

# Reconstructing a Marine Casualty: The Effectiveness of the Full-Mission Simulator as a Casualty Analysis Tool

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**ABSTRACT:** The primary purpose of a marine casualty investigation is to seek to establish the causal factors of the casualty with a view to learning the hard lessons and avoiding a repetition. The broad questions of an investigation: "who?, what?, when?, where?, why?, and how?", all help to uncover the facts. The investigation sequence will cover a diverse range of fact-finding activities, amongst which, as often the case, may be a requirement for "conducting specialised studies". Following the fact-finding stage the typical investigation progresses to analysis of the facts, reaches conclusions and makes recommendations. Keeping an open mind, to avoid premature conclusions, requires the separation of the fact-finding and analysis phases. But the analysis may well help to identify missing pieces of evidence, or different lines of enquiry that may otherwise have gone undetected. As an effective reconstruction tool, a full-mission bridge simulator offers an opportunity to examine a broad spectrum of environmental conditions and vessel characteristics, as well as equipment failures, human factors and operating procedures. A casualty incident can be reconstructed in a real-time simulated environment, to aid more detailed analysis. Within the usual confines of the legal process, comprehension of nautical 'black magic' is greatly simplified for non-mariners, by seeing the simulated casualty incident unfold, in real-time or in selected short-time segments.

## 1 REGULATION AND BEST PRACTICE IN MARINE SAFETY INVESTIGATION

### 1.1 *Casualty Investigation Code*

The global harmonisation of marine casualty investigation was taken a step further last year with the approval by the International Maritime Organization of the new Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code). The Maritime Safety Committee adopted the Casualty Investigation Code by resolution MSC.255(84). And a new regulation 6 in chapter XI-1 of the SOLAS Convention was also adopted (resolution MSC.257(84)), giving mandatory status to the Code, which takes effect on 1 January 2010. However, the IMO has invited Governments to start implementing the new Code on a voluntary basis prior to the effective date of the Code [1].

### 1.2 *Common approach of 1997*

This most recent Code incorporates and builds on the best practices in marine casualty investigation

that were established by the IMO's Code for the Investigation of Marine Casualties and Incidents, adopted in November 1997. That Code sought to promote co-operation and a common approach to marine casualty and marine incident investigations between States. While the new Code specifies some mandatory requirements, it does recognize the variations in national laws in relation to the investigation of marine casualties and incidents. But the broad aim is to facilitate and promote objective marine safety investigations for the benefit of flag States, coastal States, and the shipping industry in general.

### 1.3 *Objectives and purpose*

The objectives and purpose are well stated in the Code's opening chapter:

"1.1 The objective of this 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, as defined in this Code, is an investigation

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.”

#### 1.4 *Causal factors rather than blame or fault*

As we can see, the primary purpose of a casualty investigation is to seek to establish the causal factors of the casualty with a view to learning the hard lessons and avoiding a repetition. And while it is not, and never should be, the role of a marine safety investigation team to attribute blame or fault, that is not to say the investigating authority should refrain from fully reporting the causes because fault or liability might be inferred from its findings.

## 2 THE FACT-FINDING/ANALYSIS CONUNDRUM

### 2.1 *Uncovering the facts*

The investigation must attempt to uncover all the facts, by seeking answers to such fundamental questions as: "who?, what?, when?, where?, why?, and how?" In this regard, the fact-finding sequence of the investigation is likely to include such activities as:

- inspecting the location;
- gathering or recording physical evidence;
- interviewing witnesses;
- reviewing of documents, procedure and records;
- conducting specialised studies (as required);
- identifying conflicts in evidence;
- identifying missing information; and
- recording additional factors and possible underlying causes.

### 2.2 *Progression to analysis*

Following the fact-finding stage a typical marine casualty or incident investigation includes: analyses of the facts; conclusions; and recommendations.

### 2.3 *Fact-finding and analysis*

Investigators need to keep an open mind and avoid reaching conclusions too early. It may appear self-

evident that the fact-finding stage of the process should be separate from the analysis. But it must always be borne in mind that the analysis may well help to identify missing pieces of evidence, or different lines of enquiry that may otherwise have gone undetected.

### 2.4 *Simulator as effective reconstruction tool*

In the course of very many marine safety investigations, the availability of a full-mission bridge simulator is likely to offer a powerful and productive analytical tool. Such a tool affords the opportunity to examine a broad spectrum of environmental conditions and vessel characteristics, as well as equipment failures, human factors and operating procedures. A marine casualty may be reconstructed in a real-time simulated environment, to allow detailed analysis of the incident. Mariners who have had the benefit of full-mission simulator training will readily appreciate the merits of the debriefing/playback feature, allowing detailed examination of the exercise or simulated incident, as the replay unfolds in real-time or short-time segments.

### 2.5 *Investigation and legal proceedings enhanced*

Such simulation can be replayed at will, with very obvious benefits for expediting the work of the marine safety investigation team. In another forum, such as the civil judicial process, it has the added benefit for non-mariners of aiding the comprehension of nautical terminology with the consequent potential to expedite settlement.

## 3 COLLISION CASE STUDY

### 3.1 *Investigation and litigation*

A practical example of the potential beneficial analysis that a simulated examination might generate is given from the following marine casualty case study. It centers on a collision off the southeast coast of Ireland, in June 2000. The collision was investigated by the newly established Marine Casualty Investigation Board (MCIB) [2], who did not have access to adequate simulation facilities at that time. The case also generated High Court proceedings which, in the event, were settled shortly before the scheduled hearing.

### 3.2 *Summary of the incident*

On the morning of 13 June 2000, the beam trawler mfv STELMAR (LOA 19m, 200t) was on passage from her home port of Dunmore East, heading towards her usual fishing grounds. She was steering a

course of about 145°, and making about 8.5 knots. The weather was fair: Wind SW'ly F 3/4, with good visibility.

At the same time, the tanker mv ALMANAMA (LOA 249m, 97,000 dwt) was making a course of 256°, speed 13.8 knots, bound for Cork Harbour. The vessel had cleared the traffic separation scheme at Tuskar Rock and was now on a course that would take her across the path of STELIMAR. In fact, the two vessels were on converging courses, in circumstances where the bearing between them was not changing significantly — a collision seemed inevitable unless avoiding action was taken by one or both vessels.

This was a classic "crossing situation" for which there is clear provision in the COLREGS. Rule 15 obliged ALMANAMA, as the give-way vessel, to keep out of the way and thus avoid collision, while Rule 17 required STELIMAR, the stand-on vessel, to maintain her course and speed — in the early stage of the encounter, at any rate.

In the event, a collision did occur, at a position about 14 miles SSE of Hook Head. STELIMAR sustained substantial damage, which necessitated her being towed back to Dunmore East. Given the enormous disparity in the size and tonnage of the two vessels it was nothing less than incredible good fortune that STELIMAR did not capsize and founder.

In addition to her Rule 15 obligation, ALMANAMA was also required by Rule 16, to "...take early and substantial action to keep well clear." In discharging her obligations, ALMANAMA could have made a large alteration of course to starboard so as to make her intentions very clear to the stand-on vessel, or she could have made a substantial reduction to her speed but this action would not have been so readily apparent to the stand-on vessel. Accepting that speed reductions are rarely used by give-way vessels when taking avoiding action in open sea situations, ALMANAMA could reasonably have been expected to make a substantial alteration of course to starboard. Further, she should have done so at an early stage in the encounter so as to avoid putting STELIMAR in the unnecessary and difficult position of having to take avoiding action under Rule 17(a)(ii).

### 3.3 'Factual' conflict

The MCIB investigation report noted the "Factual Report of the Collision..." from STELIMAR's perspective, and a similar "Factual Report..." from ALMANAMA. There should be no surprise that these 'factual reports' were in conflict. The real surprise was that the MCIB analysis failed to resolve the conflict adequately.

### 3.4 STELIMAR's perspective

STELIMAR'S skipper first noticed a large merchant vessel visually, broad on his port bow at a distance of 6 or 7 miles, on a general W'ly heading, shaping to cross his path — she would need closer attention as the range closed.

When the radar image of this large ship, soon to be identified as ALMANAMA, first appeared at the extremity of his 3-mile radar display, the skipper began to pay continuous attention to her progress. He believed that she was making 14 or 15 knots, and his concern was heightened by the developing situation, as presented in Fig. 1: he was in a crossing situation with a large vessel, whose bearing appeared to remain the same or nearly so.

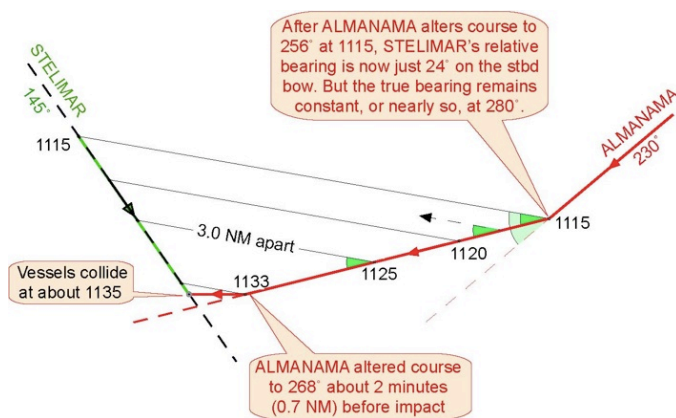


Figure 1. A reconstruction of the crossing encounter

### 3.5 Imminent collision

When the vessels were about 1.5 miles apart, and ALMANAMA had still not altered course, STELIMAR came to the conclusion that he would have to take avoiding action.

He could have altered course to starboard but the skipper felt this would have prolonged the period of uncertainty. In the event, he chose to de-clutch the main engine and allow STELIMAR'S speed to quickly run down. He estimated he did this when the vessels were about 0.75 to 0.5 miles apart — or about 2 to 2.5 minutes before impact.

In taking the speed off his vessel the skipper anticipated that ALMANAMA would pass safely ahead of him. However, very shortly afterwards (perhaps when 0.5 to 0.25 miles apart) he was alarmed to see a man on ALMANAMA'S starboard bridge wing running into the bridge in an agitated state. He was deeply concerned at this and, believing that he now had a full emergency on hand, he put his engine to "Full astern". He estimates the two vessels were about 0.25 miles apart at this point and that he was at "Full astern" for 30 to 40 seconds until the collision. He believed that ALMANAMA was turn-

ing slowly to starboard, towards STELIMAR as she gained stern-way.

### 3.6 ALMANAMA's perspective

Meanwhile, the "Factual Report..." from the other vessel has the OOW on the bridge of ALMANAMA, plotting a fix for 1115 and altering course to 256°. The vessel's speed was about 13.8 knots.

At 1120 he observed a small target (STELIMAR) some 40° to 50° on the starboard bow at a distance of 5 or 6 miles. He claims he acquired and plotted this target on the ARPA, which predicted a CPA of 1 to 1.5 miles with the target crossing ahead. He also took a series of visual bearings, which indicated that the vessel was passing ahead, but did acknowledge that the bearings were changing very slowly. He estimated that the fishing vessel was heading on a course of about 150° at about 10 or 11 Knots.

When the fishing vessel was between 2.5 and 3.5 miles off and about 1.5 to 2.5 points on the starboard bow, the OOW tried to call it on VHF Channel 16, but there was no reply from STELIMAR.

### 3.7 Belated course alteration

He now altered course to starboard, to 268°, though the fishing vessel was still fine to starboard and about 1 mile off. He claimed that STELIMAR altered course to port to about 120° and possibly reduced speed also. ALMANAMA then applied hard-to-port helm in a final, and ultimately vain, attempt at trying to avoid collision.

## 4 CLOSE-QUARTERS ANALYSIS

### 4.1 Course recorder trace

ALMANAMA's course recorder trace confirmed her course alteration from 230° to 256° at 1115. It also showed that her next course alteration, to 268°, was made just about two minutes prior to the collision, and that the hard-to-port manoeuvre had practically no effect before impact.

### 4.2 Hard lesson on failure to "take early and substantial action"

Deconstruction of the final phase of this collision encounter was clear to all; STELIMAR took emergency "full astern" action when it seemed clear to her that collision could not otherwise be avoided, but the action was unsuccessful because the beneficial effect of her stern-way motion was nullified by the very belated turn to starboard by ALMANAMA, culminating in the collision.

### 4.3 Making relative velocity simple

The most glaring and unresolved conflict between the two parties was ALMANAMA's contention that STELIMAR was expected to cross ahead at a CPA of 1 to 1.5 miles, this information allegedly predicted from ARPA. Such contention is readily refuted by means of a standard relative velocity plot, though not so readily understood by non-mariners. However, the use of a bridge simulator easily overcomes those difficulties.

### 4.4 Construction of RelVel triangle

The veracity of the relative velocity information is dependant on the vector accuracy for each ship. In the case of ALMANAMA, her course and speed were established from log records and instrumentation, while STELIMAR's course and speed were consistent with her recent departure (about 2 hours) from her home port. Reversing the vectors from the collision point allows construction of the basic relative velocity triangle, as given in Fig. 2. Because of uncertainty in the precise timing of each vessel's movements in the final moments of the encounter the plot may contain an inherent error, but nothing of any significant consequence. This was confirmed by rerunning the incident as a test exercise on the NMCI bridge simulators.

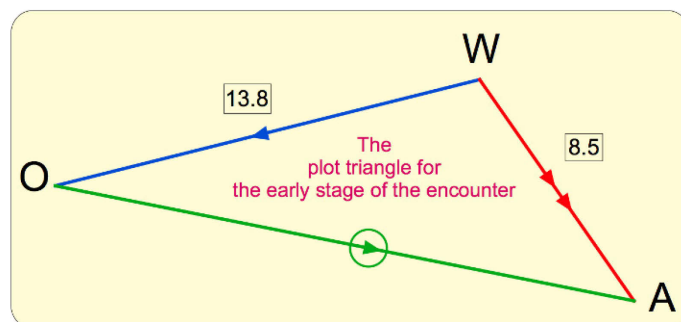


Figure 2. The Relative velocity triangle, from ALMANAMA's perspective

### 4.5 Critical relative bearings

Given the geometry of this encounter, as outlined at Fig. 1, it will be seen that STELIMAR was bearing 280° from ALMANAMA, or 50° on her starboard bow before she altered course at 1115. The contention that STELIMAR was observed at 1120, about 40°/50° x 5/6 miles on ALMANAMA's starboard bow, conflicts with the Fig. 1 plot which shows that the vessels were no more than 4.4 miles apart then. It is certainly the case that STELIMAR could not have been seen 50° on the bow at any time **after** ALMANAMA altered course at 1115 — if it were so, a collision could not possibly have happened. The only rational conclusion is that STELIMAR was

seen broad (50°) on the starboard bow **before** ALMANAMA altered course to 256°.

## 5 ARPA SIMULATION

### 5.1 ARPA vectors — ‘true’ or ‘relative’?

The change in the relative bearing of STELMAR (from 50° on the bow, drawing left to 24°) may well have misled the OOW on ALMANAMA into believing that STELMAR was crossing clear ahead of his own vessel. It is also possible that he confused the “true” and “relative” vector information presented by his ARPA radar. In any event, he chose to disregard (until too late) the warning of his own eyes when he observed that the compass bearing of STELMAR was changing only very slowly.

### 5.2 ARPA information

The simulated ARPA display in Fig. 3 presents an early stage of the encounter from the ALMANAMA perspective; her course is 256°, and STELMAR (the acquired target) is bearing 281° (25° on the starboard bow), range 5.1NM. The target’s ‘true’ vector is clearly visible, indicating a crossing condition.

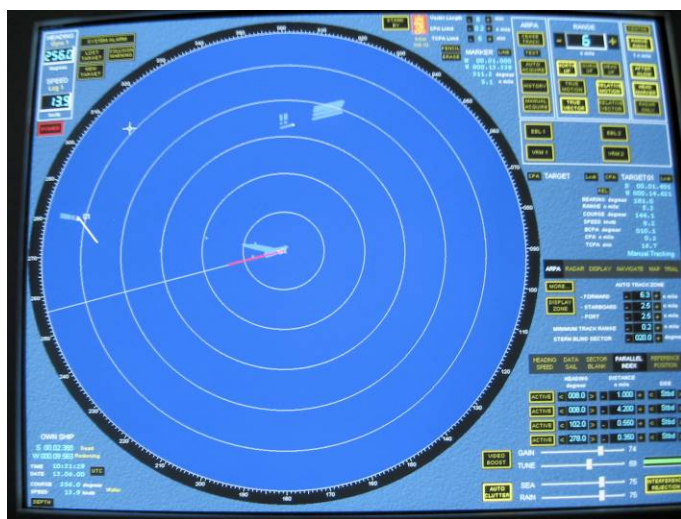


Figure 3. The ARPA simulation displays a ‘true’ vector from the acquired target on ALMANAMA’s starboard bow

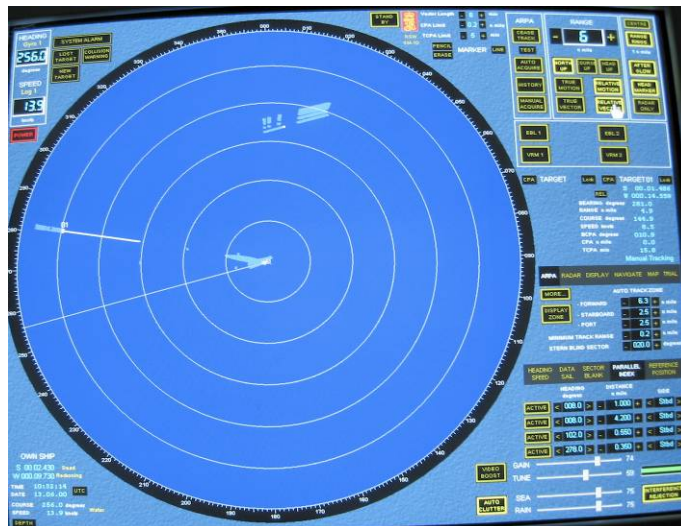


Figure 4. The target’s ‘relative’ vector signals a developing collision condition

A short time later, as presented in Fig.4, the navigational situation remains the same but the ARPA vector presentation is now ‘relative’. On any normally functioning and operated ARPA equipment, this developing close-quarters situation will trigger all the usual audible and visible alarms.

## 6 CONCLUSIONS

As demonstrated in this case study, full-mission bridge simulation lends itself easily and readily to collision analysis. The incident was reconstructed in a real-time simulated environment, aiding the more detailed analysis than that offered in the MCIB report. The simulator reconstruction exposed possible equipment failure, human factors and shortcomings in operating procedures. These are weaknesses that frequently flag missing evidence, which in turn, prompt investigators to pursue different lines of enquiry. The complexity of nautical technology is greatly simplified by a simulated reconstruction, which has clear benefits for all parties within the strictures of the legal process.

## REFERENCES

- [1] IMO, 2008. The Maritime Safety Committee, at its eighty-fourth session (7 to 16 May 2008), adopted the Casualty Investigation Code by resolution MSC.255(84) and a new regulation 6 in chapter XI-1 of the SOLAS Convention by resolution MSC.257(84) to make the Code mandatory. The Committee agreed that the Casualty Investigation Code should take effect on 1 January 2010, noting that the effective date should be the same as the date of entry into force of the new SOLAS regulation XI-1/6.
- [2] MCIB, 2005. Investigation Report by the Marine Casualty Investigation Board into ALMANAMA/STELMAR collision.