Introduction

1. [SLIDE 1] My name is Sheryl Hurst and I'm a Principal Consultant with Risktec Solutions Limited. I have a BSc degree in physics and I'm a member of the Institute of Risk Management and the Energy Institute. I have 20 years' experience of conducting risk assessments for clients in the oil and gas industry and other industries worldwide and I specialise in developing Safety Cases and bowtie analysis (I will expand on both Safety Cases and bowtie analysis in the rest of my evidence).
2. I have worked on the Corrib project since 2007, when I facilitated a bowtie analysis workshop for the onshore pipeline. Since then, I have conducted further pipeline bowtie workshops in 2008, 2009 and 2010.
3. I am the author of Appendix Q6.3, in Volume 2 Book 6 of the EIS, Qualitative Risk Assessment which has been submitted in direct response to recommendation (e), page 3 of An Bord Pleanála's letter of 2nd November 2009.
4. In my evidence today I will present to you:
   a. a brief explanation of what qualitative risk assessment involves and the qualitative risk assessments carried out for the Corrib project;
   b. an explanation of bowtie analysis;
   c. a description of the Corrib bowtie workshops and the Corrib pipeline bowties;
   d. an overview of the Safety Case and our plans for the Corrib Safety Case; and
   e. a summary of the current position and future plans with respect to bowties and qualitative risk assessment for the Corrib facilities.
5. During my evidence, I will describe, with the help of some slides, various basic risk assessment concepts.

What does qualitative risk assessment involve?

6. Before I explain what qualitative risk assessment involves, I will define what I mean by "risk". In the context of this evidence, risk is defined as the likelihood of something going wrong or the likelihood of harm occurring. When we conduct a risk assessment, we make an estimate of the level of harm, and of how likely that level of harm will be.
7. Qualitative risk assessment involves identifying hazards, assessing the risks and identifying measures which could reduce the risks, without the use of detailed numerical calculations and data. It involves the following basic steps [SLIDE 2]:

   STEP 1 identify the hazards by asking "what can go wrong?" or "what could cause harm?"

   STEP 2 assess the level of risk for each hazard by asking "how likely is it to go wrong?" and also "how bad could it be?". Categorise the risk for each hazard as 'High', 'Medium' or 'Low'.

   STEP 3 specify the controls in place to manage the risk by asking "what measures do we have in place to prevent it going wrong?" and also by asking "if things do go wrong, what measures do we have in place to deal with the situation and minimise any effects?" Finally,

   STEP 4 reduce the risk to As Low As Reasonably Practicable by asking "are these measures good enough to control that hazard?" or "is there anything else we could practicably do?"
8. In this way we build up a picture of *all* the possible risks associated with the facility or activity under consideration and which ones are high, medium or low risks. Assessing the level of risk for each hazard (in Step 2) allows us to prioritise our efforts towards those events with the highest potential risk, for example we might subject these to more detailed assessment.

What qualitative risk assessment has been carried out for the Corrib project?

9. There are different types of qualitative risk assessment studies that can be carried out, all following these same basic steps; the chosen method depends on the purpose and objectives of the assessment

and what you are trying to achieve. For Corrib, a large number of different types of qualitative risk assessments have been undertaken since the start of the project. These have included:

a. HAZard IDentification workshops which use checklists of hazards to systematically identify the hazards which are relevant to the pipeline;

b. HAZard and OPerability studies (otherwise known as HAZOP studies) which assess the adequacy and operability of the pipeline control and safety systems, in other words these studies check that what is being designed can actually be operated;

c. reliability studies which focus on how a specific piece of equipment or control system might fail; and

d. bowtie analysis which provides a detailed examination of the controls in place to manage a particular risk.

What is a bowtie analysis?

10. Bowtie analysis is an internationally accepted form of qualitative risk assessment. It involves building up a bowtie diagram, step by step. The finished diagram provides a readily understandable visualisation of the relationships between the causes of accidents, the escalation of such events to a range of possible outcomes, the controls preventing the event from occurring and, should the event occur despite these preventive controls, the recovery controls in place to limit the consequences.

11. Section 1.3 of Appendix Q6.3 of the EIS explains how the risk assessment process adopted for the Corrib pipeline complies with the risk assessment requirements of the pipeline codes I.S. EN 14161, I.S. 328 and BS PD 8010. In terms of international and industry standards, the bowtie method we have adopted complies with guidance given in:

a. ISO 17776 Guidelines on Tools and Techniques for Hazard Identification and Risk Assessment;

b. UK Health and Safety Executive Guidance on Risk Assessment for Offshore Installations Information Sheet No. 3/2006;

c. a guide by the International Association of Oil and Gas Producers on Asset Integrity – the Key to Managing Major Incident Risks, OGP Report No. 415; and

d. the ARAMIS Accidental Risk Assessment Methodology for Industries in the context of the Seveso II Directive, which is a European joint initiative for onshore facilities.

12. I will now take you through a step-by-step explanation of how we conduct bowtie analysis.

13. A hazard is defined as something which has the potential to cause injury, damage or loss. Examples of hazards are air travel, electricity, alcohol, working on a ladder. Hazards do not normally cause harm because they are kept under control. For example, electricity is 'contained' in properly rated and installed wiring and equipment so that it usually doesn't do us any harm. However, if control of the hazard is lost, an initial incident will occur – this is known as the top event and is shown at the centre of the bowtie diagram [SLIDE 3]. In the example shown on the slide, the hazard is air travel (something we do which has the potential to cause harm if it goes wrong) and the top event is loss of control of the aeroplane, in other words the hazard air travel is no longer under control.

14. [SLIDE 4] The causes on the left of the bowtie illustrate the various ways in which we could lose control of the hazard. The example causes shown here are:

a. pilot error;

b. engine failure; or

c. severe weather.

Any of these could bring about loss of control of the aircraft and there may be many more.

15. Once control is lost and the top event occurs, there may be several different ways in which the event can develop and these are illustrated on the right side of the bowtie [SLIDE 5]. Each of these consequences will result in a specific type and extent of harm. In the example on the slide, consequences that might happen include:

a. the pilot recovers control of the aircraft and continues as normal. No harm is done;

b. the pilot manages to execute an emergency landing of the aeroplane. There may be some people suffering from shock and minor injuries, and some damage to the aircraft; or

c. there is an uncontrolled crash landing with multiple fatalities and serious injuries.

16. Back on the left side of the bowtie, there are controls in place to prevent loss of control of the hazard in the first place, to prevent each of the causes leading to the top event. These controls can be items of equipment or actions taken in accordance with training and procedures [SLIDE 6]. Taking the example of the pilot error cause, preventive controls may include providing the pilot with training, making sure that there are two pilots for every flight – a main pilot and a back up co-pilot - and having an aircraft with autopilot and various automatic warning and safety devices. All of these controls help to minimise the chances of pilot error leading to loss of control of the aircraft.

17. In a bowtie workshop, the team looks at each branch in turn and identifies all the preventive controls in place to stop the cause resulting in a loss of control.

18. However, if the preventive controls on the left side of the bowtie fail to maintain control and the top event occurs, further controls can be brought into play to interrupt development of the scenario and mitigate or recover from the consequences. These recovery controls are illustrated on the right side of the bowtie because they minimise the chance of the top event resulting in the consequence [SLIDE 7]. In the example on the slide, we have highlighted that the pre-flight safety demonstration and emergency equipment such as emergency lighting and lifejackets, help to minimise the number and extent of injuries.

19. Again, in the bowtie workshop, the team looks at each consequence branch and identifies all the recovery controls in place.

20. [SLIDE 8] Circumstances may arise which undermine a control measure and reduce its effectiveness; these are recorded on the diagram by means of yellow escalation factors. They could potentially allow the scenario to escalate. For example, the safety devices we claimed as a preventive control may not have been maintained properly.

21. Escalation factors are, in turn, managed by further controls. On the example bowtie here, we show that maintenance procedures are in place and maintenance personnel are fully trained, so safety devices should always be properly maintained.

22. On the right side of the bowtie [SLIDE 9], we have used an escalation factor to show that the safety briefing given at the start of the flight may have been ignored, or people might panic in the event of an incident and forget what they have been told in the briefing. So, in this case, we have an extra control of fully trained cabin crew who reinforce the instructions given during the briefing and help to make sure that passengers take the appropriate emergency action in the event of a crash landing.

23. [SLIDE 10] Illustrating the preventive and recovery controls against their respective causes and consequences in such a systematic and structured way makes sure that risks are understood and are being controlled and highlights any gaps in risk control which should be a focus for remedial action.

How have we applied the bowtie method for Corrib?

24. So, how have we applied the bowtie method for Corrib? Firstly we carried out a hazard identification exercise to compile a register of all the potential risks associated with the pipeline. The completed register is presented in Attachment A to Appendix Q6.3 of the EIS. There are a large number of risks listed in the register and I realise that to a non-risk specialist this can appear daunting. However, the aim of the exercise was to be as thorough as possible, and identify all the possible things that could go wrong, however unlikely. This was an important and essential first step in our risk assessment process. We had to make sure our risk identification was as complete as possible so that we could engineer in the right controls to cover every eventuality.

25. Figure 3.1 in Appendix Q6.3 of the EIS summarises the process of compiling the risk register. A standard checklist was used by the team to make sure no hazards were overlooked. For each hazard, we used a risk matrix to measure the worst possible consequences that could happen if all our controls failed and then we estimated the likelihood of that event. As I said earlier, risk is a combination of consequence *and* likelihood, considering one without the other does not provide an accurate picture of the risk. Once we had measured the risk, this gave us a profile of which hazards were the highest risk and therefore needed more attention – this is where we focused the rest of our analysis effort.

26. So, we then carried out more detailed qualitative risk assessment in the form of bowtie analysis for the highest risks. These bowtie risk assessments have also been submitted as part of the EIS in Attachment B to Appendix Q6.3.

27. The risk register and bowtie analyses have been subject to several updates during the design phase involving teams of design, safety, operations and maintenance personnel.

28. The Corrib pipeline bowtie workshops typically involved between four and eight people drawn from the project design, safety, operations and maintenance teams; some workshops were much larger. Each workshop was facilitated by a chairperson who guided the team through the structured bowtie analysis process I have just described, building up the bowtie diagrams step-by-step, challenging the information provided and recording the workshop output.

29. Subsequent workshops revisited the same bowties at various stages during the design process to verify and expand on the information recorded in the bowtie diagram. The collective workshop outputs were also subject to a quality assurance review by assigned bowtie branch owners and by Shell's safety advisors and Production Technical Authority.

30. Further bowtie analysis workshops will be held before the pipeline is brought into service, to confirm the bowtie risk assessments against the detailed pipeline operating procedures and maintenance routines

31. [SLIDE 11] This slide shows how the bowtie theory I have described translates for the Corrib onshore pipeline. [CLICK] The hazard we have is hydrocarbon gas – it has the potential to cause harm if we do not control it. [CLICK] The top event in the centre of the bowtie is loss of containment of the hazard – a release of gas from the pipeline.

32. [CLICK] The left side of the bowtie lists the potential causes which could bring about a release of gas. The slide shows a few examples:

    a. Corrosion of the pipeline;

    b. Accidental impact with the pipeline; or

    c. Threat of peat fires on the integrity of the pipeline.

33. These are some examples - the bowtie workshops identified all the scenarios where the team considered potential release of gas from the onshore pipeline and they are *all* listed in the bowties submitted in Attachment B to Appendix Q6.3. The workshops involved a lot of open discussion and interaction between technical specialists – the aim was to brainstorm as many release scenarios as possible, and explore every possibility irrespective of how unlikely it may be, so the end result is that we have very large and detailed bowtie diagrams.

34. We looked at each scenario in turn and identified all the preventive controls in place to stop a gas release. [SLIDE 12] This slide shows an example of one branch expanded to show the controls in place to manage and protect against accidental impact with the onshore pipeline where it is on land (not the section where it passes beneath the bay – that is covered by a separate accidental impact branch). The slide identifies the controls in place for preventing a gas release from accidental impact:

    a. Firstly, the pipeline is not on the surface – it is buried, and is within a stone road where it passes through peat areas, with extra concrete protection in place at road crossings. So, in order to accidentally impact the pipeline, someone would have to physically dig at the pipeline location;

    b. The people who own the land that the pipeline passes through are well aware of its presence, and activities within 14m of the pipeline location are restricted – so in order to accidentally impact the pipeline, someone would either have to physically dig at the pipeline location without the landowner's permission, or the landowner would have to forget exactly where the pipeline was located under their land;

    c. The pipeline route is marked at field boundaries and road crossings. Below ground, but above the pipeline, there is marker tape to indicate the presence of the pipeline. So, if the first two controls fail and someone starts to dig on top of the pipeline, they should stop digging when they come across the warning tape, before they reach the pipeline itself;

    d. Once the pipeline is built and operating, the route of the pipeline will be surveyed periodically as part of the Pipeline Integrity Management Scheme. So if there is any excavation activity in the vicinity of the pipeline, this would be noticed.

e. If SEPIL itself arranges some excavation work in the vicinity of the pipeline, the work will need to be carried out in accordance with their safety controls and permits, and will include a job-specific safety assessment to make sure the workers are aware of the presence of the pipeline;

f. Finally, the wall of the pipeline is 27.1mm thick high strength carbon steel. Calculations presented in Appendix Q4.10 have shown that in order to puncture a pipeline this thick, you would need a 150 tonne excavator, and to cause a dent in the pipeline which might subsequently lead to failure, you would need a 65 tonne excavator. This compares with excavators in use in the area which are normally of the size of 15 – 20 tonnes. So even if all the other controls failed and an excavator actually came into contact with the pipeline, it will probably not have sufficient energy to puncture the pipeline.

35. We carried out the same process for every one of the possible causes which might result in a release of gas from the onshore pipeline – more extracts are included in Attachment B of Appendix Q6.3 of the EIS.

36. [SLIDE 13] On the right side of this pipeline bowtie, we asked the question "if, despite all these preventive controls, we still get a release of gas from the pipeline, then what might the consequences be and how can these be mitigated?". The slide shows some example consequences:

a. Large release of unignited gas; and

b. Ignited release of gas from the pipeline.

37. Then the workshop team looked at each of the branches on the right of the bowtie in turn and identified the recovery controls in place. [SLIDE 14] The slide shows the bowtie branch for the large gas release consequence, and identifies the following recovery controls:

a. There are two leak detection systems in place which will pick up the fact that there is a release of gas. In fact, the fibre optic leak detection system works by detecting vibrations so in the situation where an excavator is digging towards the pipeline this system will alert operators well before a leak happens;

b. There is an Emergency Response Plan in place so that the operator at the gas terminal knows what to do if there is a leak from the pipeline, including (depending on the nature of the incident) notifying the public of the leak;

c. Even if the operator doesn't do anything, once the pressure of gas in the pipeline and feeding into the gas terminal drops because of the leak, there are automatic trips in place which shut down the terminal inlet safety valve and offshore safety valves and initiate gas, condensate and methanol system shutdown; and finally

d. Once a leak has been confirmed, the authorities and emergency services are contacted and brought in to deal with the incident.

38. [SLIDE 15] So, if we look at the whole pipeline bowtie, from left to right following the scenario of accidental impact with the on-land sections of the pipeline through to the ultimate consequence of a large gas release, we have a total of 10 controls, 6 preventive controls and 4 recovery controls.

Demonstrating that the risks are ALARP?

39. One objective of the Corrib bowtie workshops was to demonstrate that the risks associated with the pipeline had been reduced to levels which were ALARP which means As Low As Reasonably Practicable.

40. Section 6 of Appendix Q6.3 of the EIS describes the concept of ALARP in detail. It was submitted in direct response to item 3(a), page 2 of An Bord Pleanála's letter of 2nd November 2009 and item 2, page 1 of An Bord Pleanála's letter of 29th January 2010, where the board requested that *"in the event that individual risk of 10^{-6} or higher applies then the undertaker will have to demonstrate ALARP".* Even though the Quantitative Risk Assessment submitted in Appendix Q6.4 concludes that the individual risk is significantly less than the Board's suggested level of one in one million per year, we have still included a demonstration of ALARP in the EIS.

41. [SLIDE 16] The slide shows schematically that the level of risk associated with any facility or activity can range from relatively low to relatively high. At the lower end of the risk spectrum, the risks are comparable with those we are subjected to as part of our every day activities and, as such, the risk is deemed "broadly acceptable". At the opposite end of the risk range, the risk is so high that it cannot be tolerated and must be reduced. Between these two extremes, there is a mid-range of risk values where

the risk can be tolerated provided that it is demonstrated that the risk has been reduced to a level which is As Low As Reasonably Practicable (ALARP).

42. For the Corrib pipeline, the quantitative risk assessment described in Appendix Q6.4 of the EIS concludes that the overall risk lies well within the broadly acceptable zone. However, when conducting the bowtie workshops, we still went through the process of demonstrating that the risks had been reduced to ALARP levels, to ensure that all practicable controls were in place.

43. The bowtie analysis demonstrates that the risk associated with each scenario has been reduced, by the introduction of these preventive and mitigative control measures, to As Low As Reasonably Practicable levels. We achieved this by asking the following questions during the bowtie workshops:

    a. "do we comply with company and industry standards in terms of control measures?"

    b. "are we comfortable that there are sufficient independent, effective control measures in place on each branch of the bowtie?"

    c. "can we improve the effectiveness of any of the controls?"

    d. "are there any more measures that can be implemented to reduce the risk?"

44. If the bowtie workshop did identify more measures, over and above the currently planned controls, which might reduce the risk still further, they were assessed by the workshop team in terms of the benefit gained from adopting the measure and the potential effort, time, difficulty and cost of implementing the measure. Measures were recommended for implementation or for further, more detailed evaluation unless the effort was assessed to be grossly disproportionate to the benefit gained.

45. In most cases, and particularly for the most recent bowtie workshops, there were already an extensive number of effective controls in place, so the scope for identifying additional, practicable, risk reduction measures was limited. However, the early bowtie workshops did collectively identify the following risk reduction measures which were implemented and have been incorporated into the pipeline design:

    a. landfall valve installation design now comprises duplicated, high integrity, fail closed valves;

    b. a vibration assessment was carried out for the pipework at the Landfall Valve Installation;

    c. an independent audit is to be carried out of the construction quality assurance and quality control regime;

    d. the detailed design of concrete slabs at pipeline road crossings was to be reviewed given the new pipeline route defined for the 2009 EIS;

    e. where the pipeline crosses the river (remember this was at an early bowtie workshop which was looking at the 2009 EIS pipeline route), the potential for movement of backfill material above the pipeline due to river water action was to be investigated and the design amended accordingly. This recommendation has been superseded because the latest pipeline route is with the pipeline inside a concrete tunnel under the bay rather than simply being buried under the river bed.

What is the Current Status of the Corrib Pipeline Bowtie Analysis?

46. In total, since the initial Corrib bowties were first drafted in 2006, there have been seven workshops reviewing and updating the Corrib pipeline bowties, including considerable review and update since the 2009 EIS. Bowtie analysis is an iterative process, building on the events described initially in the risk register, to incorporate more and more detail as the design has evolved.

47. [SLIDE 17] There are currently three detailed bowtie diagrams for the major risks associated with the Corrib pipeline. These are:

    a. Hydrocarbon releases from offshore pipeline;

    b. Hydrocarbon releases from Landfall Valve Installation; and

    c. Hydrocarbon releases from onshore pipeline.

48. In addition to these three major risk bowties, we have developed a fourth pipeline-related bowtie covering:

    d. Failure of the control umbilical.

This is not, in itself, a major safety risk, but it was subjected to bowtie analysis as it is recognised as being important to pipeline integrity and process control.

49. The four pipeline bowties are very large and very detailed. Although on initial reading this might raise concerns, for example the bowtie for the onshore pipeline shows that there are thirty two potential threats to the pipeline, as a risk specialist however, I can say that this is not how the bowties should be interpreted. The size and extent of the bowties reflects the scale and the thoroughness of our analysis. We have made sure that every conceivable event which could lead to a release from the pipeline has been addressed. Irrespective of how unlikely it is, we have captured each potential event, put it on the diagram and then identified all the controls we need to have in place to manage it. So, the bowties cover all locations along the pipeline route and address different operating conditions, such as start up, normal operations and shut down. [CLICK] They cover all imaginable events which might possibly result in a release of gas from the pipeline, including corrosion and erosion, impact damage, landslides, low temperature, hydrate formation, overpressure.

50. The entire range of scenarios, all the causes and consequences for each bowtie, are shown in Attachment B to Appendix Q6.3 of the EIS, together with expanded extracts to show the preventive and recovery controls in place for selected branches. The bowtie extracts have been selected on the basis that they:

    a. illustrate risks which cannot be easily defined mathematically;

    b. include scenarios which are relevant to and contribute to the QRA;

    c. address issues of concern which were raised at the 2009 oral hearing; and that they

    d. cover a range of locations and operating conditions.

51. [SLIDE 18] This slide shows the next steps for further refinement of the Corrib pipeline bowties. [CLICK] In preparation for operations, the preventive and recovery controls on the bowtie are linked to responsible individuals. Critical roles and activities are defined, so that the controls continue to function as needed. [CLICK] We also make a link between these safety critical activities and the workforce training programmes and the operating procedures SEPIL is developing. These help to make sure that individuals know what is expected of them and carry out their critical activities properly.

52. [CLICK] Where preventive and recovery controls involve a critical piece of equipment such as a safety shut down valve or a leak detection system, these items of equipment have defined standards which they must meet. [CLICK] The controls on the bowties are linked to maintenance arrangements in place to make sure that equipment is fully tested and operational.

53. [CLICK] These systems that I have mentioned – the training programmes, operating procedures and maintenance arrangements – are all part of the SEPIL overall Safety Management System.

54. By taking this next step in the bowtie analysis, it means that the bowtie evaluates not only what controls are in place now, at the time of the assessment, but also why the controls will continue to be in place in the future (because people are made responsible for each control and systems are put in place to make sure controls are maintained).

The Safety Case

55. [SLIDE 19] In its letter of 5th August, in the section headed "Draft Questions Expected", An Bord Pleanála asks specifically about the Safety Case at Glengad. Appendix Q of the EIS makes the case for safety for the entire pipeline, including the LVI at Glengad. A Safety Case document will be submitted, in compliance with the requirements of the Petroleum (Exploration and Extraction) Safety Act 2010. Work started in support of the Corrib Safety Case in 2006.

56. For the benefit of those who may not be familiar with the term, I would like to explain briefly what a Safety Case is. It is a formal, detailed document whose primary purpose is to demonstrate that there has been, and continues to be, systematic risk assessment of the facilities so that controls are in place and risks are actively reduced to levels that are As Low As Reasonably Practicable.

57. In some industries, and some jurisdictions, a Safety Case is a legal requirement and, with the passing of the Petroleum (Exploration and Extraction) Safety Act, the concept of a Safety Case as a legal requirement for petroleum activities has been introduced in Ireland. A Safety Case is also an internal Shell requirement for all its petroleum operations worldwide, regardless of the legal requirements.

58. [SLIDE 20] The slide shows what we currently plan the Corrib Safety Case will contain. It includes some descriptive sections but the most important parts of the document [CLICK] are the sections which describe the risk assessment processes carried out and list all the risks and the controls in place to manage them.

59. Work on the Corrib Safety Case to date has focussed on these risk assessment sections, specifically the risk register that I have already described, the detailed bowtie analysis of the highest risks and the numerical Quantitative Risk Assessment (the QRA) which has been prepared and is included in the EIS. This work is fully documented and has been submitted as Appendices Q6.3 and Q6.4 of the EIS. These appendices will therefore form the risk assessment parts of the Safety Case document.

60. The Safety Case will continue to be developed and built upon as the design stage transitions into operations. As I explained earlier, the measures in place to manage risk need to be linked to operating procedures and maintenance routines and will be embedded in the responsibilities of individual members of the workforce.

61. In order to be an effective risk management tool, the Safety Case will continue to be a living document, with its component parts being used for training or auditing purposes for example, and its risk assessments being revisited and updated as necessary.

Summary Matrix of Qualitative Risk Assessment

62. Also in its letter of 5th August, again in the section headed "Draft Questions Expected", An Bord Pleanála asks specifically about a "summary matrix of qualitative risk assessment" so I am now going to present a summary matrix, but first I have to explain a little about how the risk matrix was used. [SLIDE 21] Attachment A of Appendix Q6.3 shows the risk matrix that was used to measure the risk of each scenario identified for the Corrib pipeline and the slide shows a summary of the risk matrix.

63. As I explained earlier, we used this risk matrix for every hazard we identified and listed in the risk register. The severity of the worst case consequences, assuming all the controls fail, is measured using the vertical scale on the left side, which ranges from no or low consequence at the top to high consequence at the bottom. The likelihood of the event is measured across the horizontal scale along the top, from low likelihood on the left to high likelihood at the right. Risk is the combination of the consequence on the left vertical scale, and the likelihood along the top horizontal scale. Low risks lie in the blue area of the risk matrix, medium risks in the yellow, and high risks in the red. Under Shell's safety standards, the effort required to manage each hazard is proportionate to where it sits on the risk matrix. So, [CLICK], events which lie in the blue, low risk zone of the matrix are managed by implementing our general Safety Management System. [CLICK] Events in the yellow zone of the matrix are managed by implementing controls specifically targeted at the individual events, until the risk has been reduced to As Low As Reasonably Practicable (ALARP). [CLICK] Events in the red zone of the matrix are similarly managed, by implementing specific controls until the risk is reduced to ALARP, but we must also provide a documented demonstration that the risk is reduced to ALARP levels.

64. [CLICK] The matrix shows the *unmitigated* risk from each scenario, because we have assumed that all the control measures in place to mitigate the severity happen to fail. This is an extremely conservative assumption, but we adopt this approach so that we can identify which scenarios have the *potential* to result in the worst consequences.

65. Some hazards, such as getting a paper cut on your finger CLICK, have a very low potential severity, even with no controls in place. Some hazards, such as a car accident CLICK, have a much higher potential severity – car accidents can result in fatalities. But, because of the controls we put in place for car travel – the need to take a driving test, the NCT checks on your vehicle, wearing a seat belt, sticking to the speed limit – we reduce that risk CLICK and we are left with a relatively low *residual risk* that means most of us are happy to drive our cars.

66. If we plotted the mitigated, residual risk from both of these events on the risk matrix, they would both lie in the blue, low risk zone as shown on the slide. Now if we imagine that the way we treat both of these risks depends on where they lie on the risk matrix, we might be tempted to treat both of them the same, with the same degree of caution, because we think that they both have the same risk.

67. If instead of plotting the mitigated, residual risk on the matrix we plot the unmitigated risk, which is the approach we have adopted in the Corrib risk register CLICK, we see that the paper cut and the vehicle accident lie in *different* parts of the risk matrix. A paper cut is still in the low risk zone – the worst that can possibly happen if all your controls fail, is that you get a cut finger. A vehicle accident is in the high

risk zone now – if you drive too fast, if your brakes are defective or if you don't wear your seatbelt, for example, a vehicle accident might be fatal. So this clearly shows that because the vehicle accident has the *potential* for a very high severity consequence, we need to put some strong controls in place to manage it.

68. This is the approach we took when measuring the risk for the Corrib pipeline. Each of the risk scores in the risk register in Appendix Q6.3 are the *unmitigated* risk showing the potential severity if all the control measures we put in place fail. Then we know what our biggest potential risks are, and we can make sure we put sufficient effective controls in place to manage them and bring their residual risk down into the low region of the risk matrix.

69. SLIDE 22 This slide shows all the risks recorded in the risk register for the Corrib pipeline, as requested by An Bord Pleanála. The risk register includes a total of 51 different events which have a potential risk for people's safety and each one of these 51 events is counted on the risk matrix here. These events are associated with operation of the pipeline, not its construction. The slide shows where each of these potential safety events would sit on the risk matrix, if all the control measures in place to manage them were not present and the risks were unmitigated – we would have 20 events with low *potential* risk, 26 with medium potential risk and 5 with high potential risk. Again, this looks like there are lots of risks associated with the pipeline, but remember this is the *unmitigated, potential risk.* This is a very conservative approach, because we know, from the bowtie analysis, that there are hundreds of controls in place to manage the risk.

70. We can look at the events behind the numbers on the slide. For example, four out of the five events with a *potential* risk in the red area relate to a release of gas at the LVI which results in a fire. They are listed as four separate events on the risk register because they have different causes for example vehicle impact with equipment at the LVI, or an object being lifted by a hoist at the LVI which might be dropped and impact with equipment, where the impact results in a release of gas which then ignites.

71. The other event in the red zone, with a potential risk of C5, relates to a release of gas from the onshore pipeline which leads to a fire.

72. Of the yellow, medium risk items in the risk register, the event in B5 is an ignited release of gas from the subsea wells or offshore pipeline. The event with a potential risk of A5 is sinking of a vessel engaged in inspecting the wells and offshore pipeline. This was assessed to be an extremely rare event, so it has a very low likelihood, but it has the potential for loss of life from the vessel's crew so it scored highly on the potential severity scale of the risk matrix.

73. There are nine events rated as having a potential severity of C4 – medium risk. As with many of the medium risk events, these 9 relate to incidents which could cause injury to one or two individuals from the workforce, for example, a worker falling from scaffolding or a worker being crushed or cut by equipment.

74. Once we had compiled the risk register and identified what events had the highest *potential* risk, as I explained earlier in my statement the next part of our risk assessment process involved focussing on the highest risk scenarios – those in the red and yellow at the bottom right of the risk matrix. Each of the higher risk scenarios was subjected to very rigorous bowtie analysis, following the method I have previously described, to build up a detailed picture of all the controls in place to prevent the incident from occurring, and to mitigate the consequences should the incident occur.

75. SLIDE 23. The effect of all these preventive and mitigative controls which we have documented on the bowties CLICK is to reduce the risk so that it moves from the high risk area towards the lower risk area.

76. This effect is confirmed by the Quantitative Risk Assessment (the QRA) described in Appendix Q6.4 of the EIS. The QRA takes credit for the preventive and mitigative controls in place and calculates the *mitigated* residual risk remaining to be in the blue, broadly acceptable, region of the risk matrix.

77. So, in the same way that most people are happy to drive their cars, because they accept that there may be a high *potential* risk but the mitigated, residual risk is low, the Corrib pipeline is safe to operate because, although there may be a high potential risk, the mitigated residual risk is shown, by all the controls we have illustrated on the bowties and the results of the QRA, to be low.

Conclusions

78. SLIDE 24 In conclusion,

a. Extensive qualitative risk assessment has been conducted, in various forms, throughout the design of the Corrib pipeline.

b. The qualitative risk assessment process described here complies with the pipeline code requirements for risk assessment and also with international and industry best practice.

c. All safety risks associated with the Corrib pipeline have been identified and assessed and are captured in the Corrib Risk Register.

d. The Corrib bowtie assessments have been developed over a number of years and are extremely comprehensive.

e. Qualitative risk assessment is an ongoing process which feeds into the Safety Case and will be further updated through construction and commissioning, and into operations. The Safety Case itself will also be revisited and updated as required.

Corrib Onshore Pipeline

Qualitative Risk Assessment

By Sheryl Hurst

(PL16.GA0004)

Risk Assessment Process

"What can go wrong?"

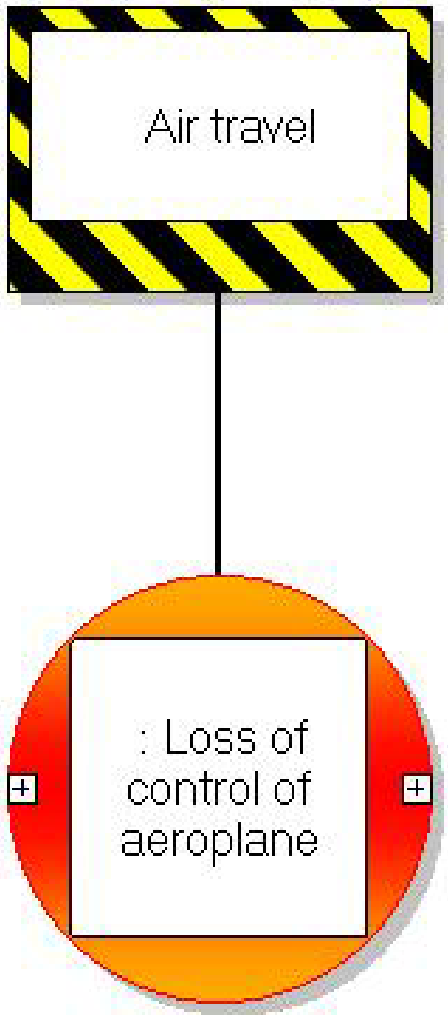
"How bad can it be?"

"What measures do we have in place to prevent it going wrong?"

"If things do go wrong, what measures do we have in place to minimise the effects?"

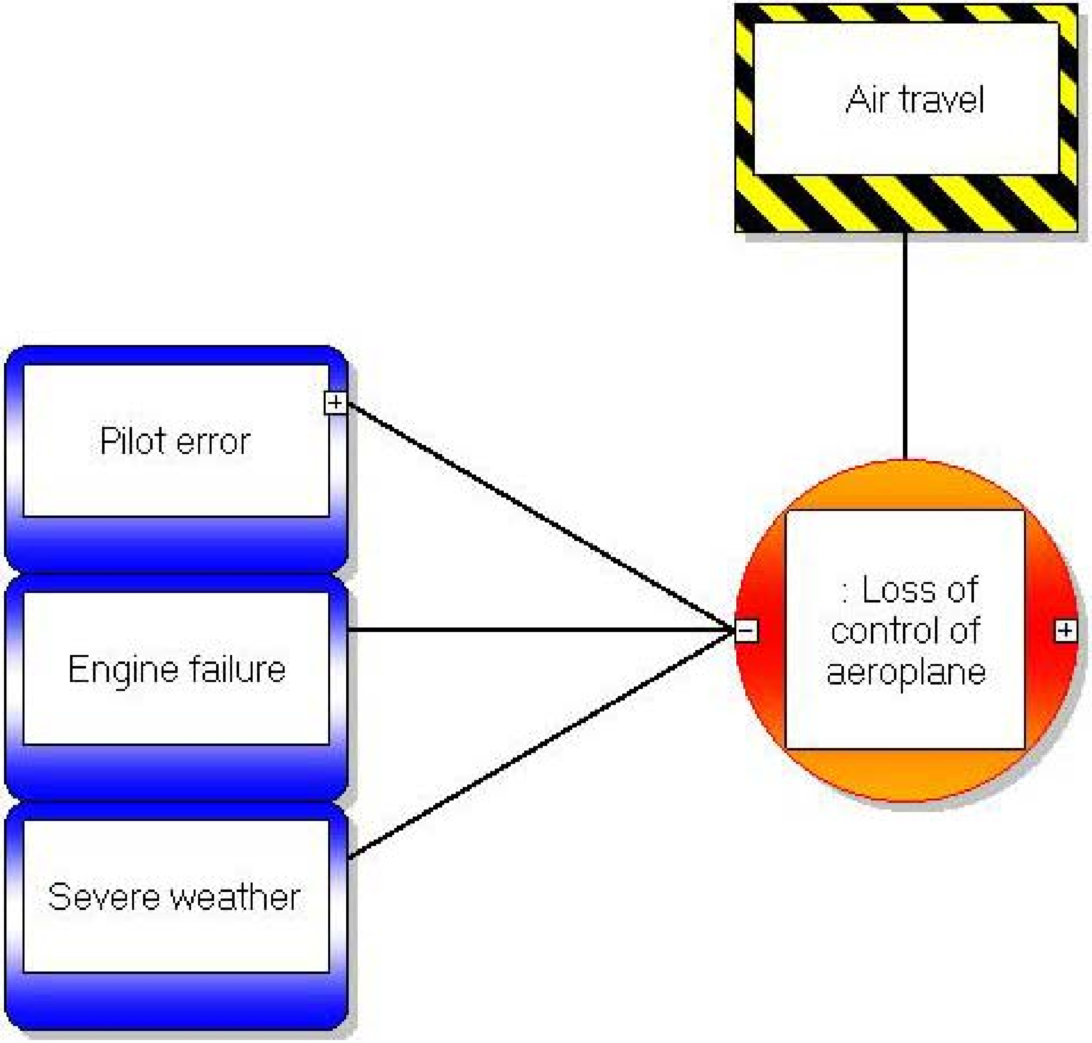
"Are these measures good enough?"

Hazard and Top Event
Centre of the Bowtie



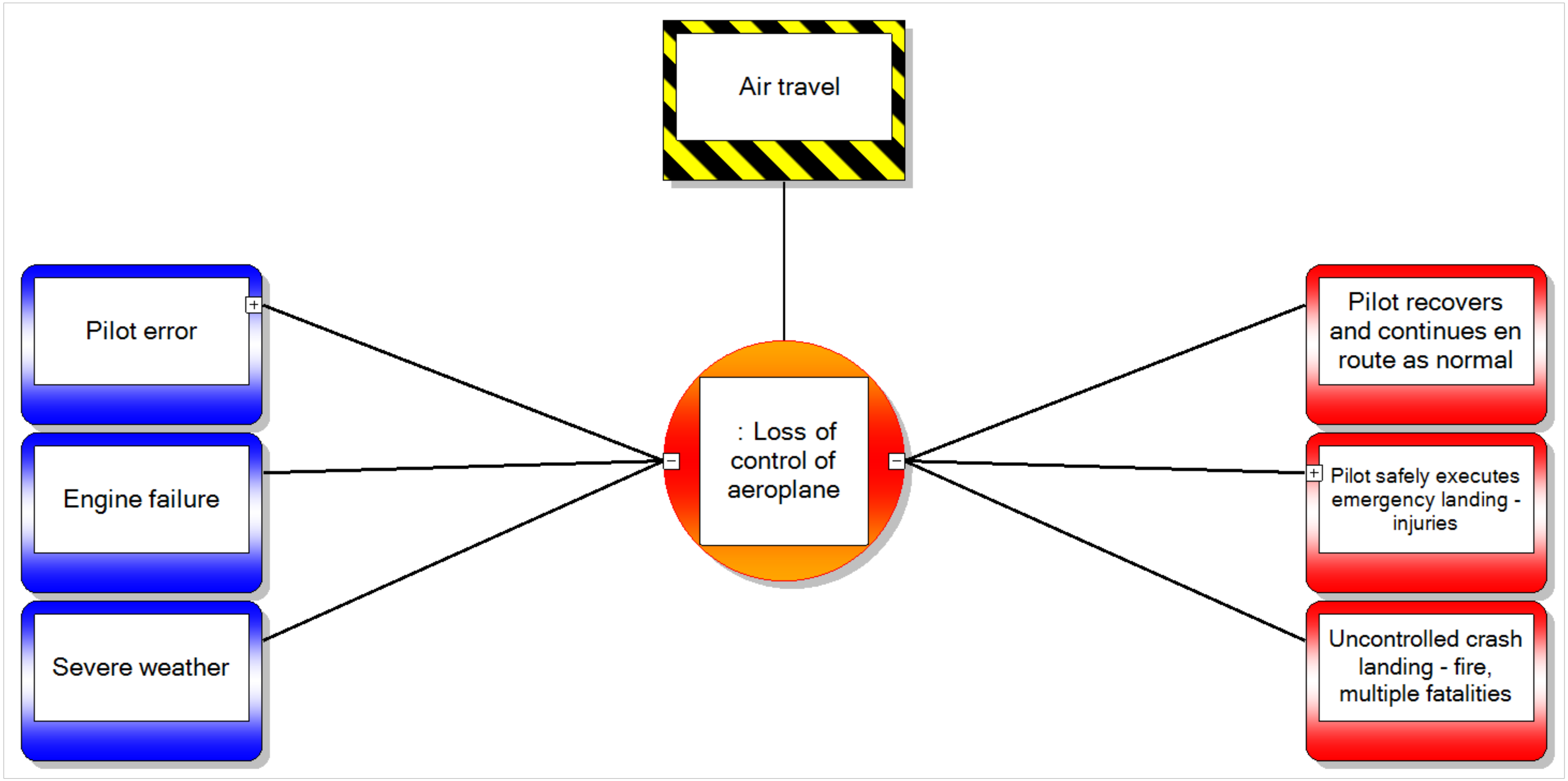
Causes

Left Side of the Bowtie

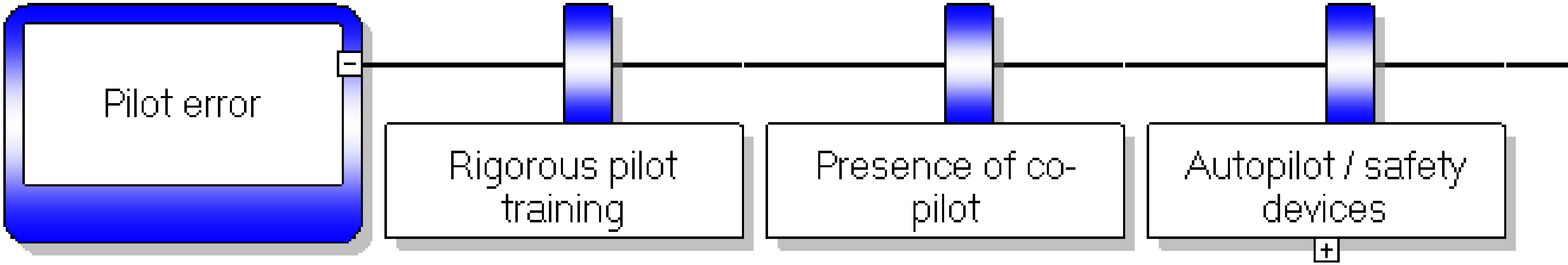


Consequences

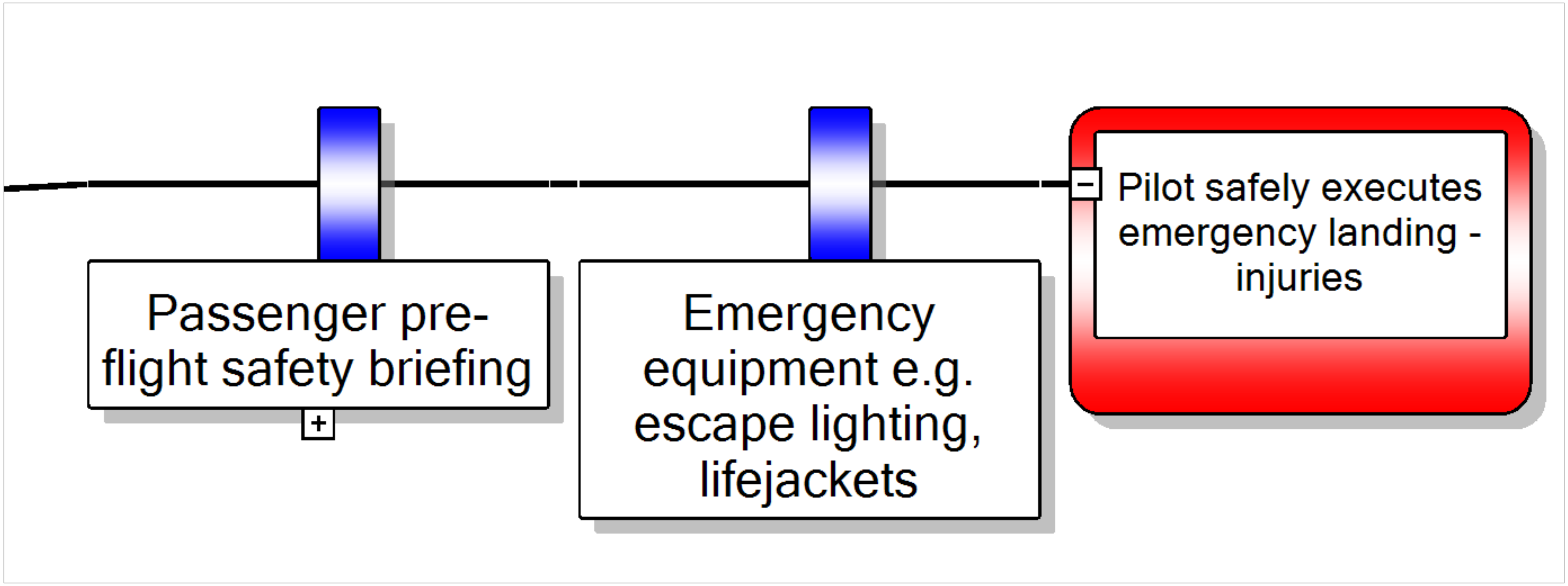
Right Side of the Bowtie



Preventive Controls
Left Side of the Bowtie

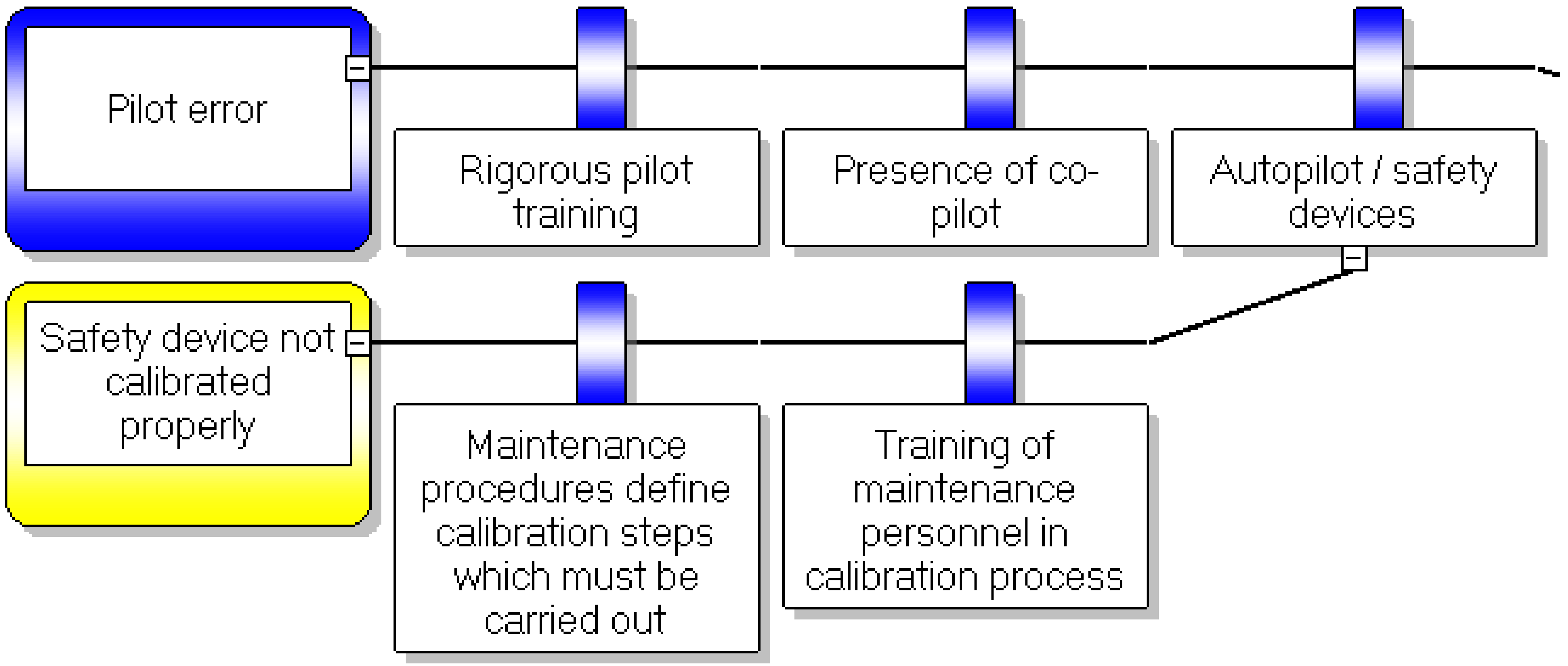


Recovery Controls
Right Side of the Bowtie



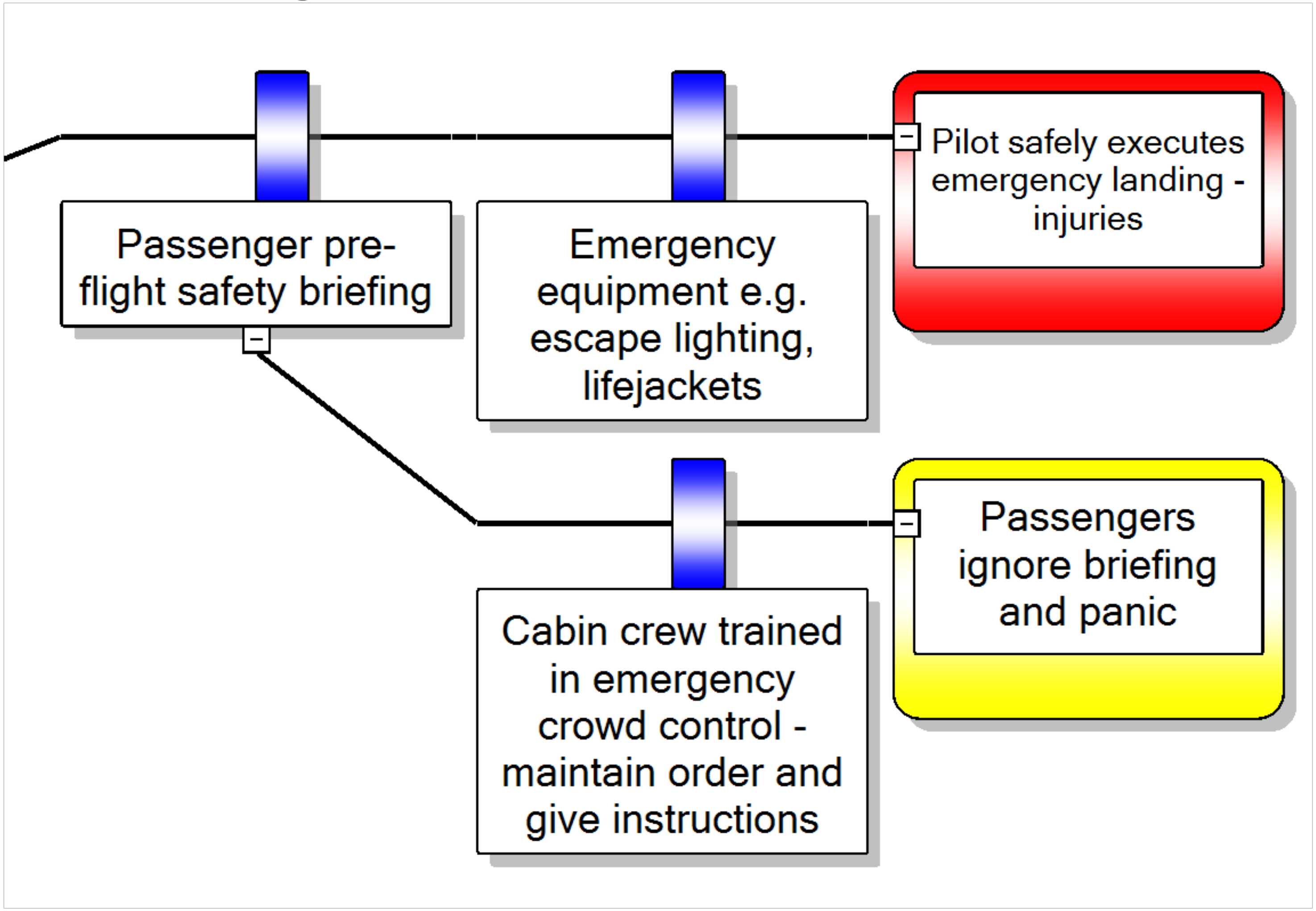
Escalation Factor Example

Left Side of the Bowtie

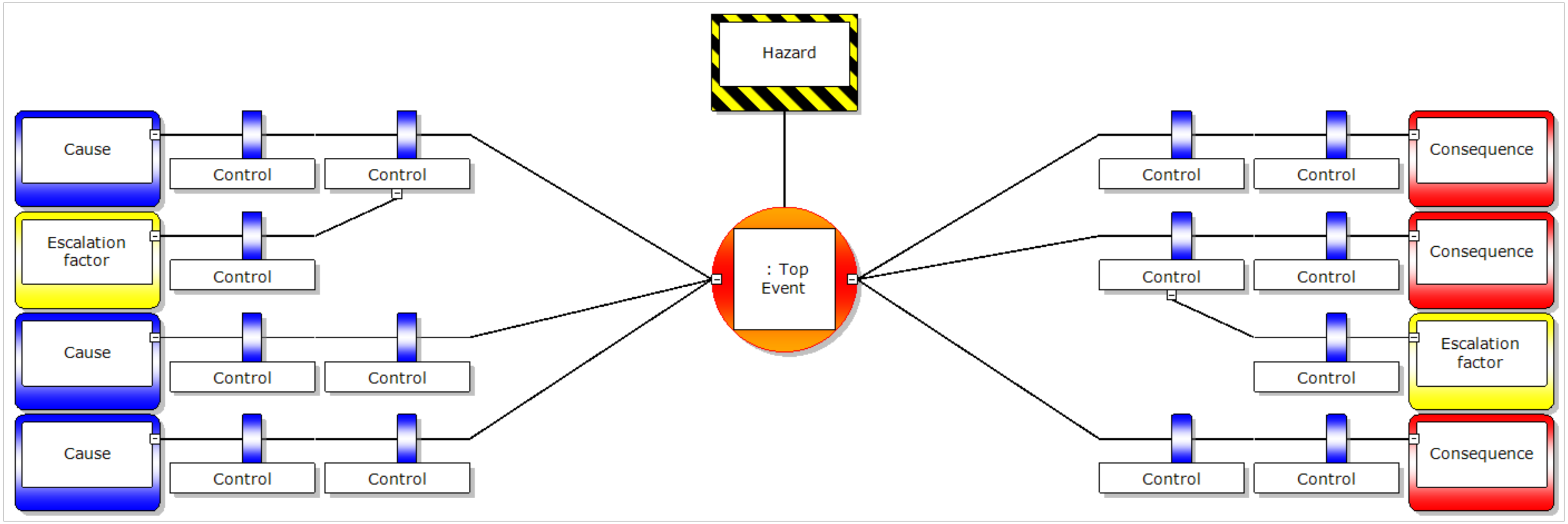


Escalation Factor Example

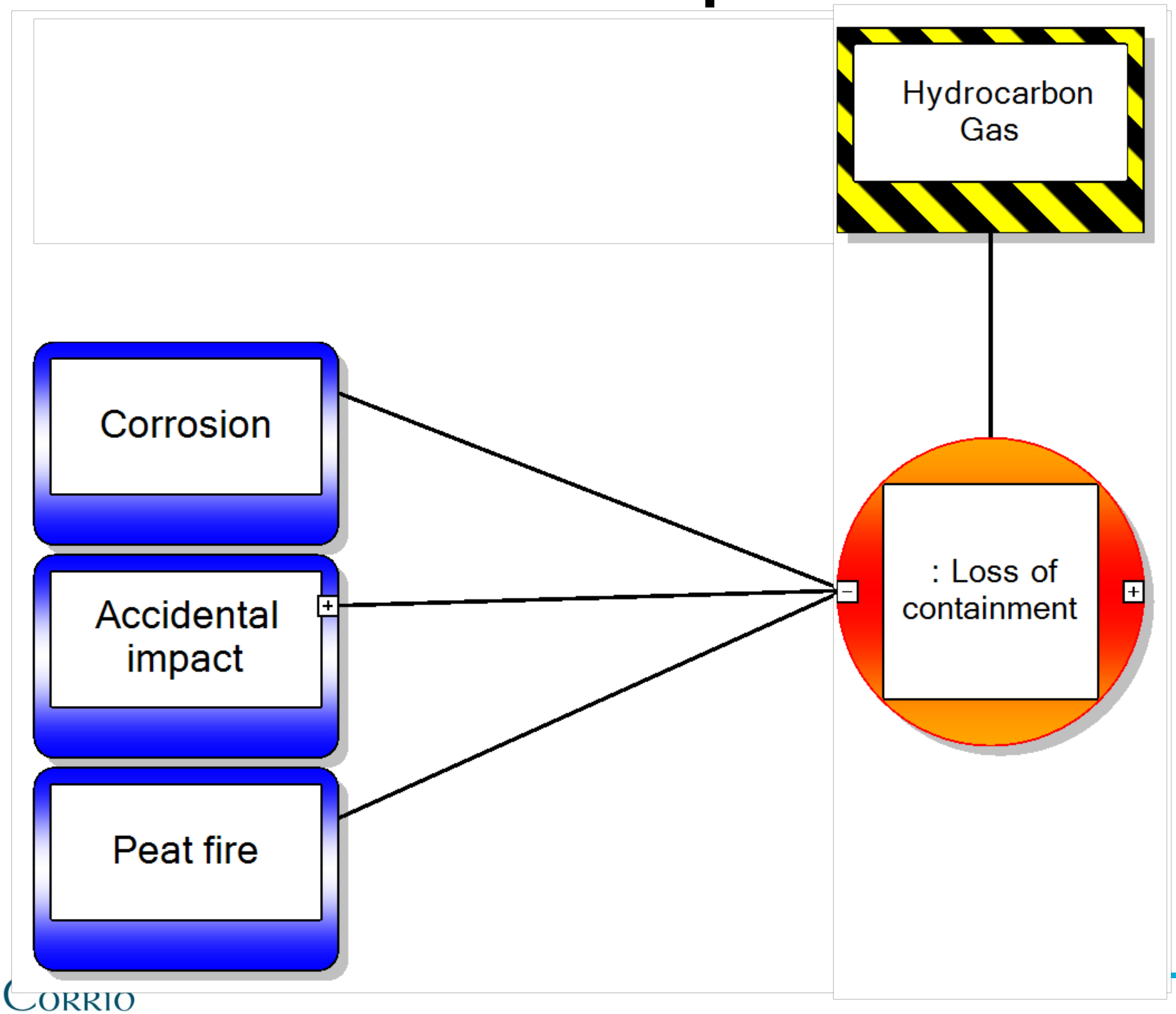
Right Side of the Bowtie



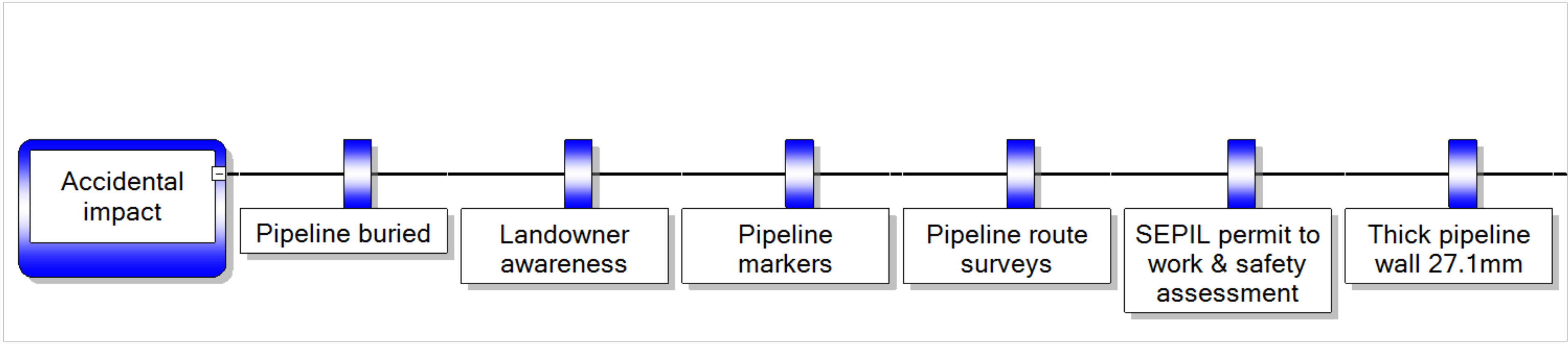
Complete Bowtie



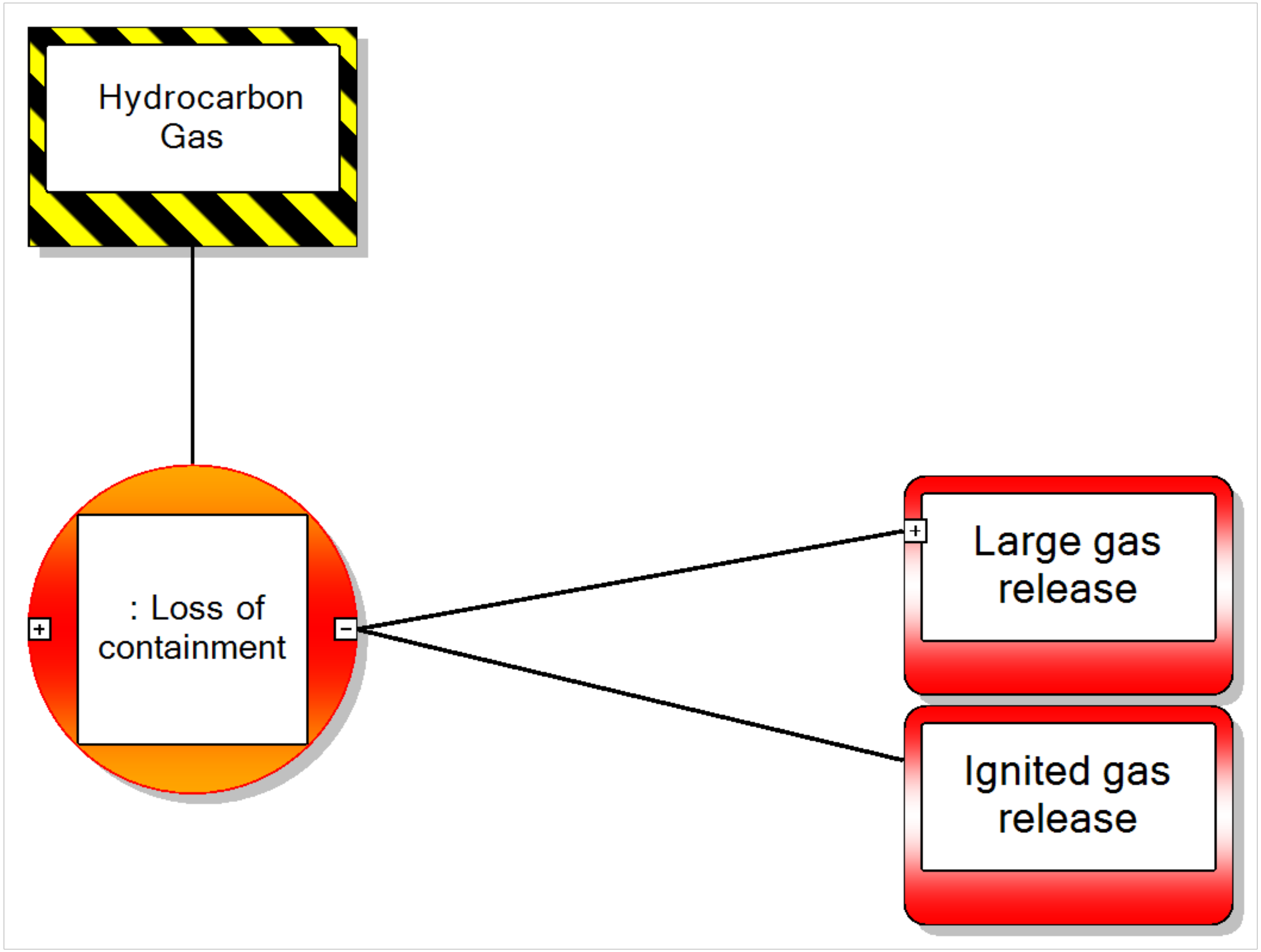
Corrib Pipeline Bowtie



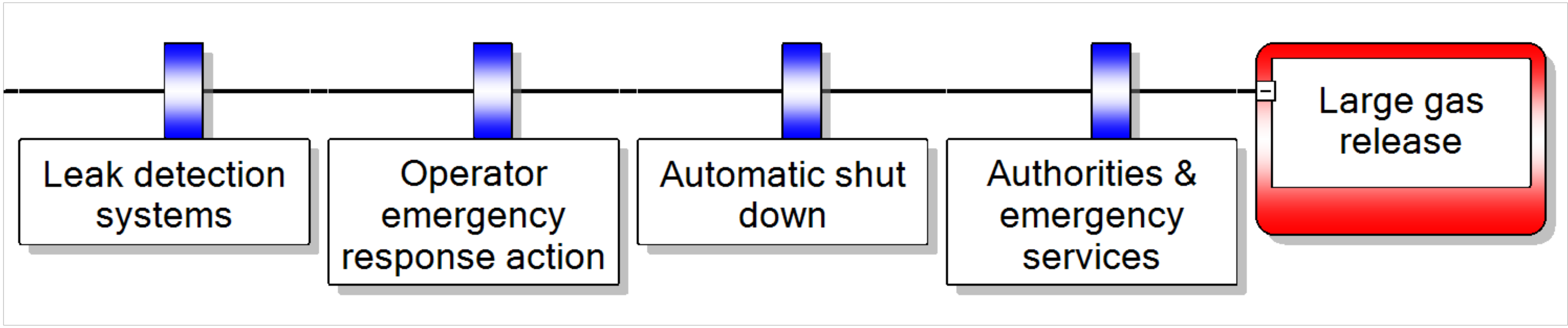
Corrib Pipeline Bowtie



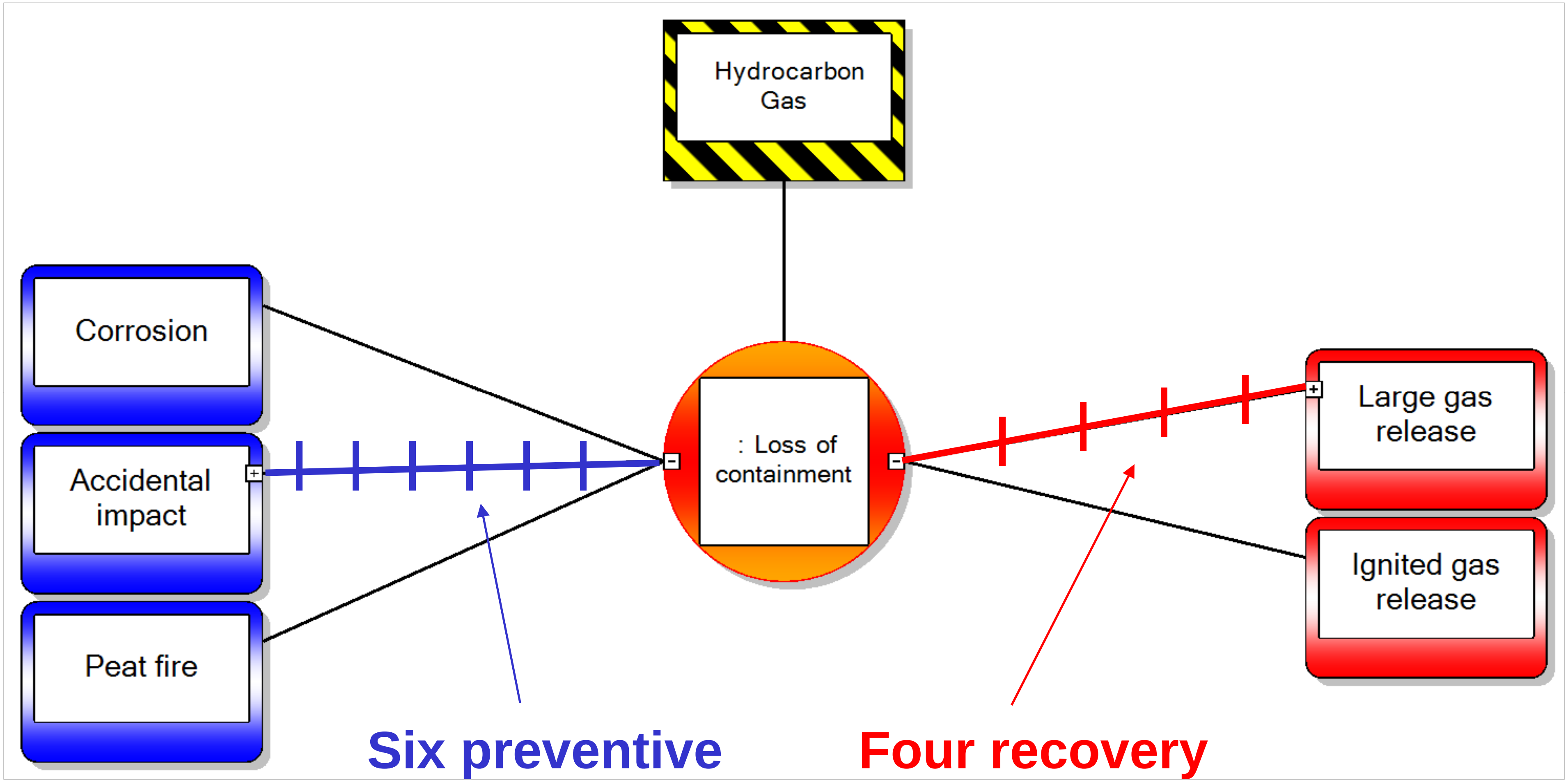
Corrib Pipeline Bowtie



Corrib Pipeline Bowtie



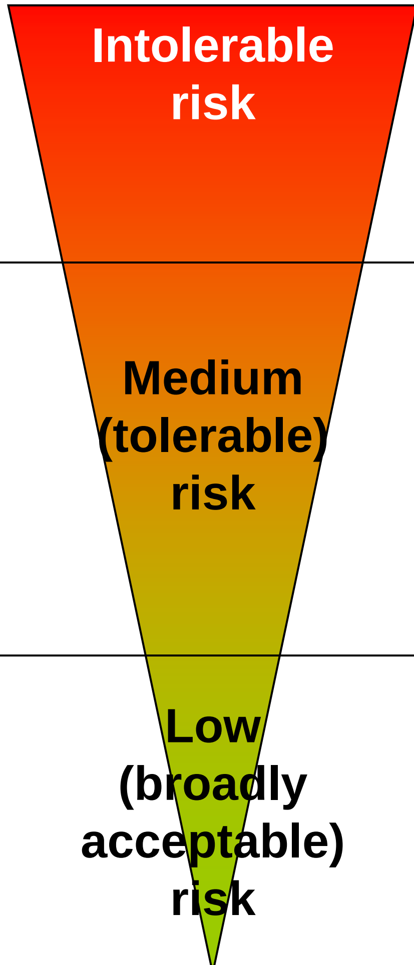
Corrib Pipeline Bowtie



Six preventive controls

Four recovery controls

Risk Levels and ALARP
(As Low As Reasonably Practicable)



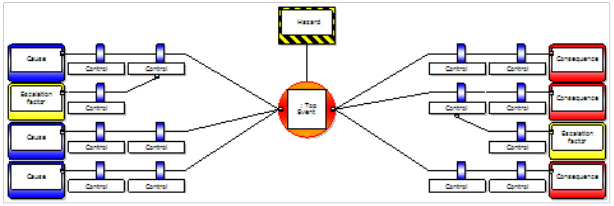
Risk cannot be justified except in exceptional circumstances. Additional risk reduction measures *must* be pursued.

Demonstration of ALARP shall be made. Risk can be tolerated if further risk reduction is impracticable or if the cost and effort is unreasonably disproportionate to the benefit gained.

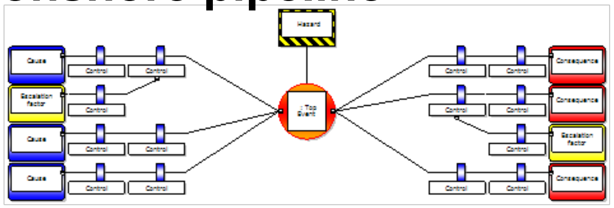
Consider cost effective risk reduction measures. No need for detailed working to demonstrate ALARP. Necessary to maintain assurance that risk remains at this level.

Current Pipeline Bowtie Status

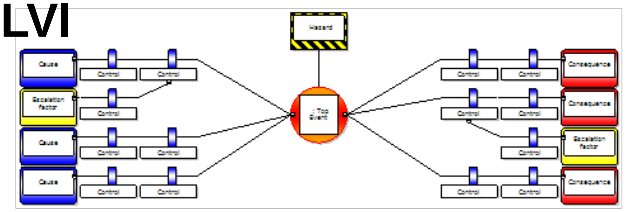
Offshore gas release



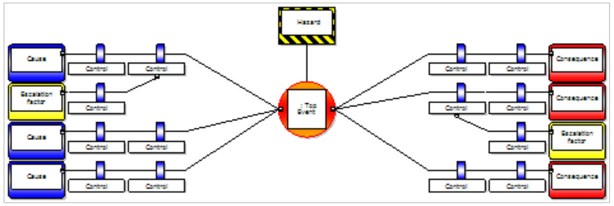
Gas release from onshore pipeline



Gas release at LVI



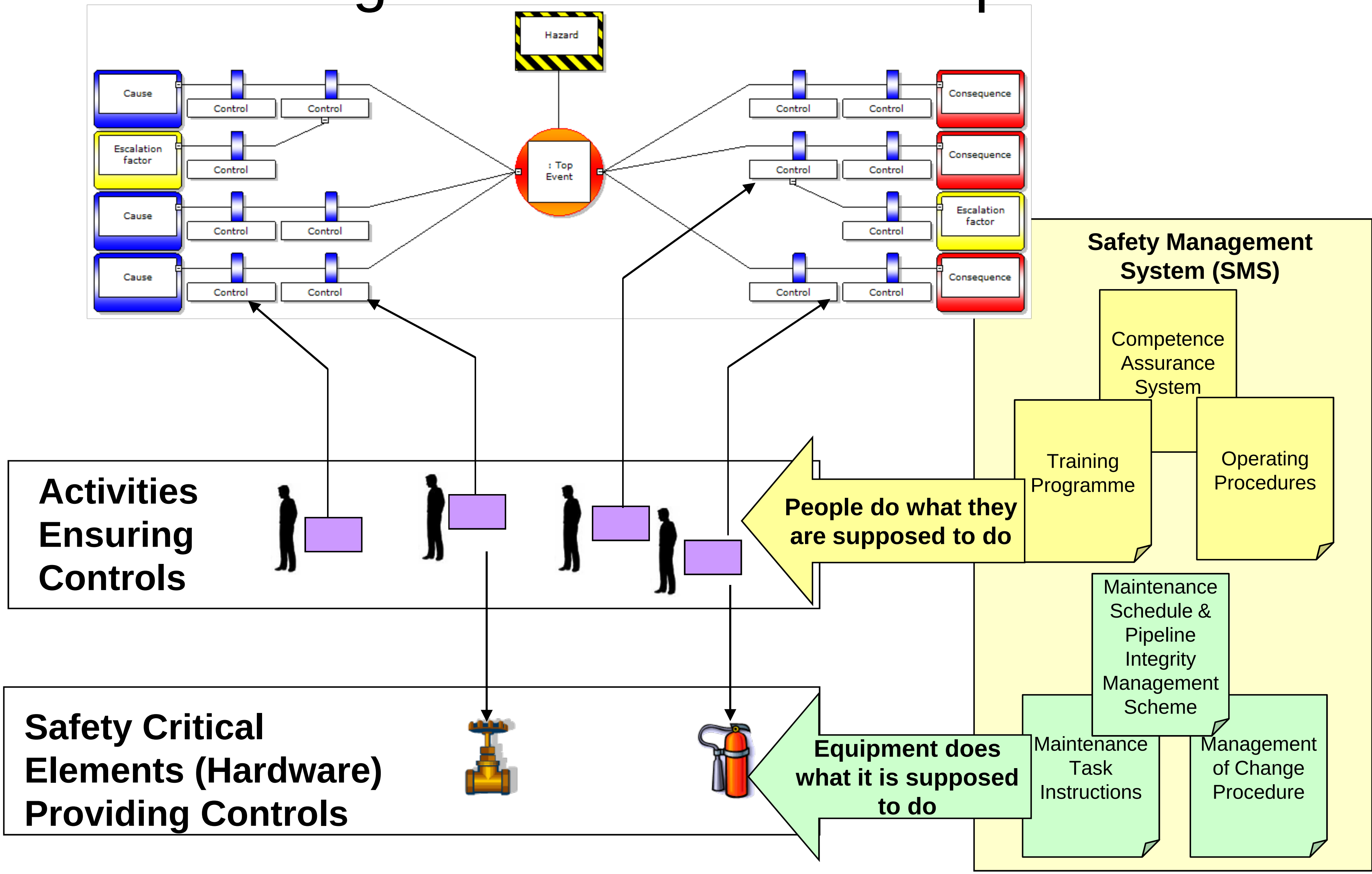
Umbilical failure



Major Risks

Corrosion, erosion, impact, ground movement, low temperature, hydrates, overpressure

Embedding Risk Controls into Operations



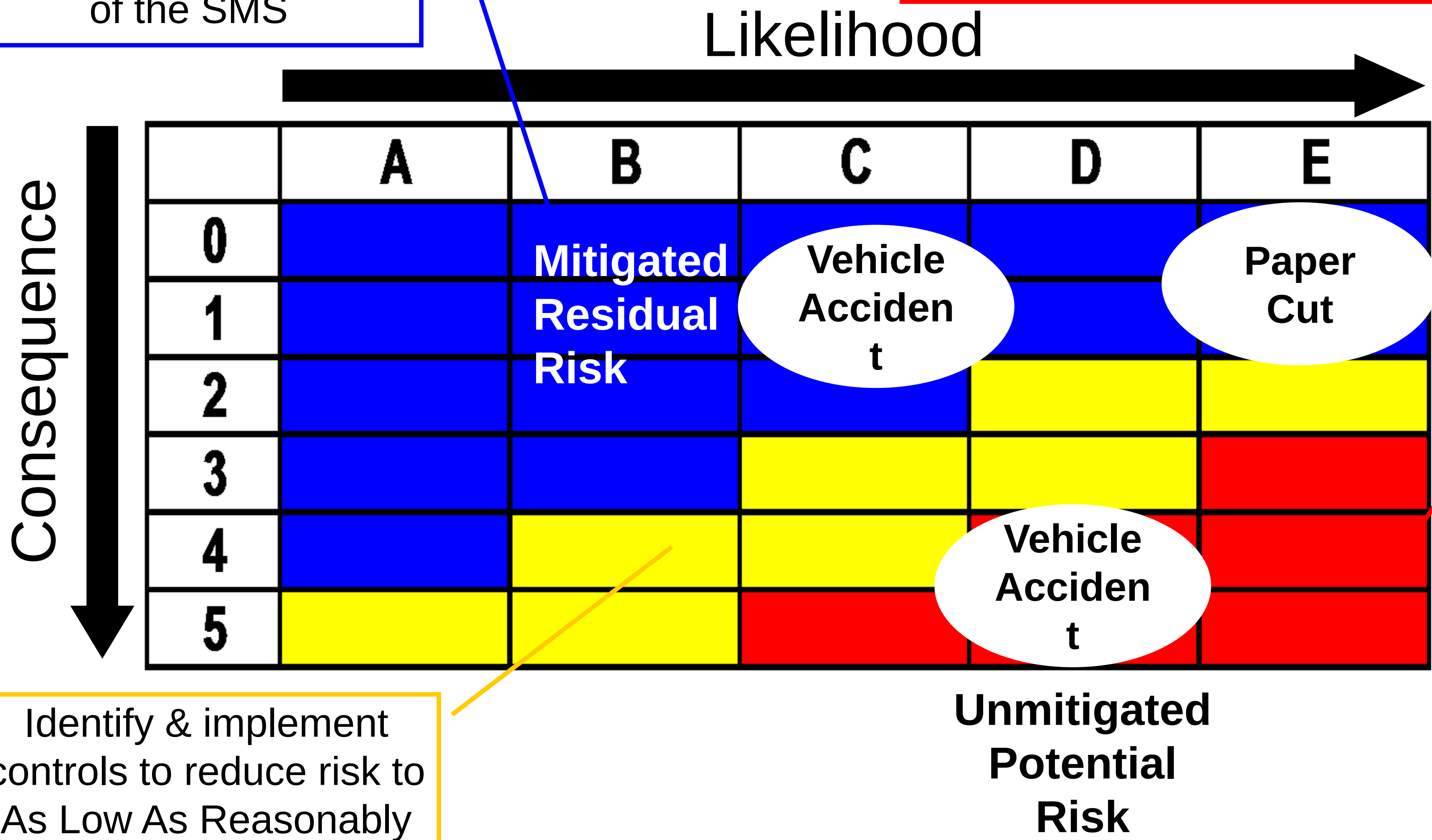
Safety Case Structure

1 Introduction	2 Facility & Operation Description	3 Safety Management Systems	4 Risk Assessment	5 Risk Control	6 Action Plan

Core of the Safety Case (4 Risk Assessment, 5 Risk Control)

Manage for continuous improvement through effective implementation of the SMS

Identify & implement controls to reduce risk to ALARP and provide a documented demonstration of ALARP



Identify & implement controls to reduce risk to As Low As Reasonably Practicable (ALARP)

Unmitigated Potential Risk

Likelihood →

Consequence ↓

	A	B	C	D	E
0	1	2	3		
1				1	1
2		1	4	1	
3	1	6	7	2	
4		5	9	2	
5	1	1	3		

Mitigated Residual Risk