The Human Factor
Looking forward – Looking back

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Yesterday, Today and Tomorrow

- Tripod – Accident Causation
- Inter-regnum – Why do People do these things?
- Safety Culture
- Hearts and Minds – Intrinsic motivation for HSE
- The theory – wrapping it all together
- The challenges still to come

Yesterday

- Tripod research program started beginning 1987
- Jim Reason had proposed Pathogens
- Willem-Albert Wagenaar had the 'impossible accident'
- Shell funded us under the heading Accident Causation
- Primary focus was always on major accidents, personal safety was secondary
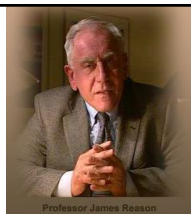
Seminal Events

- Piper Alpha
- The Herald of Free Enterprise
- Chernobyl
- The Challenger

- These events were what we wanted
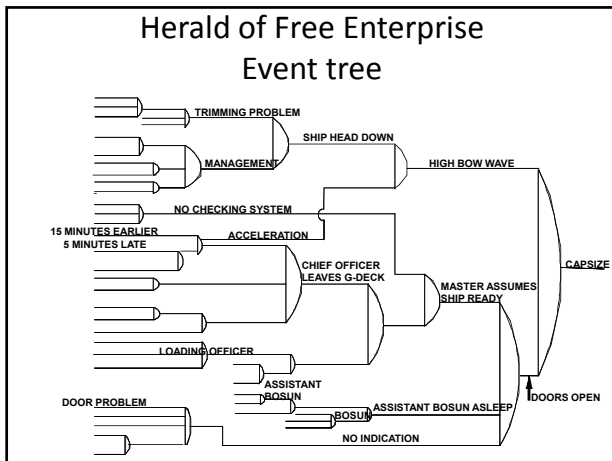 - To understand – as scientists
  - To prevent – as consultants

Piper Alpha
167 dead

The Herald of Free Enterprise
183 dead

Herald of Free Enterprise
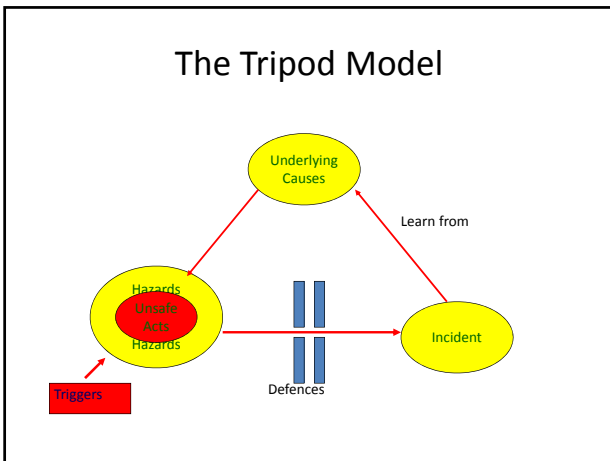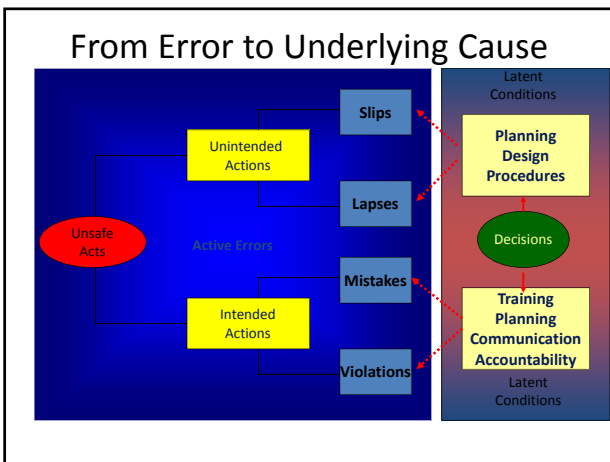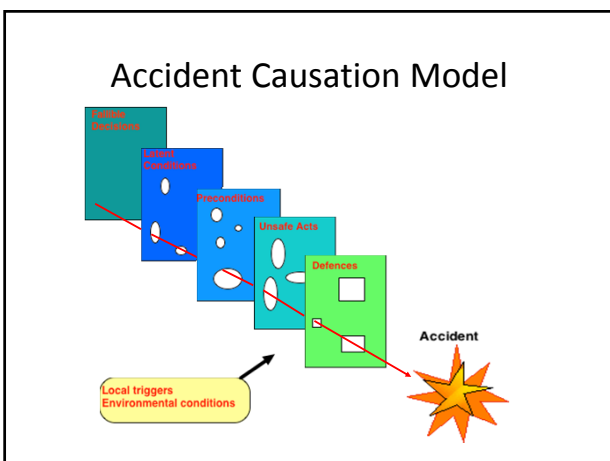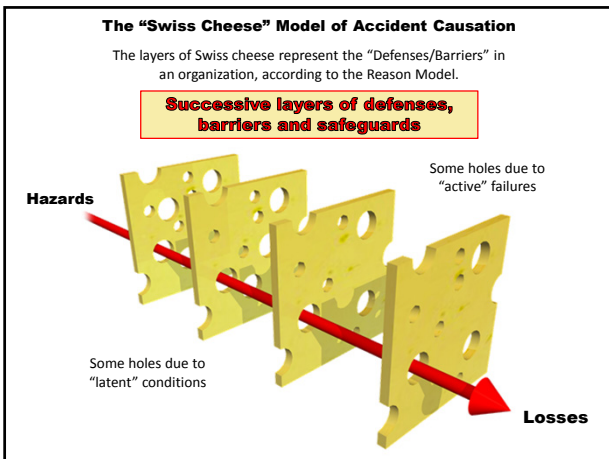## Event tree

Accident Complexity

- Industrial accidents are complex events
  - The number of 'causes' easily exceeds 100
- The number of causes identified is limited by funding (Moshansky's analysis of Dryden)
- Technical issues are restricted to the later proximate causes
- Human beings are 'causal' going all the way back
  - As individuals, supervisors, managers, owners etc

The Tripod Model

Underlying Causes

Learn from

Hazards
Unsafe Acts
Hazards

Incident

Triggers

Defences

From Error to Underlying Cause

Latent Conditions

Slips

Unintended Actions

Planning Design Procedures

Lapses

Unsafe Acts

Active Errors

Decisions

Mistakes

Training Planning Communication Accountability

Intended Actions

Violations

Latent Conditions

Accident Causation Model

Fallible Decisions

Latent Conditions

Preconditions

Unsafe Acts

Defences

Accident

Local triggers
Environmental conditions

The "Swiss Cheese" Model of Accident Causation

The layers of Swiss cheese represent the "Defenses/Barriers" in an organization, according to the Reason Model.

Successive layers of defenses, barriers and safeguards

Hazards

Some holes due to "active" failures

Some holes due to "latent" conditions
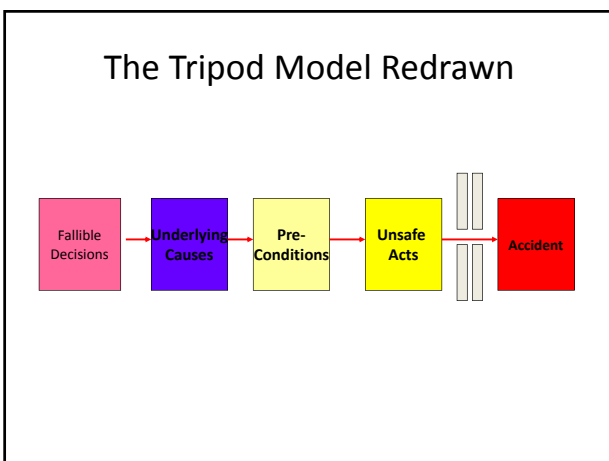
Losses

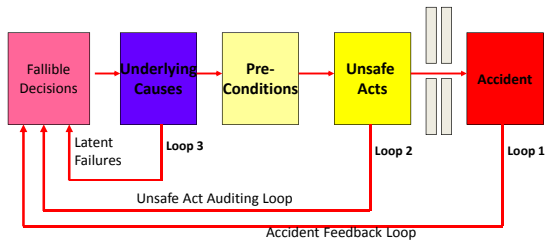## Two Approaches

Reactive
– From Accident to Decision-making
– Easier to do but requires accidents

Proactive
– From Latent Conditions to Decision-making
– Requires setting up an auditing system

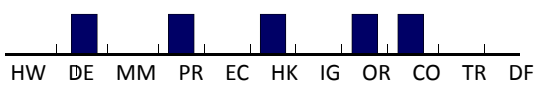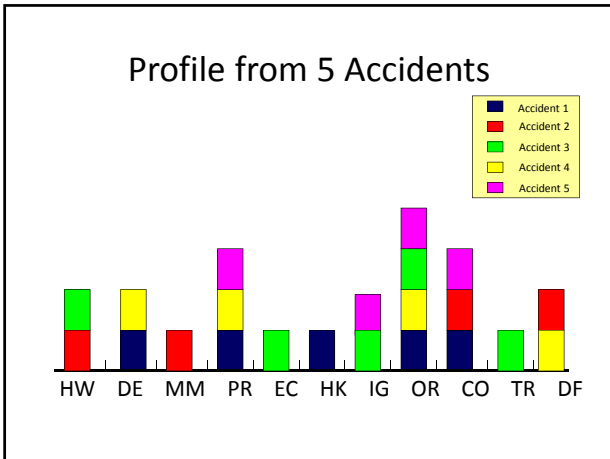## The Tripod Model Redrawn

Fallible Decisions → Underlying Causes → Pre-Conditions → Unsafe Acts → Accident

Feedback Loops

Tripod Beta - The Complete Tree

Profile from 1 Accident

HW   DE   MM   PR   EC   HK   IG   OR   CO   TR   DF
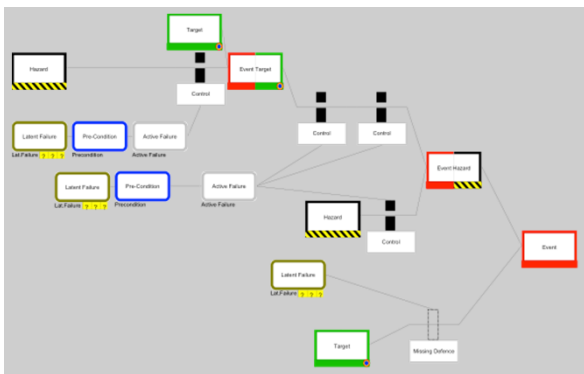
Profile from 5 Accidents

Tripod DELTA
Proactive Latent Failure Auditing

- Distinguish a useful set of Dimensions
- Develop a database of indicators for each dimension
  - Negative   Failure to meet standard
  - Positive   Evidence of meeting standard
- Make a test by scoring indicators
- Develop a Failure State Profile
- Profile can identify areas for concern (latent conditions)
- Profiles can also identify areas of strength
- Improvement plans can be based on using what goes well to fix what doesn't

Failure State Profile

Failure State Profile

Failure Score

HW DE MM PR EC HK IG OR CO TR DF

-1 σ

μ

+1 σ
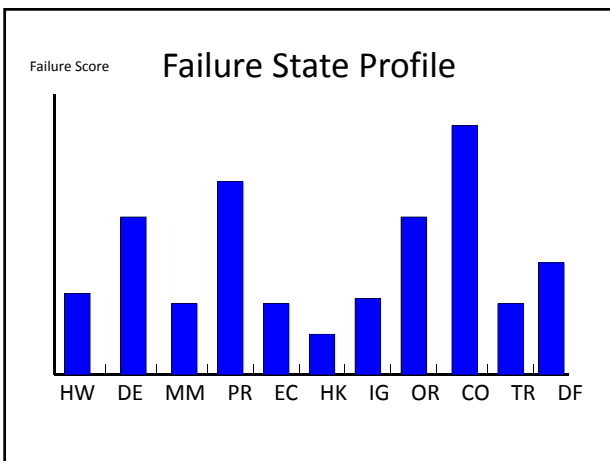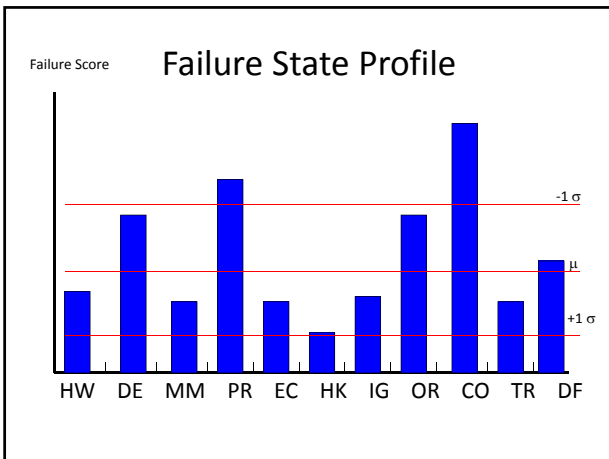
Conclusions of Tripod Research

- The most important causes of Accidents are Latent Failures, waiting to happen
- Reactive Analysis allows us to uncover Latent Failures
- Proactive techniques can do this without incidents
- We don't need accidents to improve
- Many organisational cultures, nevertheless, often need accidents to do anything

- First reference to culture in presentations

The Resilientists

- At this point the Tripod team was identified in the Royal Society special issue (1992) as 'The resilientists'
- As opposed to 'the anticipationists'
- Classical approaches to risk analyses were seen as imagination limited
- Our approach in Tripod Delta was based on what was
  - Good practice
  - What made accidents *less* likely

## Shell's versions

- The model was always understood as pointing up the organisational structure
- Shell, the customer, added levels of responsibility to the layers of cheese going backwards
- Use of the model in Shell Oil was restricted to legally privileged investigations
- I wasn't allowed into the USA until 1998 when Shell Group 'took over' Shell Oil

Incident Prevention

Became extended

Swiss Cheese
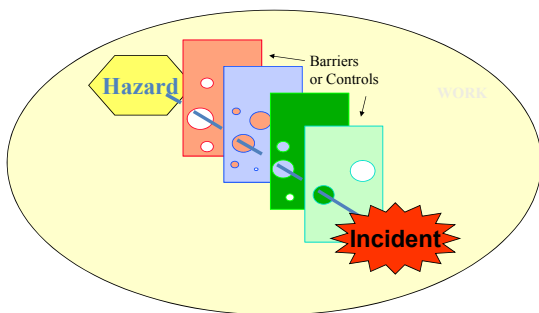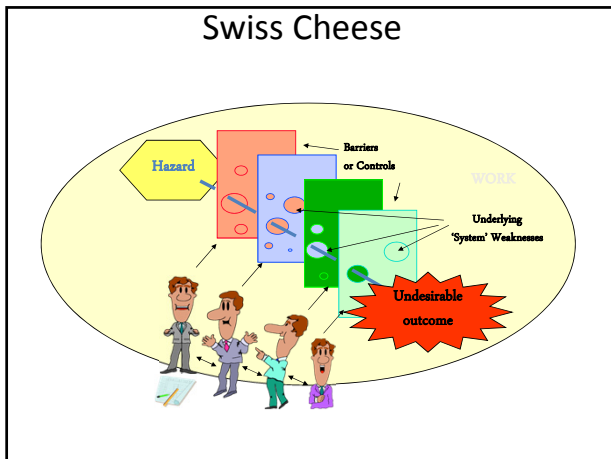
Inter-regnum

- After Tripod had been delivered there were a number of issues clear
1. Violation was a common immediate cause of accidents, but some violators were also more senior
2. Costs of accidents were unclear
    - Was safety a cost or an investment?
3. Studies for Shell Aircraft in 1992 had delivered the Rule of Three as a preventative tool
    - The environment in which accidents take place is complex
    - Summing any three oranges can sum to red

Errors and violations
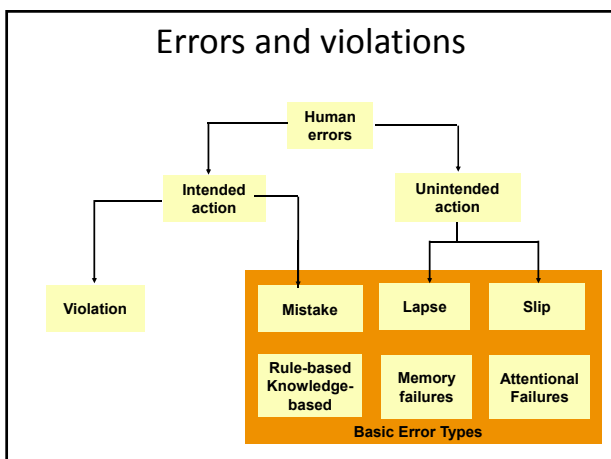
Major study on Rule-Breaking (Violation/non-compliance)

- Survey/interview study of 95 North Sea staff at all levels
- UK and Dutch sectors (no differences)
- Very believable responses on rule-breaking
  - Identical high frequency of rule-breaking in both interview and postal studies
- Led to the "Violation Manual"
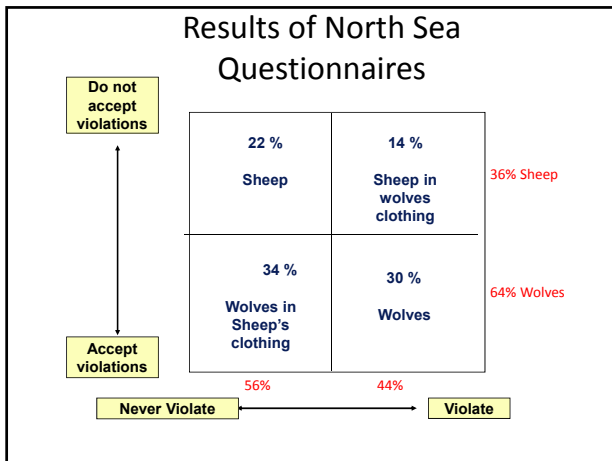 - Considerable interest inside Shell and industry
  - No further effect on behaviours

Results of North Sea Questionnaires

Do not accept violations		
	22 % Sheep	14 % Sheep in wolves clothing	36% Sheep
	34 % Wolves in Sheep's clothing	30 % Wolves	64% Wolves
Accept violations	56%	44%	
	Never Violate	Violate	

The Behavioural Cause Model
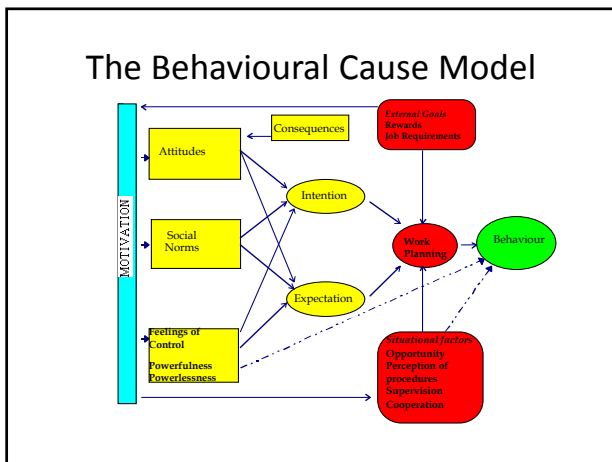
The Principal Factors

- Planning (Action, Job, Pre-planning)
- External Factors (Pay, Rewards, Supervision)
- Opportunity
- Intention and Expectation
- Attitudes (Beliefs, Values, Consequences)
- Norms (Group, Personal)
- Feeling of Control (Powerfulness,Powerlessness)

Testing the Model

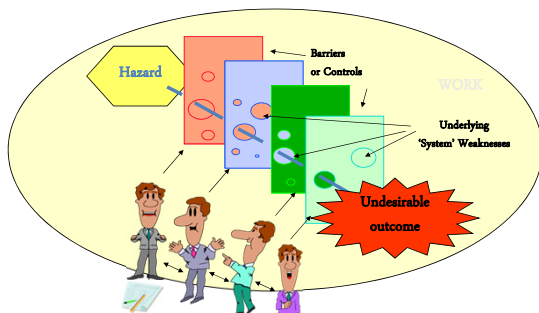| Factors	Cum	Var
1. Action Planning	9.9%	9.9%
2. Pre-planning; Opportunity; Job planning	26.2%	16.3%
3. Expectation	43.2%	17.0%
4. Intention	44.3%	1.1%
5. Attitudes	44.9%	0.6%
6. Powerfulness; Powerlessness	59.3%	14.4%
7. Compliance; Conformity	60.6%	1.3%
8. Personal Norms	60.8%	0.2%
14. Routine Violations	61.5%	0.7%
20. Rewards; Pay; Supervision etc	64.2%	2.7%

The Lethal Cocktail
The Main Predictors

Expectation	Expectation that rules will have to be bent to get the work done
Powerfulness	The feeling that one has the ability and experience to do the job without slavishly following the procedures
Opportunities	Seeing opportunities that present themselves for short cuts or to do things 'better'
Planning	Inadequate work planning and advance preparation, leading to working 'on the fly' and solving problems as they arise

Swiss Cheese needs context

Core System Elements

Stages in the development and investigation of an organisational accident
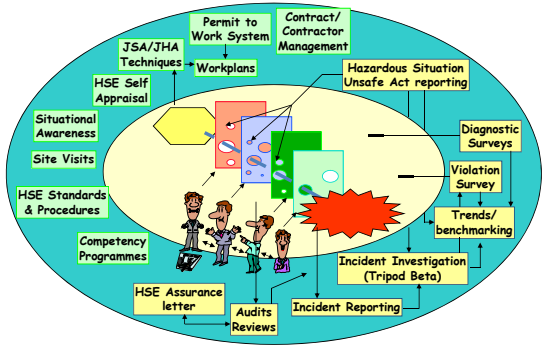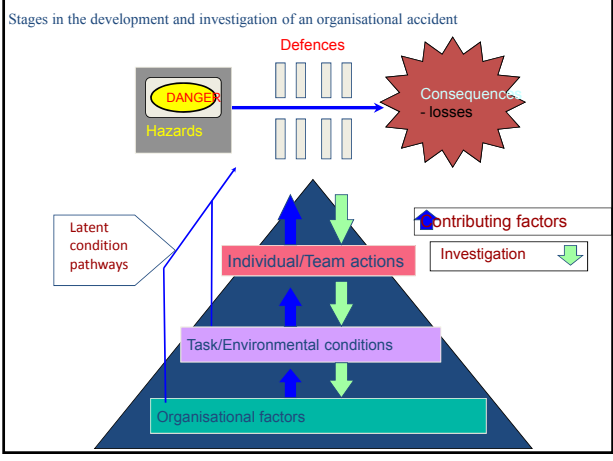
Why don't the
HSE-Management System elements
always work?

The Causes of Causes

Custom
    Bad Habits
    "How We Do Things Round Here"
Resources
    Time
    People
    Money
Decision Making
    No Decisions Made
    Poor Information used
    Distance and Asynchrony
Organisational
    Accountability
    Responsibility

The Rule of Three

- Accidents have many causes (50+)
- A number of dimensions were marginal
- Marginal conditions score as Orange
- NO-Go conditions score as Red

- The Rule of 3 is Three Oranges = Red

Aircraft Operation Dimensions

- Crew Factors Experience, Duty time, CRM
- Aircraft Perf. Category, Aids, Fuel, ADDs
- Weather Cloud base, wind, density alt, icing, wind
- Airfield Nav Aids, ATC, Dimensions, Topography
- Environment Night/day, Traffic, en route situation
- Plan Change, Adequacy, Pressures, Timing
- Platform Design, Stability, Management

The Rule of Three
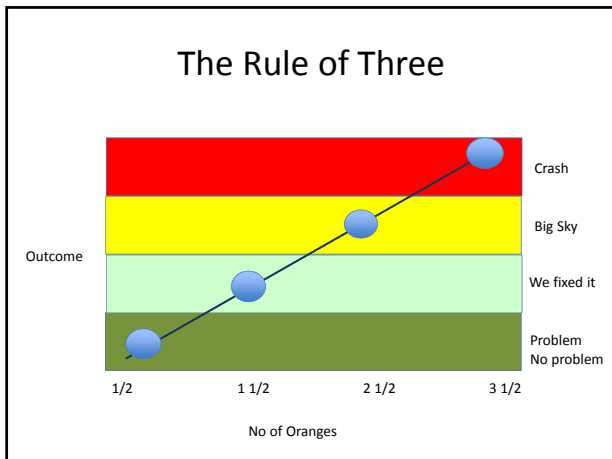
Why does the rule work?

- People use cognitive capacity to allow for increasing risk
- As the oranges increase the remaining available capacity is reduced
- At 3 oranges there is little available capacity remaining
- Any trigger can de-stabilize the system
- An accident suddenly becomes very likely

The Edge
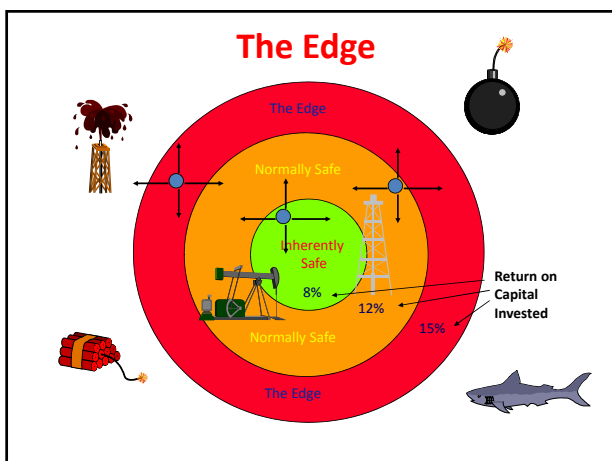
Culture rears its head

- Culture had been discussed from the start
- Ron Westrum's 3-stage level of communication was first presented at the World Bank workshop in 1988
  - Pathological, Bureaucratic, Generative
- Jim Reason had about 8 stages
  - Incipient Reactive; Worried Reactive; Conservative Calculative etc
- 5-stage model first presented by me at OECD workshop on accident causation Tokyo 1992
- One common element of culture identified how organisations deal with rule-breaking
  - The Just Culture became a trend

The Safety Culture Ladder

The Just Culture version 1

A Just and Fair Culture v 3

Just and Fair Culture

- Need seen to have positive as well as negative components in the process
- Understanding that violation does not take place in a managerial vacuum
- Realisation that errors and violations could be brought under a single umbrella
  - Recognition both are symptoms of organisational issues

- Concentration on individuals, but right up the line
  - Initial evaluations at time of sacking of Shell CEO for mishandling the Reserves Problem

The old discredited model

Were the actions as intended? — NO → Knowingly Violating Procedures? — NO → Pass Substitution Test? — YES → History of Violating Procedures?

YES — NO — YES — NO — NO

Were the results as intended? | Procedure Clear and Workable? | | | NO Blame Error

YES — YES — NO — YES

Sabotage or Malevolent Act | Violation | System Induced Violation | Negligent Error | System Produced Error

Diminishing Individual Culpability >> — COACHING
VERBAL WARNING
FIRST WARNING LETTER
FINAL WARNING LETTER
DISMISSAL — << Increasing Individual Culpability

| Expected			Human error	Routine
Normal behaviour 'I did my job the way I'm supposed to, according to all rules and good practices.'			**Slips and lapses** 'Oops'	'Does this happen a lot?'
	Behaviour at or above expectation; Identify action, performance or behaviour that deserves recognition or reward.	Behaviour below expectation; Identify all the actions and choose the right classification.	**Mistakes** 'I thought I did the right thing'	
Intervention 'I identified unsafe acts/conditions, stopped work and made or suggested improvements'			**Violation**	**Routine**
Exemplary			**Unintended** 'I was not aware' 'I did not understand'	'Would others do it that way?'
Creating a more effective work environment 'I helped us understand and improve our work environment'	Action or behaviour to which you want to apply appropriate consequences		**Situational** 'I cannot get the job done if I follow the rules, but I did the job anyway'	and/or 'Does this person have a history of violating?'
Excellent planning and Risk management 'I avoided Human Error and the creation of situations that lead to violations'	START HERE		**Organisational Optimising** 'It was better for the company to do it that way'	
Effective sharing of lessons learned 'I helped others learn from failures and successes'			**Personal Optimising** 'It suited me better to do it that way'	
Other 'I did something exceptional that had a desirable outcome but does not fit the previous descriptions'			**Reckless** 'I did not think or care about the consequences'	

What is a culture?

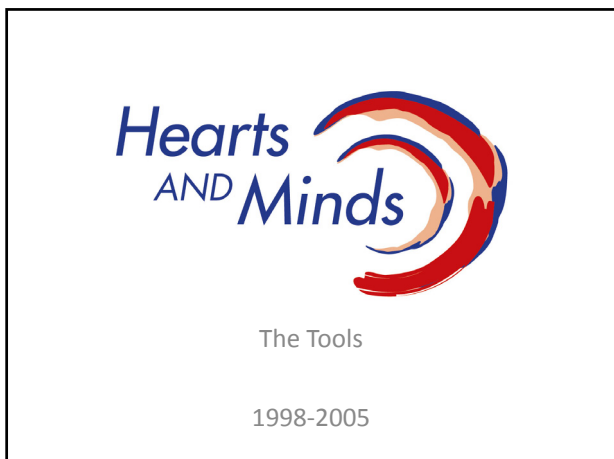What is a safety culture?

Organisational Culture

- Common internal characteristic of company
- Invisible to those inside, obvious to outsiders
- Common **Values** and **Beliefs** - <u>Static</u>
- Common **Working Practices** and **Problem-Solving Methods -** <u>Dynamic</u>
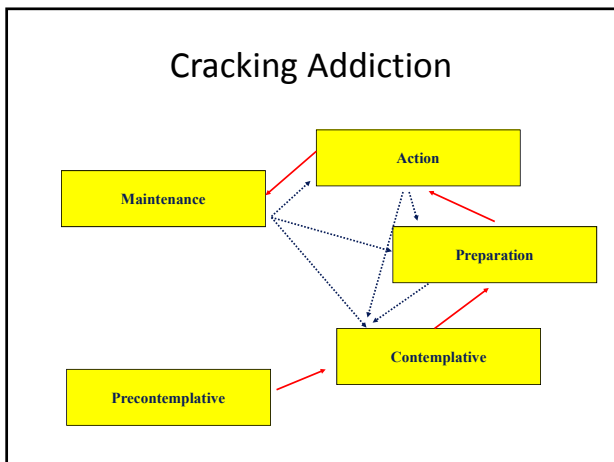- Commonality leads to **Interoperability - a major strength**
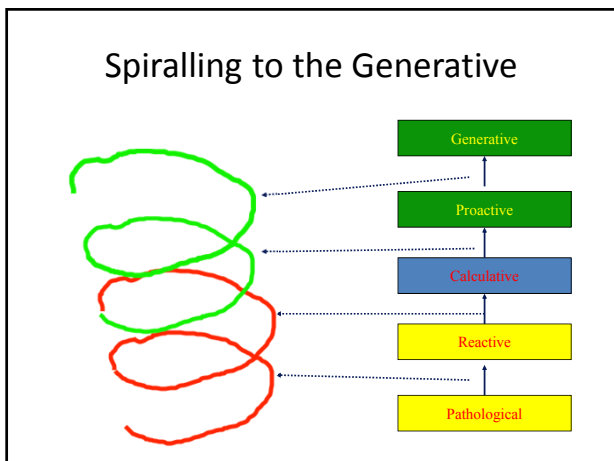
An Analogue to the Accident Model
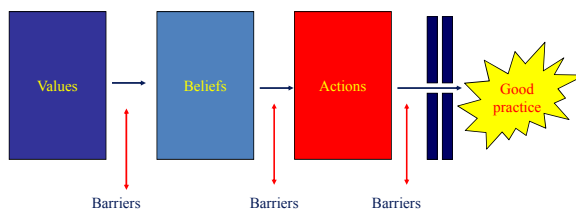
How can you do this

- OGP Human Factors Workshop in Wassenaar (NL) 2000
- Culture became a major topic
  - Attendees Rhona Flin, Sue Cox, Dianne Parker, Me
- 5-stage ladder provided a roadmap to cultural improvement
- Agreement by a number of major players to fund a study of the ladder
  - Shell, Exxon, BP, Chevron, Schlumberger, Western Geophysical

Hearts AND Minds

The Tools

1998-2005

Cracking Addiction

Action

Maintenance

Preparation

Contemplative

Precontemplative

Spiralling to the Generative

Generative

Proactive

Calculative

Reactive

Pathological

Hearts and Minds tools

- Brochures designed to support small groups
  - Work together finding ways to solve their problems
- Brochures are small and self-contained for non-experts
  - Science designed into process and worksheets
  - Facilitation by local people (managers, supervisors, HSE staff)
- Methods are those people are already used to
  - Syndicate groups taking 1-3 hours to identify **and solve** problems
  - Gap analysis - give an engineer a gap and they will fill it
- Centrefolds can be used in stand-alone mode
  - Brochures provide background and facilitator information
- Brochures similar in format to reduce learning time
  - Contents vary but commonalities are identified and used
- Tools designed to minimise need for outside facilitation

Tools available	What they do and When to use them
HSE Understanding your Culture	**What:** An engagement tool to identify local strengths and weaknesses identifying a way to improve. **When:** Use 1st to engage people, discover their aspirations and build a case for change (2-3 hours + follow up).
Seeing Yourself as Others See You	**What:** HSE upwards appraisal tool to understand other's perceptions and identify how commitment is turned into action. **When:** Use 2nd to challenge the commitment and behaviours of any "safety leaders", (20 minutes + follow up).
Making Change Last	**What:** A general tool for managing change and supporting any improvement process or organisational change programmes. **When:** To design your own tools (1 –2 hours to start).
Risk Assessment Matrix: Bringing it to life	**What:** Helps people understand their risks, makes them personal and stimulate action. **When:** Anytime to better manage the risks. (1 hour).
Achieving Situation Awareness: The Rule of 3	**What:** To help everyone make better risk based decisions and be able to justify them. **When:** If people lose sight of their risks, or if complacency threatens to set in. Can be used anytime, especially when there is change (<5 minutes).
Managing Rule-Breaking	**What:** To prevent incidents being caused by rule breaking. **When:** If procedures are not being followed, or a need to improve procedures (2-3 hours initially then, 1 hour per issue).
Improving Supervision	**What:** To improve the non-technical skills of supervisors. **When:** If the quality of supervision, is identified as a (possible) cause of incidents (4-5 hours first time).
Working Safely	**What:** Intervention programme that builds on and supports existing programmes or can be run by itself. **When:** If safe working practices are not being followed (8 hours in total, 1 hour slots).
Driving Better	**What:** A suite of exercises to change the behaviour of drivers and the people who manage them. **When:** When driving is a significant risk, professionally or personally (8 hours in total, 1 hour slots).

Human Error and Violation Decision Flowchart

Does Hearts and Minds work?

Today
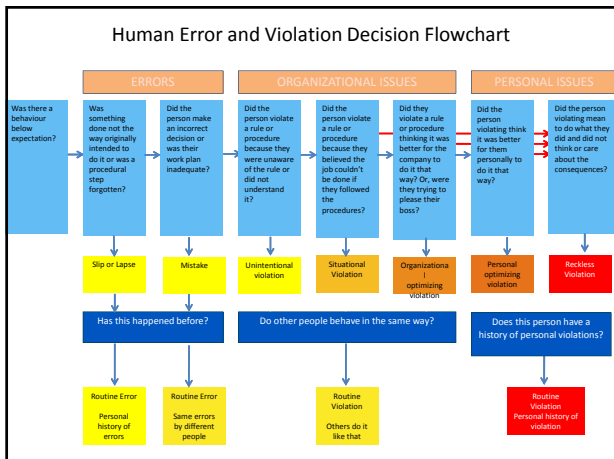
Where to Next?

- Hearts and Minds was closed out after 2005
  - Program given to the Energy Institute
- Issues about how individuals and organisations cause accidents appeared to have been fixed
- The problem of culture as a contributing factor still remained to be resolved
- The nature of causality has to be reconceived as you move away from the direct proximate causes

Later version of the Just and Fair Culture decision process

- Need to have the positive side reinforced
- Messages that managers found punishment much easier than reward and encouragement

Human Safe Behaviour Decision Flowchart
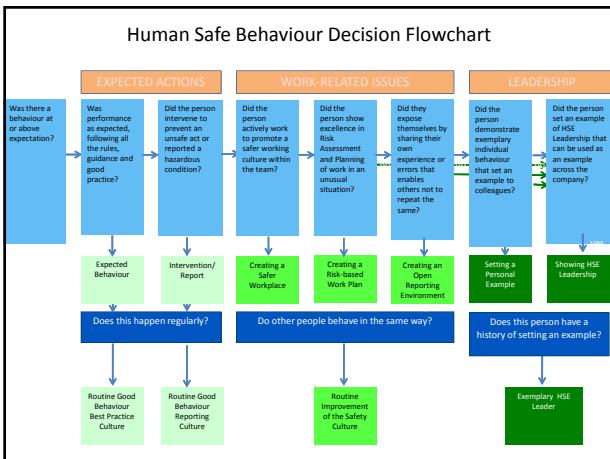
Moving on from Swiss Cheese

- Rob Lee (who had originally called it Swiss Cheese) and I started to integrate this model with the bowtie
- The bowtie also needed to be set on a cleaner theoretical basis
- Causes and contributing factors of accidents could no longer just be seen as simple, linear and deterministic
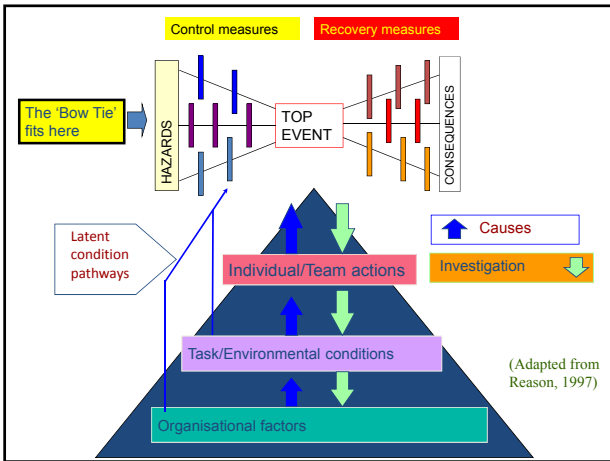
Level 1 immediate controls
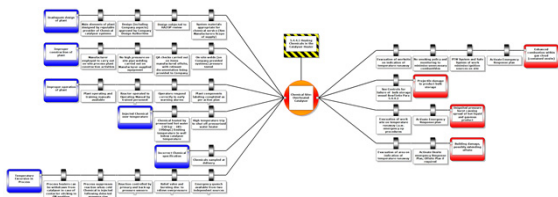
Level 2 full analysis with escalating factor controls – Adding management
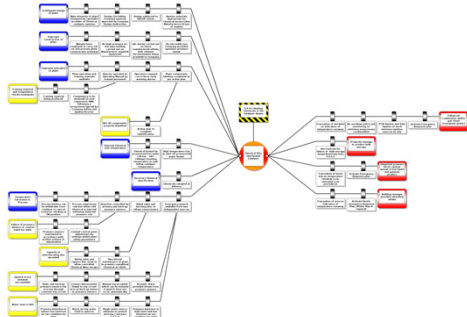
Level 3 Culture and Regulation impact on management then individuals
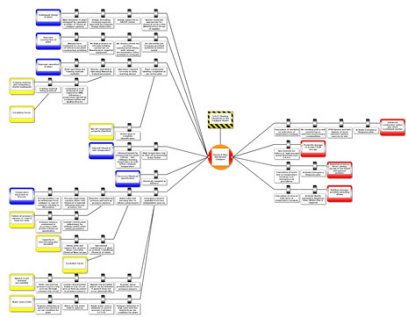
Level 3 full analysis
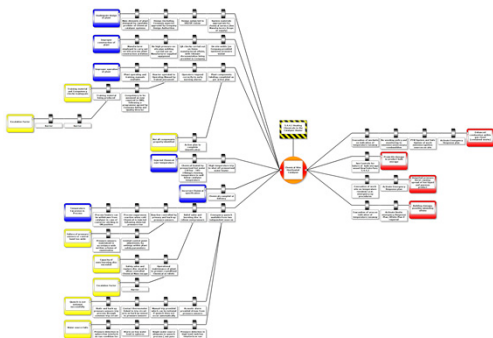
Levels and accountabilities

	L₁ Front line operators	L₂ Line Management	L₃ Culture and Regulation
Threats (Escalating factors)	• Improper operations • External conditions • Variability in process	• Design problems • Poor procedures • Lack of training • Insufficient necessary pre-conditions for operation	• Non-compliance • Low or inappropriate priority setting • Hands-off regulation • Incompatible goals
Barriers types of control	• Detection • Competence • Design & construction	• Provision of equipment, services, training and procedures	• Support for best practice • Enforcement • Mindfulness
Accountable individuals	• Front line individuals e.g. driller, driver, pilot, doctor, nurse, maintenance engineer	• Line management, supervisors, back-room staff	• Executive management • Regulatory bodies

Safety Management System (SMS)

DISASTER

Production

Better defenses converted to increased production

BANKRUPTCY

Protection

Safety Management System (SMS)
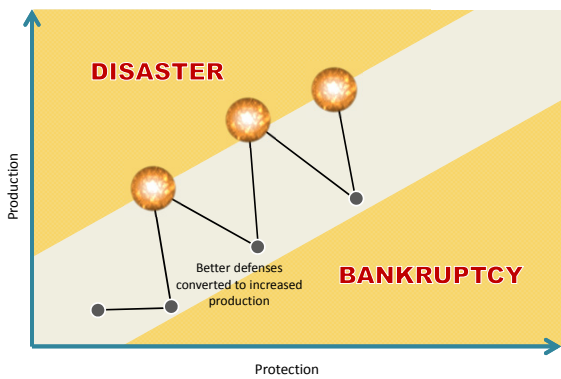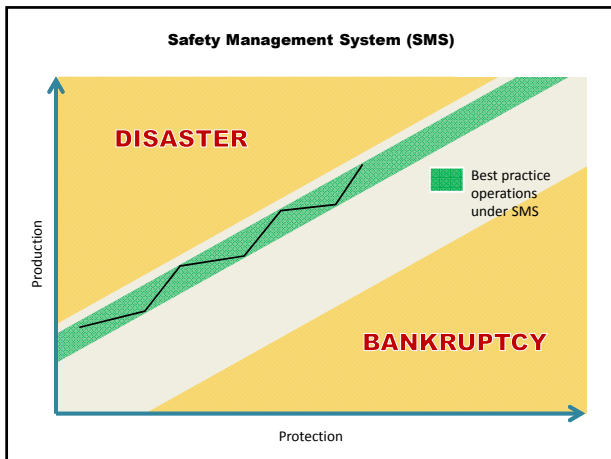
What was an SMS doing?

- SMS allowed hazardous activities to be closer to the edge of failure without going over
- The closer you get to the edge the more money you make, until disaster strikes
- The Rule of Three proposed that disaster became more likely (probable) as dimensions approached their 'red' zones
- Safety was really about operating in your risk space
- But organisations were still being caught out

Changing theories

- Need to move from simple to complex models of causation
- Theory 1 – Newton
- Theory 2 – Einstein
- Theory 3 - Shrödinger

Theory 1 - how accidents are caused

- Linear causes – A causes B causes C

- Deterministic - either it is a cause or it isn't

- We can compute both backwards and forwards

- People are seen as the problem – human error etc

- Probably good enough to catch 80% of the accidents we are likely to have (Pareto assumption)
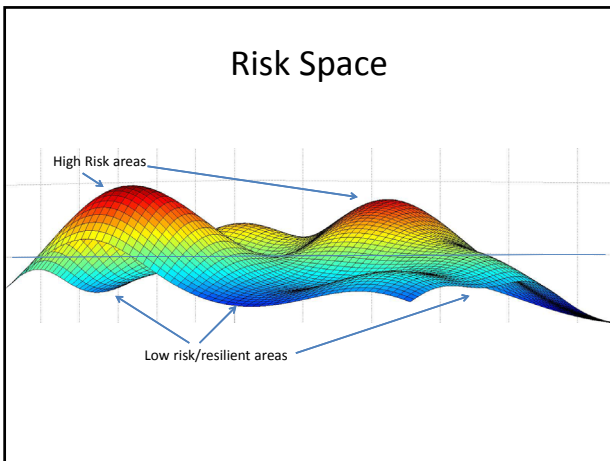
Theory 2 - how accidents are caused

- Non-Linear causes
  - Cause and consequence may be disproportionate
  - These causes are organizational, not individual

- Deterministic dynamics-
  - Either it is a cause or it isn't

- We can compute both backwards and forwards
  - Increasingly difficult with non-linear causes

- This is the Organizational Accident Model

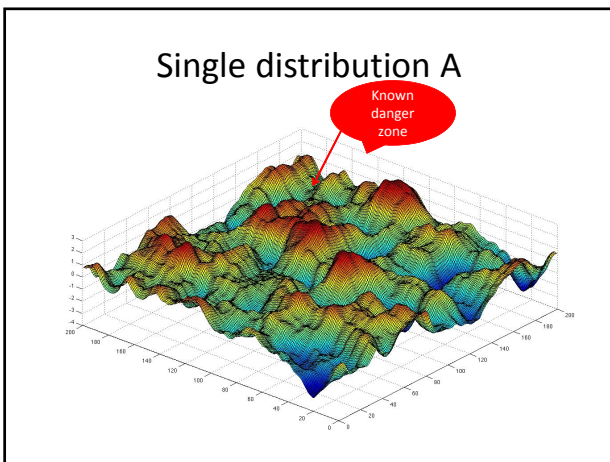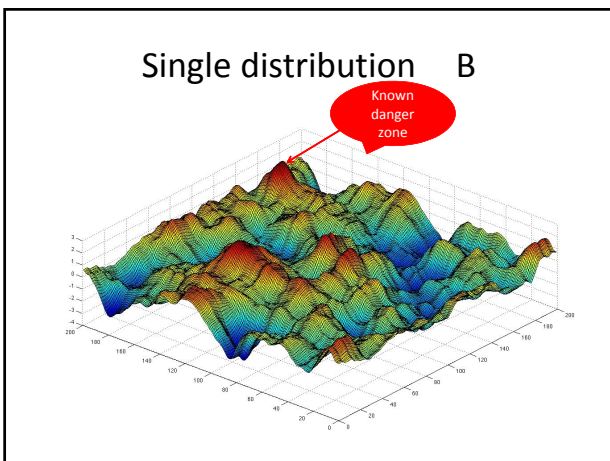- Probably good enough to catch 80% of the residual accidents = 96%
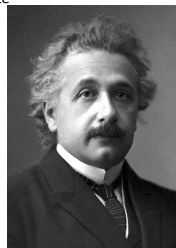
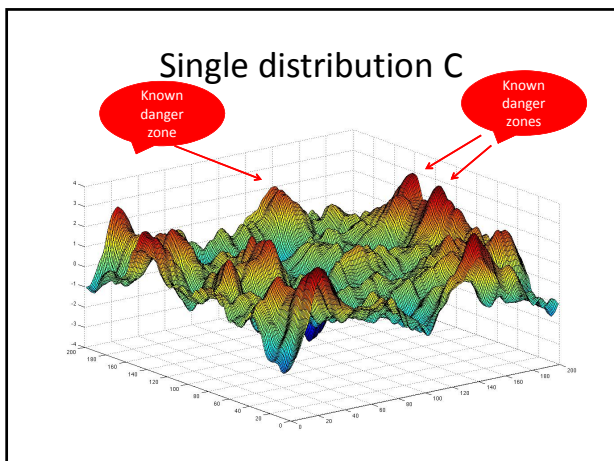## Theory 3 - how accidents are caused

- Non-Linear causes

- Non-Deterministic dynamics
  - Probabilistic rather than specific
  - Influences on outcomes by people and the organisation
- Probabilities may be distributions rather that single values
- We cannot compute both backwards and forwards

- The dominant accidents that remain are WEIRD
  - WILDLY
  - ERRATIC
  - INCIDENTS
  - RESULTING IN
  - DISASTER

- Prior to an event there may be a multitude of possible future outcomes (Superpositions)
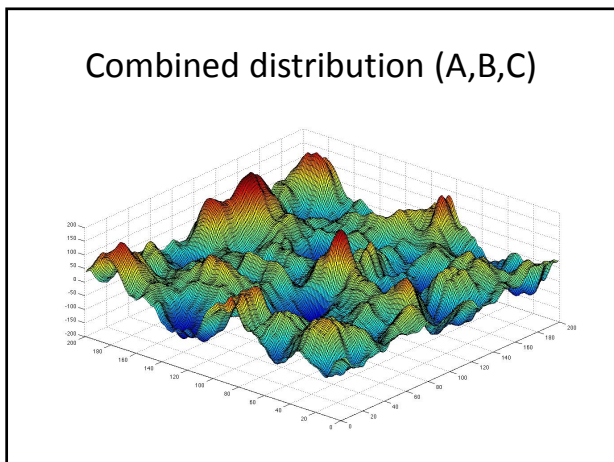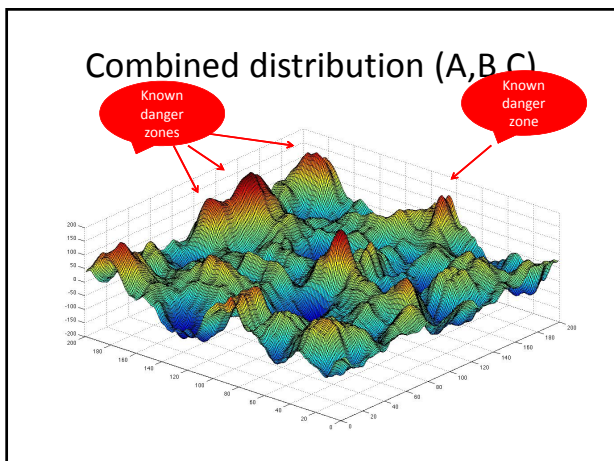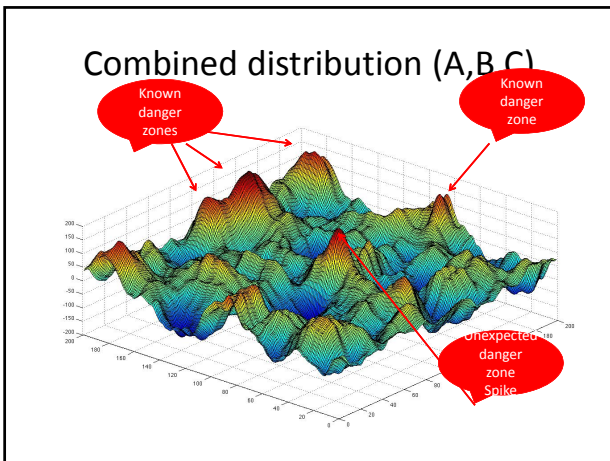- May account for 99.2% of accidents (96 + 4x0.8)
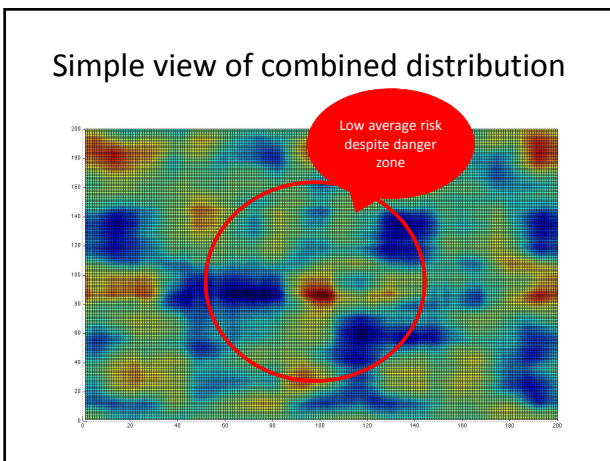
$$\psi_{kitty} = \frac{1}{\sqrt{2}}\psi_{alive} + \frac{1}{\sqrt{2}}\psi_{dead}$$

Risk Space

High Risk areas

Low risk/resilient areas

Single distribution A

Known danger zone

Single distribution   B

Known danger zone

Single distribution C

Combined distribution (A,B,C)

Combined distribution (A,B,C)
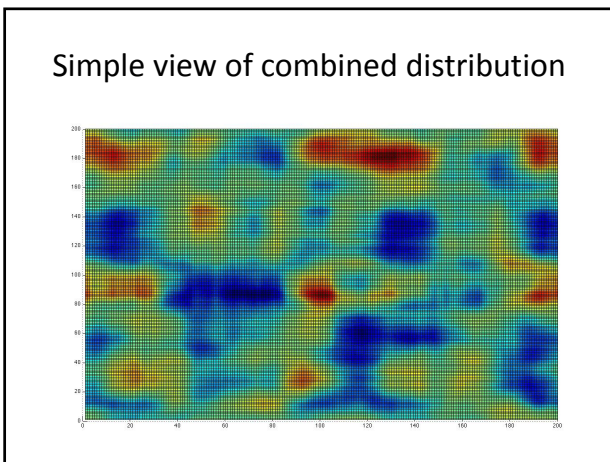
Combined distribution (A,B,C)

Simple view of combined distribution

Simple view of combined distribution

Simple view of combined distribution

Medium average risk despite danger zone

Simple view of combined distribution

High average risk due to sufficient granularity
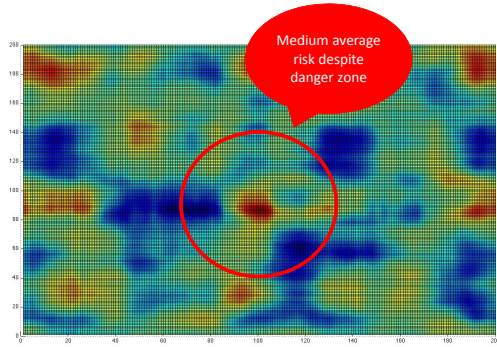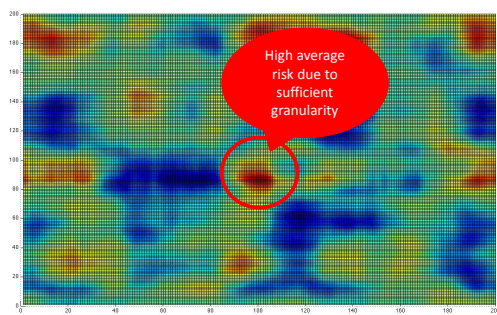
Safety Culture
and
Risk Understanding

- Safety is now about how individuals and organisations understand and handle risks

- Different stages on the safety culture ladder may be the result of changes in granularity plus different organizational cultures that can cope with increasing sophistication

Summary

- We started with individual human error
- This has transitioned to organisational failings
- At the organisational level we can also consider doing things well, or at least better, as well as badly
- Winning Hearts and Minds is about pushing power and accountability to where it is needed (whose hearts and minds? *Up and down*)
- To understand the role of culture we need to do more than hand-waving and making pious noises

Future Challenges

- Safety science has moved away from simple attributions of error by individuals to developing understanding of how the context shapes individuals' behaviours
- Mature organisations have made most of this transition, but most organisations are still immature
- Improving cultures from Calculative to Proactive is really hard
- This stuff is hard to understand, really hard to implement
  - Managers want simplicity (Theory 1)
  - The Law still seems stuck on Theory 1 and proximate cause

Final Challenge

- The number of major process accidents does not appear to be reducing, at least in the USA (Chemical Safety Board)
- We know how to get people to be safe
  - Pearl GTL - Ras Laffan Qatar 77,000,000 hrs LTI free
- We know a lot about how to make organisations safer
- Major incident reviews show the biggest problem is implementing what we already know