5065 The Vessel Entry and Transfer Ashore Doors are active systems whose reliabilities are sufficient to discount any hazard to the docking vessel. The seismic withstand has been demonstrated for the Reference Earthquake and for higher intensities up to and including 0.35g a robust argument has been made showing that the consequence of failure would have no impact on the safety of the submarine.

5066 The Berthing Equipment itself has no hazard withstand requirements beyond the need to operate following a 10^{-2}/year level of external hazard. The loading which could be transferred to the Civil structure through the Berthing Equipment is no greater than direct loads from the vessel on to the Civil structure in a hazardous state which have already been shown to be acceptable. Redundancy within the Equipment allows individual failures to occur without having any affect on safety.

5067 Finally the management of the ICCP has been demonstrated to be able to accept the amount of downtime necessary to prevent damage to the Shiplift Platform and at the same time keeping the corrosion on the piles below the acceptable loss.

5068 The understanding is that the higher tides expected from the updated tide study, now reported in DGD505 (Ref [23]), are not expected to have any significant effect on the integrity of the jetties. However an assessment of this is cited in the outstanding issues presented in Part 7 of this FSC.

Shiplift Platform

Design Improvements

5069 A series of design improvements have been carried out on the Shiplift Platform since its original commissioning. These improvements have contributed significantly to increases in the Structural Reliability of the Platform. The main improvements have been:

a. The change from 3m cradle spacing to 3.6m spacing. With the larger spacing the benefit of sitting the cradles directly on to the MTB and thereby avoiding the loading at the centre of the LBs far outweighs the increase in cradle load due to less cradles being available to support the vessel.

b. The installation of a rail with an increased web thickness. The detailed analysis of the response of the Shiplift Platform showed that the original rail, designed for mainly vertical load, was inadequate to withstand the transverse loads particularly under fault loads. The new rail with the increased web thickness allowed the block load differential under normal loading to be increased to 100t. This had previously been restricted to 50t because of the lack of rail capacity.

c. The Fabreeka pads positioned between the strongbacks and the cradle bogies have been replaced with a more flexible Andre Pad to more readily accommodate the relative movements between the structures and thereby reduce the peak loads.

d. The local areas of the cradle bogies have been strengthened to improve the capacity by its ability to distribute the load more evenly below the Andre Pad and above the wheel support.

5070 Further improvements to the original design through additional stiffeners being added to the rigid bay and increasing the knuckle joint stiffener had been carried out in the early 90s. These were mainly to solve problems due to the 3m spacing but do

contribute to the strength and stability of the Platform components with the current spacing.

5071 Reference to the original design specification, the Shiplift Design Specification Appendix A (GDA 834200/1/1 (Ref. [24])) shows that the lifting capacity of the Platform is in excess of 25000t with a total hoist and brake capacity of 36800t from the 92 hoists.

5072 In the design of the cradle assemblies the specification is based on the maximum predicted load of 600t obtained from a detailed model of the Shiplift Platform. Therefore, all standard cradle assemblies have the capacity to carry the maximum load such that, during the preparation for a docking, the cradles do not have to be specifically arranged. The sliding block strongbacks have the same sections as the standard strongbacks but the maximum load is normally half that predicted for the standard strongbacks.

5073 These implied margins in the design assume that the weight of the vessel is uniformly distributed and supported. Results from the mathematical model and from the loads measured during docking show that the cradles in the central region of the vessel carry more load such that margins in the maximum loaded part of the structure will be reduced. This is covered in the structural assessments presented in the Platform DSR. The analyses underlying these assessments are conservative as they do not allow yield to limit the load, although this load limiting process is assumed in the Syncrolift design.

5074 The capacity of the Shiplift Platform has been increased significantly since its original design providing greater safety margins to satisfactorily withstand the loads that could arise in normal operation and from foreseeable fault and hazard conditions. This applies to all three classes of nuclear vessel.

Protection Systems

5075 The protection systems are described in Part 3 of this FSC, whose function is to avoid an unacceptable load being created by either a hoist not behaving synchronously or an individual brake failing to stop or release.

5076 Two significant improvements were made to the actual Control and Protection Systems, (C&P), during the Stage Improvement Programme (SIP). These were:

- The introduction of three additional protection lines in the form of the hoist rotation detection system, an additional up off pin timer and a further back up limit switch.

- Additional break down of the pre-operational tests to obtain confirmation of specific component operation and additional intermediate step in the undocking sequence to check the down systems prior to removing the pins.

5077 Improvements have also been made to the reliability analysis with much greater detail included in the fault trees and event trees with an endorsement from the designers, Syncrolift, on the latter.

5078 The result of these improvements is discussed in the Shiplift Platform DSR (Ref. [25]) but it has been shown that the predicted frequency of any event has been significantly reduced even though the maximum 'design' docking period has been increased from [redacted] to [redacted] days. Many of the events tripped by the highest trip of 368te were previously included in the design capability assessments but have now been either removed from

assessment altogether or feature only in the design demonstration range. While much of the emphasis for this reduction in demand was associated with improvement of the cradle bogies the benefits are found in the structural assessment of the whole of the platform.

5079 The operational experience is discussed in Part 6 of this FSC, which includes a review of the control and protection faults recorded to date. The predicted frequency for the faults is based on generic data. Comparison with the observed rate found to July 2001 shows good agreement in the trends between the two sets of data with actual faults being observed for those events with the higher predicted frequencies. The main use of operational data in the reliability analysis has been the reduction in the predicted failure rate of the brakes compared with the value based solely on generic data. This has an affect upon the predicted event frequency of individual faults initiated by brake failure as well as the predicted frequency of events associated with common mode failure of the brakes.

Structural Assessment

NORMAL AND FAULT CONDITIONS

5080 The structural assessment of the Shiplift platform is summarised in the DSR (Ref. 25) for normal operating conditions as well as for faults and hazards. The detailed analysis of all the faults has been conducted and, based on a comparison of block loads, hoist loads, wheel loads and relative displacements between prime members, a bounding load case has been identified for each decade of the frequency range and for each prime member. From this matrix of events bounding fault cases have been assigned for the design capability range and design demonstration range of events down to a frequency of 10^{-7} per year.

5081 Using the normal operating loads and the bounding fault loads the structural analysis of the platform prime members has been carried out and the assessment carried out against the requirements of BS5400 Part 3:2000 (Ref.[26]). This work is reported in a series of Technical Reports, which support the DSR (Ref. 25) where it has been shown that all the prime members meet the requirements of the code for the design capability range. For most of the events in the Design Demonstration range it has also been shown that the prime members are code compliant using the appropriate (reduced) partial safety factors as described in the Shiplift Safety Principles Paper, Ref. [27]. Where code compliance has not been demonstrated for these lower frequency events only local areas are shown to be outside the code requirements such that gross failure of the platform will not occur.

5082 The information given in the DSR (Ref 25) shows that the Shiplift Platform is very defect tolerant with critical defects being at worst twice the size of defect that is likely to remain after inspection of the plates and welds during manufacture.

5083 The number of significant lifts expected during the design life of 40 years is unlikely to exceed [redacted] such that the fatigue usage within the main components will be low with any significant damage occurring in the plate or welds judged to be extremely unlikely. Forewarning of any significant damage or deterioration of the structures which could affect its performance would be obtained during the regular inspection of the Platform including all important connections.

DROPPED LOAD

5084 The dropped load hazard is discussed in the Shiplift platform DSR (Ref. 25) and its frequency of occurrence led to the platform being specifically analysed for this event.

Since the withstand of the unprotected platform has been demonstrated for a dropped load of 0.5t from 20m (0.1MJ) it is necessary to provide some protection against dropped loads of higher energies. The requirements for operational support to the submarines is to be able to lift a maximum load of 10te up to a height of 20m giving an energy of 2MJ.

5085 Crash mats to withstand dropped loads generating energy up to 2MJ were designed and manufactured during the SIP. The crash mats are of a modular design to be constructed on the platform at the time of docking in those places where loads above an energy of 0.1MJ are to be lifted. The DSR shows that this design is able to protect the platform against the impulse from a dropped load which has been conservatively assumed to be rigid of up to 2MJ. The affect of this impulse at the hanger support has been used in the demonstration of withstand of the civil structure against dropped loads.

SEISMIC LOADING

5086 The Shiplift platform is stopped in the event of an earthquake in excess of 0.05g by a seismic trigger to ensure no spurious movements of the platform even though the control and protection systems are qualified to levels associated with the reference earthquake loading. However, to ensure the support to the vessel remains stable for the frequency of earthquake in the design capability range, the platform has been assessed against the reference earthquake and the seismic margin earthquake to show the absence of any cliff edge.

5087 The seismic withstand capacity for an earthquake represented by the Principia Mechanica Limited (PML) spectra for a hard site and a peak ground horizontal acceleration of 0.2g is presented in the Shiplift Platform DSR (Ref. 25). The analysis has covered both extremes of the platform on long ropes, short ropes and hanger links where it has been shown that the most onerous loadings occur when supported on links. Using this analysis it has been demonstrated that all prime members remain code compliant for both the 0.2g reference earthquake and the 0.28g margins earthquake. This shows that there is no non-linear involvement between these two levels of earthquake with no clashing predicted between the platform and the jetty. A further margin has been demonstrated in the basic input response spectra represented by the broad band PML spectra which allows a qualitative argument to be made for a withstand up to 0.35g.

QUALITY OF CONSTRUCTION

5088 The specifications for the materials and processes used in the construction of the load path components of the Platform required full traceability of all materials, including weld consumables with additional testing such as low temperature properties, "Clean Steel" with low Sulphur and Phosphorus content and ultrasonic testing of plate and forged steel. A review of primary load path component as-built material properties, NDE and in-service inspection is reported in TR/3112 (Ref. [28]).

5089 Fabrication of the welded structures was undertaken by organisations experienced in this type of structure. All welds were subject to 100% visual examination with additional Ultrasonic and Magnetic Particle examination of butt welds and fillet welds in main components. Welds were identified by unique numbers on the fabrication drawings, which were referred back to individual Non-destructive Test Reports, which are available in the Lifetime Records.

5090 Each of the hoists was subjected to a full load test and performance check before being despatched to site.

5091 The Main and Rudder sections of the Platform were load tested to the equivalent of 177t/m using four transfer cradles at 3m centres loaded with steel kentledge providing a total test weight of 2124t. This load was moved along the platform rails and stopped when centred over each rigid main transverse assembly. The whole Platform was then raised off pins, levelled, lowered a distance equivalent to a full revolution of the hoist rope drum, raised and levelled and finally lowered on to pins. By lowering onto pins this test proved the load path components of the structure for both the 'On Pins' and 'On Ropes' conditions.

5092 The quality of the build of the Platform and the inspection and testing have, therefore, been carried out to a standard commensurate with a structure requiring high confidence in its structural integrity.

EOT Crane

5093 The description of the EOT cranes and their operation is given in Part 3 of this FSC, with the structural assessment to withstand normal and fault loading as well as hazard loadings is presented in detail in the EOT Crane DSR. This shows that the as-built crane has a nuclear lift capacity of 47.8t, which provides adequate margin over the maximum lift expected of 36t if a propulsor is changed on the V Class of submarine. This lift occurs over the rudder section whilst the limit on loads moved over the main section when a boat is docked remains at 10te in recognition of the need to limit the dropped load threat to the Platform.

5094 An extensive fault tree analysis has been conducted for the EOT crane and its operation. This has taken into account engineered crane/lifting safeguards and human error and shows that the frequency of events which lead to a threat from dropped loads, hook-up and hang-up are acceptably low. For a majority of these events the loading on the crane remains within design code allowables. However for some extreme lifting faults that involve a combination of both human error (requiring a serious lack of attention by the crane operators and independent emergency stop operator) and engineered safeguard failures (failure of the crane's snag load protection/hoist overload protection systems) it is possible that significant damage to the EOT crane could result. The very low frequency of occurrence of such beyond design basis events that could lead to significant crane damage is invoked in the demonstration of an acceptable fault tolerance for the potential hazards posed to visiting submarines or the Shiplift platform that supports docked submarines.

5095 During a seismic event the EOT cranes will respond to the secondary spectra at the rails. The seismic analysis supporting the EOT Crane DSR has shown that there is no non-linear feedback between the building and the crane such that the linear analysis of the civil structure including the crane provides valid input against which to assess the crane. No physical improvements have been made to the original design although modifications of the mathematical models of the crane have been undertaken to take account of its higher as-built mass.

5096 The assessment has shown that, with the inclusion of the effect of the non-linear behaviour of the interface between the trolley and the crane girder and the extremes of the stiffness of the slider mechanism, the crane girders, long travel gear, crane rails and trolley are code compliant for the 0.2g reference and 0.28g margins earthquake, with a 5t load on the hook. Seismic load cases combining the 0.2g RE with a hook load >5t have been shown to be at a frequency which is beyond design base. The only shortfall has been found in the cross rail clips on the trolley for which a mitigating argument has been made using the trolley retention clips against the trolley becoming detached from the girder thereby posing a threat to the submarine.

5097 The loads have been defined against which the clips need to be designed. This has been identified in the outstanding issues in Part 7 of this FSC.

12 Berth Crane

5098 The design and substantiation of the 12 Berth Crane is presented in its DSR which demonstrates that the structural capacity of the crane to withstand normal and fault loads as well as environmental loads is acceptable including the earthquake hazard. The detailed seismic analysis of the crane, which includes the effect of any non-linearity at the crane supports, shows that during the event separation of the wheel and the rail occurs but there is no threat of instability. Also there are margins against instability for the 10^{-2} per year and 10^{-4} per year wind. Therefore from the DSR it can be concluded that the extreme hook-up with no operator intervention is the only potential event that can lead to possible instability of the crane. This has a predicted initiating frequency of 1.5×10^{-5} per year which is acceptably low from the PRA calculations but further reduction of nearly a decade to 3.7×10^{-6} per year would be achieved if the PLC detecting drive resistance was reinstated. The PLC tripping function has been disabled due to nuisance tripping. This remains an outstanding issue.

5099 The detailed assessment of the seismic loading of the as-built crane has shown that even with the jib in the worst position, the crane structures are code compliant and the electrical equipment qualification is adequate. There was an original shortfall in the seismic withstand at the bolted connection of a truss member on the upper superframe. This component was not part of the main load path but provided restraint between members such that failure would not lead to failure of the crane or loss of support to the attached load. A simple modification was undertaken to replace the original truss member with a strengthened connection to meet the seismic withstand requirements.

5100 To prevent excessive articulation when the crane travels along the jetty, a 10mm thick packer was fitted to one of the front truck leg bolted joints during commissioning. This modification ensures that any potential loss of support locally is avoided and that all four legs in the structure provide support to the crane as assumed in its design.

5101 The reliability of the crane has been assessed including the effects of human factors and this shows that the frequency of dropped loads or uncontrolled lowering of load is acceptably low from the point of view of the loss of overside services. This includes the threat of either a direct drop on the submarine or a drop on the jetty through which the services pass. There is currently a prohibition on the use of the 12 Berth Crane when the Platform is operated during a vessel docking/undocking. This is to eliminate the risk of secondary damage to the Platform or Platform support following collision between the crane and the superstructure due to an uncontrolled jib movement. Further safeguards are managed by placing a restriction on the wind speed as described in Part 4 of this FSC.

Support Systems

5102 The support systems listed below, which are described in Part 3 of this FSC, provide safety related services. The contribution to safety and substantiation of these systems is addressed within the Facility safety case insofar as this is consistent with the scope of the safety case as summarised below. Certain of the systems are generic to the Facilities in HMNB Clyde Faslane or the Base as a whole. The relevant interfaces are acknowledged within the Facility safety case documentation as a whole, and the Safety Functional Requirements SFR, Ref. 2, sets out the requirements imposed by

the Facility. The relationship between the documentation that supports the generic systems and the Shiplift Facility FSC documentation is presented in Annexe B.

a. Cooling Water and Firefighting System.

b. Electrical Overside Service:

c. Catamarans.

d. Fire Protection.

e. Communication Systems.

f. Ventilation and Air Conditioning.

g. Dockside Installed Reactor Accident Monitoring System (DIRAMS).

5103 The design and substantiation of these systems are shown to be acceptable in their relevant DSRs. These show that the required capability has been achieved against the required targets and successful operation has proven the systems in practice. The loss of cooling water and electrical supply has been considered directly in the hazard assessment and they are considered in the dominant hazard category. The other systems listed have been used in the mitigation of other hazards in the Hazard Assessment.

5104 The required withstand from the environmental loading as well as hazards has been demonstrated, and where improvements in the system have been incorporated these have been identified in Part 6 of this FSC.

5105 The main threat to the electrical and cooling water systems is the earthquake which has been addressed in the DSR. The seismic withstand of these systems has been assessed and shown to be code compliant. However this has only been achieved for the as-built cooling water system by assuming that certain changes are made to the support arrangements. This is to cater for both the seismic and thermal loading where a balance of flexibility and constraints are required. This is an outstanding issue and its significance and resolution is addressed in Part 7 of this FSC.

5106 From the assessment of the Catamarans it has been shown that their stability and response to berthing and mooring loads is acceptable. However, with the expected increase in tide heights as reported in DGD505 (Ref 23) it is projected that the size of the increase will be sufficient to cause clashing between the mooring yokes and the jetty. Whilst failures are not expected to the extent of causing a threat to the berthed submarine, the yoke will not maintain code compliance under the clash loading. This is an outstanding issue and is included in Part 7 of this FSC.

Additional Engineered Safeguards fitted to Reactor Plant

5107 The section is limited to a discussion of PMLF as this is the major additional safeguard offered in mitigation of the failure to demonstrate a sufficiently robust fault tolerance of the platform and cranes. This mitigates against the potential for criticality accidents which could result from loss of stable support or crane collapse. Following from a range of studies whose results are summarised below it has been concluded that the fitment of PMLF is not appropriate in all cases, as identified below.

5108 In addition to mitigating against EBA, PMLFs mitigate against inadvertent criticality due to potential rod bounce from direct and indirect impacts arising from dropped load/crane collapse onto the submarine.

5109 A Control Rod Arrest Feature (CRAF) is now fitted to all but one of V Class vessels. CRAF prevents control rod ejection in EBA.

5110 Fitting PMLFs involves certain risks, which require to be fully assessed against the protection offered by PMLF in preventing control rod movement during submarine roll and rod bounce scenarios. Preliminary PMLF fitment detriment studies were undertaken to determine any additional risk to NSRP operation, submarine availability and individual risk which can be compared with the derived risks assuming PMLF is fitted (RRMP 00831/0403/06/01 GJF/Tmo/5 10/12/99 (Ref. [29])). This assessment, which was primarily based on a T Class submarine in a dry dock at Devonport, concluded that there was a minimum docking period, below which no net benefit in terms of individual risk could be claimed. It was concluded that similar benefits could be expected for docking in the Shiplift although it was judged that further development of the Shiplift specific T Class EBA risk model was necessary to enable robust ALARP arguments concerning the merits of fitment/non-fitment of PMLF to be deployed.

5111 Hull impact studies performed as part of the V Class Hull Impact Programme have shown that there is a low probability of rod bounce with impact energies of less than 10MJ, Ref. [27]. With the exception of crane collapse this withstand level is comfortably above the dropped load energies associated with lifting operations in the Shiplift.

5112 The Facility PRA (Ref 11) presents a sensitivity study of the risk benefit that may be achieved by fitting PMLF to control rod bounce in the event of docked submarine EBA. If this information is taken into account, it is apparent from the comparatively low level of risk that would arise from EBA that there is little benefit to be derived from the fitment of PMLF.

5113 For V Class submarines the individual risk to the public is assessed to be 1.86×10^{-8} on the basis of the assumptions that no PMLF was fitted and no rod bounce capable of leading to criticality would occur due to the slapdown impact of the submarine on the water in the event of a loss of submarine support, as substantiated in the Facility Probabilistic Risk Assessment (Ref 11).

5114 The same event with PMLF fitted would yield a public risk of 5.14×10^{-10}. It is considered that this risk reduction, for the risk from a hypothetical fault condition that already falls below the BSO* by a factor of greater than 50 is not worthwhile when balanced against the actual detriments associated with PMLF fitment which include:

- Increased radiation exposure of Facility workers
- Increased nuclear risk due to process of fitment including tunnel plug removal
- Trouble and cost associated with the fitment which delays essential maintenance/defect repair work by four days per docking

* Based on the JSP 518 Issue 2 public risk BSO of 10^{-6}. The implications of the BSO and BSL risk levels now presented in the NNSPs (Ref 8) are discussed later in this section.

5115 On this basis V Class dockings now take place without the fitment of PMLF.

5116 In respect of S&T Class submarines the risk associated with EBA is greater at 5.10 x 10^{-8} and more careful consideration is required, taking into account the risk of crane collapse. Collapse of an EOT crane onto a docked S & T Class vessel is capable of inducing sufficient rod bounce for a criticality event to occur. This is a significant distinction from the V Class case, for which it has been shown deterministically that no significant rod bounce would occur, with some significant margin available.

5117 For S&T Class vessels it has been demonstrated in RRMP 23050, Ref [30] that the shock induced by EOT crane collapse could possibly cause a prompt criticality, and that the shock acceleration induced in the PMLF device has a predicted acceleration of 14g, against an assessed PMLF capability of 22g.

5118 The fitting of PMLF only provides protection against those hazards leading to inadvertent criticality excursions. To provide additional protection against loss of heat sink accidents, the decay heat prior to docking submarines in the Shiplift is currently limited to [redacted] ([redacted] for S Class), which ensures extended grace times to recover from potential loss of heat sink accident scenarios. The requirement to fit PMLF, which takes up to [redacted] to install, ensures that this decay heat limit is not a significant operational penalty.

Probabilistic Risk Assessment

5119 The probabilistic risk assessment provides a quantitative assessment of the risks associated with the operation, maintenance and repair of nuclear submarines within the Shiplift Facility. Operations are broken down into sets or states and the occupancy of each state is assigned appropriately on the basis of an analysis of PAG sheets spanning eight years. These occupancies are combined with initiating event frequencies and hazard specific risk data for each plant state, to give risk contributions. The sum of these risk contributions is compared with the targets for each of the critical population groups identified in the SPSCs. The assessment considers those hazards for which the residual risks are significant, as determined from the Facility hazard assessment (Ref. 1).

5120 Full details of the risk derivation is presented in the Facility PRA (Ref. 11).

5121 The PRA presents the risks associated with operation of the Facility over a typical year for the SSBN/SSN occupancy set out in Table 5.4. These risks will then be taken into account at the Site level and all the separate facility risks (from those facilities that comprise the site) will be summated and compared to the Safety Criteria, in the HMNB Clyde SSC (Ref. 3).

Annualised Individual Risk Data

5122 The PRA assessment is based on risk information from published Reactor Plant Safety Justification (RPSJ) information, and also on risk assessments incorporating developments in the site definition of external hazards for Vanguard Class. As such the risk information is an update of the Shiplift Facility specific external hazards information in RRMP 22176, Issue 3 (Ref. [31]). This Core H information has been subject to INSA and is the best available; it bounds relevant Core G information. These developments have also been used to form the basis of an external hazards read-across assessment of Trafalgar Class at the Facility. This read across is considered to be pessimistic in respect of the embedded radiological consequences modelling. The risk information used in the assessment of risks associated with

Swiftsure Class is a read across of the Trafalgar Class information, justified by the DA for the purposes of the PRA assessment. The information has been consolidated and is presented as normalised risks in Ref. [32].

Occupancy Data

5123 On the basis of the historical data derived from PAG sheets the projected annual occupancy of the Facility is as presented in Table 5.4.

Table 5.4 PRA Assumed Occupancy Figures for Shiplift Facility

Submarine Class	Submarine Occupancy (Days)	
	Shiplift	12 Berth
Swiftsure	[redacted]	[redacted]
Trafalgar		
Vanguard	[redacted]	[redacted]

5124 The actual occupancy is reviewed on an annual basis and reported in the Facility Annual Reviews. Data from the years 2005 to 2008 show the Shiplift average annual occupancy to be significantly below that assumed in the PRA for both SSBN and SSN. For 12 Berth the actual SSN occupancy has been an annual average only [redacted] of that assumed in the PRA. SSBN occupancy at 12 Berth has been an average of [redacted] above that assumed in the PRA. The actual occupancies will continue to be reviewed against that assumed. The effect of occupancy deviations on the facility risk is discussed below.

5125 The assessed overall annual risk to the three population groups (public, site workers, and members of the crew) of Facility operations based on the PRA assumed occupancy is given below.

Table 5.5 Risk Estimates for Shiplift Facility

Facility	Public Risk	Worker Risk	Crew Risk
Shiplift	3.22×10^{-6}	2.00×10^{-5}	1.99×10^{-5}
12 Berth	2.79×10^{-6}	1.73×10^{-5}	1.59×10^{-5}
Total	6.02×10^{-6}	3.73×10^{-5}	3.58×10^{-5}
BSL*	10^{-4}	10^{-4}	10^{-4}
BSO*	10^{-6}	10^{-6}	10^{-6}
Proportion of BSL (% Risk/BSL-BSO)	6%	37%	36%

* BSL and BSO as set in JSP 518 Issue 2 (Ref 7).

5126 These risks are the combined risk taking into account both submarine internal and external hazards. From this table it can be seen that the risks from 12 Berth and Shiplift operations are of the same order of magnitude, with the risks associated with Shiplift operations being marginally greater than those due to the alongside operations.

5127 The following table presents the assessed risk contributions arising from internal and external submarine hazards (hazards with event sequences that commence with an

event internal or external to a submarine), together with the contribution made to the total risk by Plant State transitions at 12 Berth.

Table 5.6 Internal/External Risk Estimates for Shiplift Facility

Facility	Hazard Type	Public Risk	Worker Risk	Crew Risk
Shiplift	External	6.15×10^{-7}	6.57×10^{-7}	6.40×10^{-7}
Shiplift	Internal	2.61×10^{-6}	1.94×10^{-5}	1.93×10^{-5}
12 Berth	External	1.35×10^{-6}	1.38×10^{-6}	1.35×10^{-6}
12 Berth	Internal	8.79×10^{-7}	1.47×10^{-5}	1.46×10^{-5}
12 Berth	Transitions	5.60×10^{-7}	1.17×10^{-6}	1.67×10^{-8}
Total		6.02×10^{-6}	3.73×10^{-5}	3.58×10^{-5}

5128 The internal hazards risks are inherent to the submarine are in general not significantly influenced by Facility operations. The contributions that are substantially influenced by Facility operations are external hazards and Plant State transitions. (Fundamentally the risk from transitions is inherent to the submarine, however, the number of transitions is dependent on the maintenance, repair and test processes that are required to be performed for the Facility to fulfil fleet requirements).

5129 The level of Facility risks is affected by deviations between assumed and actual occupancy. However the annual reviews show that the combined Shiplift and 12 Berth risk does not exceed that assumed in the PRA. Future annual reviews will continue to identify the deviations in facility risk.

5130 The contributions made by individual hazards to the total risk to the public are shown in pie-chart form in Figures 5.4 to 5.8. Figure 5.3 shows that submarine internal hazards (67%) are the dominant public risk contributors for the Shiplift Facility when taken as a whole, with the PRA (Ref 11) showing that the LOCA and internal flood hazards are the most significant elements of this, the next most significant risk is crane collapse (31%).

5131 Figures 5.5 and 5.6 show that for Vanguard Class vessels on the Shiplift platform and at 12 Berth respectively, the public risks are in both cases dominated by crane collapse followed by submarine internal hazards. Whereas Figures 5.7 and 5.8 show that for Swiftsure/Trafalgar Class vessels on the Shiplift platform and at 12 Berth respectively, the situation is reversed and public risks are dominated by submarine internal hazards followed by crane collapse reflecting the differing submarine operational mode occupancies when docked and alongside.

5132 The calculated risk figures for the Facility are currently assessed against the BSL/BSO risk targets in JSP 518 Issue 2 (Ref 7). The NNSPs (Ref 8) set the Public Risk BSL/BSO as $10^{-5}/10^{-7}$ based on a single facility rather than whole site risk. The calculated public risk for the Facility would then be 60% of the BSL. A current work strategy (Ref [33]) is to achieve a transition to an NRP, rather than facility, focused safety justification through the output of the Shut-Down Safety Case (SDSC). This will allow the facility risk to be better assessed against the NNSP risk targets. This is an outstanding issue discussed in Part 7.

ALARP Assessment

5133 The risks from the Shiplift Facility are currently predicted to be 6% of the public BSL and approximately one third of the BSL for site workers and crew. This is considered to result from the application of excessively pessimistic data rather than a realistic representation of the activities associated with the operation of the Facility. A number of specific pessimisms have been identified against the dominant accident sequences which if corrected would remove some of the excessive dominance from these sequences.

5134 Refinement of the conditional risk data, which underpins the PRA, is on-going. The development of the Shut-Down Safety Case as reported in Reference 33will better inform the risk data and form the focus for the improvements. Radiological risks are currently mitigated by the requirement that boats docked in the Shiplift must be in Plant State B with low decay heat ([redacted]S Class).

5135 As shown in Fig 5.4, the following hazards dominate the total risk, ranked by risk to the public:

- Crane collapse (Ref. 11)
- Internal flood (Ref 11)
- LOCA (Ref. 11)
- EBA (Ref 11)

5136 The risk from crane collapse is driven by the initiating event frequencies. The most recent assessment takes into account human error and this combined with pessimistic assumptions concerning the likelihood of hook-up and hang-up result in event frequencies which are pessimistic.

5137 The risk of EOT crane collapse in the Shiplift is predominantly attributable to hook-up and hang-up faults. Robust safety management arrangement arrangements are in place to mitigate against human error which is the dominant initiating event for fault sequences leading to crane collapse. The lifts are directed by a crane supervisor, check lifts are carried out before the full lift takes place, and an independent emergency stop operator mans a separate control to stop the crane. Over 90% of the lifts are less than 2t and these are undertaken using the auxiliary hoist. It is judged that hang-up/hook-up faults using the 2t auxiliary hoist would result in failures in the load path before crane collapse would be initiated.

5138 PMLF is fitted to SSN docking in the Shiplift. This mitigates against rod bounce caused by crane impacts. An ALARP assessment for V Class concluded that the detriments in the PMLF fitting process outweigh the potential risk reductions.

5139 At 12 Berth hook-up and hang-up are also the dominant source of potential crane collapse and/or topple (including the jib considered as a separate element of structure). Robust safety management arrangements are in place broadly similar to the EOT crane. A banksman has access during the lift to an emergency stop button on the crane.

5140 The risk from internal flood is dominated by that assessed for S&T Class vessels. The normalised risk assessment undertaken for T Class vessels is considered significantly pessimistic and predicts risks several orders of magnitude greater than

those predicted for V Class vessels, which were performed using different assessment methods.

5141 The risk from LOCA predominantly arises from S&T Class vessels, and is considered pessimistic. The SDSC studies will better inform the level of risk which should realistically be attributed to this fault sequence.

5142 There are four contributors to Excessive Boat Attitude (EBA). These are as follows:

- Seismic events (7%) - the majority of this unreliability stems from the seismic trigger system (platform on ropes) and this unreliability is dominated by the unreliability associated with the system's software. The seismic trigger system is regularly maintained and tested.

- Normal operation (32%) - more than 90% of this component of the unreliability is due to hoist brake CMF. A possible means of reducing this risk (in principle) would be the introduction of a third brake.

- C&P faults (21%) - the contribution to the unreliability of the platform from the C&P systems is comprised of many small contributions with none that are dominant in influencing this element of the total risk. The Platform has a number of discrete levels of protection which is sufficient to reduce the risk to ALARP whilst maintaining an efficient level of operation

- Dropped loads (40%) - the majority of this contribution is due to dropped loads larger than 4t. Crash mats are deployed for the lifting of loads to withstand impact energies up to 2 MJ. The crash mats will withstand the impact of a 10t load from 20m which would allow for the normal lifting envelope required to support Vanguard Class docking. Robust safety management arrangements are in place to mitigate against operator or slinging errors which are the main contributors to drop load.

Conclusion

5143 There are a number of current workstreams in progress which will allow a more effective demonstration of compliance with the ALARP principle when completed. These are:

- An updated ALARP review is currently being completed against the known shortfalls in order to demonstrate that the risk in continued operation of the Facility is tolerable and ALARP

- A current work strategy (Ref 33) is to achieve a transition to an NRP, rather than facility, focused safety justification through the output of the Shut-Down Safety Case (SDSC). This will allow a better understanding of the significant safety issues and where robust ALARP needs to be demonstrated

- A Periodic Safety Review (PSR) is currently in progress. This includes the review and update of the current hazard listing, and the subsequent production of a comprehensive fault schedule. An updated fault schedule constitutes the framework for the deterministic and probabilistic case within the Safety Case, which determines whether the facility and/or its operations are both tolerable and ALARP.

The updated fault schedule will take cognisance of the output from the SDSC project and therefore may allow claims to be made against previously unsubstantiated onboard Safety Measures and lessen the demands on overside services and the support provided to the vessel by the Facility.

5144 It is concluded that the current Facility Safety Case demonstrates that the risks in operating the Facility are in the tolerable region. The work currently in hand to develop the safety case against modern standards will allow a more robust demonstration of ALARP to be made.

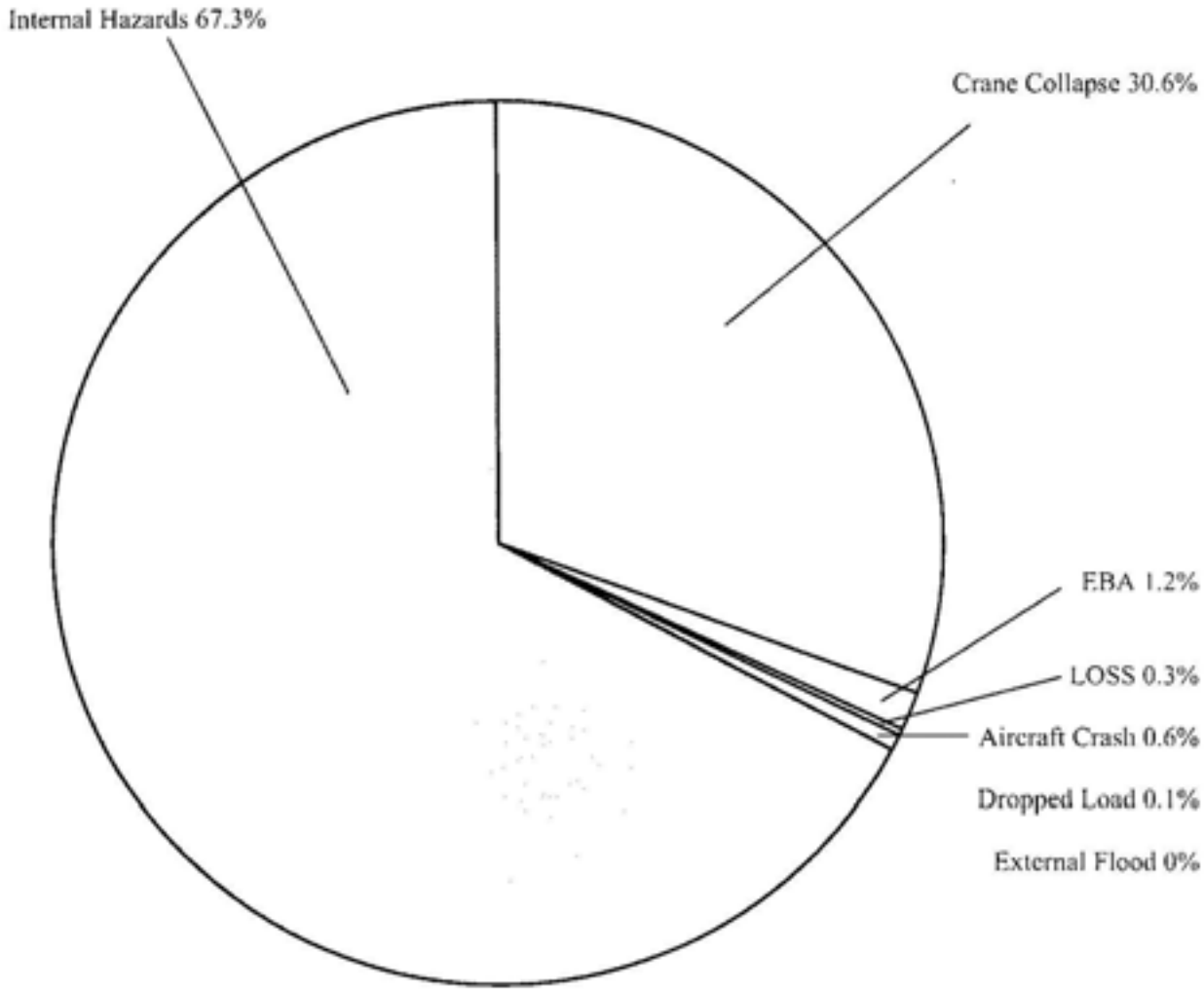

Figure 5.4 Shiplift Facility (Platform and 12 Berth) Individual Public Risk Distribution by Hazard

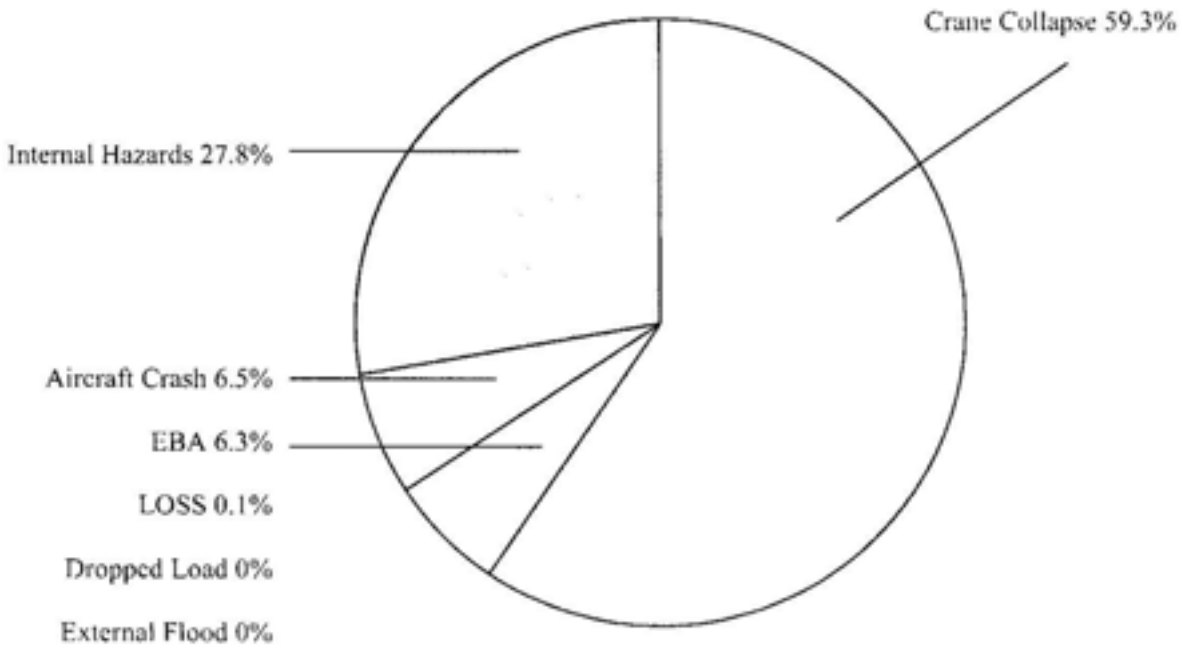

Figure 5.5 Shiplift Platform Vanguard Class Public Risk Distribution by Hazard

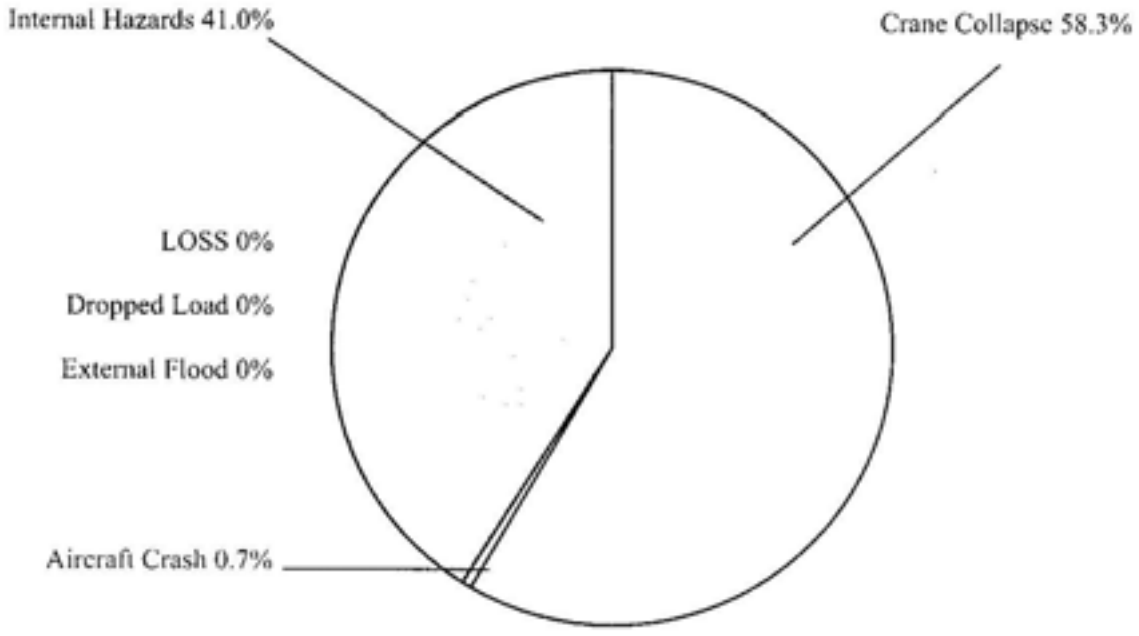

Figure 5.6 Vanguard Class 12 Berth Public Risk Distribution by Hazard

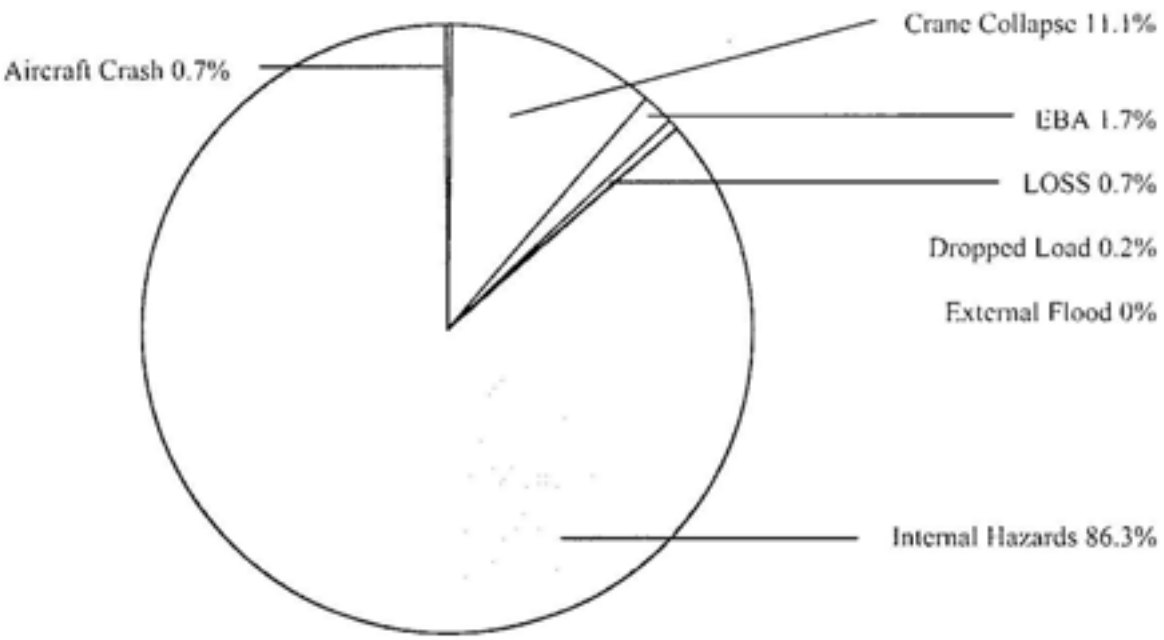

Figure 5.7 Shiplift Platform Swiftsure/Trafalgar Class Public Risk Distribution by Hazard

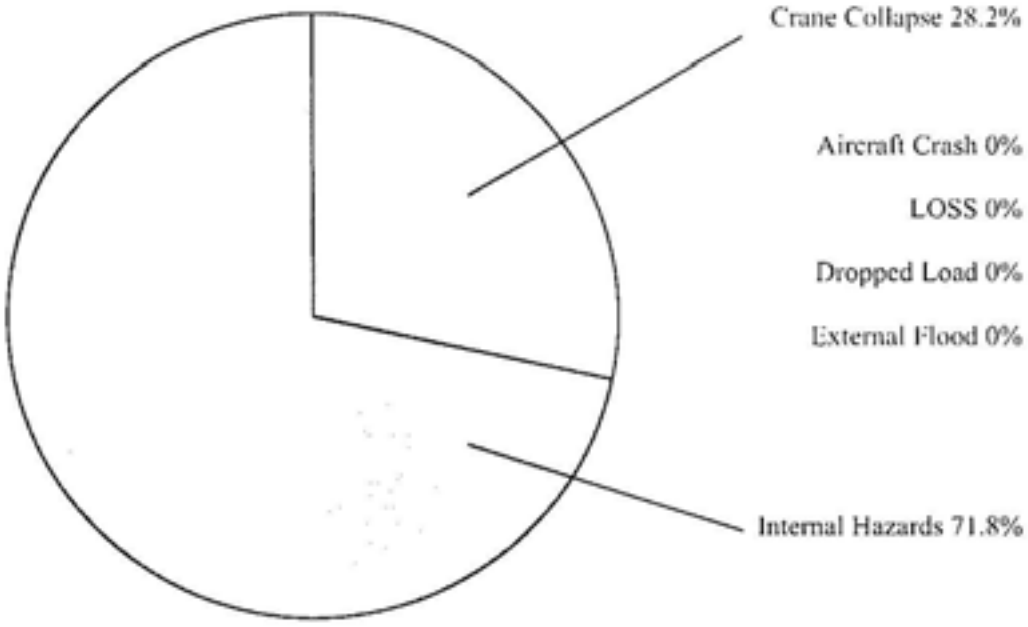

Figure 5.8 Swiftsure/Trafalgar Class 12 Berth Public Risk Distribution by Hazard

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