Methods of Vessel Casualty Process Assessment

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ABSTRACT: Maritime casualty is an event of considerable economic and social impact. For this reason, implemented the reporting systems of accidents at sea, and the Administration was obligated to establish a Commission of Maritime Accidents. On the basis of casualty analysis and reports are developed proposals preventing similar casualties in the future. However, there is no uniform evaluation system which check references of existing regulations and recommendations to the occurred casualties. This paper presents a method to evaluate the used methods of casualty prediction with respect to the real incident and catastrophe.

1 INTRODUCTION

History of shipping is directly and consistently connected with shipping casualties. These disasters due to the size of vessels, number of people and cargo carried by ships are events of great psychological, economic and social impact. Historically, the causes of maritime disasters due to lack of information was attributed to the force majeure (God's Will). Growing up in recent centuries, ships technical systems, communication and control arrangement of the vessel allow for a more precise determination of the causes of the disaster and its stages. Knowledge of cause and effect is the basis for the analysis of disasters and disaster countermeasures drawing conclusions or to rectify the consequences.

The purpose of this article is to present the problem of assessing maritime casualty in terms of the SHELL system which consists of: the ship, its crew, the marine environment and procedures.

Currently, the rules and principles of analysis of causes and effects are oriented on technical aspects, human factors and the impact of weather conditions and correlation between them, but often without gradation of factors. Reports describing sea casualty include detailed analysis of the failure process and large amounts of information about the different weight and importance. Thus, the analysis of disasters and synthesis of important information in relation to the process of disaster is difficult to carry out. Most of the accidents analysis is based on calculations, simulations and expert opinion. Conclusions are drawn principally based on expert opinions within limited range of knowledge.

The casualty indicators allow assessing the casualty and comparing the processes of casualty. Also casualty factors determine the validity of the various factors. In addition, the casualty index factor can be used to determine the reliability of expert opinions.

2 RULES AFFECTING INVESTIGATION INTO MARITIME CASUALTY

Nationally and internationally reported statistics on marine accidents show that 80% or more of all marine accidents are caused fully or in part by human error (Human Factors). In order to prevent similar casualties and incidents in the future, it is necessary to identify the circumstances of the casualty under investigation and to establish the causes and contributing factors. IMO (International Maritime Organization) adopted Casualty Investigation Code with the guidelines for the Investigation of Human Factors in Marine Casualties and Incidents in order to promote a common approach to the safety investigation of marine casualties and incidents, and also to promote co-operation between States in identifying the contributing factors leading to marine casualties. The Code entered into force on 1 January 2010. [1]

Collect occurence data

Determine occurence data

Identify threat and unsafe condition

Identify error or threat

Identify underlaying factors

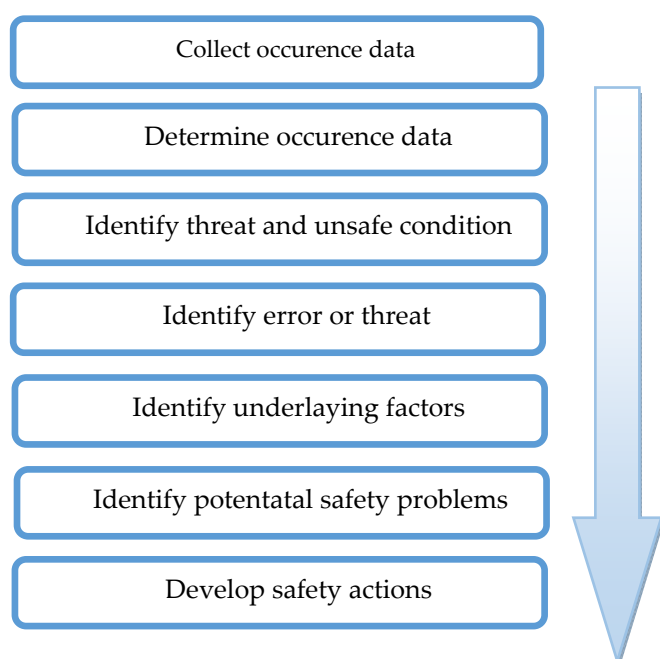Identify potentatal safety problems

Develop safety actions

Figure 1. Investigation Procedures acc. to IMO Res. 884

The objective of te Code is to provide a common approach for States to adopt in the conduct of marine safety investigations into marine casualties and marine incidents. Marine safety investigations do not seek to apportion blame or determine liability. Instead a marine safety investigation is conducted with the objective of preventing marine casualties and marine incidents in the future. The Code envisages that this aim will be achieved through States:

1   applying consistent methodology and approach, to enable and encourage a broad ranging investigation, where necessary, in the interests of uncovering the causal factors and other safety risks; and
2   providing reports to the Organization to enable a wide dissemination of information to assist the

international marine industry to address safety issues.

A marine safety investigation should be separate from, and independent of, any other form of investigation. However, it is not the purpose of this Code to preclude any other form of investigation, including investigations for action in civil, criminal and administrative proceedings. Further, it is not the intent of the Code for a State or States conducting a marine safety investigation to refrain from fully reporting on the causal factors of a marine casualty or marine incident because blame or liability, may be inferred from the findings.

A marine casualty means an event, or a sequence of events, that has resulted in any of the following which has occurred directly in connection with the operations of a ship:
1   the death of, or serious injury to, a person;
2   the loss of a person from a ship;
3   the loss, presumed loss or abandonment of a ship;
4   material damage to a ship;
5   the stranding or disabling of a ship, or the involvement of a ship in a collision;
6   material damage to marine infrastructure external to a ship, that could seriously endanger the safety of the ship, another ship or an individual; or
7   severe damage to the environment, or the potential for severe damage to the environment, brought about by the damage of a ship or ships.

Final element of an investigation is report which provide necessary information for avoid mentioned threats and errors in the future. A marine safety investigation report contains:
1   a summary outlining the basic facts of the marine casualty or marine incident and stating whether any deaths, injuries or pollution occurred as a result;
2   the identity of the flag State, owners, operators, the company as identified in the safety management certificate, and the classification society (subject to any national laws concerning privacy);
3   where relevant the details of the dimensions and engines of any ship involved, together with a description of the crew, work routine and other matters, such as time served on the ship;
4   a narrative detailing the circumstances of the marine casualty or marine incident;
5   analysis and comment on the causal factors including any mechanical, human and organizational factors;
6   a discussion of the marine safety investigation's findings, including the identification of safety issues, and the marine safety investigation's conclusions; and
7   where appropriate, recommendations with a view to preventing future marine casualties and marine incidents.

3 INVESTIGATION PROCEDURES AND TECHNIQUES

Each State is obliged to develops of investigation procedures. Classification Societies provide

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[1] Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident ,IMO, RESOLUTION MSC.255(84) (adopted on 16 May 2008)

investigation guidance which makes this process without errors and unnecessary delay.[2]

These guidance provide instructions for the performance of incident investigation activities, including:
– Incident Investigation Initiation
– Data Gathering
– Data Analysis
– Root Cause Determination
– Generating Recommendations
– Reporting and Trending of Incident Investigation Results

Marine casualty investigation can be divided into three main steps:

3.1 Step 1: Data collection & occurrence sequence determination

The first stage of the investigation involves collecting the accident information as far as possible which may be of interest in determining causes. Once the information has been collected, the next stage is to develop a sequence of events and circumstances. In this stage, the unsafe acts and decisions or conditions can be identified using the cognitive process model.
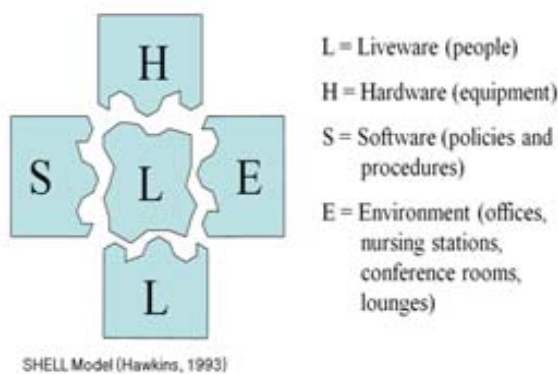

L = Liveware (people)
H = Hardware (equipment)
S = Software (policies and procedures)
E = Environment (offices, nursing stations, conference rooms, lounges)

SHELL Model (Hawkins, 1993)

Figure 2. SHELL Model & Cognitive Process Model

3.2 Step 2: Factors identification and classification

The objective of this stage is to classify unsafe acts and/or conditions identified during previous stages

into human factor group as: slip, lapse, mistakes and violation. Also during this step environmental and hardware factors should be identified. Identification and classification process can be realized by experts and simulations of the casualty process.

Main problem in this step is identifying of underlying factors that might cause identified unsafe acts to occur using the Human Factors Identification and Classification Model. Underlying factors are classified into three categories, i.e., external underlying factors, ship-related underlying factors and shipping company-related underlying factors.

Step 3: Safety actions development
The final step of the factors investigation is to identify potential safety problems and to develop safety actions in order to reduce the probability of occurrence of human error and vessel construction with arrangement and/or to mitigate the consequence of marine accidents. In this step, causal chains (with brainstorming technique) can be used to assist the identification and the selection of the safety actions.

American Bureau of shipping develops marine incident investigation methodology MaRCAT™ (Marine Root Cause Analysis Technique) which is designed for use in investigating and categorizing the underlying causes of incidents, including accidents and near misses, with safety, health, environmental, quality, reliability, production and financial impacts.
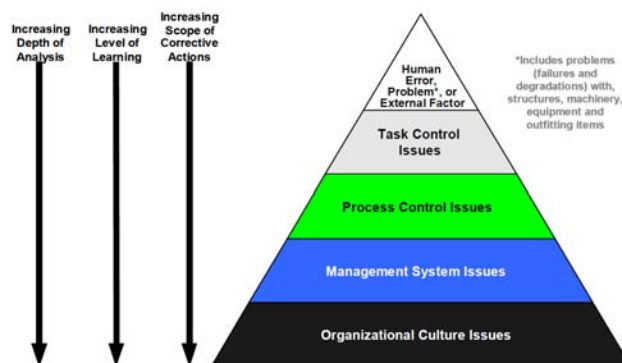

Figure 3. Task Triangle Showing Possible Depths of Analyses
ABS GUIDANCE NOTES ON THE INVESTIGATION OF MARINE INCIDENTS, 2005

4 CASUALTY FACTORS

In necessity to provide for the development of the emergency state will be introduced the following definitions:
– Incident - the moment of the event, which will find a ship in a dangerous condition.
– Loss event - the moment of occurrence of the sequence of events leading directly to the destruction of the ship.
– Casualty period - for the purpose of this study it was assumed that this is the condition of the vessel requiring rescue action to saving the ship, passengers and crew.

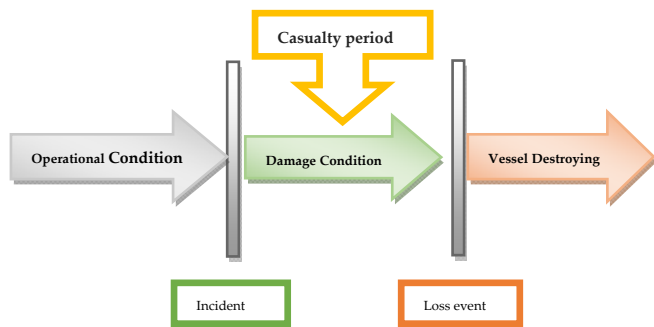[2] GUIDANCE NOTES ON THE INVESTIGATION OF MARINE INCIDENTS, ABS, 2005

Figure 4. Maritime casualty process

In the aim of maritime casualty process describing following factors will be used:
- C_I – a priori factor shows the parameters which determines casualty process track by statistical analysis, model testing, simulation and heuristic methods. A priori factor is calculated on basis of rules, vessel construction, procedures and assumed conditions of the casualty. CI shows expected impact of each factor for the casualty.
- C_F – a posteriori factor shows the class parameters of the casualty process track on the basis of the research, simulation and expert judgment after casualty investigation. CI shows achieved impact of each factor for the casualty and it is calculated on the basis of casualty investigation.

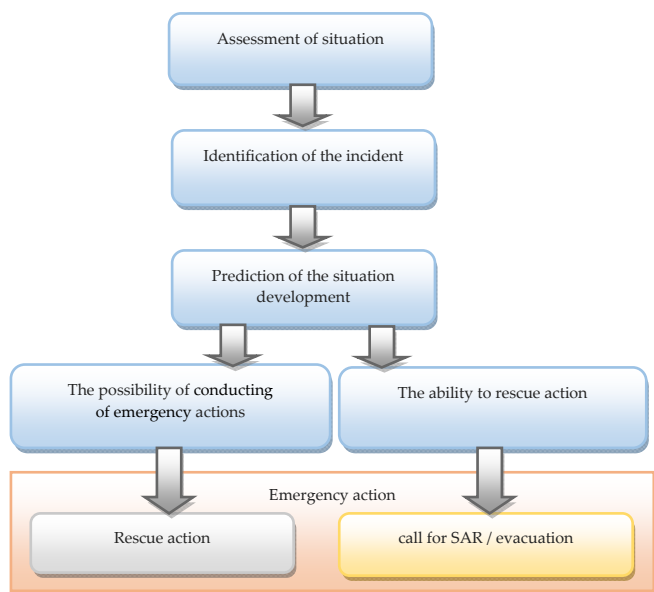Stages of operation crew in a dangerous condition:

Figure 5. Steps of a vessels crew casualty actions

Generally qualitative estimates of the potential outcomes for the incident are used. It is not practical to develop quantitative estimates of the potential consequences for each incident. Therefore, the incident investigation team will often use a loss potential matrix to estimate potential consequences. Although this is a very subjective estimate, it will provide the guidance needed to develop effective corrective actions and to perform incident trending.

The probability of recurrence should estimate the probability that the incident occurs again, assuming that no corrective actions are taken. Estimating of probability of each dangerous event and process

which lead to the catastrophe is very difficult. Easier method is using of classes for determining factors influence on catastrophe.

Class of individual factors determine their impact on the process of failure in relation to the destruction of the ship or its evacuation. Class 5 indicates the factors leading to the direct destruction of the vessel or to prevent the escape, class 1 denotes no such effects.

Factors are divided into six categories: threat, crew, weather, vessel construction and arrangement, cargo and seas area.

Table 1. Casualty factors

Class	Description
5	the duration of the ship in emergency condition shorter than that for the evacuation, the factor caused immediate destruction of the ship, crew is not able to take any action leading to the evacuation and/or vessel rescue, the design of the ship and the technical solutions makes impossible rescuing the ship and evacuation, sea area makes it impossible to save the ship or survivors
4	the duration of the ship in emergency not sufficient to complete the evacuation and / or rescue vessel, the factor made it impossible to evacuate and caused shortening the time to destroy the ship crew took action to evacuate and ship rescue, the design of the ship and the technical solutions makes impossible rescuing the ship and makes it difficult to evacuate, sea area makes it impossible to save the ship and makes it difficult to rescue survivors
3	the duration of the ship in a dangerous condition sufficient to evacuate, but not enough to save the ship, the factor hampered the evacuation and resulted in shortening the time to destroy the ship, the crew took all possible actions to secure the evacuation and ship recue, ship design and technical solutions hampering of the ship rescue and makes difficult to evacuation, sea area makes it difficult to save the ship and makes it difficult to rescue survivors
2	the duration of a ship in a dangerous condition sufficient than needed for evacuation or rescue vessel, the factor hampered the evacuation but did not result in the destruction of the ship the crew has taken all possible actions to secure the evacuation and restricted to rescue the ship, ship design and technical solutions makes it difficult to save the ship and not hinder evacuation, sea area makes it difficult to save the ship and not hampered rescue survivors
1	the duration of a ship in a dangerous condition much longer than needed for evacuation or rescue vessel, the factor did not affect the ship in an emergency or evacuation, the crew has taken all possible actions to secure the evacuation and rescue vessel, ship design and technical solutions do not hinder of rescue the ship and not hinder evacuation, sea area does not affect the possibility of saving the ship and survivors

Index of accident predictability:

$$CAT_i = C_{Fi} - C_{Ii}$$

C_F and C_I index allows to assess the impact of various internal and external factors on the catastrophe.

C_F factor is evaluated basing on assumption of the theoretical impact of a given indicator for casualty.

The factor classes can be achieved before the accident basing on the event tree analysis or failure tree analysis by the heuristic evaluation, performed by an expert participating in disaster investigation and the reports developed after. The expert may present values of the parameters characterizing the vessel in relation to the disaster:

- type of vessel
- design solutions ,
- spatial plans of the ship,
- technical equipment of the ship,
- procedures for the ship ,
- the organization of work ,
- the quality of the ship's crew ,
- characteristics of the transported cargo and passengers.

Factor C_I may be determined also on the basis of simulation and experimental analysis of casualty.

Factor C_F is determined based on the obtained effect of the (i-th) factor in the process of casualty and catastrophe. The index value is determined on the basis of a report by the expert consultants.

CAT index values are obtained from 4 to -4 . The resulting value of the CAT defines:

- 4 - failure developed by an unexpected scenario, the ship's structure, equipment, procedures, organization of the crew did not work properly, the weather much bigger impact than expected. It could also mean errors of experts in determining the value of each indicator.
- 0 - posed were correct assumptions about the disaster and fit of all parameters characterizing the ship , crew actions were effective.
- -4 - Failure developed by an unexpected scenario, the impact of each factor was much smaller than expected, there was an overstatement of the negative in the analysis of the disaster. This means that errors of experts in determining the value of each indicator .

The index value 4 indicates the need for changes to the law or the organization staff on matters relating to the safety of the ship, a value of 0 does not require any changes, while the value of - 4 suggests overestimation of vessel construction, safety systems, organizations towards the safety of the crew.

CAT index may be used to evaluate predictions of events in relation to the individual experts. They indicate when an overstatement or understatement of the impact factors of the crash for a single expert, or you can refer to the individual factors of failure, pointing to their widespread underestimation or overestimation.

Table 2. CAT index

CAT		Apriori				
		5	4	3	2	1
Aposteriori	5	0	1	2	3	4
	4	-1	0	1	2	3
	3	-2	-1	0	1	2
	2	-3	-2	-1	0	1
	1	-4	-3	-2	-1	0

To evaluate the obtained indicators CAT can use average values of absolute errors (MAE) or root mean square error (RMSE):

$$MAE = \frac{\sum |CAT_i - CATm|}{n}$$

$$RMSE = \sqrt{\frac{\sum (CAT_i - CATm)^2}{n}}$$

RMESE is more sensitive to extreme values of the error. CATm factor is the expected value of 0.

Sum of all C indicators indicates the quality of the ship and its crew in relation to the presumed data weather conditions in designated water areas.

Disadvantages of determining predictability casualty factor depend on knowledge about the effects of a catastrophe which can significantly affect the evaluation index a priori, a posteriori factors are also determined on the basis of the report, evidences and testimony of witnesses, so it may be an error on the assessment of causes. However advantages of determining casualty predictability factor give the possibility of segregation casualty factors and assess their reliability; allow cchecking the reliability of the methods used for modeling and simulations and generate the ability to avoid tragedy in the future.

For most organizations, the first step towards performing an investigation is the generation of a Corrective Action Request (CAR). Although CARs can be generated for many reasons, some of the CARs will result in triggering an investigation.

Table 3. Maritime casualties

No	Name	IMO no	Date & Position	Threat	Catastrophe	Consequences
1	Riverdance	7635361	31.08.2008 Off Lune Deep	Cargo shifting	Capsizing	Total Loss due to capsizing and grounding. Nobody die
2	Star Princess	9192363	23.03.2006 passage from Grand Cayman to Montego Bay	Fire	Fire on board	The damaged area covered 3 vertical fire zones on 5 decks Nobody die
3	Bourbon Dolphin	9351983	12.04.2007 Rosebank oilfield	External Forces and lack of vessel stability	Capsizing	Total loss due to capsizing 15 crew memebers die
4	Couguar Ace	9051375	23.07.2005 South of Aleutian Islands	Debalsting and weather	Capsizing	Total Loss of cargo
5	Rozgwiazda		17.10.2008 South Baltic	Water ingress and weather	Capsizing	5 crew memebers

Table 4. Casualty factors

Vessel	C1	C2	C3	C4	C5	C6
Riverdance	2	3	3	2	2	4
Star Princess	3	2	1	1	3	1
Bourbon Dolphin	5	5	2	2	3	1
Couguar Ace	2	2	1	2	2	2
Rozgwiazda	5	5	3	2	3	1

In the table are shown parameters for a experts judgement factors and the CAT index. First shows the most optimistic expertise of casualty factors, the fifths shows the most pessimistic expertise.

Table 5. CAT factor determining for the example casualty.

	I	II	III	IV	V
C1	-4	-2	-1	1	3
C2	-3	-1	0	1	4
C3	-2	-1	0	1	2
C4	-2	-1	0	1	3
C5	-4	0	0	1	2
C6	-3	-1	0	1	2

MAE	I	II	III	IV	V
MAE	-3.00	-1.00	-0.17	1.00	2.67

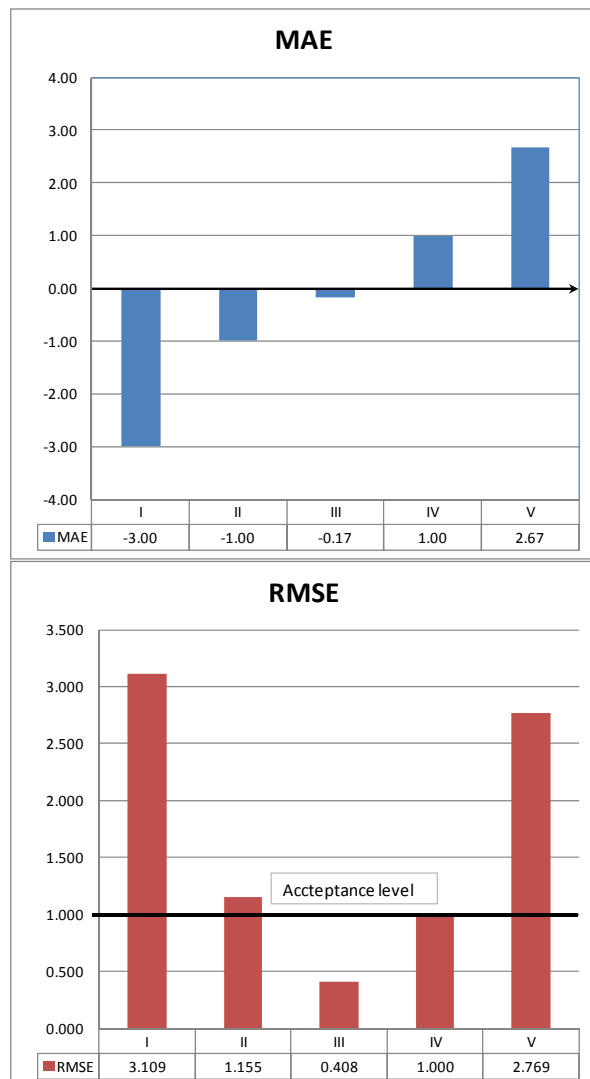| RMSE	I	II	III	IV	V
RMSE	3.109	1.155	0.408	1.000	2.769

Acceptance level

Figure 6. CAT index with MAE and RMSE

Acceptance level can be established to skip expertises with a great divergence. That method eliminate methods witch conduct to unreal results with a casualty analysis.

5 CONCLUSIONS

Rating disasters by the media is unreliable information leading to an incorrect assessment of the causes and consequences of maritime disaster. This implies the actions of politicians influencing the introduction of rules on the safety of the vessel.

The media casualty assessment is characterized by:
− Visual aspects of maritime disasters - as the "greater " are judged crash recorded by the media , as exemplified by the recent disasters relationships passenger ships Costa Concordia.
− Large asymmetry ratings events, resulting from the nationality of the ship, survivors or body of water , which was a disaster. The catastrophe in the waters or the participation of citizens in developed countries is considered "greater " than occurring in underdeveloped countries , such as the EU and the Philippines;
− The lack of reliable, documented knowledge of the disaster;
− Suggest and interpret events before examining the disaster;
− The use of so-called media Experts (publicly suggesting the cause of the crash, the predicted failure scenarios - without the knowledge of the disaster beyond the formal reports).

The use of indicators catastrophe (CAT) will allow for accurate assessment of the potential actions of the crew, the impact of the construction and equipment of the vessel and the impact of weather and local conditions on the casualty process. It is necessary therefore to introduce a wider range of indicators, which are able to describe ship crews activities in emergency condition, vessel construction, vessel arrangement and seaworthiness influence.

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