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SPEECH BY THE HON. SIR CHARLES HADDON-CAVE

"LEADERSHIP & CULTURE, PRINCIPLES & PROFESSIONALISM, SIMPLICITY & SAFETY – LESSONS FROM THE NIMROD REVIEW"

ABSTRACT

RAF Nimrod XV230 suffered a catastrophic mid-air fire whilst on a routine mission over Helmand Province in Afghanistan on 2nd September 2006. This led to the total loss of the aircraft and the death of all 14 service personnel on board. It was the biggest single loss of life of British service personnel in one incident since the Falklands War. The cause was not enemy fire, but leaking fuel being ignited by an exposed hot cross-feed pipe. It was a pure technical failure. It was an accident waiting to happen. The deeper causes were organizational and managerial:

- A failure of *Leadership, Culture and Priorities*
- Seven Steps to the loss of Nimrod (over 30 years)
- Seven Themes of Nimrod
- Seven Pillars of Nimrod
- The four LIPS Principles *(Leadership, Independence, People and Simplicity)*
- The four classic cultures *(Flexible, Just, Learning and Reporting Cultures)*
- The vital fifth culture *(A Questioning Culture)*
- The four States of Man *(Risk Ignorant, Cavalier, Averse and Sensible)*
- Inconvenient Truths
- The importance of simplicity

"*Any intelligent fool can make things bigger, more complex, and more violent.*
It takes a touch of genius – and a lot of courage – to move in the opposite direction."
(E.F. Schumacher)

Introduction

1. It is a great privilege to be invited to speak to you at this remarkable *"PIPER 25"* conference. I congratulate Malcolm Webb and Oil & Gas UK for the inspired idea of marking the 25th anniversary of the loss of *Piper Alpha* by organizing this unique gathering of the oil and gas industry and speakers from all over the world. It is valuable to take stock and openly share experiences and ideas with colleagues across industry and to learn the lessons of the past. There was no more important or hard lesson for the oil and gas industry than the terrible loss of Piper Alpha on 6th July 1988

NIMROD XV230

2. I have been asked to talk to you this morning about *The Nimrod Review* following the loss of *RAF Nimrod MR2 XV230*[1] - and highlight some of the hard lessons that have been learned from this painful episode in British military aviation history.

3. On 2nd September 2006, *XV230* was on a routine mission over Helmand Province in Southern Afghanistan in support of NATO and Afghani troops. Within 90 seconds of completing air-to-air refueling from a Tristar tanker, the crew were alerted by two almost simultaneous warnings: a fire warning in the bomb bay and a smoke/hydraulic mist warning in the elevator bay. Within a minute the aircraft depressurised. Within two minutes the spy camera operator reported "*we have flames coming from the rear of the engines on the starboard side*". Emergency drills were carried out and a 'MAYDAY' transmitted. The pilots immediately diverted to Kandahar airfield. Faced with a life-threatening emergency, every member of the crew acted with calmness, bravery and professionalism, and in accordance with their training. Six minutes after the first fire warning, however, a Harrier saw *XV230* explode at about 3,000 feet and crash.

4. The crew had had no chance of controlling the fire. Their fate was already sealed before the first fire warning went off. The fire had broken out in a part of the lower fuselage of the aircraft which was unreachable and not covered by an automatic fire suppression system. It was the biggest single loss of life of British service personnel in once incident in theatre since the Falklands War in 1982.

5. The RAF Board of Inquiry found that the cause of the fire was not enemy action but fuel leaking during air-to-air refueling or from fuel couplings being ignited by a hot cross-feed pipe. That is to say, it was an engineering failure. This caused a major shock both in the military community and with British public because pure 'tech' accidents simply should not happen.

6. These sorts of major catastrophic accidents with a long gestation are, mercifully, rare; but they are a golden, once-in-a-generation, opportunity to learn deep and important lessons, if organisations are prepared to submit themselves to rigorous, objective examination and a real measure of soul-searching. It was a hard lesson for the RAF and military but a free lesson for everyone else.

[1] *Nimrod MR2* aircraft were specialized RAF reconnaissance aircraft which were manufactured in 1960s and in active service until recently.

Inquiry – 2007-2009

7. With a small military and civilian team, I conducted a two-year inquiry at the request of the Secretary of State for Defence from 2007-2009. We had valuable assistance from the US military, NASA, the HSE, the CAA, British Airways and others. I would also like to acknowledge the huge debt that my thinking owed to the seminal work of Lord Cullen who is here at the Conference today. It is perhaps fitting that Nimrods were circling over Piper Alpha on the fateful day of 6th July 1988, helping co-ordinate the rescue mission.

SEVEN STEPS TO LOSS OF NIMROD

8. We investigated 30 years of history of the aircraft, its design, maintenance and operation and discovered a series of flaws or matters– which when linked together over time had fatally combined to let to this major loss. It was an accident waiting to happen (for several decades). The history or genesis of the accident can be traced through the concatenation the following seven 'steps' which took place over 30 years:

   (1) **Poor design** and modifications from 1960s onwards gave risk to the risk of fuel coming into contact with 400 deg hot pipes in the bottom of the fuselage at any time.

   (2) There was **history of fuel leaks** in 1970s and 1980s which did not ring alarm bells (and had become 'the normalization of deviance').

   (3) There was an **increase in operational tempo** in late 1990s and early 2000s with the heavy use of Nimrod aircraft particularly in theatres such as Kosovo, Afghanistan and Iraq.

   (4) There were increasing **problems of maintenance** of an increasingly aging aircraft, with its out-of-service date being regularly extended.

   (5) There were meanwhile **distractions of major organizational change and cuts** in funding in the MOD in 2000-2005 following the Strategic Defence Review of 1998.

   (6) There was the **outsourcing of the Nimrod Safety Case** in 2004-5 which produced a large amount of paper which said that the aircraft was safe – but it manifestly was not. The Safety Case missed obvious risks.

   (7) And then on 2nd September 2006, following **air-to-air refueling**, the inevitable happened.

9. I also looked carefully into the underlying organizational causes and found a fundamental failure of *Leadership*, *Culture* and *Priorities*. My Report was laid before Parliament in October 2009. I made 84 recommendations (many of which went to clarifying responsibility and simplifying process) which were almost all accepted by the Government.

The Military Aviation Authority

10. I would like to pay tribute to the MOD and to the Military Aviation Authority which, under the outstanding leadership of Air Marshal Sir Timo Anderson KCB DSO,

immediately set about implementing the full lessons of *The Nimrod Review* and is well on the way to building a world-class organization in a remarkably short period of time.

SEVEN THEMES OF NIMROD

11. The following seven themes struck me forcibly as I began to investigate the Nimrod story:

    (1) **Complexity.** The Byzantine complexity of the organisation, the rules, the standards, the safety processes in the MOD was remarkable. Complexity and change had become the altar at which a lot of senior people worshipped – but had become the problem rather than solution.[2]

    (2) **Dilution.** The immediate casualty of this complexity was a dilution of responsibility and accountability – it was difficult to divine who was responsible or accountable for what. Accountability is the 'reciprocal' of Responsibility.

    (3) **Management by committee and consensus**. There were more committees, sub-committees, working parties *etc* dealing with safety-related matters than the UN.

    (4) **Lack of challenge.** There was a culture which rewarded conformity rather than the asking of awkward questions.

    (5) **Migration.** There was a migration of decision-making and budgetary power away from those with most direct working knowledge to those sitting in warm offices back home.

    (6) **Triumph of generalists over specialists.** There was too little appreciation of engineering specialist skills, too great a reverence to for the young MBA.

    (7) **Paper safety.** Safety was increasingly a paper, coloured diagram and PowerPoints exercise, rather than a people, process and cultural matter.

SEVEN LESSONS FROM NIMROD

12. I want to highlight seven particular lessons from *The Nimrod Review* for you:

13. **First, it is important to look at the underlying organisational causes of any major accident.** It is easy to blame the guy with the screwdriver or the joystick or the clipboard in his hand. But it is vital important to examine the fundamental 'organisational causes' of accidents. I found 12 uncanny, and worrying, parallels between the organisational causes of the loss of Nimrod XV230 and the loss of the NASA Space Shuttle '*Columbia*':[3]

[2] A medieval philosophical saying was widely ignored: *"entities should not procreate themselves"*. (Lat. "*entia non sunt multiplicanda praeter necessitatem"*- attributed to the 14th-century English logician, theologian and Franciscan friar Father William of Ockham (d'Okham)).
[3] Chapter 17, *The Nimrod Review*.

(1) The 'can do' attitude and 'perfect place' culture.
(2) Torrent of changes and organisational turmoil.
(3) Imposition of 'business' principles.
(4) Cuts in resources and manpower.
(5) Dangers of outsourcing to contractors.
(6) Dilution of risk management processes.
(7) Dysfunctional databases.
(8) 'PowerPoint engineering'.
(9) Uncertainties as to Out-of-Service date.
(10) 'Normalisation of deviance'.
(11) 'Success-engendered optimism'.
(12) 'The few, the tired'.

14. **Second, beware assumptions.** Certainly, beware making assumptions without being satisfied or checking that the assumptions you are making are valid, sensible and/or still justified. It was assumed that the Nimrod type was safe because it had flown safely for 30 years. Big mistake. It was assumed the Nimrod safety regime was safe because there was a complex safety system. Big mistake. It was assumed that if you outsourced the Safety Case to the original Nimrod manufacturers you could relax. Big mistake. The SAS have a saying which I would like you to remember (if you remember nothing else from my sermon this morning) – which I will express is slightly less colourful language than they do: *"Assumptions are the mother of all [cock-ups]"*.

15. **Third, avoid change for change's sake.** Change can become addictive - but can distract and disrupt people for doing the day job and be dangerous (as well as wasteful). There was constant change in the MOD following the SDR in 1998. I recommended that: *"The Orwellian-named Director General Change MOD be re-named Director General <u>Stability</u> MOD"*.[4]

16. **Fourth, avoid what I call the three 'comfort blankets' of complexity, compliance and consensus.** They can lull one into a (warm) sense of false security and conceal dangers:

    (1) *There is a false comfort in 'complexity'.* As Martin Anderson of the HSE memorably said to me: *"NASA was so complex it could not describe itself to others."* I believe that complexity is more often than not the enemy of safety. Simplicity is your friend.

    (2) *There is a false comfort in 'compliance'.* Compliance with prolix regulations may give one a warm feeling – but (like 'New Math') can lead to a focus on the process rather than the problem.[5]

[4] Chapter 28, *The Nimrod Review*.
[5] And as the enlightened Dutch traffic guru Hans Monderman said and I quote in Chapter 27 of *The Nimrod Review: "The greater the number of prescriptions, the more people's sense of personal responsibility dwindles."* He worked out that if you removed the cornucopia of confusing traffic signs littering some streets, accident rates actually went *down* because both cars and pedestrians took more care and thought about what they were doing, *i.e.* rather than just driving at 30 mph because the sign said so.

(3) *There is a false comfort in 'consensus'.* It is easy for everyone to hold hands and have warm feelings at a meeting about safety but I am a great believer in Mr Awkward at the back of the room throwing the curve-ball.

17. **Fifth, if you have to outsource, it is important not to outsource your thinking and to remain an *'intelligent customer'*.** Companies and government departments have increasingly become hooked on the heroin of outsourcing, which can be a quick fix and get employees off balance sheet. But outsourcing has many perils. It can lead to unclarity as to where risk lies. It can be corrosive to in-house skills, culture and corporate memory. It can be an irreversible mistake to cede control over processes, thinking and decision-making. NASA's shuttle programme had become a *"slimmed down, contractor run operation"* to its ultimate cost. The keys to sensible outsourcing are (a) intelligent and rigorous contracts and (b) remain an 'intelligent customer'.[6]

18. **Sixth, (as Lord Cullen said) Safety Case should be an aid to thinking, not an end in themselves.** I felt strongly that the Safety Case regime[7] had lost its way in certain environments. It had led to a culture of 'paper safety' at the expense of *real* safety and did not represent value for money. Its shortcomings included: bureaucratic length; obscure language; a failure to see the wood for the trees; archaeological documentary exercises; routine outsourcing to Industry; lack of vital operator input; disproportionality; ignoring of age issues; compliance-only exercises; audits of process only; and prior assumptions of safety and 'shelf-ware'.[8] I recommended in the Military Domain that Safety Cases should be renamed *"Risk Cases"* and conform in the future to the six Principles: ***S**uccinct; **H**ome-grown; **A**ccessible; **P**roportionate; **E**asy to understand; and **D**ocument-lite.*[9] Like the Pompidou Centre in Paris, Safety Cases should have their workings visible on the outside.

19. **Seventh, age matters. The age of equipment is important.** Increasingly aging kit – and extensions of out-of-service dates – is an increasing problem.[10] Age matters, but it is not necessarily an insoluble problem. Older kit generally need greater rigour, resources, and vigilance. But with the right care, 'legacy' aircraft can continue to fly safely for many years. It is a question of resources, priorities, and unrelenting attention to detail. Good collection and analysis of data, trends and patterns is vital.[11]

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[6] See recommendations in Chapters 24 and 25 of *The Nimrod Review.*

[7] A 'Safety Case is often defined as *"a structured argument, supported by a body of evidence that provides a compelling, comprehensive and valid case that a system [or platform] is safe for a given application in a given environment".* (*c.f.* DEFSTAN 00-56, para. 9.1; and US military OSS&E system (Operational Safety, Suitability and Effectiveness)).

[8] Many of these criticisms of Safety Cases were not new: see the *Ladbroke Grove Rail Inquiry* and the writings of Professor McDermid's Department at the University of York.

[9] The '***SHAPED'*** Principles – Chapter 22 of *The Nimrod Review.*

[10] Problems of 'legacy' aircraft include: (1) Design to standards which would not be acceptable today; (2) Difficulties of access and maintenance; (3) Diminishing pool of skilled engineers; (4) Decline of 'corporate knowledge' and memory; (5) Dwindling spares; (6) Difficulties of incorporating modifications and new systems; (7) Different aging rates of systems and components; (8) Degradation of components.

[11] The advances in pre-emptive Human Factors (HF) reporting using Human Factors Maintenance Error Management Systems ((M)EMS) are impressive. The great advantage of HF M(EMS) is that it encourages a pro-active reporting and trend analysis culture which focuses attention on the 'below the waterline' near-

Lessons are not new

20. As the head of the HSE, Judith Hackitt, said yesterday "*There are no new accidents*". It is important to remember that many of these lessons to be learned are not new.[12] The organisational causes of the loss of Nimrod XV230 echo other cases, not just the loss of the Space Shuttles *Challenger and Columbia*, but other catastrophic accidents such as the *Zebrugge Disaster* (1987), *King's Cross Fire* (1987), *The Marchioness* (1989) – and more recent ones such as *BP Texas City* (2005) and the recent *BP Gulf* imbroglio.

21. I am a great believer in identifying the right principles and culture and sticking to them.

THE 'LIPS' PRINCIPLES

22. Franklin D. Roosevelt said, "*Rules are not necessarily sacred, principles are*"[13]. In *The Nimrod Review*, I highlighted four principles which I regarded as of paradigm importance: **Leadership, Independence, People (not just Process and Paper) and Simplicity**.[14]

    (1) □ Leadership: **Principle of *Leadership*: There must be strong leadership from the very top, demanding and demonstrating by example active and constant commitment to safety and risk management as an overriding priorities.** As Lord Cullen said in Ladbroke Grove Rail Inquiry Report (2001) "*[T]he first priority for a successful safety culture is leadership*".[15]

    "*When a 3-Star is interested in safety, everyone is interested in safety.*" (Junior RAF officer, 2009)

    "*There was no doubt that the culture at the time had switched. In the days of Sir Colin Terry you had to be on top of airworthiness. By 2004, you had to be on top of your budget, if you wanted to get ahead*". *(Former Senior RAF Officer, 2008)*

    "Generally speaking, organisations behave and teams behave in the way that their management, immediate boss, does, this dictates culture. So if you have a boss in a bank who likes to take risks, his staff will take risks. ...And you end up with a culture of risk." (Witness L [QinetiQ], Safety Engineer, 2009)

    (2) □ Independence: **Principle of *Independence*: There must be thorough independence throughout the regulatory regime, in particular in the setting of safety and risk policy, regulation, auditing and**

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misses, which, if openly and honestly reported in sufficient numbers, provide valuable information and visibility of potential issues *before* an incident or accident occurs. This changes fundamentally the approach of hazard management from reactive to pro-active. (see Chapter 18 of *The Nimrod Review*).

[12] Chapter 17, *The Nimrod Review.*

[13] Franklin D. Roosevelt (1882-1945)

[14] Chapter 20, *The Nimrod Review.*

[15] Ladbroke Grove Rail Inquiry Part 2 Report (2001), Chapter 1, paragraph 1.11.

enforcement. As the Legal Advisor to CAA, Rupert Britton, said to me and I quote in my Report, "*It is important that that regulation is truly independent of operation.*"

(3) *People (not just Process and Paper)*: **Principle of *People*: There must be much greater focus on People in the delivery of high standards of Safety and Airworthiness (and not just on *Process* and *Paper*).** Whatever elaborate Processes and Paper requirements are in place, it is People who ultimately have to ensure they take care, pay attention, think things through and carry out the right tasks and procedures at the right time and exercise caution where necessary. As Defence Nuclear Safety Regulator, Commodore Andrew McFarlane, said to me and I quote in my Report: "*Safety is delivered by people, not paper*".

(4) Simplicity: **Principle of *Simplicity*: Regulatory structures, processes and rules must be as simple and straightforward as possible so that everyone can understand them.** A safe system is generally a simple and stable system. As Director of Engineering, British Airways, Garry Copeland said to me and I quote in my Report: "*We believe hugely in simplicity and stability*".

23. I am a great fan of E.F. Schumacher who wrote 'Small is Beautiful' and said memorably: "*Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius – and a lot of courage – to move in the opposite direction.*"

SAFETY CULTURE

24. I also believe that fostering and maintaining a strong and effective Safety Culture[16] is vital to reducing accidents. It is often said but easily forgotten. There is much to be learned from the work of NASA and the US Joint Planning and Development Office who have adopted Professor James Reason's four-part approach to creating an "Engaged" Safety Culture which includes four elements:[17]

- **A Reporting Culture:** an organisational climate where people readily report problems, errors and near misses.
- **A Just Culture:** strikes a sensible balance between a 'blame culture' and a 'blame-free culture', *i.e.* between holding people properly accountable for their acts or omissions and ensuring the right lessons are learned for the future.
- **A Flexible Culture:** a culture that can adapt to changing circumstances and demands while maintaining its focus on safety.

[16] *"Safety culture is that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, safety issues receive the attention warranted by their significance"* (International Nuclear Safety Advisory Group).

[17] Professor Reason's composite approach has been adopted by NASA and the US Joint Planning and Development Office (JPDO) in its NextGen project to account for a three-fold increase in air traffic by 2025.

- **A Learning Culture:** the willingness and competence to draw the right conclusions from its safety information and the will to implement major safety reforms.

Fifth Culture

25. To the four NASA cultures, a **Reporting Culture, a Just Culture, a Flexible Culture, a Learning Culture,** I have added a fifth – and I believe vital – element:

    - **A Questioning Culture:**1 It is vital to ask "*What if?*" and "*Why?*" questions.

26. The keystone of a strong Safety Culture is, in my view, however, is this vital fifth element, namely a '*Questioning Culture*'. At all stages of the safety pilgrimage it is vital to ask questions such as "*What if?*", "*Why?*", "*Can you explain?*", "*Can you show me?*", "*Can you prove it?*". As a presaged earlier, Questions are the antidote to assumptions, which so often incubate mistakes. It is important always to think.

<u>Four states of man</u>

27. There are to my mind four states of Man: *Risk Ignorant, Risk Cavalier, Risk Averse* and (the state what I advocate in Nimrod one should aim for) *Risk Sensible*.[18] My big message is to encourage everybody not to be *Risk Ignorant, Risk Cavalier,* or *Risk Averse*, but to be *Risk Sensible.*

28. It is tempting to parcel risk and the 'safety thing' up into neat packages, PowerPoints or graphs and statistics and, after a committee meeting with all the 'stakeholders present', tie them up and hand them back to the relevant corporate risk department with a pat on the head and a thank you. Risk is Safety, however, is everyone's personal responsibility. And it starts at the very top – and should cascade right through the organisation.

29. Being *Risk Sensible* means embracing risk, unbundling it, analysing it and taking a measured and balanced view.

30. What I want to do is encourage everybody, from the top to bottom of every organisation, whether military, civilian, public or private, governmental or NGO, to embrace risk and responsibility on a personal and collective basis. Unbundle risks, look at the pros and cons and make sensible decisions. Everybody has a role to play, but the role of you as leaders is critical to this endeavour.

31. In times of increasingly scarce resources and financial pressures, how do you get that balance right? One of the ways is to focus your time, energy and resources on areas that you think really matter in terms of *outcomes*. Don't be misty-eyed about safety. Be hard-nosed. Look at the stats and see what you most common, serious and habitual risks are and target those. Share and discuss knowledge, experiences, concerns and *outcomes* with colleagues, industry and regulators.

[18] *"Risk Sensible"* is referred to in *e.g. The Monro Review* on Child Protection 2011.

Inconvenient truths

32. There are four 'inconvenient truths' which form the backdrop to any discussion of risk in today's oil world and make this conference especially important:

    (a) First, like it or not, we live in an instant media and internet age - with 24/7 TV News coverage, the Web, blogs, and tweeting, *etc.*- and increasing public scepticism – regarding government and 'big business' and the need to hold 'grey suits' to account..

    (b) Second, we live in a consumer and litigious age of burgeoning 'rights' of all kinds – and multi-party litigation.

    (c) Third, there is an insatiable demand for oil and gas – and greater technical challenges and risks to be faced in satisfying that demand.

    (d) Fourth, there is a great deal of 'legacy' equipment out there, rigs which are past their original out-of-service dates – and how to deal with that equipment is something of a time-bomb.

Self-preservation' Management and Regulation

33. There is an increasing tendency towards what I call the 'Self-preservation' Management and Regulation. By this I mean three things in particular:

    (1) First, an increase in *Defensive engineering* (*i.e.* being over-cautious, being reluctant to take decisions, unnecessary outsourcing, over specifying and including a *plethora* of unnecessary checks);

    (2) Second, further *Dilution of Responsibility* (*i.e.* shedding, spreading and delegating responsibility far and wide so that the picture as to ultimate responsibility is unclear and diffuse); and

    (3) Third, more (of what I call) *Promiscuous Procedure* (*i.e.* organisations and individuals wrapping themselves in a protective blanket of more and more procedure and becoming slaves to process, box-ticking and paperwork).

34. These tendencies have a baleful effect on safety and must be halted and reversed.

SUMMARY

35. In summary, I advocate in *The Nimrod Review* three things in particular:

    (a) a return to a focus on, and belief in, core values and technical skills;

    (b) a tightening of lines of responsibility and the clear identification of Duty Holders; and

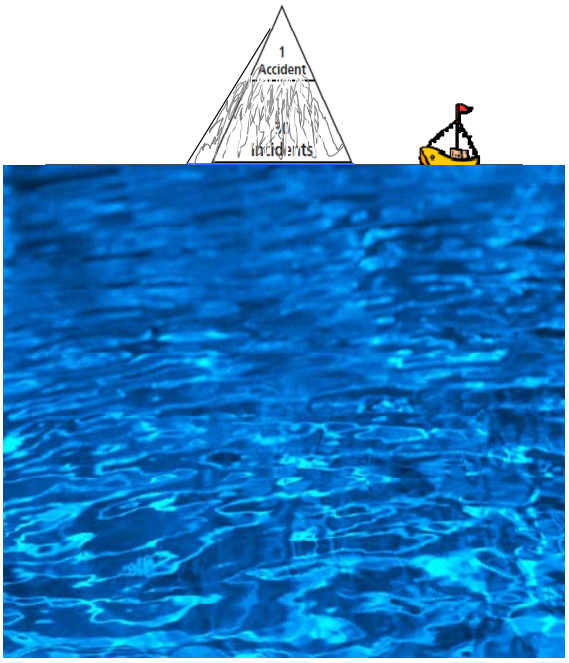
    (c) a rolling back of the comfort blanket of procedure and, above all, simplifying process.

POWERPOINTS

36. I recommend in my Report: *"The ubiquitous use of PowerPoint should be discouraged. It can lead the audience to watch rather than think".*[19] But here are a few which you may find useful:-

ICE-BERG

37. Imagine an ice-berg – and plain sailing around it:



[19] *The Nimrod Review,* Recommendation 28.2**.**

HEINRICH'S TRIANGLE

38. But it is what lies beneath the surface that really matters:

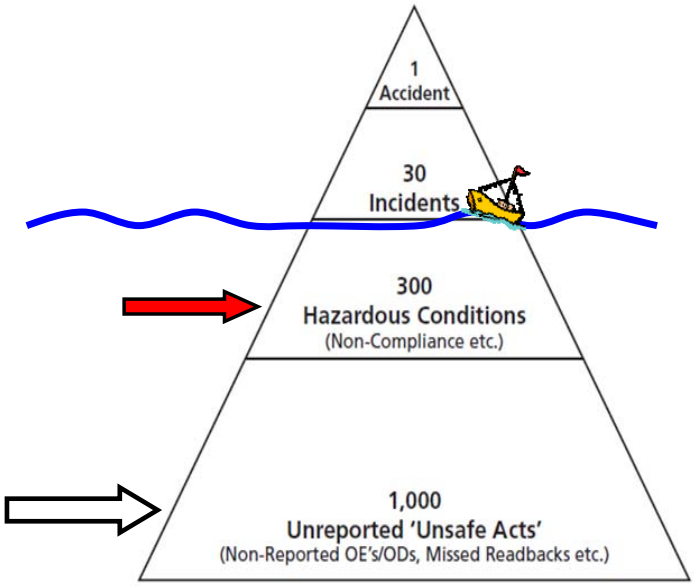


Figure 18.5: Examples of Heinrich's Triangle

39. Heinrich was clever and inspired. His analysed a series of 1920s industrial accidents and drew "*Heinrich's Triangle*" showing the relationship between low-level deviations and accidents. Ratios of 600:1 are often reported. The example above illustrates data reported from air traffic management about the number of low level Operational Errors (OE) and Operational Deviations (OD). Whatever the precise ratio in any given field, the key point is to capture and understand these low level errors and deviations before they conspire to cause an incident or accident. It is important that errors and 'near misses' are reported to accident investigators.[20] Mine the data from the bottom. Avoid having to learn from your own headline accident.

Accident theory

40. It pays to have an understanding of Accident Theory, particularly in the context of managing safety in relation to high-risk technologies. I recommend study of the work of the leading academics in the field such as James Reason, Charles Perrow, Scott Sagan, Diane Vaughan, and Karl Weick.[21] There are two main Accident Theories: *Normal Accident Theory* and *High Reliability Theory*. Their proponents

[20] As Professor John McDermid of York University has pointed out, there are many 'low-level' errors which are precursors of, and hence warnings of, impending accidents. He emphasises, *"Good safety management identifies these low-level issues and feeds them back to reduce risk"* (JA McDermid, PHD, FREng, University of York, *Through Life Safety Management: Some Concepts and Issues, 2007*).
[21] Chapter 18, *The Nimrod Review.*

share the same goal, *i.e.* effective safety management at both an individual and an organisational level.

(1) *Normal Accident Theory*: 'Normal Accident Theory' holds that, when technologies become very complex and 'tightly coupled', accidents become inevitable and therefore, in a sense, 'normal'. This theory takes a pessimistic, but not defeatist, view of the ability of organisations and individuals to manage high risk technologies.

(2) *High Reliability Theory*: 'High Reliability Theory' argues that organisations responsible for operating high risk technologies can successfully compensate for inevitable human shortcomings which would normally lead to catastrophic failures. Proper design, management and training are seen as important requisites for being a highly reliable organisation. Both sets of theorists share the same goal, *i.e.* effective safety management at both an individual and an organisational level, but differ about the degree to which it is ultimately possible to avoid errors, incidents, accidents, and catastrophes. Both strive to achieve the 'dynamic non-event' that represents 'reliability' in high-risk technologies. It is 'dynamic' because processes remain within acceptable limits due to moment-to-moment adjustments and compensations by the human operators. It is a 'non-event' because safe outcomes claim little or no attention. The paradox is rooted in the fact that accidents are salient, while 'normalcy' is not.

41. In my view, there is value in both philosophies, but neither has a monopoly on veracity. The pessimism of Normal Accident theory must give way to rigorous and pro-active safety management during one's tenure of responsibility. The optimism of High Reliability must yield to human fallibility and the truth that *"...the one hazard for which there is no technological remedy: the insidious concatenation of latent human failures that are an inevitable part of any large organisation."* (James Reason, *Human Error*, 1990, page 250).

THE *'SWISS CHEESE'* AND *'BOW TIE' MODELS*

42. I am sure that most of you will have seen or heard of the Swiss Cheese Model. Professor James Reason's inspired way of illustrating how accidents occur:

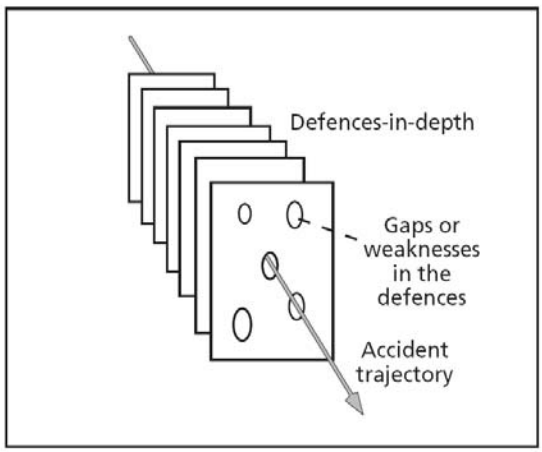


Figure 18.1: Classic 'Swiss Cheese' Model from Beyond Aviation Human Factors (Ashgate Publishing)

43. Applied to the Nimrod story, the 'Swiss Cheese' model looks like this (and gives you a clear idea of the long gestation period that this sort of catastrophic accident can have):

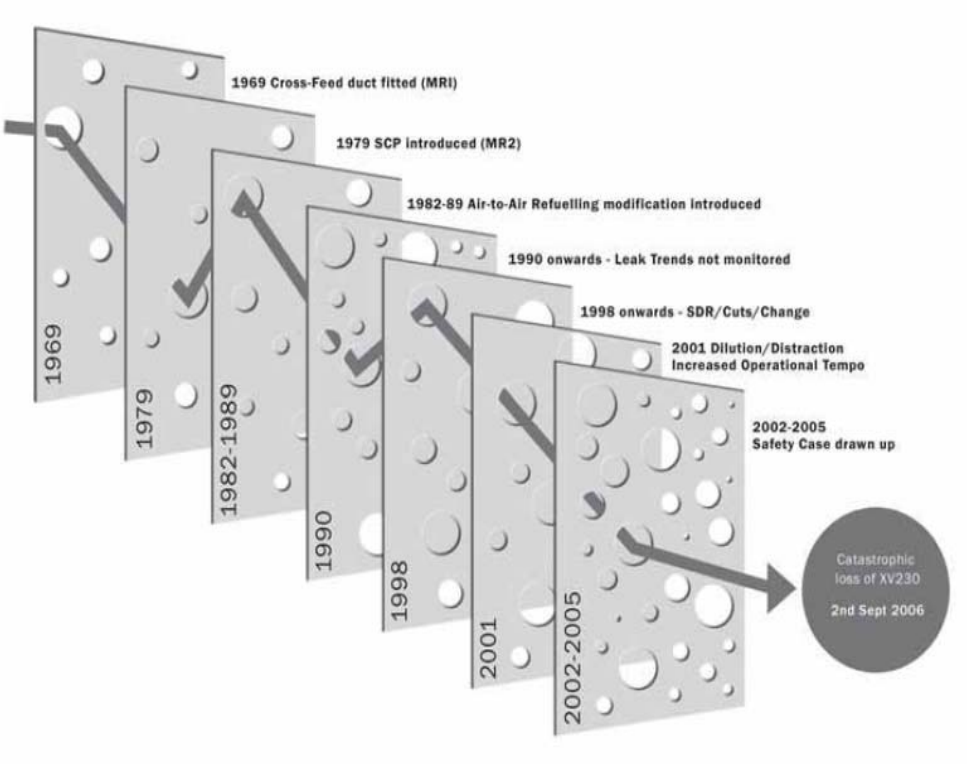


Figure 18.2: 'Swiss Cheese' Model as applied to XV230

44. You may also be have seen the '*Bow Tie*' model which elegantly distinguishes between the two distinct categories of defences, preventative and ameliorating measures.

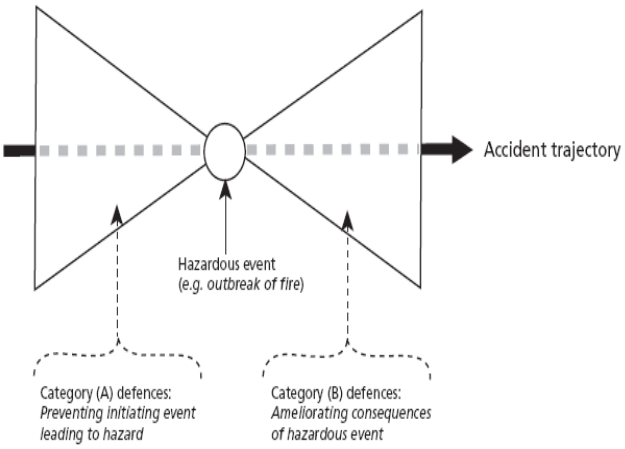


Figure 18.3: Classic 'Bow Tie' Model

H-C's COMPOSITE MODEL

45. In order to aid understanding of accident theory, I have combined Professor James Reason's classic 'Swiss Cheese' and the 'Bow Tie' models to form a composite 3-D model which may prove a useful tool in illustrating how the various layers of defences and the 'hierarchy' of preventative and ameliorating measures may be logically placed. It can also be a valuable management and teaching tool to help explain to those tasked with particular responsibilities, where they sit in the chain and why their particular role is important in the overall preventative scheme.

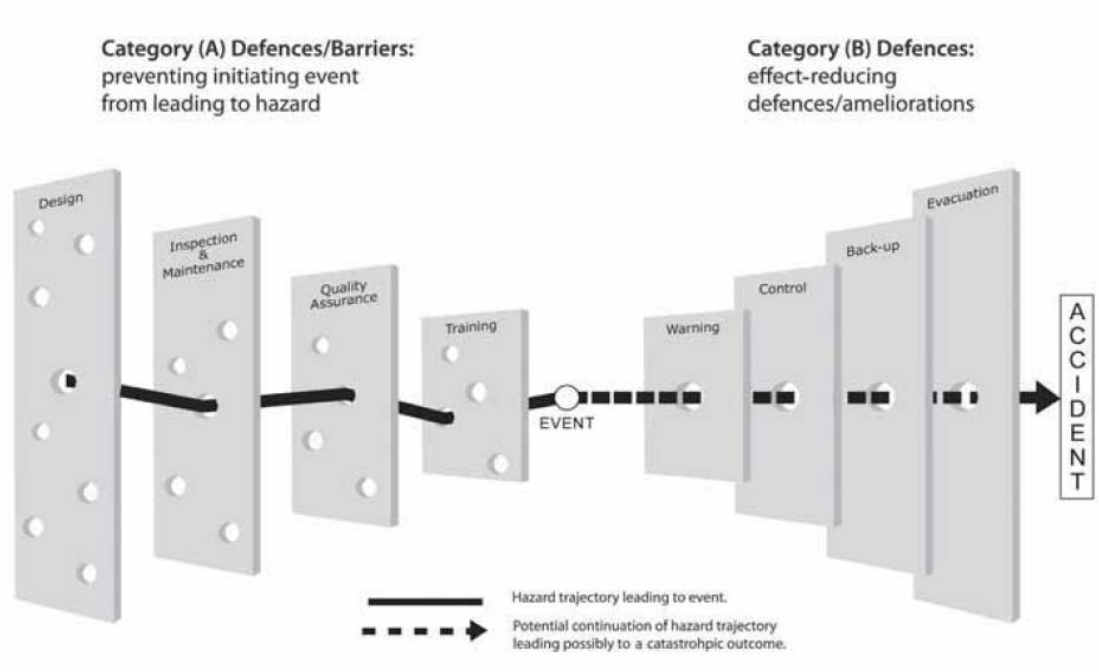


Figure 18.4: 'Composite Model'

AGE MATTERS

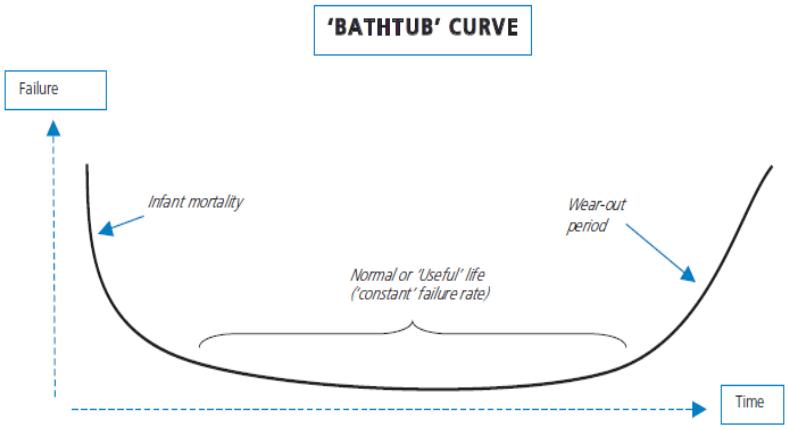


Figure 23.1 The 'bathtub' Curve

46. It is important to remind oneself regularly of the trusty 'bath curve'. Age is no bar to continued success – but the older kit gets, generally the greater vigilance, maintenance and resources is required to keep it up to scratch. It is a question of resources, priorities, and unrelenting attention to detail.

47. In the late 1990s, the Nimrod fleet was already beginning to be described as "*old*" and reaching the end of the 'bathtub' curve. The generic problems in relation to some aged and 'legacy' aircraft include:

(1) Design to standards which would not be acceptable today;
(2) Difficulties of access and maintenance;
(3) Diminishing pool of skilled engineers;
(4) Decline of 'corporate knowledge';
(5) Dwindling spares;
(6) Difficulties of incorporating modifications and new systems;
(7) Different aging rates of systems and components; and
(8) Degradation of components.

COMPLEXITY and SIMPLICITY

48. In 1990s the organizational structure of the MOD looked like this:

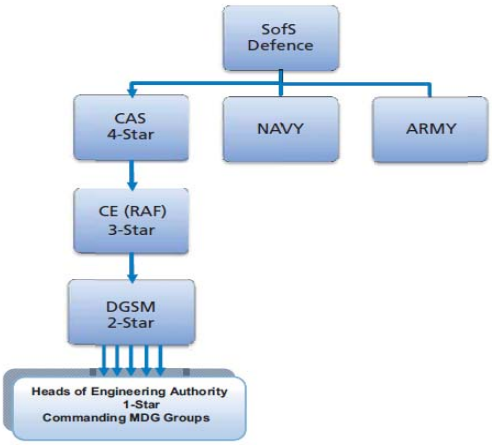
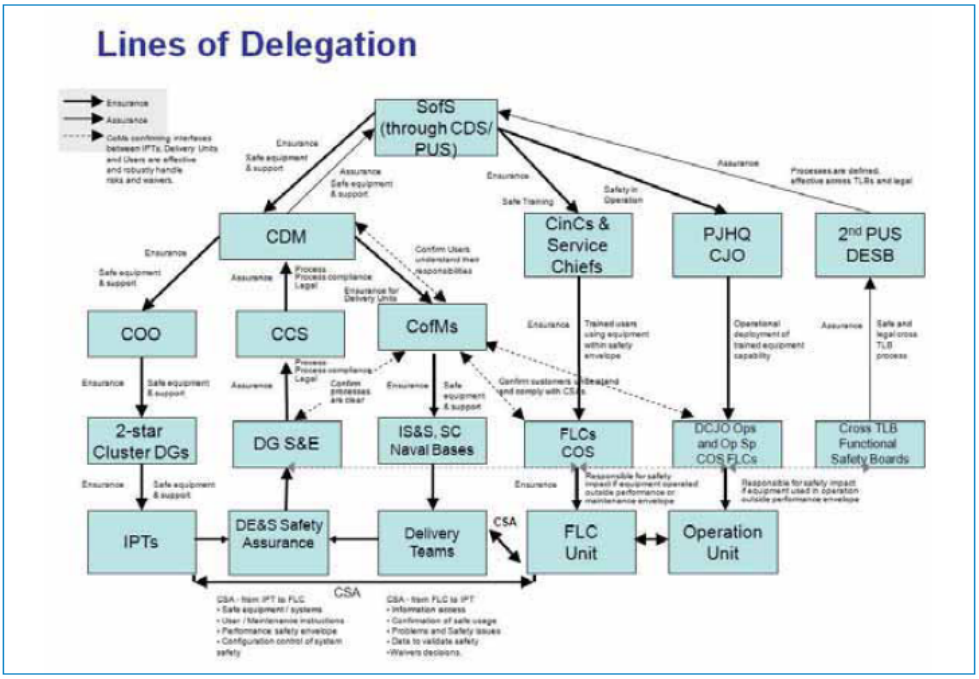


Figure 13.4: Chain of delegation for airworthiness in 1990s

49. By 2005 the organizational structure of the MOD looked like this:



FIFTH CULTURE

50. My final slide illustrates the four NASA cultures, a **Reporting Culture, a Just Culture, a Flexible Culture, a Learning Culture,** to which I have added a fifth – and I believe vital – element: **A Questioning** Culture. As I have said, it is vital to ask questions such as "*What if?*", "*Why?*", "*Can you explain?*", "*Can you show me?*", "*Can you prove it?*". Questions are the antidote to assumptions, which so often incubate mistakes. It is important always to think.

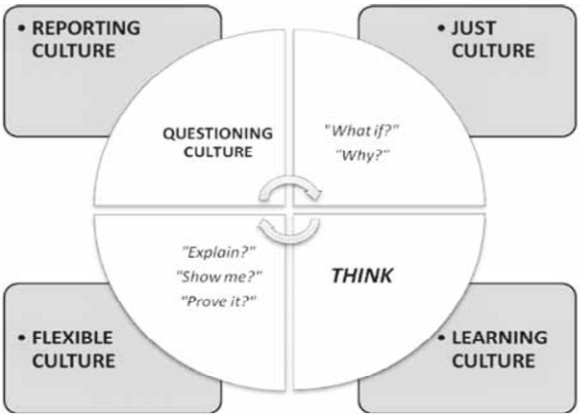


Figure 27.1: Engaged Organisation and Safety Culture

51. Thank you. I wish you every success with this great conference.

CH-C
Aberdeen,
19th June 2013
