive. The day-to-day business is not characterized by loopholes in the legislative framework anymore. Thus, time-consuming treaty negotiations may be less and less an issue. Instead, there should be time to identify proactively issues that require action from IMO member states. The 2010 amendments of the STCW Convention is an example for a revision of a major IMO instrument that does not seem to have its roots in maritime accidents (IMO 2010a). It is hoped that more instruments will confirm the proactive developments in IMO in future years.

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