



Australian Government

Australian Maritime Safety Authority

Analysis of reported shipping incidents and incidents in relation to machinery, main engines, electrical failures and other equipment failures

Executive Summary

1. Recent maritime incidents, some involving mechanical failures which have, or could have, resulted in ship groundings and/or serious pollution, have prompted interest in the frequency of such events in Australian waters.
2. AMSA has, accordingly, undertaken a comprehensive analysis of such incidents over recent years to identify trends in rates of occurrence of serious incidents of these types so that consideration can be given to whether specific safety regulatory actions, aimed at minimising such occurrences, are warranted by AMSA.
3. This paper is the result of an initial analysis of mechanical failures in the context of both Australian and international data. For the purposes of this report, “incidents of interest” include machinery related incidents, main engine breakdowns, electrical and equipment failures.
4. The main findings of this analysis are:
 - a. Overall, since 1999, the incidence of mechanical failures, and in particular, main engine failures, which have resulted in serious outcomes in Australian waters, is very low, and is below Global average frequencies for such occurrences. Independent academic research¹ using other techniques further indicates that ship safety has improved in general over recent years and that the Australasian/South Pacific region did not represent a high risk region for machinery related incidents.
 - b. The probability of major hull and machinery related incidents in Australian waters shows a decreasing trend from 2006 to 2009 and is similar to, for example, experience in the United States shipping industry – data is not available to allow comparisons with industry experience in other regions. In addition, passenger vessels are more risk prone than all other ship types in both regions and that Australian ports with an increasing incidents trend are Devonport, Cairns and Townsville although the changes are minimal. There is a slightly higher rate of incidents for container ships in Australia, as well.

¹ Knapp S, van de Velden M, Visualization of Ship Risk Profiles for the Shipping Industry, ERIM report ERD-2010-013-LIS, <http://hdl.handle.net/1765/19197>, March 2010

- c. The number of such serious incidents is so low in Australia that it would probably not be possible to draw any statistically valid conclusions with respect to the root cause, which could assist in framing preventative initiatives. Indeed, there is little data available world wide as to causal factors, so it is not possible to identify those serious incidents which may have resulted from the actions of the crew in question, as opposed to external factors such as bad weather, sub-standard spare parts or poor quality fuel. Consideration of world-wide data, however, can provide some guidance as to the risks of ship casualties in a manner similar to the risk profiles (that is the probability of detention) AMSA has for some years allocated to ships in respect of port state control inspections.
5. There is clear evidence that, over the last three or so years, AMSA as a whole have taken a far more active and coordinated role in monitoring and overseeing the status of ships stopped at sea. The greater maritime domain awareness by information from AIS, Radar, Inmarsat polling, Long Range Identification and Tracking (LRIT), aerial surveillance, Barrier Reef vessels tracking, etc. has enabled AMSA to monitor ships more readily. It is likely that our intelligence and understanding of incidents is much better now than was the case some years ago. In addition, by coordinating between AMSA's Divisions, this allows for a more complete awareness of an incident and specific history of the ship(s) involved. Incidents can then be managed more holistically so that not only is the immediate incident managed, but so are the ship's actions during and after the incident by incorporating Port State Control inspection histories, including those conducted by other administrations in the Asia Pacific region, or undertaking investigations as appropriate.
6. While there has been an overall trend of increases in incident reporting to AMSA over the last five years, exceeding that of global trends, this increase is considered to be largely driven by more complete reporting, rather than any genuinely adverse trend, although only anecdotal evidence of this can be provided. The vast majority of mechanical failure incidents reported to AMSA in recent years have been of low or very low severity, with no serious adverse outcomes.
7. The data show that the number of machinery related failures has also increased with the overall incidents trend. If, however, the proportion of machinery related failures to total incidents is compared, rates of occurrence are relatively constant. On this basis it cannot be concluded that there is any worsening of the rate of machinery failures.
8. Further analysis in the future could be undertaken by obtaining global data on incidents and combining that data with AMSA's own data to estimate incident risk profiles which can be combined with the probability of detention which has been in use by AMSA for the last 10 years. Various risk profiles and levels could then be estimated in more detail than at present for each ship that arrives in Australia, allowing these risk profiles to be monitored over a certain time frame to see how they may change.

Outcomes of Analysis

9. For the time period 1999 to 2010, AMSA's incident database records 10,091 incidents of which 3,147 (31.8% of the total) are incidents of interest, although the majority of these are of minor severity. Out of these 3,147 incidents of interest, a little over half, namely 52.3%, are machinery related failures, 29.6% are main engine breakdowns and 18% are related to equipment and electrical failures. If only machinery related failures and main engine breakdowns are taken into consideration, these represent 25.5% of total incidents, much the same as the international rate of 25.6%.
10. At an Australian level, only 9 incidents of high severity (Category 1 and 2) recorded by AMSA are machinery related or main engine breakdowns – which translates to 0.09% of total incidents of all severity grades (10,091) reported over the same time period. Put into context of arrivals, the frequency of occurrence of any type of serious mechanical problem is no more than about 0.00005 per voyage.
11. This very low number and frequency of more severe category 1 to 3 incidents ***in Australia*** would not be sufficient to allow useful modelling of national data to test whether relationships such as flag, ownership, ship type and other factors may show a correlation with incidents. This low frequency of such incidents also makes it difficult to conclude whether ships that arrived in Australia have become more or less risk prone over time towards machinery related incidents. A possible alternative approach is to estimate, based on a global incident dataset, probabilities of severe incidents for ships arriving in Australia based on a similar method used for identifying risk of detention for port state control purposes. AMSA is currently working on such models, which may allow estimating probabilities of incident types for each vessel that arrives.

Background

12. According to Prof. Charles Perrow in his 1984 publication "*Normal Accidents: Living with High Risk Technologies*" - updated in 1999 - the maritime industry is the second most incident-prone industry on Earth. It is worth noting though that, while the international maritime industry has many incidents, very few of these incidents have serious outcomes, as major shipping disasters are generally the result of several adverse factors coinciding – e.g. severe weather conditions, combined with human error and/or mechanical failure.
13. AMSA has maintained a database on marine incidents since the mid-1990s. Although there have been sizeable increases in the annual numbers of incidents recorded since the database's creation, there is a strong indication that more rigorous reporting is occurring, rather than there being a strong rate of growth of such incidents. It is likely that in past years many minor incidents were not reported and would not otherwise have been brought to AMSA's attention if there had been no general adverse consequences. It is also possible that any such machinery failure reports during this time may have been listed under a more

general category and so were not able to be identified in the data sets used for this analysis.

14. Figures 1 and 2 below provide an overview of Australian data for the years 1999 to 2010.

Figure 1: Total number of incidents and incidents of interest

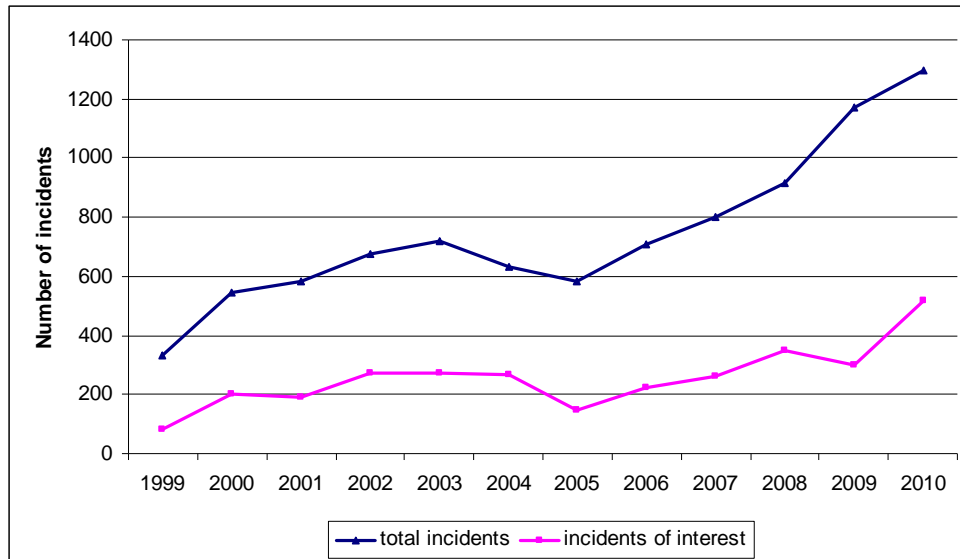
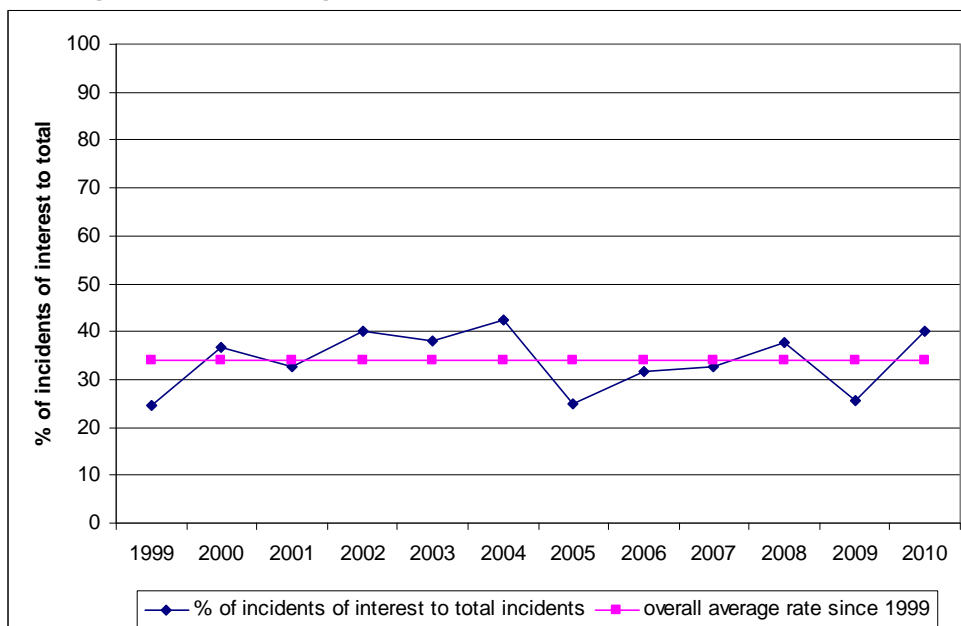


Figure 2: Percentage of incidents of interest to total incidents



15. For several years, the AMSA database has had the ability to categorise each incident as to its severity (with a five-level grading from very minor to very serious), although there would be a degree of subjectivity in such ratings. This severity rating was developed to align with the then ATSB ratings (which have since been revised), but does not align with the most recent categorization of incidents adopted by the International Maritime Organization (IMO), thus making comparisons with global data difficult. By far the highest number of Australian incidents is recorded against the lowest AMSA severity rating (category 5), and these include minor issues; such as a ship stopping at sea to undertake scheduled

maintenance – i.e. an event of no particular risk or consequence in the vast majority of cases. In addition, limitations to the functionality of AMSA’s incident data have also led to some duplicate records, hence some incidents were found more than once in the database, thus increasing counts and potentially biasing analysis outcomes (although not to a major extent).

16. Furthermore, the categorisation of data does not cover the potential of an incident (i.e. the risk of occurrence). Noting paragraph 12 above in that major disasters are generally a result of alignment of several unassociated factors, this means that recording data based only on the inherent risk is a limitation with data captured for analysis both nationally and internationally.
17. In risk management terms, the inherent risk (what did happen) is usually mitigated by control measures aimed at minimising the resulting residual risk (what is likely to occur with controls in place). At the moment, incidents are only categorised based on what actually happened, i.e. inherent risk, rather than the more serious potential outcomes of what could have happened, i.e. residual risk. As the “controls” that influence incident outcomes are often external factors, e.g. weather, tide, location etc, these outcomes can be the result of ‘good luck’ rather than good management and in regard to classification of the severity of an incident under the current regime, this is not captured. Similarly, if the outcome is affected by intervention of any type, this also does not impact on the categorisation.
18. This limitation has resulted in a situation whereby analysis of the current data captured in both national and international databases is unable to consider the potential of an incident. For example, under current international reporting requirements – the International Maritime Organisation (IMO) and its GISIS database - a machinery failure that required intervention to prevent a major incident is treated no differently to another similar incident where there were similar outcomes even though no intervention was required. For such potentially serious incidents neither case is required to be reported to IMO. For AMSA data though, the intervention, in what ever form it takes, does not always escalate the categorisation of an incident record, so there are many low severity incidents, at least some of which might have had much more adverse outcomes subject to chance.
19. Detailed analysis of AMSA incidents which are likely to represent actual or potentially adverse outcomes, such as major damage to the ship, serious pollution, etc, should exclude the low severity (category 4 and 5) incidents. It is also possible to make some comparisons with global incident data by combining data from the IMO and commercial data providers and by recoding the severity ratings of Australian incidents to align with IMO definitions. IMO data and commercial data are not likely to include incidents of negligible seriousness as is recorded in AMSA’s category 4 and 5 incidents.
20. Global data also varies with respect to the grouping of incidents. Some sources of global data do not distinguish between hull-related incidents and machinery-related incidents, although manual reclassification can overcome this shortcoming

to a certain degree. Commercial data sources, too, do not necessarily have the detail to distinguish between incidents such as those related to main engine breakdown or steering gear, whereas the AMSA database does separately identify several main categories within machinery related failures. In addition, commercial data and AMSA data also do not distinguish between initial events (possible causes) and consequences. **A comparison with available global data indicates that AMSA's proportion of machinery related incidents within the severe/serious categories 1, 2 and 3 is substantially lower than the global experience.**

21. There is also little data readily available as to the causal factors involved in marine incidents, so it is not possible to identify, for example, those engine failures resulting from lack of maintenance or human error, as distinct from engine failures caused by tainted fuel, poor quality spare parts or other reasons beyond the control of the crew. There are many potential causes of main engine breakdowns, some of which are due to factors largely outside of the control of the crew, and sheer chance or external influences such as weather conditions would often determine whether any of these engine failures resulted in benign or serious outcomes.
22. On the global level, the European Maritime Safety Agency (EMSA) has developed an incident database (EMCIP - European Marine Casualty Information Platform) with the aim of facilitating root cause analysis for incident investigations, which is an advance on the IMO's casualty module in the Global Integrated Ship Information System (GISIS). In addition, EMCIP follows internationally agreed categorizations with respect to incident types, severity and pollution classifications. A presentation by EMSA on the EMCIP system was given to the General Manager Maritime Operations Division and the Manager Ship Inspections during their attendance at the IMO Flag State Implementation Sub-Committee meeting in February 2011. This will allow for consideration as to whether the taxonomy of EMCIP may be taken into account when re-designing the incident module of AMSA's redeveloped Shipsys database
23. To provide a high level overview of risk associated with ships that arrive in Australia, statistical models based on Knapp et al (2010)² were reapplied to AMSA arrival data and average probabilities of various incident types calculated. For this particular analysis, no distinction is made between hull related and incident related incidents and the probabilities are also irrespective of severity. This can and will be remedied in the future since AMSA is currently redeveloping its risk formula for the probability of detention and as part of this work will also re-estimate the incident type models. In the future, AMSA may be able to estimate a more comprehensive set of probabilities (e.g. detention, deficiency types, incident types) for each vessel arriving or transiting Australia. On average, the probability of hull and machinery related incidents of ships arriving in Australia show a decreasing trend from 2006 to 2009. It further indicates that passenger vessels are more risk prone than all

² Knapp S, Bijwaard G and Heij C, Estimated Incident Cost Savings in Shipping Due to Inspections, Accident Analysis and Prevention 2011, forthcoming

other ship types in both regions and that Australian ports with an increasing trend are Devonport, Cairns and Townsville although the changes are minimal.

24. In addition to the findings outlined above, Knapp and van de Velden (2010) indicate that ship safety has improved over recent years and that the Australasian/South Pacific region did not represent a high risk region for machinery related incidents.

Data Capture

25. During the course of this analysis some limitations in data capture were identified. It was found that the categorisation of incident data is not standardised internationally or nationally. Similarly, the definition of the various incident categories in AMSA's records does not align accurately with the latest international standard.
26. Of even greater significance, this analysis and subsequent consideration has shown that all incident data is based only on the actual incident and not on the potential. This represents a very significant limitation in data collection and analysis. For example, whilst the definitions vary across databases, the fundamental principles are that actual damage, injury and/or pollution must have resulted for an incident to be categorised as "Category 1 - Very Serious" or "Category 2 - Serious".
27. On a number of occasions AMSA has been forced into intervention action or even less formal directions to prevent an incident becoming significant. This is not reflected in the seriousness of the incident data as, by definition, no casualty ultimately occurred due to timely intervention action by AMSA.
28. As examples of this, the Pasha Bulker, Shen Neng 1 and Ocean Emperor incidents did not meet the international definitions of "very serious casualty". At the IMO level, only "very serious" and "serious" casualties must be reported. The Ocean Emperor incident would also not have met either of these classification criteria, as the intervention action by AMSA prevented almost certain serious outcomes.
29. This means that comparisons of our data with international data have limited scope for producing valid outcomes.
30. Whilst AMSA's incident database does not currently capture the potential impact in the categorisation of an incident, the details of response and intervention actions are captured in the free text comments section of the *Shipsys* database and also in the Rescue Coordination Centre's *Nexus* database.
31. In comparisons to global data, it also needs to be recognised that the Australian data captures a far broader range of incidents than that available internationally. For example, our legislation requires reporting of any incident, near miss, or dangerous occurrence, including OHS, Marine Orders 32 (Cargo handling equipment), etc. AMSA also encourage, accept and record incident reports from third parties such as pilots, stevedores etc. On this basis our numbers of reports

appears disproportionately high compared to international reports as many of the reports received by AMSA are minor or very minor in nature.

Response

32. On the basis of the analysis in this paper , AMSA has undertaken to:
- a) Raise with IMO the need for internationally consistent categorisation of incidents;
 - b) Raise with IMO the importance of the categories reflecting the potential of an incident and not just the actual outcome. This may simply amount to capture of any incident that required a flag or coastal state to intervene in any way. This will allow a greater ability to analyse and compare incident statistics more thoroughly;
 - c) Review AMSA internal procedures to re-categorise an incident based on actual interventions and outcomes, rather than just basing severity ratings on initial reports;
 - d) Ensure that the phase II work on the current redevelopment of the *Shipsys* database, involving the incident module, enables accurate reporting and analysis of incidents and their root causes and allows multiple associations of one incident (which is not currently possible);
 - e) Review the EMCIP incidents system developed by EMSA to determine its potential application to AMSA for the phase II redevelopment of the incidents module of *Shipsys*;
 - f) Continue to monitor trends in incidents; and
 - g) Enable multiple data exchange feeds of incidents (e.g. synchronization with the IMO GISIS database and data feeds from commercial data providers) into the new AMSA incident database.

Maritime Operations Division

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