UK P&I CLUB

Risk Focus:
Loss of power

Industry has noted an increasing number of blackouts and main engine failures

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Increasing numbers of main engine failure related incidents and accidents following blackouts have led to a data collection exercise by the UK Club's risk assessors and a detailed analysis of more than 700 claims which has given cause for concern. A significant number of these claims for third party property damage, many of which were enormously expensive and in some cases amounted to millions of dollars could be attributed, directly or indirectly, to main engine failures or electrical blackouts.

Ships effectively out of control as a result of these problems have caused extensive damage to berths, locks, bridges, dolphins, navigational marks, loading arms, cranes and gantries along with moored ships. Costly collision and grounding claims can similarly be caused by these failures.

It is no exaggeration to suggest that main engine failures and blackouts tend to occur most regularly at the point in a voyage where the ship is at its most vulnerable. In confined waters or entering and leaving port, the stable loads which will generally prevail with the ship on passage are disturbed. There is additionally some evidence that compliance with the low sulphur fuel regulations and changing from one grade of fuel to another has exacerbated these problems.

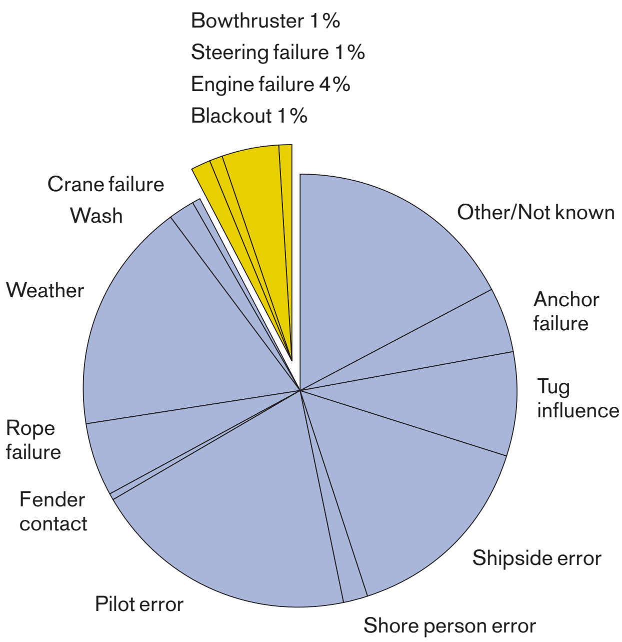
Reports from pilots, operating in emission control areas where fuel grade changes have been implemented, indicate that these problems have become quite widespread, noting that ships regularly seem to be experiencing power losses, invariably at critical times in their manoeuvres and which are attributed to 'fuel problems'. In the Club's recent Loss Prevention Bulletin 785-09/11(fuel switching), Members were alerted to warnings from the US Coast Guard which had just enforced their own ECA, noting a marked increase in incidents after vessels lost propulsion and had linked many of these incidents to vessels operating on marine distillate fuels.

Vulnerability of ships to such problems has also tended to increase as a result of the 'self-sufficiency' of modern vessels, the provision of lateral thrusters tending to persuade operators to minimise their dependence upon tug assistance in port waters. Thus, where in an earlier era a vessel experiencing mechanical difficulties would be merely held safely in position by assisting tugs, a single tug in attendance may not be able to sufficiently intervene with a large ship suffering a blackout or main engine failure at a critical point in the manoeuvres.

The consequences of main engine failures or blackouts leading to steering gear failure can be little short of disastrous, in terms of the enormous third party property damage claims which can result. An entire canal system or waterway could be put out of action as a result of an out of control ship damaging a lock or bridge, while months of expensive inactivity could be suffered should a specialist berth with bulk loaders or gantries be damaged by a ship. The costs of ships rendered inactive as a result of third party damage can be substantial as can all claims from collisions and groundings attributable to such causes.

The Club's analysis of more than 700 claims provides ample evidence that these problems are not merely anecdotal, as the graphical presentation of large third party property claims (diagram 1) illustrates. Engine failures, steering failures, failure of bow thruster or blackouts (which may well be connected) amounts to a substantial percentage of the whole.

1. Cause of large third party property claims

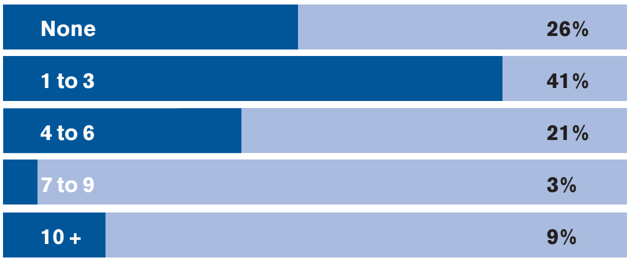


Evidence has been provided by a twelve month exercise by the Club's in-house assessors employing a questionnaire during their routine ship visits, which was designed to identify and highlight problems experienced aboard the Club's entered vessels. Altogether, 249 ships' crews were questioned during this investigation about their experience with blackouts, main engine failures and fuel switching problems.

Blackouts

While there may be an understandable reluctance to admit to having such a problem, with a total of 64 (26%) of chief engineers claiming that they had never had a blackout on board any ship, it is considered that this is likely to be understated. There were 22 chief engineers (9%) who reported that they had experienced more than ten blackouts. The graphical representation (diagram 2) indicates that such problems are certainly not unknown, with around three quarters of all chief engineers questioned reporting blackouts.

2. Number of blackouts as reported by chief engineers



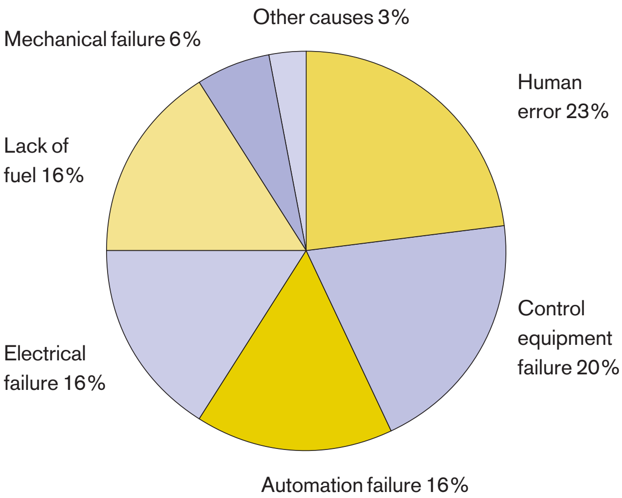
Their answers on the causes of blackouts, which are thought to be fairly accurate, are similarly revealing and may be listed thus:

- **Automation failure**
  (auxiliaries load control/sharing failure etc)
- **Control equipment failure**
  (eg. governor failure, defective trips for high temperature cooling or low luboil pressure etc)
- **Electrical failure**
  (eg. overload, reverse power trip, preferential trip device failure etc)
- **Lack of fuel**
  (eg. blocked filters, water in fuel, fuel supply piping and pump failures etc)
- **Mechanical failure**
  (eg. lack of compression, engine seizure, loss of lubrication, overheating etc)
- **Human error**
- **Other causes**

Out of a total of 400 reported blackouts, the highest number (90 or 23%) was attributable to human error. Several of these incidents were caused by procedural errors - ‘pressing the wrong button’ - and stopping or tripping an on-load generator.

A further 65 (16%) were caused by electrical failure and a notably high number of these blackouts were reported as a result of starting bow thrusters and deck machinery such as mooring winches or cranes, with insufficient electrical power being available. It is clearly not always realised that the starting current of electrical motors can be several times the full ‘on load’ current and starting large motors can sometimes cause breakers to trip and lead to blackouts. While many modern ships have in-built safety features to prevent this happening, it is still a sensible precaution to have routines in place to ensure that adequate generating power is available before starting large electrical motors.

3. Cause of blackouts



A shortage of fuel supply to the generating engines accounted for 64 (16%) of reported blackouts, with a high proportion of these attributed to blocked fuel filters.

Automation failure was blamed for 16% of blackouts, failure of control equipment 20% and mechanical failure 7% of those reported. There was, however, no noteworthy reason provided for these failures.

Main generator

Main engine manoeuvring failures

There was a perhaps understandable reluctance to report main engine manoeuvring failures, with a high percentage of engineers reporting fewer than four failures during their careers and a surprising 44% admitting to any failures at all. Nevertheless, there were a total of 249 such failures reported by the chief engineers interviewed.

4. Number of main engine manoeuvring failures as reported by chief engineers

None	56%
1 to 3	31%
4 to 6	8%
7 to 9	2%
10 +	2%

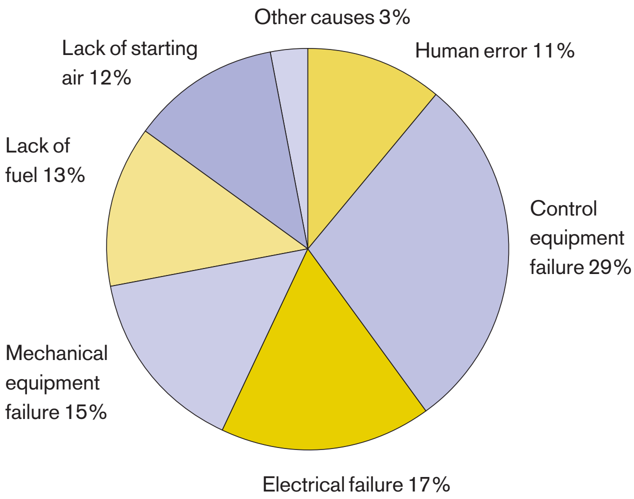
These failures were categorised as follows:

- **Control equipment failure** (eg. governor failure, load control failure, defective trips for high temperature cooling or low luboil pressure etc).
- **Electric failure** (eg. loss of electrical power etc)
- **Human error**
- **Lack of fuel** (eg. blocked filters, water in fuel, fuel supply piping and failure of pumps etc)
- **Lack of starting air**
- **Mechanical failure** (eg. reversal system failure, lack of compression, engine seizure, loss of lubrication, overheating, crankcase oil mist, scavenge fire, gearbox problems etc)
- **Other causes**

Depleted air bottles: Excessive numbers of engine starts/stops during manoeuvring will deplete pressure in the main engine start bottles which can result in loss of control of the vessel at critical times, such as when docking, due to the engine failing to start.

Good start air pressure with safe operational limits marked

5. Causes of main engine manoeuvring failures

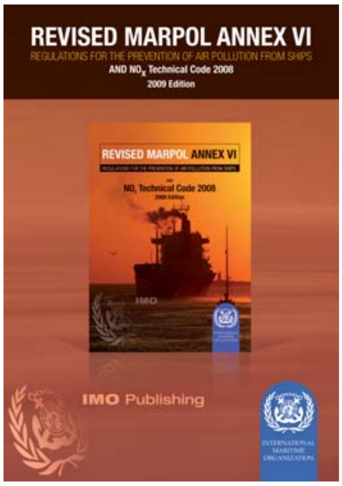


As is illustrated in diagram 5, control equipment failure accounted for the greatest proportion of main engine manoeuvring failures, this being mainly caused by the lack of or leakage of control air, along with other malfunctions. Blackouts (as discussed previously) accounted for the next highest cause of electrical failure. Of the 15% of mechanical failures, these were attributed to defects with pneumatic valves, start air valves and defects in reversing systems.

Lack of fuel accounted for 13% of failures, and as with generator failures, blocked filters were identified as the main reason for these. While 12% of manoeuvring failures were attributed to a lack of starting air, it is important that the start air pressure is monitored while the ship is being manoeuvred and also vital that the pilot and bridge team are made aware of the maximum number of consecutive engine starts they can demand. Human error of various kinds accounted for a further 11% of failures.

Main air compressor

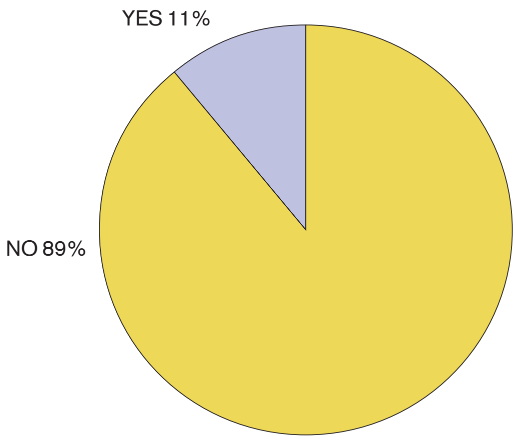
Low sulphur fuel problems



Of the chief engineers questioned, 28 (11%) confirmed that they have experienced, or were anticipating, problems complying with the low sulphur fuel regulations. (See diagram 6).

It might however be suggested that these are relatively early days, and the spread of emission control areas relatively limited. Stricter implementation of regulations and an extending network of ECAs around the world may well see the problems multiplying for those aboard ship.

6. Number of chief engineers reporting problems complying with fuel regulations

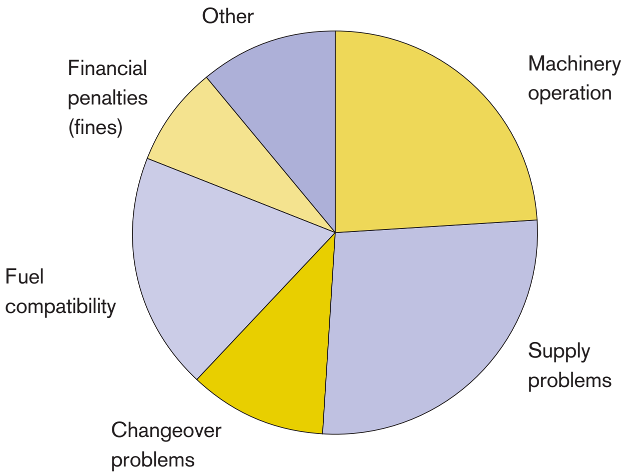


Problems already encountered and reported to the Club's assessors included that of supply and storage, difficulties with machinery operation, fuel compatibility difficulties, changeover problems, financial penalties and others. (See diagram 7).

Supply and storage problems were reported by the chief engineers of ten ships. While there is now said to be widespread availability of low sulphur fuel around the world at the major bunker supply ports, the cost differential compared to high sulphur fuel is between $20 and $80 per tonne.

Storage problems have been reported on particularly older ships because of the lack of dedicated settling/service tanks for both types of fuel, difficulties being encountered when changing from one grade of fuel to another.

7. Type of problems associated with low sulphur fuel regulations



Nine ships reported having problems with machinery operation when operating on low sulphur fuel, which included fuel oil lubrication of pumps and nozzles, sticking fuel pumps, generator starting problems, fuel oil leakages and delayed pick up speed of engines.

Seven ships suffered compatibility problems between the two fuel types, resulting in purifiers requiring more frequent cleaning and filters becoming blocked. It is also pointed out that if a vessel changes over from higher sulphur fuel (HFO), when MGO is introduced into the system it may act like a solvent, releasing any asphaltenes which then collect in the fuel filters/ strainers and clog them.

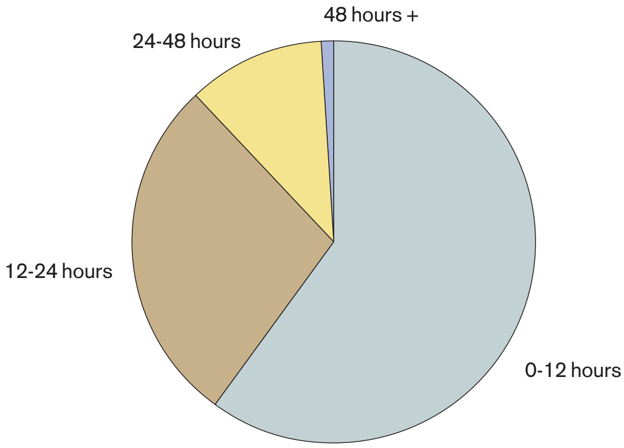
Only four ships reported having any problems when changing over from one fuel type to another and one vessel reported that the changeover time had been miscalculated and the ship had been subsequently fined and detained. Another ship reported being fined after the <1% sulphur fuel bunkered was found to contain >1% sulphur when analysed.

It was reported that 60% of ships took up to 12 hours to change the main engine over from one type of fuel to another. However, this included many ships which were operating exclusively on low sulphur fuel. Some 28% of ships took between 12 and 24 hours to effect the changeover and the remainder longer.

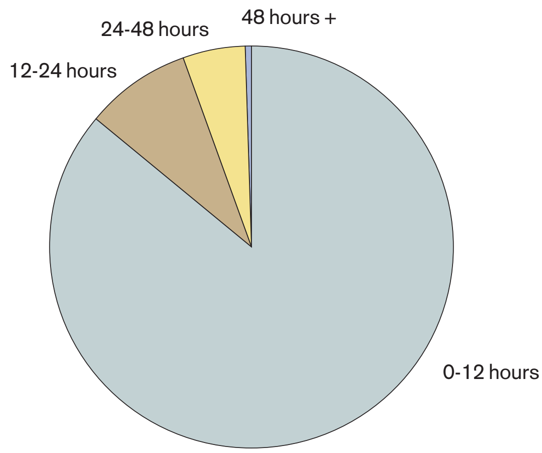
It was reported that 66% of ships had dedicated storage tanks for low sulphur fuels and if the ship is equipped with two day or service tanks, then the requirement for the changeover procedure will be very much reduced.

It is assumed that the one day or the service tank will contain higher sulphur fuel (HFO) with the other tank already filled with the required low sulphur fuel oil. Thus

8. Fuel changeover times for main engines



9. Fuel changeover times for generators



the whole procedure will only require the isolation of the feed from the HFO service tank and the flushing of the feed pipeline to the engines from the low sulphur day or service tank.

If the ship is equipped with only a single day or service tank then flushing of the system will take very much longer, this procedure consisting of:

- Reducing or emptying as far as is possible the settling tank of the previous HFO
- Flushing the pipeline to the settling tank and filling it with low sulphur fuel
- Reducing or emptying as far as possible the day or service tank
- Flushing the connecting pipeline from the settling tank to the service or day tank with low sulphur fuel from the settling tank
- Filling the service tank with low sulphur fuel and commencing to use this fuel before entry into the ECA

It was reported that 19% of ships had required new equipment to be installed in order to run the engines or boilers and 28% had been required to carry more than one lubricant. If engines are expected to operate for lengthy periods within an emission control area, then the lubricating /cylinder oils may need to be replaced by low base number oils. The engine manufacturer's guidance should be obtained about this matter.

Only 2% of ships considered that they had inadequate storage capacity for the different grades of oils.

In order to run on low sulphur fuels, 10% of ships reported that they needed to adjust the fuel pumps of their engines.

Switchboard load out of balance

Recommendations to reduce the risk of power losses and blackouts

- Engine and boiler manufacturers should be consulted for advice on operation with low sulphur fuel and the need for any equipment/system modifications
- Ensure correct maintenance of all equipment; engines, purifiers, filters, fuel systems and sealing arrangements
- Ensure fuel oil viscosity and temperature control equipment is accurate and fully operational
- Ensure that system temperature and pressure alarms, fuel filter differential pressure transmitters etc are accurate and operational
- Ensure fuel changeover procedures are clearly defined and understood
- Ensure that engineers are fully familiar with fuel systems and main engine starting systems and establish 'failure to start' procedures. These should include familiarisation with operation locally and from the engine control room
- Ensure that the starting air pressure is monitored during manoeuvring operations and that the deck department appreciates the limitations of starting air availability
- During standby, run two (or more) generators in parallel whilst ensuring sufficient power availability should one stop or trip. Monitor and balance switchboard power loads equally
- Test the astern operation of the main engine prior to arriving at the pilot station and, if practical, before approaching the berth
- Establish procedures to ensure that there is adequate electrical capacity available before starting up lateral thrusters, mooring equipment or other heavy equipment, bearing in mind that simultaneous starting of large electric motors will lead to a large power surge and possible overload
- Ships fitted with shaft generators should, where appropriate, change over to to auxiliary generator power well before entering restricted waters and undertaking critical manoeuvres. Manufacturer's guidelines should be followed and ship's staff guided accordingly.

Photo by kind permission of Australian Transport Safety Bureau

Loss of power - the 'Bowtie approach'

Hazard, threats and consequences: In the centre of the diagram, Loss of Power is identified as the 'hazard' , while blue squares to the left identify a range of 'threats' , which, if not controlled, could cause a serious incident involving P&I claims and other consequences which can be seen in the red shape on the far right of the diagram.

Controls: Between these extremities can be seen the 'controls' which, if they work properly, will prevent the accident happening and on the right hand side of the diagram, controls which will mitigate the consequences.

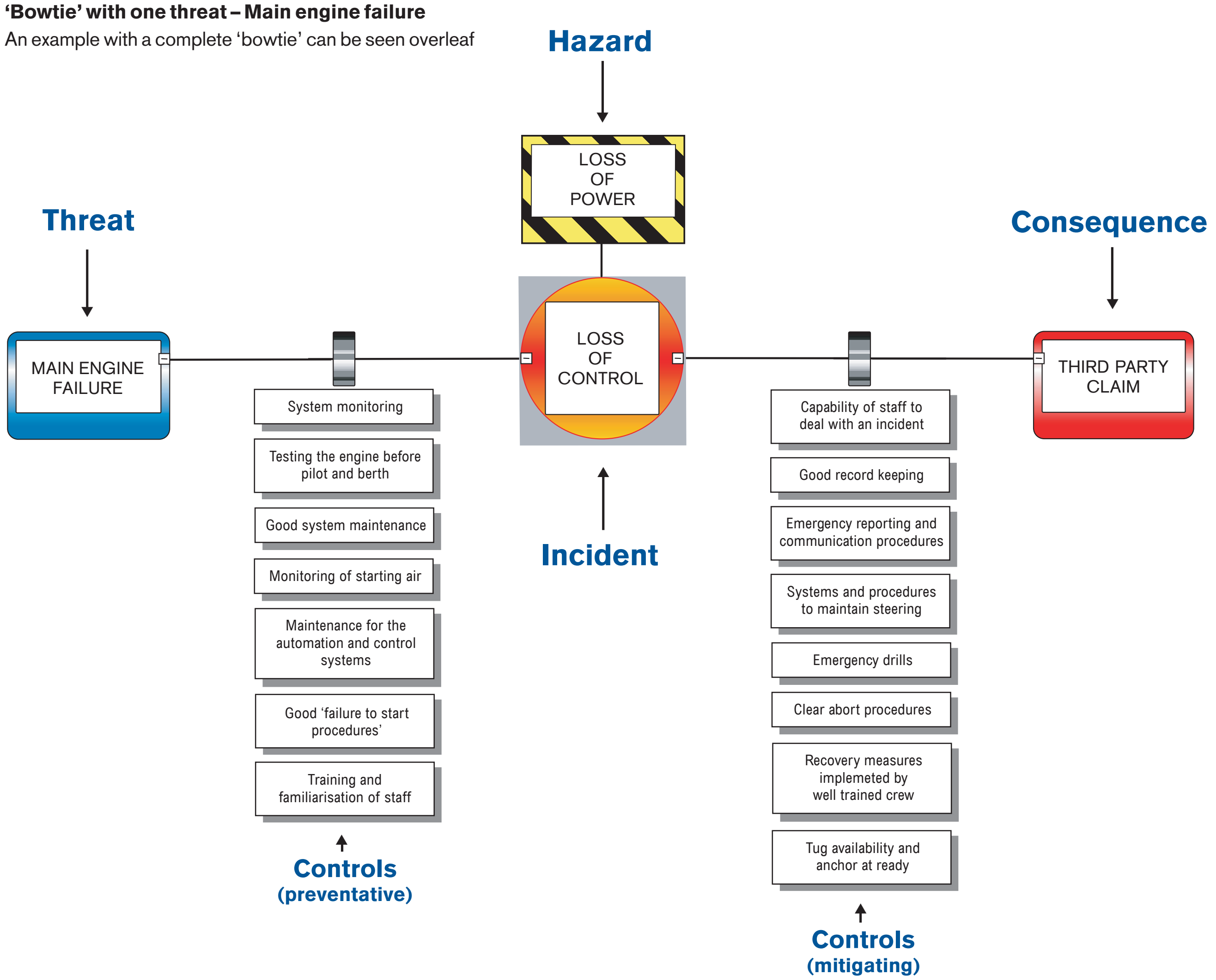
Thus taking as an example the threat of Main Engine Failure (left hand side), controls which should be in place to prevent this include system monitoring, testing the engine before pilot and berth, the monitoring of starting air, good system maintenance, tests and maintenance for the automation and control systems, good 'failure to start' procedures and training and familiarisation of staff.

Consequences: The consequences of an accident (right hand side)will be mitigated by the capability of the crew to deal with an incident, good record keeping, emergency reporting and communication procedures, systems and procedures to maintain steering, emergency drills, clear abort procedures, recovery measures implemented by a well trained crew, tug availability and anchor at the ready.

Threats: This example shows only one threat. A full 'Bowtie' with all the threats can be provided on request.

'Bowtie' with one threat – Main engine failure

An example with a complete 'bowtie' can be seen overleaf

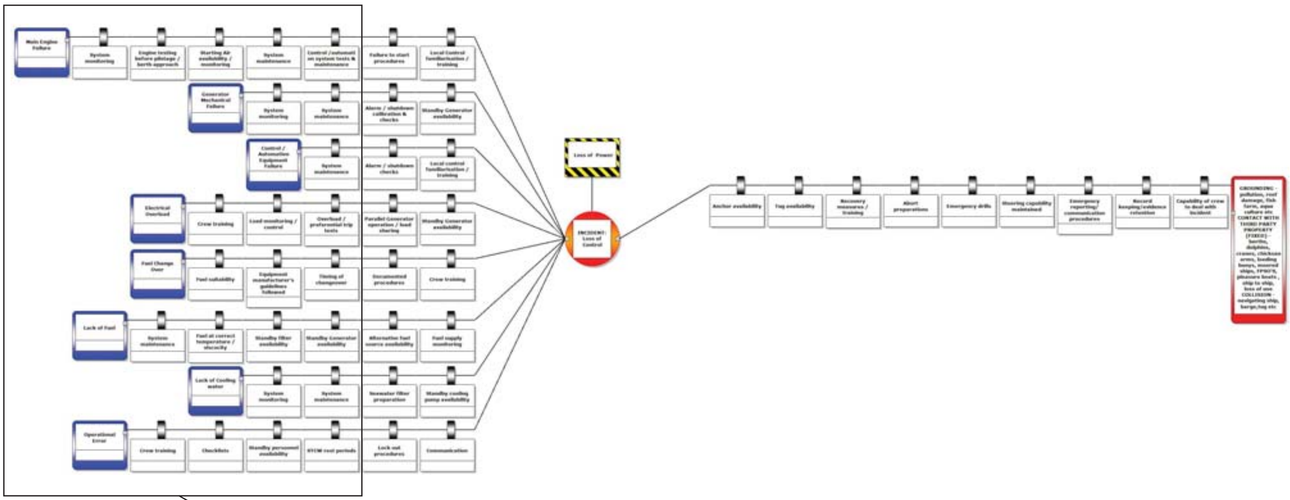


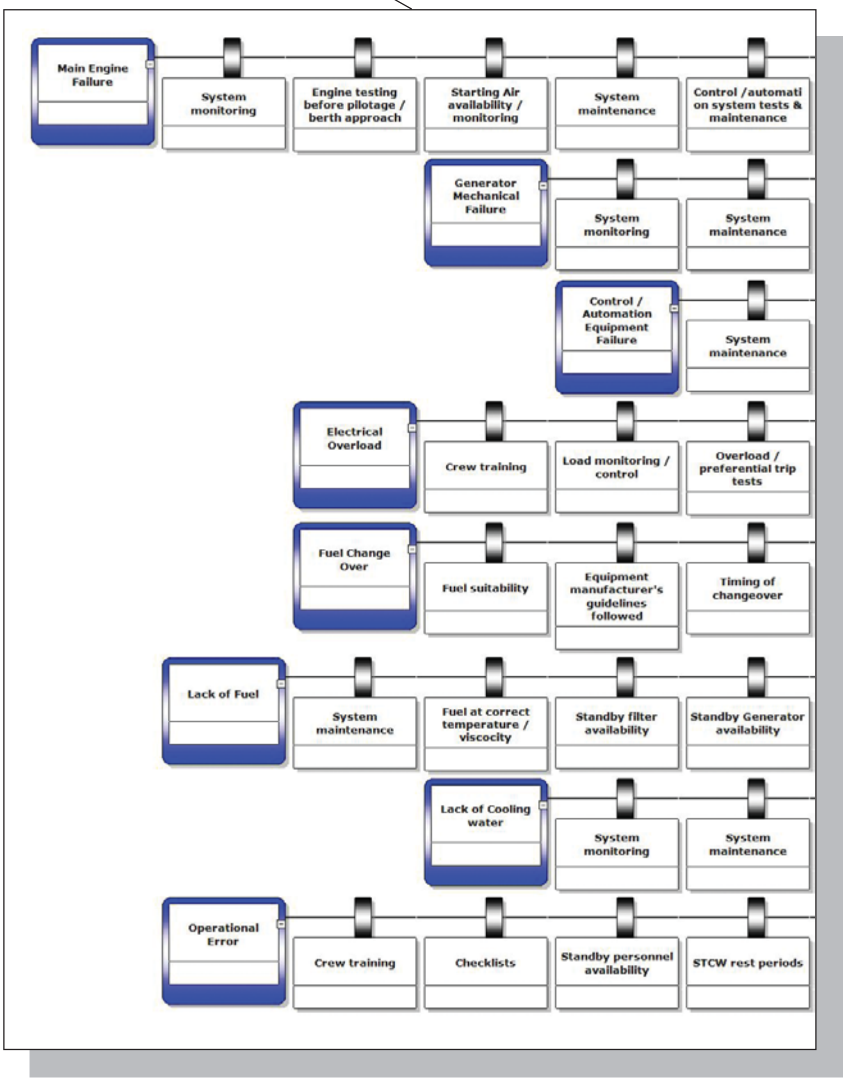
What are we checking?

How effective is that control, are there failures just waiting to happen (latent)?

Complete 'bowtie' with a list of threats

Copies of this diagram at full size may be obtained from the UK Club – details on the back cover





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