Towards a Marine Accident Frame: Extraction of Predicate-Argument Structures with Word Sketches

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Abstract This paper presents the results of a study that combines information extraction by means of word sketches with corpus-based analysis. In the analysis, terminological information was extracted from a corpus of investigation reports by retrieving the word sketches of the selected verbs. The aim of the study is to identify predicate-argument structures in a specific domain corpus by adopting the principles of Frame-based Terminology (FBT). Thus, this research shows how FBT can be applied to different scenarios such as a marine accident event, which is the object of this study. The long-term goal is to build a marine accident frame by utilising the predicate-argument structures identified in this study. The predicate-argument structures and the evolving frames can be used to enhance the representation and understanding of marine accident events. Thus, the predicate-argument structures are presented for consultation to future end users of the results, namely the stakeholders in the field of maritime safety, including maritime English teachers, as well as LSP teachers and terminologists.

Keywords corpus linguistics, Frame-based Terminology, Frame Semantics, marine accident event, predicate-argument structure

1 Introduction

Over the last twenty years, terminology has experienced a shift towards cognitive and corpus-based terminology. The shift is manifested in a cognitive approach that is known as Frame-based Terminology (FBT) (cf. Faber et al. 2006, Faber 2014: 14). FBT has adapted the basic principles of Frame Semantics (cf. Fillmore 1977, 1985, 2006 [1982], Fillmore/Atkins 1992) for structuring specialised domains and creating conceptual representations in specific domains (Faber et al. 2006: 192). In Frame Semantics, the key assumption is that the meanings of lexical units are constructed in relation to background knowledge, the structure of which is represented in semantic frames (cf. e. g. Fillmore 2006 [1982]: 378). The principles of FBT have been applied in a number of specialised domains for the creation of domain-specific frames and termbases; however, the maritime field has not been addressed in any depth. Hence, our study aims at introducing FBT in the maritime field by applying the principles and methods of FBT to one event concept, namely a *marine accident*. Here, a marine accident is an event that leads the vessel's operation from a safety sphere (state, situation) through a change towards an accident.

In texts, events are often represented linguistically in the form of predicate-argument structures (Faber 2014: 21). It is our aim to identify predicate-argument structures in a specific domain corpus and, furthermore, to describe the conceptual structures of the marine accident event and the lexical components in these structures. The evolving conceptual structures

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can be utilised for querying and organising data by researchers, terminologists and accident investigators, for example. We focus on the verbs used to express processes and activities, as well as to relate the participants involved and their roles. These participants are the semantic arguments of the predicates analysed in this study with each activating a certain argument structure. The long-term goal is to build a marine accident frame, and consequently, enhance the representation and understanding of marine accident events.

Shipping is a complex system, in which events, actions and agents combine in ways that are not always predictable or under control. Regrettably, accidents happen in spite of constant improvements in technical and administrative solutions. Achieving a comprehensive understanding of marine accidents and their development requires knowledge of the different elements involved in an accident event and the relationships between these elements. For example, to establish an overview of a collision accident, a description should include the cause of the event and its effects, as well as the entities involved.

In the field of maritime safety, recent research has focused on exploring the root causes of merchant shipping accidents. Studies have generally employed certain well-established mathematical models of risk assessment, such as Reason's (1990) Swiss Cheese model and the Bayesian Network model (cf. e. g. Pearl 2000), or frameworks, such as Human Factors Analysis and Classification System (HFACS) introduced by Shappell/Wiegmann (2000). Although these models have been widely implemented and despite the invaluable contributions in the field of safety science, some studies argue that the models have been interpreted in a linear way and the common understanding of an accident event is too simple (e. g. Schröder-Hinrichs/Hollnagel/Baldauf 2012: 156, 160). Also, researchers often focus on providing risk probabilities rather than on presenting background knowledge or defining causal concepts (cf. Mazaheri et al. 2015: 202, 204). Besides, the studies utilising these models and frameworks mainly rely on the intuition of the developers, or manual information extraction from accident reports, which is laborious and prone to subjectivity.

Unlike most of the earlier studies in the field of maritime safety, our study is corpus-based and lexicon-driven, which means that, instead of existing frameworks or classifications, we take a corpus as a starting point for our study and employ the FBT approach to compile predicate-argument structures, which manifest conceptual representations in the domain. Thus, the resulting conceptual representations are supposed to mirror real accident scenarios including concepts, conceptual relations, and the semantic roles of the entities involved. In this respect, the results of our study are intended to complement the existing domain ontologies and frameworks by providing a linguistically-based event representation. Also, instead of manual information extraction, we utilise a corpus tool and word sketches for the extraction of terminological information, i. e. information about concepts and their relations (cf. e. g. Leon-Aráuz/San Martín/Faber 2016). Word sketches are defined by Kilgarriff et al. (2014: 9) as summaries of a word's grammatical and collocational behaviour.

In the domain of maritime safety, an important source of domain-specific information are investigation reports. These reports are a rich source of data and include a meticulous analysis of individual accident cases. Investigation reports have previously been used as research material in other academic fields, such as the social sciences (e. g. Tang et al. 2013) and safety science (e. g. Mazaheri et al. 2015); however, it appears that they have not been analysed using terminological methods. Thus, a corpus study that includes an in-depth concept analysis should provide greater insight into the development of a marine accident.

The remaining sections of this paper are structured as follows: section 2 presents the the-

oretical background underlying the study and provides a short review of previous research and the applications of semantic frames in Terminology; section 3 illustrates the features of the corpus used in this study and describes the applied methodology; section 4 summarises and illustrates the results of the frame-based analysis; and section 5 presents the conclusions that can be derived from this research.

2 Frame-based Terminology

Frame-based Terminology is a cognitive approach to terminology that links specialised knowledge representation to Frame Semantics (cf. e. g. Fillmore 2006 [1982], Fillmore/Atkins 1992, Faber 2012). In Frame Semantics, frames are a structured way to present a scene or situation and are motivated by previous knowledge and experience. Another principle stemming from research shows that, regardless of the language, a set of verbs can be viewed as semantically related, as the verbs evoke the same general schematised scene (cf. Fillmore 2006 [1982]: 378, cf. also Croft/Cruse 2004: 8).

A number of studies in the field of FBT have demonstrated that the principles of Frame Semantics are applicable to specialised fields (cf. e. g. Faber/Márquez/Vega 2005, Pimentel 2014, Durán-Muñoz/L'Homme 2020). The earliest applications of FBT are the studies by Faber et al. (2006) in the domain of coastal engineering and by Faber (2012, 2014) in domain of the environment. EcoLexicon, a multilingual terminological knowledge base developed by the LexiCon Research Group at the University of Granada[1] (cf. e. g. Faber/Buendía Castro 2014), is likely to be the most extensive practical application of the methodology based on FBT. In addition to the work by the LexiCon Research Group, L'Homme (e. g. 2018) has applied a more FrameNet-oriented type of FBT in resources such as Framed DiCoEnviro. FrameNet[2] is a practical application of predicate frames originating from Fillmore's (1968) case frames and is often used as a tool in lexicography-oriented studies (cf. Fillmore/Johnson/Petruck 2003). Durán-Muñoz/L'Homme (2020) have also applied corpus-based analysis to English motion verbs in the field of adventure tourism. Researchers that have applied FBT in the field of law include Peruzzo (2014) and Pimentel (2014). However, in the specialised domains of transport, including aviation, railway, and maritime transport, the application of FBT is limited.

Events can be represented by predicate frames. Predicate frames stem from Fillmore's (1968) case frames in which verbs are characterised in terms of the semantic roles of their arguments (Faber/Reimerink 2019: 19). In FBT, the predicate frames characterising events, actions, and processes in a specialised domain are manifested by verbs and their nominalisations. Verbs also link the conceptual categories of the typical participants. The linguistic realisations of frame elements connect the linguistic level to the abstract conceptual representation of the situation (cf. Sánchez-Cárdenas/Ramisch 2019: 5). For example, in the field of maritime safety, a grounding event is an instance of a marine accident frame that includes cause, patient, and effect as core elements and symptoms and consequences as non-core elements (Pasanen 2014: 496, 498).

Our study focuses on predicate frames that describe actions and processes designated by verbs (cf. Faber/Cabezas-García 2019: 205). This starting point is based on the assumption that predicates and their arguments correspond to generic cognitive structures (Sán-

[1] http://lexicon.ugr.es/.

[2] https://framenet.icsi.berkeley.edu/fndrupal.

chez-Cárdenas/Ramisch 2019: 4). The arguments of the predicates include the frame elements that represent the main participants of a schematised situation. Moreover, the semantic nature of the arguments restricts the meaning of the predicate in the specialised domain (Faber/Cabezas-García 2019: 207). Linguistically, the arguments are generally nouns or noun phrases (Sánchez-Cárdenas/Ramisch 2019: 5).

3 Materials and methods

Within a specific domain, the specialised knowledge shared by domain experts is generally expressed in the texts produced by a community of these experts. For this reason, terminological analysis should be rooted in texts produced by domain experts (Peruzzo 2014: 152). Consequently, corpora are viewed as the main repositories of knowledge in a terminological project (L'Homme 2018: 8). A specialised corpus suitable for the purposes of this research was not available; therefore, the first step in our study was to compile a corpus.

In a terminological project, corpus texts should be selected according to criteria such as authoritative source, length, relationship with the topic, and textual genre. In the field of maritime safety, investigation reports are the main source of texts that meet these criteria and they are freely available for compiling a corpus on marine accident events. Consequently, the texts selected for the corpus in this study were all drawn from investigation reports and, therefore, all belong to the same textual genre. Investigation reports are structured documents that detail the findings of an investigation and thus represent a specialised communicative situation. The authors of these reports are investigation boards that are separately located in maritime countries, although currently many European investigation boards use the European Marine Casualty Information Platform (EMCIP) database of the European Maritime Safety Agency (EMSA) as a repository for the final reports.

The EMSA portal was used to compile the corpus for our study.[3] The filters that were activated included a casualty with a ship and cargo ship as the ship type. This search produced 296 results that covered the years 2012 to 2018 for all accident types. The reporting language is not included in the filtering options; therefore, the results were searched manually to identify the language of the investigation reports. Following the manual search, the reports provided by the Marine Accident Investigation Branch of the United Kingdom (MAIB) and the Maltese Safety Investigation Unit were selected, first, because of the high number of reports generated by these investigating bodies and, second, because all the reports were written in English.[4] Based on these criteria, 124 reports were selected for the corpus. The number of tokens was 877,693 and this total was considered sufficient when taking into account the specialised nature of the topic.

The documents downloaded from the EMCIP database have been systematically compiled by the investigation boards (Mazaheri et al. 2015: 209). A systematic working method means that all the reports presented by each investigation board have a uniform structure. This uniformity is due to the EMCIP taxonomy of input data. Introduced in 2011, the aim of the taxonomy is to facilitate the production of investigation reports and to unify their structure. By defining attributes and values that can be used to describe an occurrence, the taxonomy

[3] http://www.emsa.europa.eu/emcip.html.

[4] Cf. www.maib.gov.uk and https://mtip.gov.mt/en/Pages/MSIU/Marine-Safety-Investigation-Unit.aspx.

provides a certain standard for reporting and analysis.[5] However, Mazaheri (2017: 18) underlines the fact that accident reports are secondary sources that are prepared and collected using primary data. As secondary resources, they inevitably include a level of interpretation. Nevertheless, as Mazaheri (2017: 20) concludes, using secondary sources to analyse marine accidents is unavoidable as obtaining primary data is almost impossible.

The investigation reports published on the EMCIP portal are in PDF format. Therefore, this study first converted the reports into raw text. The documents were then loaded into the source code editor Notepad++.[6] In this application, the captions of the illustrations and figures, as well as the footnotes, were deleted unless they were in the form of complete sentences. Furthermore, texts in the illustrations, figures indicating pages or footnotes, and regular expressions, such as liability clauses, were removed. The chapters involving ship particulars, voyage particulars, and marine occurrence information, as well as contents, glossaries, annexes, and tables were also deleted.

In order to extract predicate-argument structures, the study's corpus was uploaded to the corpus query and management system Sketch Engine (Kilgarriff et al. 2015: 66; for a detailed introduction to the tool cf. Kilgarriff et al. 2014).[7] In the Sketch Engine corpus analysis application, the corpus was tagged with TreeTagger (version 2) as developed by Helmut Schmid with modifications by Sketch Engine.[8] Following the encoding using UTF-8 character, the corpus was then ready for querying and the generation of word sketches. First, we extracted a list of verbs from the corpus that included 1,122 lemmatised verbs. The 50 most frequent verbs were selected for the analysis. Table 1 shows the list of verbs and their frequency of occurrence with the topmost positions occupied by general language verbs, such as *be, have, do, take, make, use*. The general language verbs were included in the analysis because these polysemic verbs have potential special use in specific language when combined with specialised arguments (cf. Faber/Cabezas-García 2019: 208).

Table 1: 50 most frequent verbs in the corpus of Marine Accident Reports

No	Verb	Freq
1	*be*	32,483
2	*have*	9,006
3	*do*	1,618
4	*take*	1,569
5	*make*	1,279
6	*use*	1,267
7	*include*	1,159
8	*require*	1,154
9	*follow*	1,086

No	Verb	Freq
10	*provide*	1,006
11	*carry*	948
12	*indicate*	780
13	*report*	734
14	*identify*	688
15	*operate*	678
16	*ensure*	638
17	*give*	624
18	*show*	583

No	Verb	Freq
19	*remain*	563
20	*consider*	548
21	*fit*	532
22	*find*	532
23	*hold*	506
24	*leave*	500
25	*work*	495
26	*state*	484
27	*keep*	484

5 Cf. http://www.emsa.europa.eu/we-do/safety/accident-investigation/item/3024-emcip-taxonomy.html.

6 https://notepad-plus-plus.org/.

7 https://www.sketchengine.eu.

8 Cf. https://www.ims.uni-stuttgart.de/en/research/projects/textkorpora-werkzeuge/ and https://www.sketchengine.eu/english-treetagger-pipeline-2/.

No	Verb	Freq
28	*set*	483
29	*issue*	469
30	*pass*	452
31	*load*	415
32	*complete*	403
33	*see*	389
34	*conduct*	388
35	*start*	385

No	Verb	Freq
36	*result*	380
37	*call*	374
38	*inform*	369
39	*enter*	366
40	*maintain*	366
41	*go*	364
42	*monitor*	362
43	*check*	359

No	Verb	Freq
44	*confirm*	359
45	*cause*	353
46	*lead*	349
47	*avoid*	346
48	*reduce*	329
49	*become*	323
50	*increase*	318

In the next phase of the study, the word sketch function of the Sketch Engine corpus tool was used to search the corpus and find all the recurring patterns for each verb examined in the study (Kilgarriff et al. 2014: 10). The default word sketches represent the relations of verb-subject and verb-object pairs, as well as modifiers of the verb (Kilgarriff et al. 2014: 9, Faber/Cabezas-García 2019: 203). If the word being analysed is a verb, the left-hand column of the summary gives the objects of the verb (cf. Figure 1). Kilgarriff et al. (2014: 9) noted that "[t]he 'object' column is noise-free" and it was also identified useful for this study. Another effective word sketch is that of phrasal verbs (Kilgarriff et al. 2014: 10). The Sketch Engine tool also includes filters that assist with sorting the query results and focus on the most relevant output.

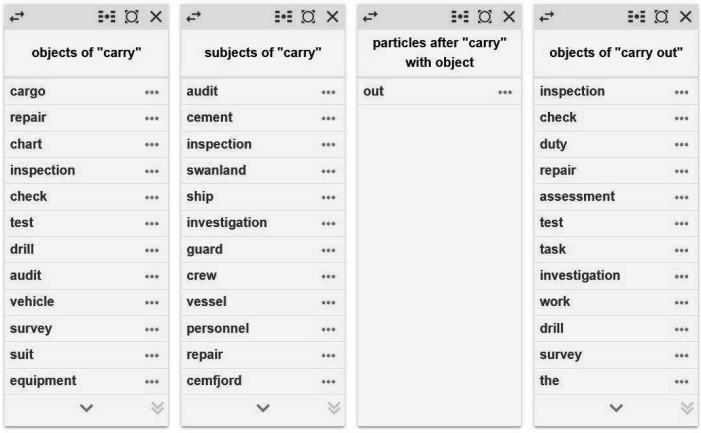

Figure 1: Word sketch of the verb carry *from Sketch Engine*

The next step in the search for predicate-argument structures was to analyse concordances of the most frequent verb-subject and verb-object pairs. We focused on the noun phrases that functioned as subjects and objects because the concordances that included these candidate terms would most likely produce valid predicate-argument structures. The threshold for candidate terms was set at four instances within the corpus. The results of concordance searches provided propositional representations of the processes; that is, the searches provided lexical representations of argument-taking lexical items, which are the verbs in our study, and their arguments. Knowledge of the types of entity that can fill the slots for the arguments (of the

predicates) is required for this process. After identifying potential arguments, we grouped them into broader conceptual categories as shown in Table 2, which presents the conceptual categories of potential human-related arguments (cf. Faber/Cabezas-García 2019: Table 2, Sánchez-Cárdenas/Ramisch 2019: Table 1). The conceptual categories were based on general semantic categories that include entities (animate and inanimate, concrete and abstract), states, processes, activities, events, and properties. The selected terms and their conceptual categories were later employed to assist the compilation and generalisation of argument structures (cf. section 4).

Table 2: Conceptual categories of potential human-related arguments

Category	**Subcategories**	**Potential arguments**
INDIVIDUAL HUMAN BEING(S)	on board	*chief engineer, chief officer, crew, crew member, engineer, lookout, master, mate, officer, pilot*
	not on board	*port captain, stevedore, surveyor*
ORGANISATION / COMPANY		*charterer, classification society, coastguard, flag state, harbour authority, owner, ship manager*
HUMAN STATE		*competence, fatigue, situational awareness*
HUMAN ACTIVITY	accident-related	*fire-fighting, investigation, rescue*
	cargo-related	*cargo operation, carriage, discharge, lashing, loading, sounding, stowage*
	navigation-related	*collision avoidance, navigation, navigational watch, manoeuvre, passage planning, pilotage, steering, watch-keeping*
	vessel-related	*audit, drill, inspection, maintenance, mooring, repair, risk assessment*
PRODUCT OF HUMAN ACTIVITY		*certificate of competency, loading manual, passage plan, recommendation, safety investigation report, safety management system, weather forecast*

The specification of argument structures involves identifying the semantic roles of the arguments based on the semantic relation between the argument and the predicate (Faber/Cabezas-García 2019: 202). Saeed (2016: 154) noted that semantic roles and grammatical relations have typical matchings; in a sentence, the subject often corresponds to the AGENT, the direct object to the THEME, and the INSTRUMENT is expressed by a prepositional phrase. Our classification of semantic roles is, in general outline, based on the VerbNet network of English verbs.[9] The semantic roles identified in our corpus are shown in Table 3.

[9] Semantic roles are dealt with in a number of sources; for example, in VerbNet: https://verbs.colorado.edu/verbnet.

Table 3: Semantic roles of the arguments (cf. Saeed 2016: 150–155, Faber/Cabezas-García 2019: 202–203, Sánchez Cárdenas/Ramisch 2019: 19)

Semantic role	Description
agent [actor]	a volitional participant, an entity, or a natural force, that initiates an action or event
beneficiary [recipient]	the entity for whose benefit the action was performed
experiencer	the living entity that experiences the action or event; is aware of the action or state; undergoes a sensory, cognitive, or emotional experience
force	non-volitional force, process, or event that produces a new entity or transforms a patient, affects a theme, or produces a result
instrument	an object or means used by an agent to perform an action or event
location	a place where an event occurs or where an object exists; path, source, goal
manner	the way in which an action takes place
patient	an entity affected by an event; undergoes transformation or change in state
purpose	the reason for which the action was performed
result	an event by an agent or a force; an entity originated or produced by an event

Table 4: Argument structures of the verb to carry

1ST ARGUMENT	PREDICATE	2ND ARGUMENT
[**artefact_vehicle**] *vessel, ship*	*carry* [**movement**]	[**product of human activity_cargo**] *cargo, general cargo, dangerous goods, forest products, Dangerous Chemicals in Bulk, vehicles, solid bulk cargo, temperature-controlled cargoes, dry cargo in bulk, heavy cargo, high density cargo, containers, coal in bulk, cargo of vegetable oil, U-IBA, cargo of steel turnings, heavy fuel oil, heavy and large volume cargoes, chemicals, products*
		[**equipment**] *radio equipment, spare full BA sets, deck lifter machine*
		[**device**] *Electronic Chart Display Information System (ECDIS), lifebuoy, lifeboat, immersion suit, firemen's outfit, AIS*
		[**product of human activity_document**] *loading manual, paper chart*
		[**human being**] *additional third officer, Filipino deckhand, watchkeeper, bosun, AB*
[**water movement**] *flood stream*	*carry* [**movement**]	[**artefact_vehicle**] *vessel, ship*

The annotation process based on the concordance searches allowed us to identify the arguments and show the relations between the predicates and the participants in the event. Table 4 presents the results of the annotation process of the verb *to carry*. In relation to an artefact,

namely a vessel or a ship in this context, the propositions with the verb *to carry* give information about the transported cargoes, the vessel's equipment and devices, as well as the crew members, passengers, or documents on board the vessel. The verb *to carry* is usually related to a vessel or a ship that has the purpose of carrying cargoes from port to port. However, the verb can also be related to a natural agent, such as a flood stream, that can carry vessels out of the fairway (cf. Table 4).

To demonstrate how linguistic information is connected to knowledge in the specialised field of maritime safety, the verb-argument structures belonging to the same lexical domain were grouped together. For the verb classification, we utilised general lexical domains that are widely used in studies on English verbs (Faber/Mairal 1999, Levin 1993, cf. also Faber/Cabezas-García 2019: 205, Faber/Reimerink 2019: 21). The lexical domains of FEELING, SOUND, and LIGHT mentioned by Faber/Mairal (1999) were excluded in our analysis due to the lack of verbs belonging to these domains in the list of 50 most frequent verbs in our corpus. Also, the lexical domain of CONTACT was excluded for the same reason. In our corpus, the domain of CONTACT is lexicalised in the combination of the support verb *make* and the noun *contact* as demonstrated in 4.1.6 and 4.1.8.

Each argument belongs to a specific conceptual category, has a semantic role, and is related to one or more concepts through a predicate; the predicate is a verb, a phrasal verb, or a verb pattern. For example, the argument *officer* belongs to the category of HUMAN BEING and has the semantic role of agent in the lexical domain of MANIPULATION; in the domain of MANIPULATION, the officer *operates safety equipment*; whereas the argument *safety equipment* belongs to the category of EQUIPMENT and has the role of instrument. In the following section, the results of the analysis are discussed and the evolving prototypical predicate-argument structures are drafted.

4 Results and discussion

4.1 The Marine Accident Event

The following section presents the results of the corpus search and includes the argument structures of a marine accident event. The argument structures are grouped under the main lexical domains of ACTION, CHANGE, EXISTENCE, MANIPULATION, MOVEMENT, PERCEPTION, POSSESSION, and SPEECH. As expected, some verbs belong to more than one lexical domain due to their multiple meanings; this is a particular feature of general language verbs (e. g. *take* and *make*). Moreover, some verbs are phrasal verbs, although in Table 1 they are listed in a base form. For example, these verbs include *carry* and its phrasal form *carry out*. Combinations of a general language verb (a support verb) and a noun, such as *take action, take place,* or *make contact,* are treated as verb patterns; in a text, they could be replaced by the verbs *act, happen,* or *contact*.

In the argument structures, the abbreviation *Arg* stands for the word *argument* and *As* stands for an *argument structure*. The second line in an argument structure is an instance from the corpus and is given to illustrate the structure.

4.1.1 Action

The lexical domain of ACTION belongs to the FrameNet frame of INTENTIONALLY_ACT that includes the core element of an agent performing an intentional act. In this analysis, performing an act includes starting and finishing the activity. In addition, verbs related to an ongoing activity (keep, maintain) belong to this domain.[10] In our corpus, the predicate verbs or phrasal verbs *carry out*, *conduct*, *complete*, *keep*, *maintain*, and *start* indicate a type of action that is taking place in the situation. The verb *take* is included in this domain as a support verb; this is because the main semantic frame is introduced by a noun (action) following the verb in the sentence (cf. Atkins/Fillmore/Johnson 2003: 270). In relation with a human agent, these verbs or phrasal verbs provide information about the actions of individual persons or groups of people, often in passive. Based on the concordances of these predicates, the following argument structures were developed:

(As 1 act)	TAKE ACTION (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{purpose}}$
	TAKE ACTION (bridge team)$_{\text{human agent}}$ (avoid/prevent an accident)$_{\text{purpose}}$
(As 2 act)	CARRY OUT (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{result}}$
	CARRY OUT (technician)$_{\text{human agent}}$ (maintenance)$_{\text{result}}$
(As 3 act)	COMPLETE (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{result}}$
	COMPLETE (officer)$_{\text{human agent}}$ (paperwork)$_{\text{result}}$
(As 4 act)	CONDUCT (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{result}}$
	CONDUCT (surveyor)$_{\text{human agent}}$ (audit)$_{\text{result}}$
(As 5 act)	KEEP (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{theme}}$
	KEEP (watchkeeper)$_{\text{human agent}}$ (navigational watch)$_{\text{theme}}$
(As 6 act)	MAINTAIN (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{theme}}$
	MAINTAIN (officer)$_{\text{human agent}}$ (lookout)$_{\text{theme}}$
(As 7 act)	START (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{theme}}$
	START (OOW)$_{\text{human agent}}$ (course alteration)$_{\text{theme}}$
	START (Arg 1)$_{\text{agent}}$ (Arg 2)$_{\text{theme}}$
	START (vessel)$_{\text{agent}}$ (a turn to port)$_{\text{theme}}$

In the first action scenario (As 1 act), a crew member or the crew collectively, a company or an organisation (Arg 1) takes an action to avoid or prevent an undesired event, such as a collision or an accident. This argument structure is normally followed by the applied measures. In the following scenarios (As 2–4 act), a human agent carries out, completes, or conducts an action that is part of the standard operation of the vessel, such as drills or maintenance; these are indicated with (Arg 2) in the argument structure. In these scenarios, the agent completes the activities. With the verb *conduct* as a predicate, the agent is often a company or an organisation rather than a crew member. Consequently, the action conducted is related to audits, inspections, and surveys (As 4 act). The predicates *keep* and *maintain* refer to ongoing navigation-related activities, particularly the action of keeping a lookout or watch. The navigation-related activities are ongoing and only cease once the navigation itself has ended (As 5–6 act). In our corpus, the verb *start* (As 7 act) is generally related to course alterations that are actions taken to prevent an accident. Thus, this verb can also indicate a change.

[10] https://framenet.icsi.berkeley.edu/fndrupal/framenet_search. All references to FrameNet refer to this source.

The conceptual categories of the arguments are interesting as a vessel or a ship, which belong to the conceptual category of VEHICLE, are often the grammatical subject in the argument structure of an action verb instead of a crew member or the crew (As 7 act). Therefore, a vessel or a ship represents the crew collectively and acts as an agent.

4.1.2 Change

In FrameNet, the frame of CHANGE has sub-frames CAUSE_CHANGE and UNDERGO_CHANGE in which an entity changes its category membership or the value of an attribute. The core elements are an entity and the initial and final categories or values. In the CAUSE_CHANGE frame, an agent is a core element. In navigation, the verbs *increase* and *reduce* often refer to the speed of the vessel (As 1–2 ch). Altering speed and course is the primary method for changing the movements of a vessel in a heavy traffic situation or in difficult weather conditions, thereby reducing the risk of an accident. In addition to the actions of crew members, natural phenomena may also affect navigation, such as fog reducing visibility.

(As 1 ch) INCREASE $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
INCREASE $(\text{master})_{\text{agent}}$ $(\text{speed})_{\text{theme}}$
(As 2 ch) REDUCE $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
REDUCE $(\text{master})_{\text{agent}}$ $(\text{speed})_{\text{theme}}$
REDUCE $(\text{fog})_{\text{agent}}$ $(\text{visibility})_{\text{theme}}$

The verb *have* is included in this domain as a support verb; this is the same application as the verb *take* in the ACTION domain (cf. 4.1.1). The main semantic frame of the verb *have* is introduced by a noun (effect, impact, influence) following the verb in the sentence. Man-made artefacts or constructions have a neutral, positive, or negative effect (impact, influence) on natural entities and can account for changes in the entity. However, the investigation reports often focus on the effect, impact, or influence of natural entities or events on other natural entities or water events (As 3 ch). In addition, artefacts or natural entities may influence water events by producing a change in the normal course of a process. Alternatively, a natural entity may have an effect on an artefact. During one event, for example, flood water on board the ship had a positive effect on the ship's stability.

(As 3 ch) HAVE EFFECT $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{patient}}$ OR $(\text{Arg 3})_{\text{theme}}$
HAVE EFFECT $(\text{dewatering system})_{\text{agent}}$ $(\text{beach})_{\text{patient}}$
HAVE IMPACT $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{patient}}$ OR $(\text{Arg 3})_{\text{theme}}$
HAVE IMPACT $(\text{wave})_{\text{agent}}$ $(\text{coastline})_{\text{patient}}$
HAVE INFLUENCE $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{patient}}$ OR $(\text{Arg 3})_{\text{theme}}$
HAVE INFLUENCE $(\text{nearshore sand bars})_{\text{agent}}$ $(\text{wave breaking})_{\text{theme}}$

Investigators have put considerable effort into studying the interactions between natural entities or events that may have had a role in the development of the accident (As 4 ch). In addition, human action or state may or may not have an effect (impact, influence) on human actions.

(As 4 ch) HAVE EFFECT $(\text{Arg 1})_{\text{force}}$ $(\text{Arg 2})_{\text{theme}}$
HAVE EFFECT $(\text{tidal velocities})_{\text{force}}$ $(\text{dune erosion})_{\text{theme}}$
HAVE EFFECT $(\text{fatigue})_{\text{force}}$ $(\text{decision making})_{\text{theme}}$
(As 5 ch) MAKE $(\text{Arg 1})_{\text{human agent}}$ $(\text{Arg 2})_{\text{result}}$
MAKE $(\text{bridge team})_{\text{human agent}}$ $(\text{course alteration})_{\text{result}}$

The verb *make* can be seen as a support verb when combined with the noun phrase *course alteration*; this combination could be replaced with the predicate verb *alter* and the noun argument *course* (As 5 ch).

4.1.3 Existence

In the field of maritime safety, the lexical domain of EXISTENCE encompasses incidents involving human actions and natural events that take place in a certain time or at a certain location, produce a result, and affect a patient. Investigators are interested in the communication between crew members and their situational awareness before, during, and after an accident event as failure to communicate effectively can *cause* or *lead to* misunderstandings (As 1–2 ex). The verb *to cause* is sometimes related to natural entities and events but also indicates the relation between the accident and an artefact-related event or a human action. Artefact-related events can include an electrical defect or fault, dust formation, cargo shift, refloating, and causing a damage or failure. Human actions can include erroneous actions of the captain, the chief engineer and the ship's crew, and a poor emergency response from the crew members. Human activities (heaving-to, lifting the stern ramp, ballasting) may cause undesired phenomena as the ship starts to drift, list, roll, vibrate, accelerate, or slide (As 1 ex). The phrasal verb *lead to* is often related to natural phenomena and the result is generally an artefact-related or natural event (As 2 ex).

(As 1 ex) CAUSE $(\text{Arg 1})_{\text{force}}$ $(\text{Arg 2})_{\text{result}}$ $(\text{Arg 3})_{\text{patient}}$ OR $(\text{Arg 3})_{\text{location}}$
CAUSE $(\text{fire})_{\text{force}}$ $(\text{damage})_{\text{result}}$ $(\text{engine room})_{\text{location}}$
CAUSE $(\text{Arg 1})_{\text{force}}$ $(\text{Arg 2})_{\text{result}}$
CAUSE $(\text{loss of situational awareness})_{\text{force}}$ $(\text{accident})_{\text{result}}$
CAUSE $(\text{ballasting})_{\text{force}}$ $(\text{listing})_{\text{result}}$

(As 2 ex) LEAD TO $(\text{Arg 1})_{\text{force}}$ $(\text{Arg 2})_{\text{result}}$
LEAD TO $(\text{lack of communication})_{\text{force}}$ $(\text{lack of mutual awareness})_{\text{result}}$
LEAD TO $(\text{slow leak})_{\text{force}}$ $(\text{build-up of pressure})_{\text{result}}$

The phrasal verb *result in* is commonly related to (erroneous) human actions (course alteration) or failures that result in losing control of the vessel or increase the risk of collision (As 3 ex).

(As 3 ex) RESULT IN $(\text{Arg 1})_{\text{force}}$ $(\text{Arg 2})_{\text{result}}$
RESULT IN $(\text{accident})_{\text{force}}$ $(\text{spill})_{\text{result}}$
RESULT IN $(\text{operational failure})_{\text{force}}$ $(\text{risk of collision})_{\text{result}}$
RESULT IN $(\text{Arg 1})_{\text{force}}$ $(\text{Arg 2})_{\text{result}}$ $(\text{Arg 3})_{\text{patient}}$
RESULT IN $(\text{water ingress})_{\text{force}}$ $(\text{damage})_{\text{result}}$ $(\text{vessel})_{\text{patient}}$

In addition to the human actions on board the vessel before and after the accident, investigators thoroughly analyse natural events that take place in the accident location or in other locations that resemble the accident position. The natural events mentioned are often related to erosion or waves (As 4 ex). The phrase *take place* is a combination of the support verb *take* and the noun *place* and has the basic meaning 'to happen'. Therefore, we treat the phrase as one lexical unit.

(As 4 ex) TAKE PLACE (Arg 1)$_{theme}$ (Arg 2)$_{time}$
TAKE PLACE (inspection)$_{theme}$ (annually)$_{time}$
TAKE PLACE (Arg 1)$_{theme}$ (Arg 2)$_{location}$
TAKE PLACE (wave breaking)$_{theme}$ (over the shoals)$_{location}$
(As 5 ex) ENSURE (Arg 1)$_{agent}$ (Arg 2)$_{theme}$
ENSURE (crew)$_{agent}$ (operation of a vessel)$_{theme}$
ENSURE (VTS)$_{agent}$ (safety of navigation)$_{theme}$
(As 6 ex) SHOW (Arg 1)$_{agent}$ (Arg 2)$_{theme}$
SHOW (vessel)$_{agent}$ (navigation lights)$_{theme}$

In the marine transportation process, the crew (Arg 1) ensures safe and professional operation of the vessel (Arg 2). In addition, human actions can be given the role of an instrument to ensure the existence of a certain state or situation, such as safe operation of the ship and the activities on board. Services that have a purpose to ensure safety of navigation (Arg 2) are also present and two examples of these are marine forecast systems and vessel traffic services (VTS) (Arg 1). The domain of EXISTENCE also encompasses verbs that indicate the perception of an entity (cf. Faber/Mairal 1999: 279). The verb *show* indicates the existence of the navigation lights for a potential observer in (As 6 ex).

4.1.4 Manipulation

The lexical domain of MANIPULATION contains various argument structures that account for the different dimensions of a vessel's operation. This lexical domain also allows for human agents (Arg 1) on board vessels or ashore. In the former case, the agent is usually the master or a crew member who operates the vessel or the equipment (Arg 2) on board in a specific manner (Arg 3). In the latter case, the agent is a company that operates vessels in a defined area and in a specific manner (Arg 3); for example, worldwide, commercially, under the Maltese flag, on international trade, on the spot market, under charter, under the company's safety management system (SMS), or in compliance with stated safety requirements. The instrument can take the grammatical place of the actual agent in a sentence, such as "the vessel operates worldwide". According to FrameNet, location, manner, and purpose are non-core elements in the frame of MANIPULATION. However, in our corpus the complements *in restricted waters* and *worldwide* in (As 1 man) are obligatory elements in the predicate-argument structures, since without the complements the sentences would be insignificant.

(As 1 man) OPERATE (Arg 1)$_{agent}$ (Arg 2)$_{instrument}$ (Arg 3)$_{location}$ OR (Arg 3)$_{manner}$
OPERATE (master)$_{agent}$ (vessel)$_{instrument}$ (in restricted waters)$_{location}$
OPERATE (Ø)$_{agent}$ (vessel)$_{instrument}$ (world-wide)$_{manner}$
(As 2 man) USE (Arg 1)$_{agent}$ (Arg 2)$_{instrument}$ (Arg 3)$_{purpose}$
USE (pilot)$_{agent}$ (radio)$_{instrument}$ (inform the coastguard)$_{purpose}$
USE (vessel)$_{agent}$ (traffic separation scheme)$_{instrument}$
USE (OOW)$_{agent}$ (radar)$_{instrument}$ (determine the risk of collision)$_{purpose}$

In the argument structure (As 2 man), the agent (Arg 1) is a crew member who uses an instrument (Arg 2) for a specific purpose (Arg 3). The instrument is usually a navigational device or a VHF radio, which is used to monitor traffic, to clarify the identity or intentions of another vessel, or to escape a hazardous situation such as manœuvring clear of the shallows. From the viewpoint of the investigation, the purpose of the action is a core element.

The actions of the crew members often include a change to the settings of the devices or equipment on board. These types of actions have the verb *to set* as the predicate in the argument structure (As 3 man). For example, the master or the officer may set the radar display north-up, the radio on a certain channel, or the propeller pitch to zero. If the device or equipment has been in the off position and is then started, the predicate verb *to start* indicates a change in the status of the device (As 4 man).

(As 3 man) SET (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{theme}}$ (Arg 3)$_{\text{result}}$
SET (master)$_{\text{human agent}}$ (engine)$_{\text{theme}}$ (to full astern)$_{\text{result}}$
(As 4 man) START (Arg 1)$_{\text{human agent}}$ (Arg 2)$_{\text{theme}}$
START (engineer)$_{\text{human agent}}$ (engine)$_{\text{theme}}$

The verb *to start* usually appears in a passive form and the indication that a human agent performs the action is only implicit (Ex 2).

4.1.5 Movement

In the prototypical MOTION frame, an entity with the role of a theme moves along a path from a source to a goal. Alternatively, the movement may take place within an area (cf. FrameNet s.v. *motion*). A vessel has a function to operate in specific sea areas with the aim to make her way at a defined speed and carry cargoes from one port to another. In this domain, the support verb *make* takes the noun *way* to introduce the main semantic frame (cf. Atkins/Fillmore/Johnson 2003: 270). While undertaking transport operations, vessels leave a port, pass waypoints, enter another port, or call at a port. Thus, vessels participate in the lexical domain of MOVEMENT. The argument structure involves an artefact in the role of a theme, as well as an argument indicating a source, path, or goal. In the verb-argument structures below, we have used the upper category of location rather than a source, path, or goal. Instead of a concrete geographical location, the location of an artefact may be artificial, such as a navigation track or a traffic lane. The argument structure may include non-core elements, such as a manner, purpose, or time.

As well as the argument structure that involves the core frame elements of an artefact and a location and the non-core elements of time and manner, the lexical domain of MOVEMENT contains human beings. Human beings make their way or go to another location on board a vessel, or enter or leave the location. Based on the concordance searches, the following argument structures evolved:

(As 1 mov) MAKE * WAY (Arg 1)$_{\text{theme}}$ (Arg 2)$_{\text{location}}$
MAKE * WAY (vessel)$_{\text{theme}}$ (into port)$_{\text{location}}$
MAKE * WAY (pilot)$_{\text{theme}}$ (to the bridge)$_{\text{location}}$
(As 2 mov) ENTER (Arg 1)$_{\text{theme}}$ (Arg 2)$_{\text{location}}$ (Arg 3)$_{\text{time}}$ (Arg 4)$_{\text{manner}}$
ENTER (vessel)$_{\text{theme}}$ (port)$_{\text{location}}$ (at 0640)$_{\text{time}}$ (safely)$_{\text{manner}}$
ENTER (Arg 1)$_{\text{theme}}$ (Arg 2)$_{\text{location}}$ (Arg 3)$_{\text{purpose}}$
ENTER (second engineer)$_{\text{theme}}$ (control room)$_{\text{location}}$ (to lock the propeller shaft)$_{\text{purpose}}$
(As 3 mov) GO (Arg 1)$_{\text{theme}}$ (Arg 2)$_{\text{location}}$
GO (second officer)$_{\text{theme}}$ (chart room)$_{\text{location}}$
(As 4 mov) LEAVE (Arg 1)$_{\text{theme}}$ (Arg 2)$_{\text{location}}$ (Arg 3)$_{\text{time}}$
LEAVE (lookout)$_{\text{theme}}$ (bridge)$_{\text{location}}$ (at 1013)$_{\text{time}}$

(As 5 mov) PASS (Arg 1)$_{theme}$ (Arg 2)$_{location}$ (Arg 3)$_{time}$
PASS (vessel)$_{theme}$ (waypoint)$_{location}$ (two hours after an event)$_{time}$
(As 6 mov) CALL AT (Arg 1)$_{theme}$ (Arg 2)$_{location}$
CALL AT (vessel)$_{theme}$ (port)$_{location}$

In the context of marine transportation, only vessels pass another vessel, area, or solid object (As 5 mov), or move, drift, or swing. Accordingly, only humans can go to another location (As 3 mov). In this context, the vessel is normally the means of conveyance of the theme, thereby fulfilling the role of a carrier. In addition to the vessel, a natural force may have the role of a carrier (As 7 mov).

(As 7 mov) CARRY (Arg 1)$_{agent}$ (Arg 2)$_{theme}$ (Arg 3)$_{location}$
CARRY (vessel)$_{agent}$ (general cargo)$_{theme}$ (to Northern Europe)$_{location}$
CARRY (flood stream)$_{agent}$ (vessel)$_{theme}$ (out of the fairway)$_{location}$
CARRY (vessel)$_{agent}$ (additional third officer)$_{theme}$

In the first scenario (As 7 mov), a vessel (Arg 1) carries cargo (Arg 2) from one geographical location to another; for example, from South America to Northern Europe (Arg 3). In the second scenario, a natural force (Arg 1) carries a vessel (Arg 2) in a certain direction (Arg 3). In the third scenario, a vessel (Arg 1) carries certain crew members on board, such as an additional third officer, a Filipino deckhand, a watchkeeper, a bosun, or an AB (Arg 2).

The verb *load* has been included in the lexical domain of MOVEMENT as the verb belongs to the FrameNet frames of PLACING, in which an agent places a theme at a location, and FILLING, in which a theme moves to a container. In FrameNet, both frames are related to the CAUSE_MOTION frame (FrameNet s.v. *load*).

(As 1 psn) LOAD (Arg 1)$_{agent}$ (Arg 2)$_{theme}$ (Arg 3)$_{location}$ (Arg 4)$_{manner}$
LOAD (vessel)$_{agent}$ (grain)$_{theme}$ (in Southampton)$_{location}$
LOAD (stevedores)$_{agent}$ (solid bulk)$_{theme}$ (in homogenous distribution)$_{manner}$

The argument structure with the verb *load* as the predicate (As 1 psn) may have either a vessel or a group of humans as the first argument (Arg 1) and in the role of an agent. The second argument (Arg 2) is the cargo that is loaded and it has the role of a theme. Interestingly, the first argument (Arg 1) limits the choice of the other arguments. The argument indicating location (Arg 3) is related to a non-human agent, which is a vessel in this context, and the argument indicating manner (Arg 4) is related to human agents.

4.1.6 Perception

In the FrameNet frame of PERCEPTION, a perceiver perceives a phenomenon. The perception may be passive or active (FrameNet s.v. *perception*). In our corpus, the active role of the perceiver is underlined by the use of the phrase *make visual contact with* (As 2 per) instead of the verb *see*. In the maritime safety context, the lexical domain of PERCEPTION contains the frame elements of a human being in the role of an agent, a water vehicle to be identified, a device to be monitored, or a natural entity. A human being (master, pilot, or officer) actively monitors or does not monitor on board devices or the surrounding navigational situation (As 4 per). A human being also checks or does not check the equipment settings, the status of equipment, the intended route of the vessel, the vessel's position, speed or movements, and natural or weather conditions in the location (As 5 per). Additionally, a human being identifies or finds defects,

deficiencies, or damages. In the engine department, the chief engineer has to check the status of the machinery and tanks, as well as steering and propulsion systems (As 5 per). The object of perception may also be damage that the artefact has suffered. The location of the object is sometimes included in the argument structure (As 1 per).

(As 1 per)	SEE $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$ $(\text{Arg 3})_{\text{location}}$
	SEE $(\text{crew member})_{\text{agent}}$ $(\text{smoke})_{\text{theme}}$ $(\text{in a cabin})_{\text{location}}$
(As 2 per)	MAKE VISUAL CONTACT WITH $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	MAKE VISUAL CONTACT WITH $(\text{pilot})_{\text{agent}}$ $(\text{fishing boat})_{\text{theme}}$
(As 3 per)	FIND $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	FIND $(\text{engineer})_{\text{agent}}$ $(\text{defect})_{\text{theme}}$
(As 4 per)	MONITOR $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	MONITOR $(\text{bridge crew})_{\text{agent}}$ $(\text{pitch indicator})_{\text{theme}}$
(As 5 per)	CHECK $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	CHECK $(\text{navigational officer})_{\text{agent}}$ $(\text{speed})_{\text{theme}}$
	CHECK $(\text{chief engineer})_{\text{agent}}$ $(\text{engine oil level})_{\text{theme}}$

The lexical domain of PERCEPTION is closely related to the domain of COGNITION that includes the use of one's mind for forming an idea of something. Perception is also related to inspections or audits, during which non-conformities of deficiencies are potentially identified. Therefore, assigning a verb to a single domain is not always a straightforward process. In this study, the verbs *monitor* and *check* have been included in the domain of PERCEPTION as visual monitoring of the devices is crucial in the navigational context, and the possible decisions to act are based on these perceptions.

4.1.7 Possession

In our corpus, the instances belonging to the lexical domain of POSSESSION have an argument structure that includes a human or an artificial agent and a theme. Examples of a theme include a device, product of human activity, information on a traffic situation, natural conditions, and water movements. These argument structures have the phrasal verb *fit with* or the verbs *carry*, *have*, *hold*, or *provide* as a predicate. In the first and second scenarios (As 1–2 poss), a vessel (bridge, engine) is fitted with, has, or carries certain devices, equipment, or documents, such as radio equipment, lifeboats, loading manual, paper charts, or immersion suits. In the third scenario (As 3 poss), a crew member (Arg 1) holds a type of certificate. The agent may also be equipment, or a man-made system or entity that includes certain parts (As 4 poss).

(As 1 poss)	FIT WITH $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	FIT WITH $(\text{vessel})_{\text{agent}}$ $(\text{double bottom})_{\text{theme}}$
(As 2 poss)	CARRY $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	CARRY $(\text{ship})_{\text{agent}}$ $(\text{certification})_{\text{theme}}$
(As 3 poss)	HOLD $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	HOLD $(\text{chief mate})_{\text{agent}}$ $(\text{endorsement})_{\text{theme}}$
(As 4 poss)	INCLUDE $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	INCLUDE $(\text{equipment})_{\text{agent}}$ $(\text{radar})_{\text{theme}}$
(As 5 poss)	PROVIDE $(\text{Arg 1})_{\text{agent}}$ $(\text{Arg 2})_{\text{theme}}$
	PROVIDE $(\text{London VTS's principal control centre})_{\text{agent}}$ $(\text{traffic information})_{\text{theme}}$

PROVIDE (wave buoy)$_{agent}$ (information)$_{theme}$
(As 6 poss) ISSUE (Arg 1)$_{agent}$ (Arg 2)$_{theme}$
ISSUE (company)$_{agent}$ (safety bulletin)$_{theme}$

In the argument structure (As 5 poss), the companies and organisations in the maritime industry (Arg 1) provide guidance and information on a certain topic, such as safe navigation, traffic situations, and meteorological situations (Arg 2). Navigational devices (Arg 1) provide data and information on traffic situations or weather conditions (Arg 2). Administrations, companies, agencies, or societies issue certificates, bulletins, circulars, and notices (As 6 poss).

4.1.8 Speech

The lexical domain of SPEECH represents scenarios that include a communicator or speaker directing communication containing a message to an addressee (see FrameNet frames CONTACTING and TELLING). In our corpus, the domain of SPEECH includes a scenario in which a person (Arg 1) on board the vessel makes a voice contact or radio contact with another ship or a coast station (Arg 2). Other scenarios include a person who reports a problem, situation, intent, or change of conditions to a receiver that may be another vessel or a shore-based station (Arg 2). The instrument used for the contact is sometimes indicated (Arg 3). In the second scenario (As 2 sp), a crew member, coast station, or shore-based service provider (Arg 1) calls another crew member, vessel, or shore-based station (Arg 2) using a radio (Arg 3). In the third scenario (As 3 sp), the intention of the agent (Arg 1) is to have the other person (Arg 2) move to another location (Arg 3). An instrument (Arg 4) may be needed if the person called is located a significant distance from the agent.

(As 1 sp) MAKE CONTACT WITH (Arg 1)$_{agent}$ (Arg 2)$_{experiencer}$ (Arg 3)$_{instrument}$
MAKE CONTACT WITH (pilot)$_{agent}$ (VTS)$_{experiencer}$ (mobile phone)$_{instrument}$
(As 2 sp) CALL (Arg 1)$_{agent}$ (Arg 2)$_{experiencer}$ (Arg 3)$_{instrument}$
CALL (VTS)$_{agent}$ (vessel)$_{experiencer}$ (on VHF channel 09)$_{instrument}$
(As 3 sp) CALL (Arg 1)$_{agent}$ (Arg 2)$_{theme}$ (Arg 3)$_{location}$ (Arg 4)$_{instrument}$
CALL (watchkeeper)$_{agent}$ (master)$_{theme}$ (to the bridge)$_{location}$ (by radio)$_{instrument}$
(As 4 sp) INFORM (Arg 1)$_{agent}$ (Arg 2)$_{beneficiary}$ (Arg 3)$_{theme}$
INFORM (master)$_{agent}$ (coastguard)$_{beneficiary}$ (collision)$_{theme}$
(As 5 sp) CONFIRM (Arg 1)$_{agent}$ (Arg 2)$_{theme}$
CONFIRM (OOW)$_{agent}$ (the change of the course)$_{theme}$

In the scenario (As 4 sp), a crew member, pilot, or another human agent (Arg 1) informs or does not inform the master, pilot, company, or shore-based service provider about, for example, a failure, an alarm, or an accident (Arg 3). In the scenario (As 5 sp), a human agent confirms by speech that a certain human activity has taken place.

4.2 Argument structure generalisation

Based on the concordance searches, it can be concluded that certain predicates are activated more frequently than others in the context of maritime safety (cf. Faber et al. 2005: 4). The marine accident frame includes the following: verbs such as *provide*, *ensure*, *indicate*, *require*, *operate*, *use*, *identify*, *report*, and *carry*; phrasal verbs such as *carry out*; and, verb patterns such

as *have an effect* and *make a contact*. These verbs, phrasal verbs, and verb patterns connect the arguments belonging to conceptual categories such as HUMAN BEINGS, HUMAN ACTIVITIES, ATMOSPHERIC PHENOMENA, WATER MOVEMENTS, EQUIPMENT, DEVICES, and VEHICLES, and they have the roles of agent, patient, theme, experiencer, location, force, purpose, result, instrument, beneficiary, or manner.

The marine accident event is conceptualised as a process that involves human agents, artefacts, and natural agents. Human agents start, carry out, and complete actions, take action to avoid events, operate and use instruments, identify and ensure a state, keep or maintain a watch, increase or reduce speed, and go from one place to another. Artefacts carry cargoes from one place to another, make a way or a contact, indicate or ensure a state, have an effect, an impact, or an influence, pass a waypoint, call at a port, and remain in a position. Natural agents take place or have an effect, an impact, or an influence, and cause or lead to a result.

In summary, a marine accident event includes a variety of participants, actions, and events, some of which lead to marine accidents while others focus on avoiding the accidents. The argument-predicate structures in the lexical domain of EXISTENCE illustrate the connection between the argument-predicate structures and a marine accident. The causal nature of marine accident events is shown through the verb *cause* and the phrasal verbs *lead to* and *result in* as they indicate the relation between a human action or an artefact-related event and the accident. These events are dynamic processes based on interacting components, the relations of which are constantly changing (cf. Faber et al. 2005). A natural phenomenon occurs and changes independently of human action. At the same time, human state changes, or a human takes action, and an artefact indicates, moves, and operates. These processes can affect the environment, humans, and artefacts. Effects can include the loss of a ship, a casualty with ships or cargo, pollution, fatalities, and injuries.

5 Conclusions

The aim of this study was to identify predicate-argument structures in the specialised discourse of maritime safety by using principles of Frame-based Terminology (FBT). The predicate-argument structures identified can be used to enhance the representation and understanding of marine accident events and potentially create a domain-specific frame for marine accidents. Thus, the predicate-argument structures are presented for consultation to future end users of the results, including the stakeholders in the field of maritime safety and terminologists.

Based on lexicon-driven analysis of a corpus consisting of marine accident investigation reports, we demonstrate that FBT can be successfully applied to a marine accident event. The methodology of information extraction by means of word sketches and corpus-based analysis has led to compilation of initial predicate-argument structures for a marine accident event. It was found that in this context, certain predicates are activated more frequently than others. A large number of these predicates are general language verbs that construct special meanings in combination with specialised arguments.

Avoiding future accidents is the common goal of all the stakeholders in the maritime field. Accident investigation is the primary method for gaining insight into how accidents develop. The corpus-based lexicon-driven analysis of a marine accident event, as manifested in accident investigation reports, shows that the chain of actions and events leading to an accident is complicated and involves a variety of elements. These elements can be natural and technical as well as human. Specifically, in the analysed accident investigation reports, it was found that a

vessel or a ship often represents the crew collectively and acts as the agent instead of the crew or crew members.

Furthermore, the relation between the marine accident event and a counteracting cause is important in the field of maritime safety as it helps researchers locate the measures that could have prevented the situation from developing and ending in an accident. Mazaheri et al. (2015: 206) call these measures safety factors that act as barriers and stop an incident from turning into an accident.

The environment in which a maritime transport event takes place can be divided into the following components: vessel, sea, and shore. The vessel and her interactions with the environment, maritime traffic, and the shore comprise a complex socio-technical system that is affected by environmental factors. It is intended that the results of this study will facilitate a better understanding of these complex systems and the processes that lead to marine accidents.

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