Analysis Method Of Compounding Maritime Incidents Using Fault Tree Analysis

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ABSTRACT
After the oil spill incident of M/V Nakhodka, Russian oil tanker, in Japan Sea in 1996, a research group on maritime risk management has started in our university. The group has developed a roll play simulation system of many kinds of marine incidents and trained the students on the email network. At the beginning, the group set the fixed scenario for a roll simulation, then the group understood that the incidents usually accompany life saving, oil spilling, fire, flooding or sinking.

Generally, we have no incident on the transportations with well-trained operators, well-maintained machinery and well-facilitated traffic systems. As a marine traffic example, marine hazards of a collision, grounding, sinking, fires or flooding are common at sea.

These incidents are usually investigated the causes and concluded human error from the psychological and medical viewpoints. After those incidents, it is very important to research for developing and improving safety devices or systems and understanding the reappearance of incident. An analysis method of compounding maritime incidents especially after collision using Event Tree Analysis and Fault Tree Analysis is introduced.

Introduction
At once marine incidents happened we always have fear of loss or damage of lives, sinking or capsizing after ships collided. And we may have serious environmental damage by spilled oil or dangerous cargos from those ships. So far there are research reports on the process and factors of ship collision[1-4], however researches on environmental damage, number of casualties, frequency of oil spilling after the marine accidents are very rare. The Incidents are varied by size, type, and voyage condition of ships.

In this paper, 470 incidents picked up from the judicial precedents of the Japan Marine Accidents Inquiry Agency[6] are surveyed, with the collision being a starting event of the process in the Event Trees and Fault Tree. And casualties or oil spill are as a result event.

Statistics of incidents
The 470 collision cases were picked up from the judicial precedents of the Japan Marine Accidents Inquiry Agency between 2001 and June 2004.

These precedents were surveyed about casualties and oil spill. We set an oil spill as a top event in the case of oil tanker and the existence of casualties as a top event in the case of the other type vessels for composing the Event Tree or Fault Tree.

The probabilities to reach the top event were calculated from these precedents.

Table1. The statistics of the damage by collision

Light or no damage on the hull 199 (42%)	Controllable condition 189 (40%)	Casualties	11 (2%)
		Non casualties	178(38%)
	Loss of propulsion 10 (2%)	Casualties	5(1%)
		Non casualties	5(1%)
Serious damage on the hull 271 (58%)	Sunk or capsized 26 (6%)	Casualties	12(3%)
		Non casualties	14(3%)
	Not sunk 245 (42%)	Casualties	64(13%)
		Non casualties	181(39%)

Result of the survey

The aftereffects of ships' collision are assumed into three categorizes 'light damage' and 'Serious damage' and 'loss of propulsions'. The cases of damage on the hull without cracks or opening, graze or bend are assumed 'Light damage'. The damages on the hull cause flooding are assumed 'Serious damage'.

The third case, the hull has minor damage but trouble of engine plants or propeller caused the loss of propulsion.

3.1 The case study of collision of oil tanker

From the result of investigation, the Event Tree of oil spill after collision of oil tanker is shown in Fig 1. In the accidents of oil tanker for 4 years, 'light damage' was 63% (12 tankers) and 'serious damage' was 37% (7 tankers). 5% (1 tanker) in the total of 'serious damage' had spilled oil.

The flow of the event reached 'oil spill' from the collision is:

> *The event flow goes to 'serious breakage on the hull' (37%) ➠ 'Not sunk' (37%) 'Breakage on oil tank' ➠ 'Oil spill' (5%).*

Fig 1. shows the effect after tankers collided, but the probability in progress has not been indicated because of that we could not find the detail of accidents for example loading condition of oil, total breakage of oil tank itself and the size of opening from the precedents.

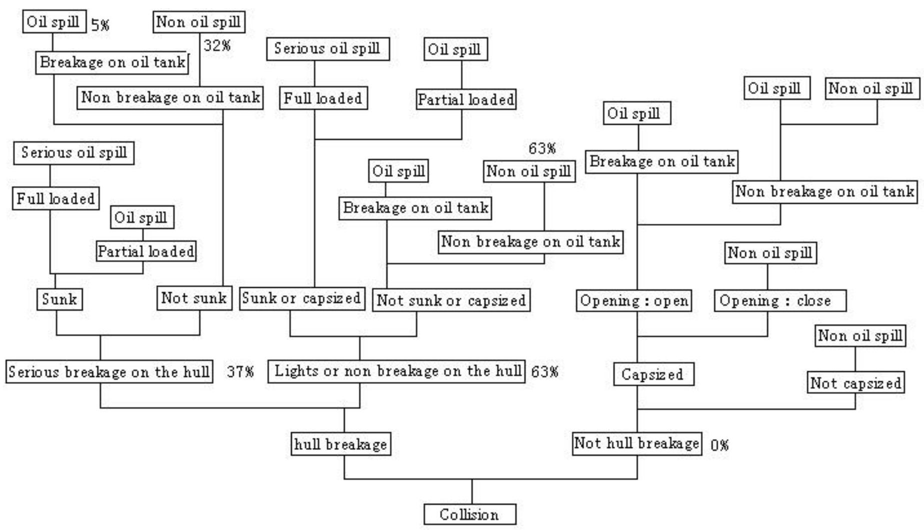

Fig.1 Event tree of the tanker

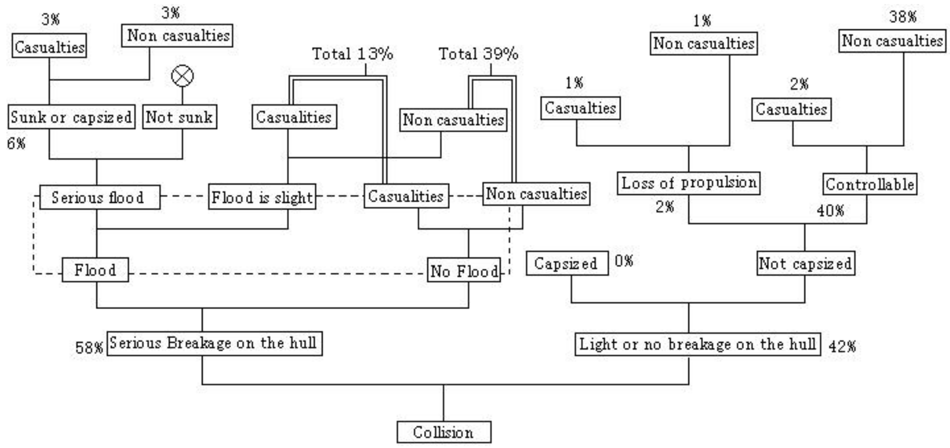

Fig.2. Event Tree of existence of casualties

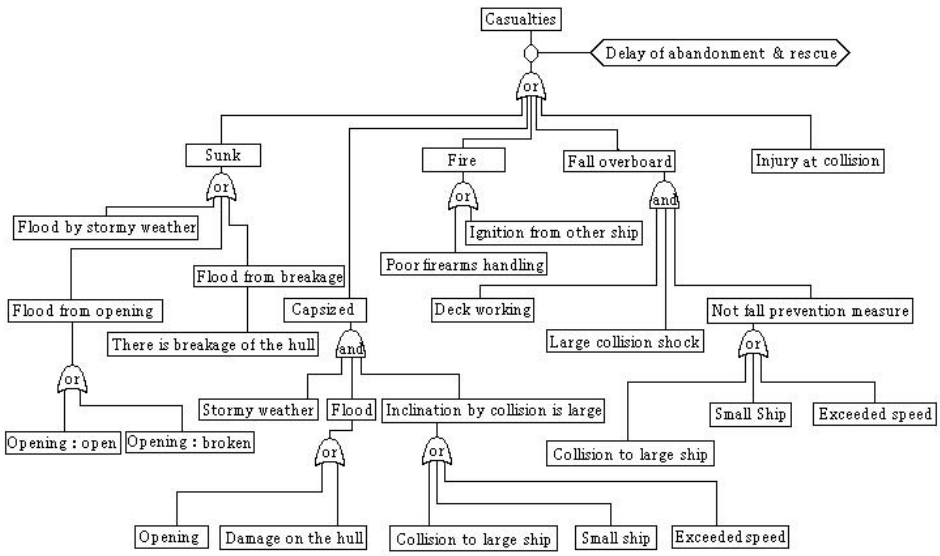

Fig.3. Fault Tree of existence of casualties

Actually the probability of tanker collisions was very small and the cases of oil spill were few. The vessels collected from Japan Marine Accident Inquiry Agency's Statistic record in 2003 are fishing boats, cargo vessels and small pleasure boats; there are few oil tankers. However we had several catastrophic environmental damage by spilled oil from collided tankers e.g. Exxon Valdez, Nakhodka, Amco Cadis. Therefore it is very important to estimate and study on the aftereffects of tanker's collision.

Moreover, we are researching on the oil spill process and reasons from oil tankers not only the case of collisions but also the case of all other accidents.

3.2 Casualties and hull damage after collision

Regarding the existence of casualties related to the damage of the hull after the collision, the Event Tree of existence of casualties is shown in Fig.2. The cases of 'serious damage' were more than 50% of total collisions and the case of 'light damage' had casualties and had very rare of 'loss of propulsion'. In the case of 'serious damage', capsize and sunk were 6% of the total accidents. The area enclosed by the dotted line is related to flooding with/without casualties. The ships are belonging to 'serious damage' without capsize/sunk had 13% casualties of and non-casualties 39% in the total accidents. Fig.3 shows the Fault Tree from same collision to the existence of casualties. In this figure, we assume that 'Fire' is one factor but there was no fire and casualties in the precedents. Consequently occurrence of 'Fire' is very low possibility at collision. The other three cases of sunk, capsize and fall overboard had a half of casualties of the total numbers. And they died by drawing. The majority of injured persons were bruised and broken a bone by the shock of collision. Some of them lead to fatal cases.

Conclusion

The 40-50% of collisions had 'light damage' and continued to sail without oil spill and casualties. The cases of 'light damage' had 14% oil spill and 28% casualties in these accidents.

The direct and important factors related to the damage of hull were speeds, collision angles, size and type of both ships. We surveyed all precedents from Japan Marine Accident Inquiry Agency for 4 years and studied the process and causes of damage of the hull or casualties after collision using the Event Tree analysis methods.

These analyses are very effective to understand and estimate the effects after collisions.

If we can use the speeds, types, details of collisions as an initial date in the calculation program. We will be able to evaluate the damage and aftereffects using these analysis methods.

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BIOGRAPHY

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