

Use Bow Tie Tool for Easy Hazard Identification

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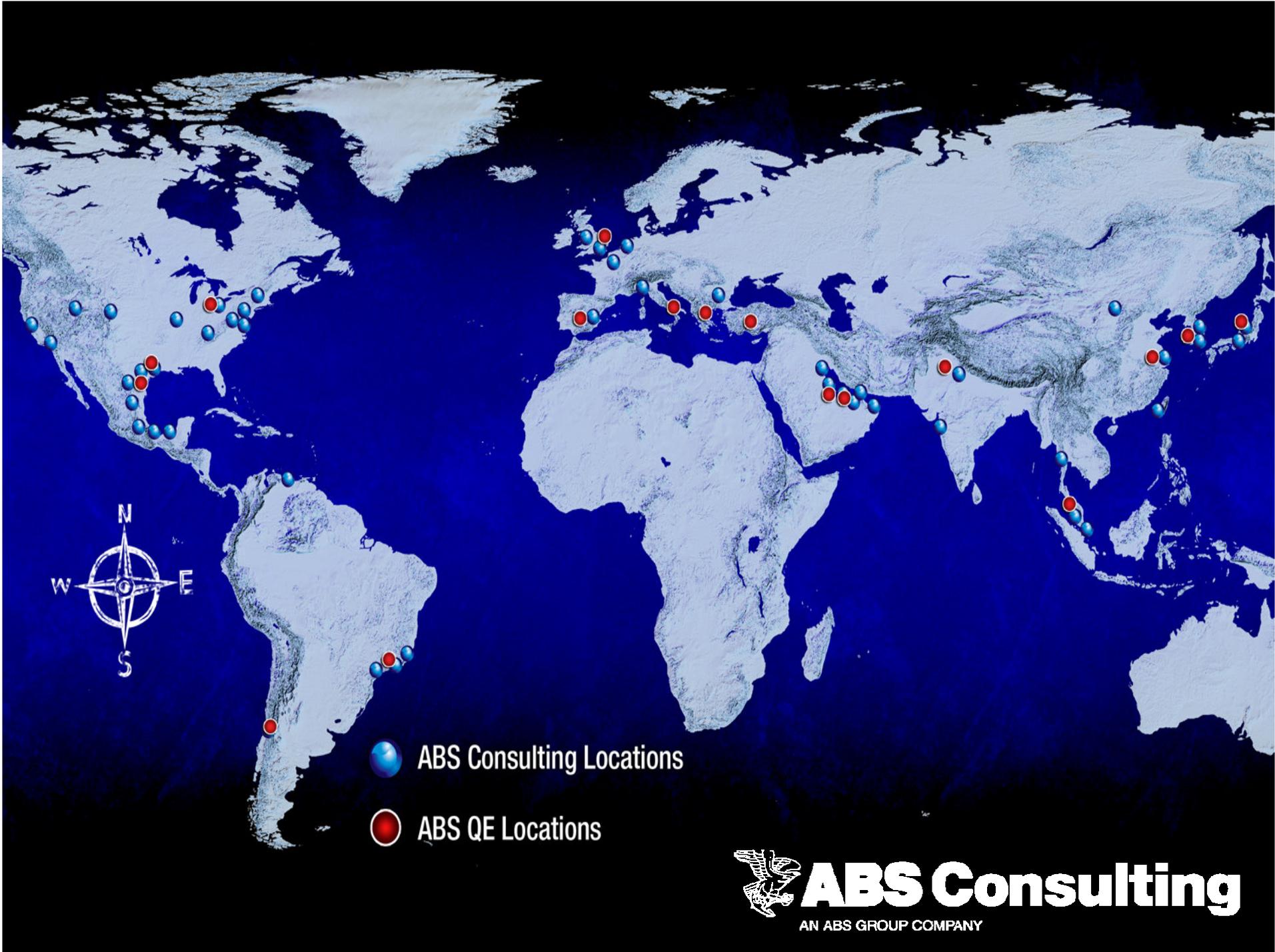
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- Global Integrity, Safety, Risk Management and Inspection Services Company
- Serving the Oil & Gas, Petrochemical, Maritime, Power Generation, Commercial, Public and Insurance/Financial Sectors
- Corporate Headquarters in Houston. Regional HQ in Europe (UK), Middle East (UAE) and Asia (Singapore).
- Over 1,300 employees, with 50+ offices in some 30 countries
- Wholly-owned subsidiary of ABS (a Marine and Offshore Classification Society), founded in 1842.



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Range of Services



■ Integrity Management

- Project Quality Management
- Inspection & Auditing
- Operational Asset Integrity Management
- Reliability & Maintenance Management
- Independent Verification Services

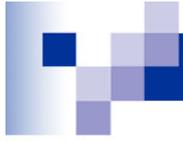
■ Safety Management

- HSE Case / Program Development
- Process Safety Assessment
- Safety Culture Assessment
- Management System Development
- Safety Training

■ Risk Management

- Enterprise Risk Management
- Operational Risks
- Manmade Risks
- Natural Hazard Risks





Objectives of Hazard Identification & Assessment

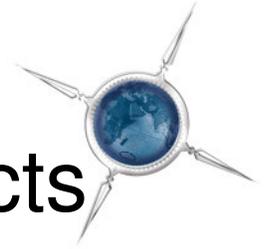
- Ensure hazards are known, understood and properly managed
- Risk is reduced to As Low As Reasonably Practicable (ALARP)

Why accidents still happen despite hazard identification & assessment being carried out?



How do you manage risk?

- Identify hazards and potential effects - ***Know & understand the hazards***
- Prevent, mitigate & recover from the hazardous events - ***Manage the hazards***



Identification of Hazards & Potential Effects

Knowing & understanding Hazards

- What are sources of hazard?
- What hazardous event (top event) could potentially occur when a hazard is released?
- What could release the hazard and cause the top event to occur? What are the "threats"?
- What are the consequences from the top event? How severe will the consequences be?



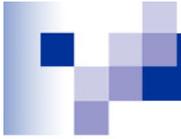
Prevention, Mitigation & Recovery

Managing hazards

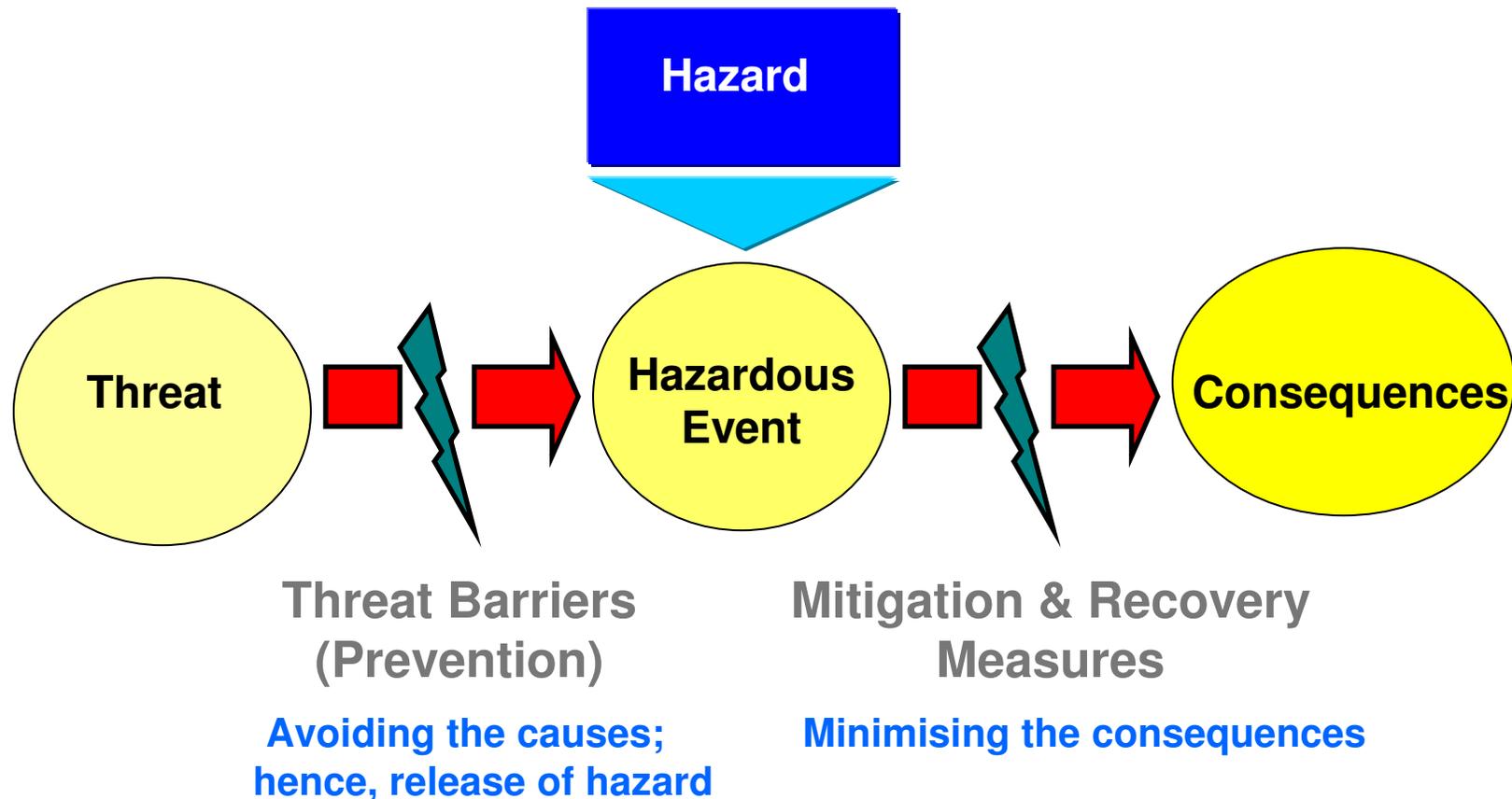
- How to avoid the threats (or causes)? – prevention or threat barriers
- How to avoid or minimise the consequences – mitigation/recovery barriers

Only possible if hazards are known and understood

- All hazard are identified
- The threat (causes) and consequences of top events are known



Managing Hazards – Risk Reduction





Hazard Identification..... You Must Get It Right



- Having done hazard identification/assessment does not guarantee safety
- Many accidents occurred despite having done hazard identification/assessment
- Why?
 - **Failure to identify hazards**
 - **Failure to manage hazards effectively**

Doing it is not enough, you must get it right



How Do You Get It right?

- Identification of hazards and potential effects must be complete
 - All relevant hazards must be identified
 - Threats (causes) & consequences identification (hazard) analysis must be comprehensive
- Threat barriers (prevention) & mitigation/recovery barriers must be adequate
 - They must be known to be or confirmed effective
 - Supported by risk assessment to determine ALARP



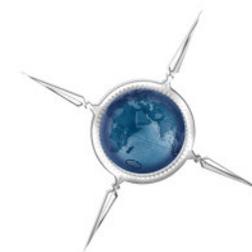
BowTie Methodology the Solution

- Simple & pragmatic approach
- Empphasis on effectiveness of risk reduction measures
- Effective visualisation
- Allows better communication of hazards
- Can be applied for all types of hazards
- Increasingly becoming the preferred techniques by regulatory bodies & leading companies
- Efficiently aided by user-friendly softwares



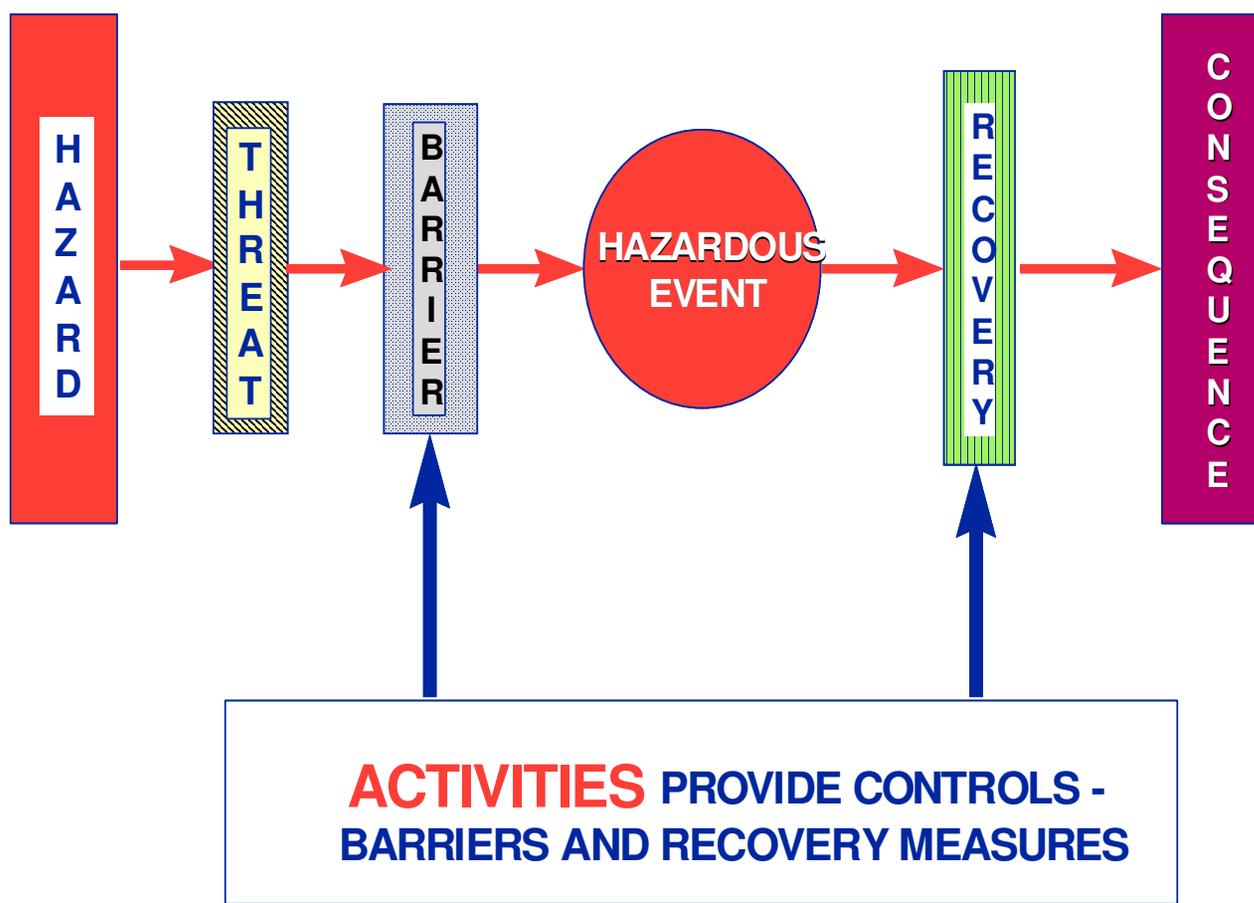
Bow Tie Methodology

- Originated as a technique for developing a “Safety Case” in the Oil & Gas Industry, post the Piper Alpha Incident in 1988
- By linking ‘Hazards’ & ‘Consequences’ to an ‘Event’ it is possible to develop the relationship to include the causes, or ‘Threats’, and the ‘Prevention’ & ‘Recovery Measures’
- Further understanding can be gained by examining the means by which these defenses can fail, and identifying the key components which demonstrate the integrity of these controls
 - Documents and Procedures
 - Control Types and Effectiveness
 - Critical Equipment and Systems
 - Tasks and the persons behind the Tasks



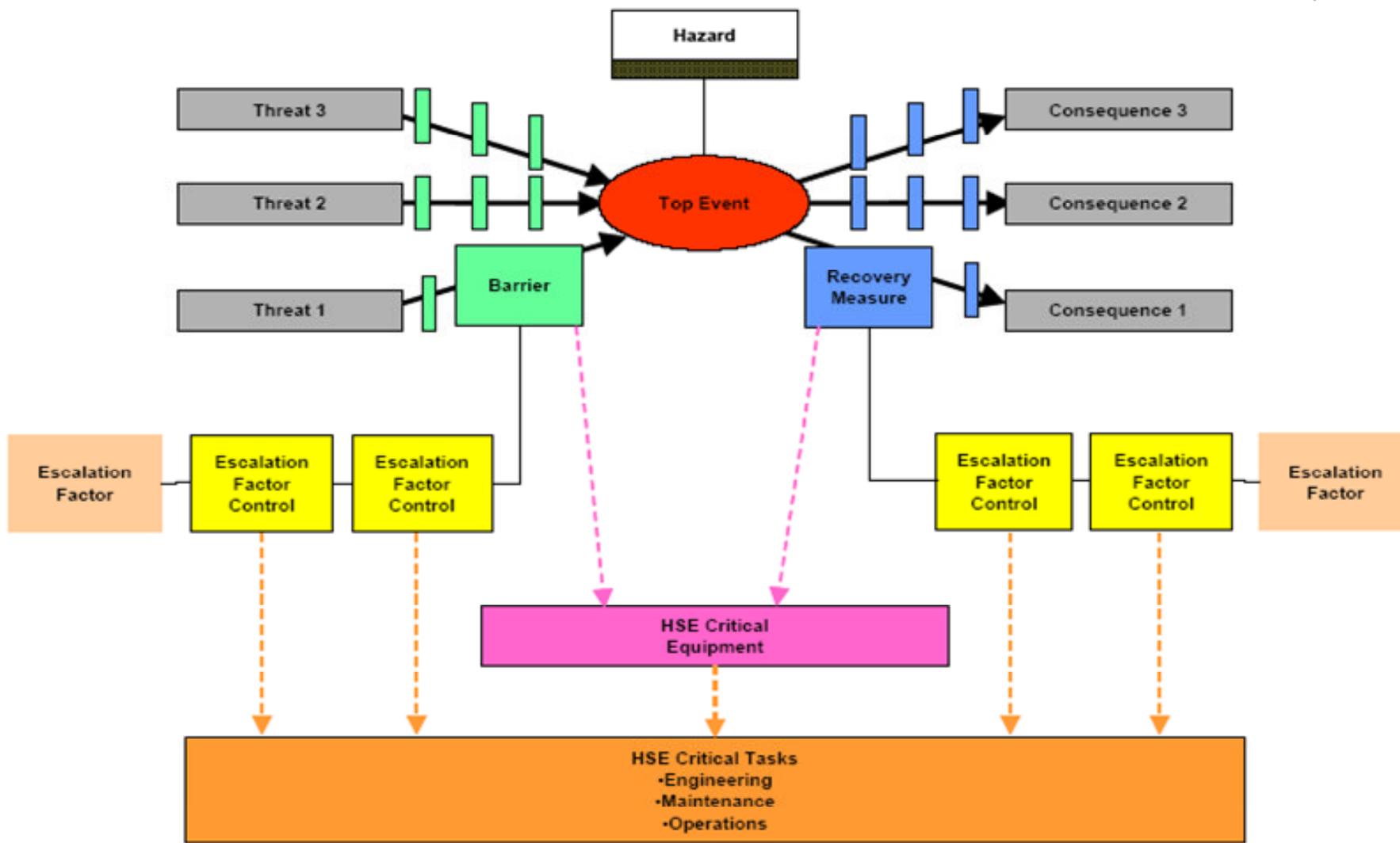
Bow Tie Connections

Bow-tie technique diagrammatically represents hazardous events in such a way to easily show the connections between hazards/threats and their consequences





Bow Tie Concept



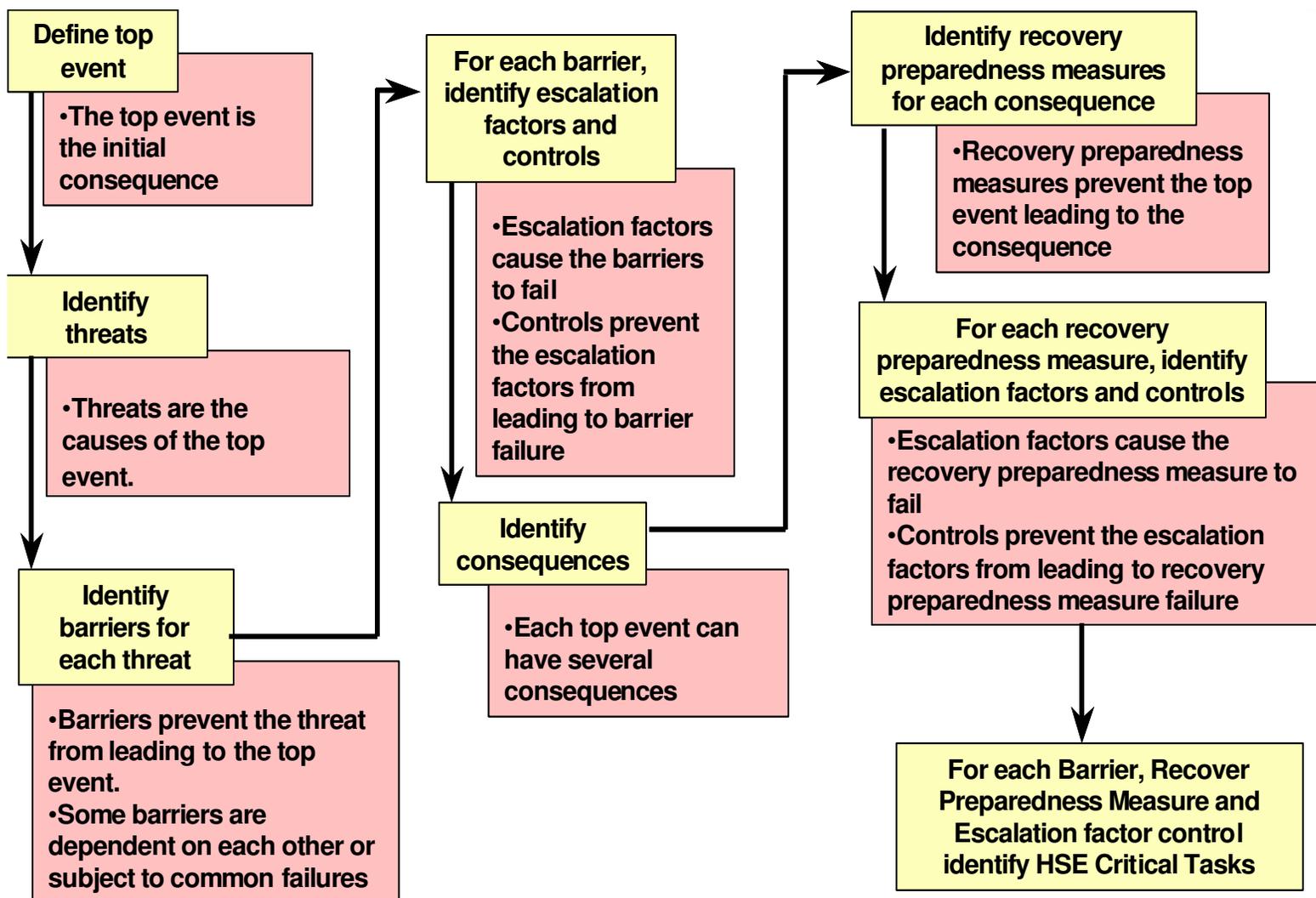


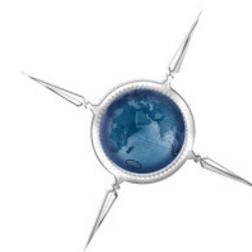
Bow Tie Terminology Definitions

- **Hazard** - Potential source of harm to people, assets, the environment and company reputation
- **Top Event** - The incident that occurs when a hazard is realized
- **Threats** - What could cause the top event to occur?
- **Consequences** - What could happen if the top event occurs?
- **Barrier** - What directly prevents or reduces the likelihood of a threat?
- **Recovery Measure** - What prevents, minimizes or helps recovery from the consequence?
- **Escalation Factor** - What could prevent the barrier or recovery measure from working as intended?
- **Escalation Factor Control** - What prevents or minimizes the chance of barriers or recovery measures becoming Ineffective?



Bow Tie Analysis Steps

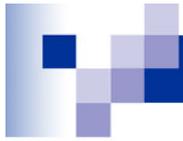




Major Hazard Classification

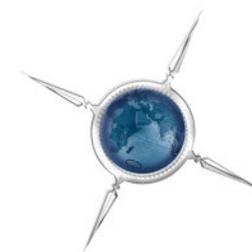
- BowTies are usually developed for only for Major Hazards – defined using Risk Assessment Matrix

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Environment	Reputation	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No impact					
1	Slight injury or health effect	Slight damage	Slight effect	Slight impact					
2	Minor injury or health effect	Minor damage	Minor effect	Minor impact					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate impact					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major impact					
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact					

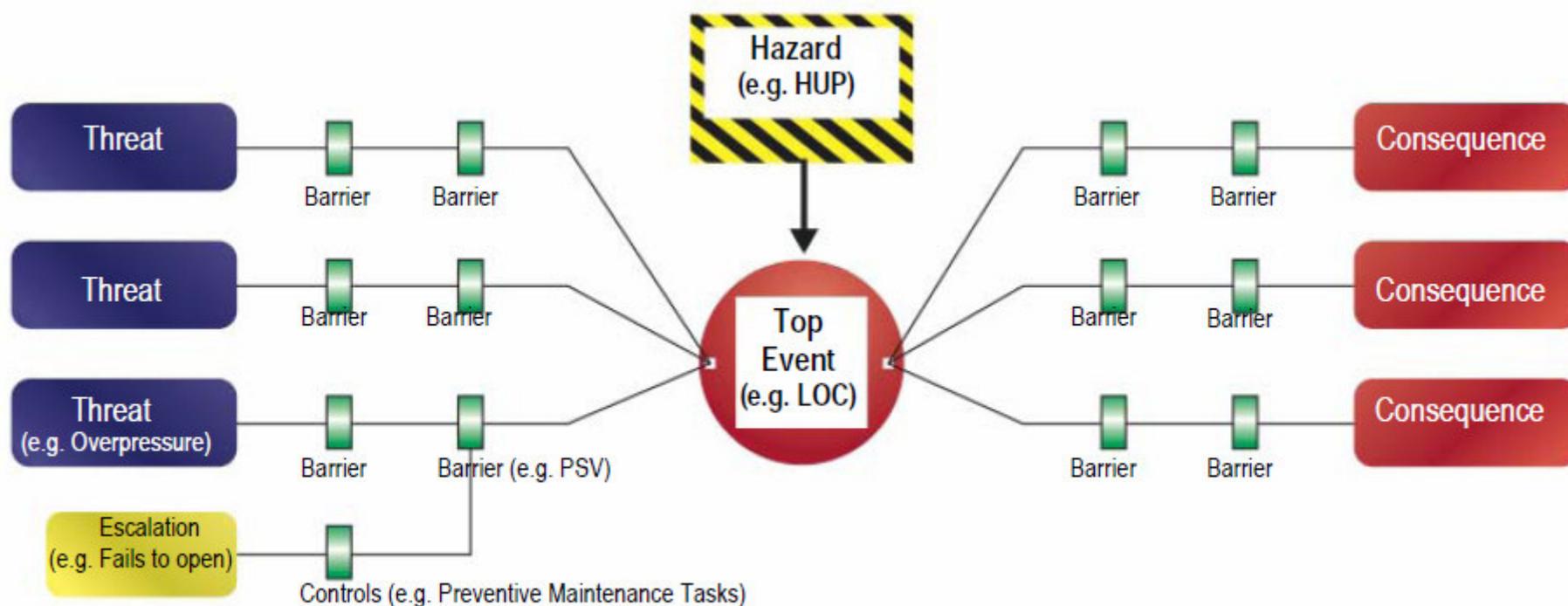


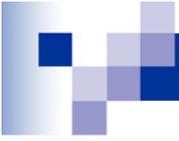
Typical Major Hazards

- Hydrocarbons – fires/explosions/blowouts/oil spills
- Toxic materials – toxic releases
- Air/marine/land transport – helicopter/boat/road accidents
- Shipping activities – marine collision
- Object under load (structure) – structural failure
- Lifting operations – dropped objects



Managing Barrier Effectiveness – Relating Critical Activities to Barriers





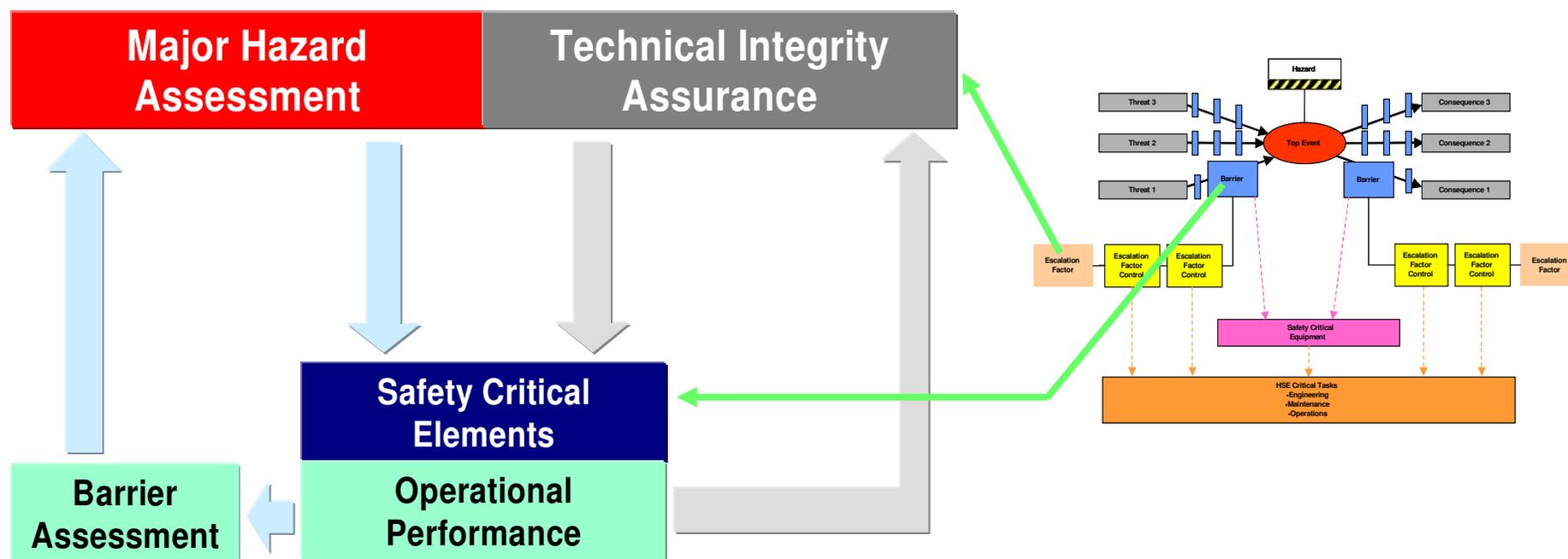
Typical Major Hazard Barriers

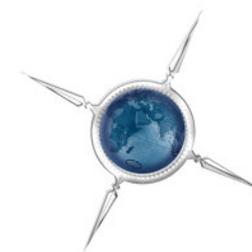


- Structures (jackets/decks) – preventive barriers
- Hydrocarbon containment - preventive barriers
- Chemical injection systems - preventive barriers
- Relief systems - preventive barriers
- Fire, gas & smoke detectors – recovery barriers
- Ignition control – recovery barriers
- Shutdown systems – preventive/ recovery barriers
- Active & passive fire protection systems – recovery barriers
- Firewater pumps & ringmain – recovery barriers
- Emergency response equipment – recovery barriers
- Emergency communication & power – recovery barriers
- Escape, evacuation & rescue provisions – recovery barriers
- Life/survival equipment – recovery barriers

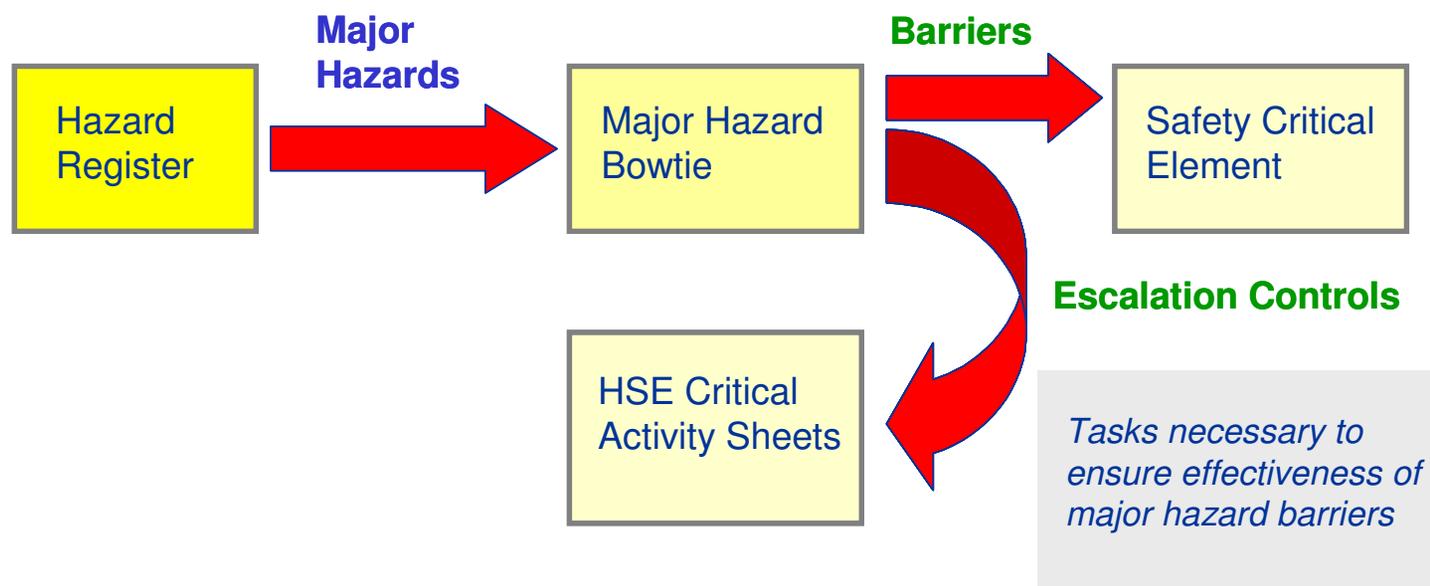


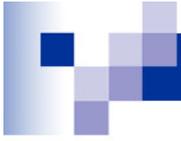
Bow Tie Allows Optimised Integrity Assurance





Use of Bow Tie for Effective Control of Major Hazard





Barrier Effectiveness Rating



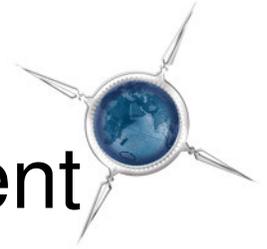
Effective



Partially Effective



Ineffective



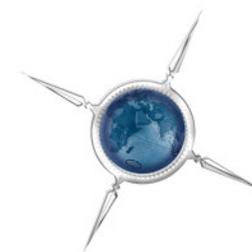
Inputs to Barrier Effectiveness Assessment

- Design standards
- Inspection/maintenance records
- Test performance results
- Asset integrity reporting
- Processes & procedures
- Audit findings
- Incident investigation findings
- Personnel competency



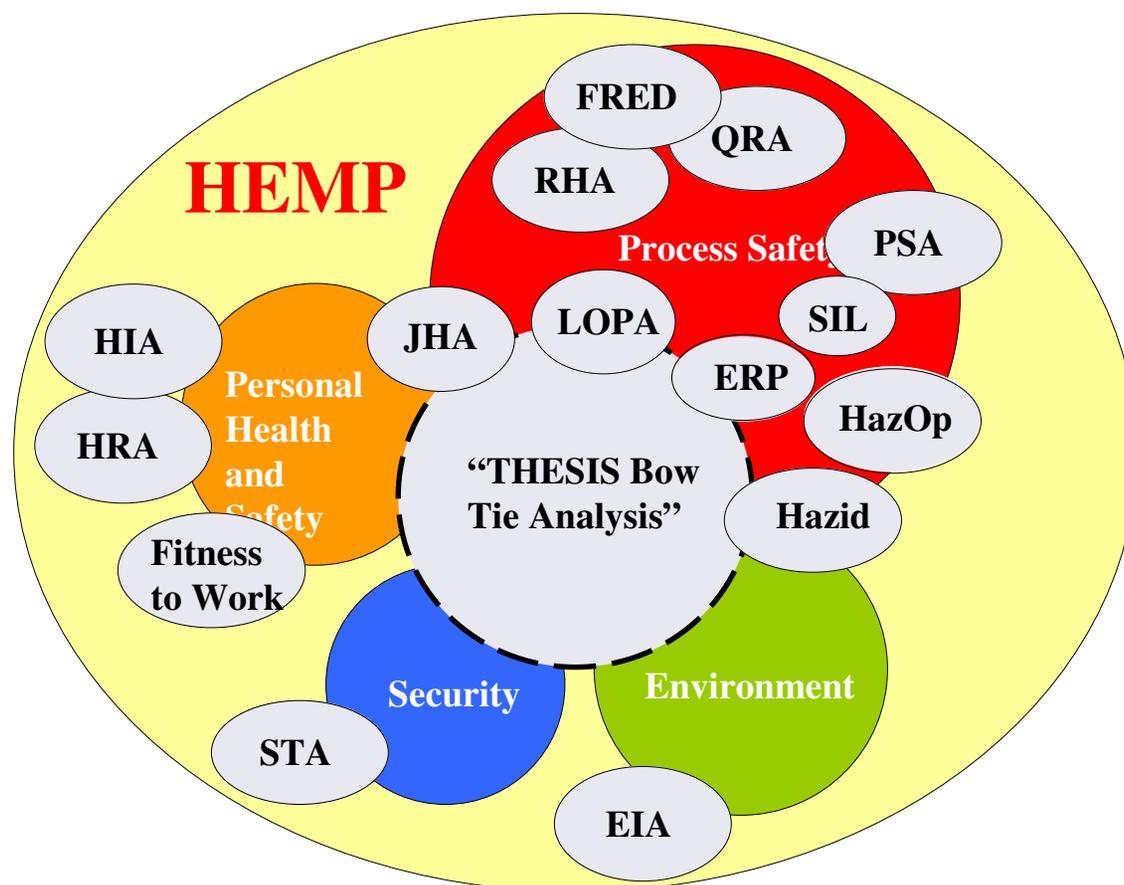
Barrier Effectiveness Assessment - Example

Barriers	Findings	Effectiveness	Remedial Actions
ESD system	IR flame detector available but provide only alarms	Yellow	Provide ESD activation based on confirmed fire detection
Certified electrical equipment	Newly installed Split unit outdoor unit at substations not Ex-rated, 20-from process area.	Red	Evaluate adequacy of ignition prevention/control at electrical substations in event of hydrocarbon leaks due to presence of non Ex-rated equipment
Piping system	Reactive approach for gaskets replacement, esp. small bore valves (ref. recent leak incident).	Yellow	Inspection for small bore piping need to be defined e.g. include UT, not merely visual inspection
Rotating equipment	Insufficient surface sand management facilities due major sand not anticipated	Yellow	Identify sand management requirements to ensure sand removal either surface or subsurface



Bow Tie vs Other Methods ?

- Many other 'risk techniques' – where does Bow Tie fit in ?
- A Management System tool which takes its knowledge from various sources to represent the 'risk picture' in a logical and usable format.
- Not intended as a replacement for any particular method





Using Bow Tie Software -THEISIS

File Edit View Tools Window Help

Zoom 100%

Case Tree Reference Tree

CS-01 -

- Port
 - Business Risks
 - Health Effects
 - Environmental Aspects
 - Safety / Major Hazards
 - H-01.P01 - Hydrocarbons (Port)/Loss of containment cargo tanks**
 - Threats
 - Failure of p/v arrangement
 - Corrosion
 - Thermal expansion of cargo
 - Consequences
 - Hull flooding. Potential for loss of stability
 - Discharge at sea. Pollution
 - Fire/explosion
 - Personnel injury/fatality
 - Shortfalls

- Sea
- Business Risks
- Health Effects
- Environmental Aspects

Ready

H-01.P01 - Hydrocarbons (Port)/Loss of containment cargo tanks

H-01.P01-Hydrocarbons (Port)

THREAT

Failure of p/v arrangement

THREAT

Corrosion

THREAT

Thermal expansion of cargo

CONSEQUENCE

Hull flooding. Potential for loss of stability

CONSEQUENCE

Discharge at sea. Pollution

CONSEQUENCE

Fire/explosion

CONSEQUENCE

Personnel injury/fatality

Loc : Port
IE : Loss of containment cargo tanks

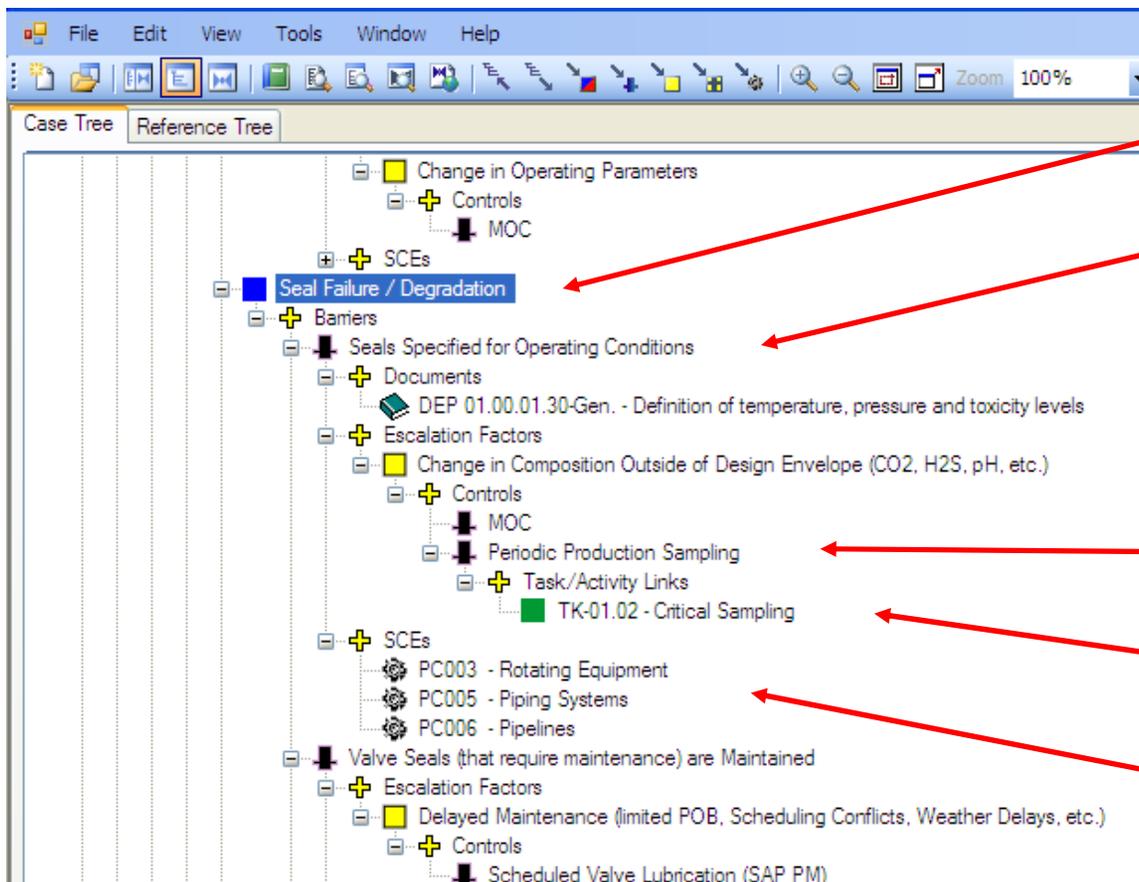
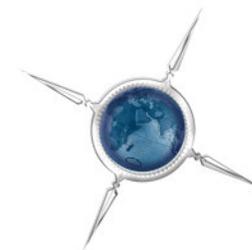
P-	A-	E-	R-
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P-	A-	E-B3	R-B3
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P-C5	A-C4	E-C3	R-C4
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P-	A-	E-	R-
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THESIS Bow Tie 'Attributes'



Threat definition

Barrier

Linked document

Escalation Factor

Escalation Control

Linked Activity/Task

Linkage of Critical Systems

THESIS 'Risk Dashboard'



Overall Risk Profile									
Code	Hazard	Top Event / Impact	Type	Consequence	P	A	E	R	
H-23.03....	Sulphuric acid	Loss of Containment - Catastrophic Fail...	HSE	Contaminated Land/Aquifer		A3	A3	A3	
H-02.01....	Refined Hydrocarbons (Lube & Seal Oil)	Loss of Containment	HSE	Soil & Groundwater Contamination	E1	E1	E2	E1	
H-23.03....	Sulphuric acid	Loss of Containment - Catastrophic Fail...	HSE	Exposure to Corrosive Acid/ Fumes	A3	A3		A3	
H-02.01....	Refined Hydrocarbons (Lube & Seal Oil)	Loss of Containment	HSE	Slippery Surface	E2	E0	E0	E1	
H-02.01....	Refined Hydrocarbons (Lube & Seal Oil)	Loss of Containment	HSE	Ignited Pool Fire	C3	C3	C1	C2	
H-02.01....	Refined Hydrocarbons (Lube & Seal Oil)	Loss of Containment	HSE	Ignited Oil Soaked Insulation	C1	C2	C1	C1	
H-02.01....	Refined Hydrocarbons (Lube & Seal Oil)	Loss of Containment	HSE	Machinery Enclosure Fire	C2	C4	C1	C3	
H-20.05....	Toxic Gas (Chlorine)	Loss of Containment	HSE	Toxic Gas Exposure	A4	A2	A1	A3	
H-02.02....	Refined Hydrocarbons (Hydraulic Oil)	Loss of Containment	HSE	Soil & Groundwater Contamination	E1	E1	E2	E1	
H-02.02....	Refined Hydrocarbons (Hydraulic Oil)	Loss of Containment	HSE	Slippery Surface	E2			E1	
H-02.02....	Refined Hydrocarbons (Hydraulic Oil)	Loss of Containment	HSE	Ignited Pool Fire	C3	C3	C1	C1	
H-02.02....	Refined Hydrocarbons (Hydraulic Oil)	Loss of Containment	HSE	Ignited Oil Soaked Insulation	C1	C2	C1	C1	
H-02.02....	Refined Hydrocarbons (Hydraulic Oil)	Loss of Containment	HSE	Machinery Enclosure Fire	C2	C4	C1	C3	
H-03.01....	Other Flammable Materials (Cellulosic ...	Ignition of Material	HSE	Fire	C4	C3	C2	C4	
H-03.02....	Other Flammable Materials (Pyrophoric ...	Iron Sulphide Exposure to Air	HSE	Autoignition & SO2 Release	D2	D1	D1	D1	
H-03.02....	Other Flammable Materials (Pyrophoric ...	Iron Sulphide Exposure to Air	HSE	Exothermic Reaction Generating High ...	C4	C4	C1	C2	
H-03.05....	Other Flammable Materials (Morphaline)	Loss of Containment	HSE	Unignited - Skin/Eye Irritation	A1	A1		A0	
H-03.05....	Other Flammable Materials (Morphaline)	Loss of Containment	HSE	Unignited - Contaminated Soil & Groun...		A1	A0	A0	
H-03.05....	Other Flammable Materials (Morphaline)	Loss of Containment	HSE	Ignited - Fire	A1	A2	A1	A1	
H-03.06....	Other Flammable Materials (Hydrogen)	Release From Batteries During Charging	HSE	Fire	B2	B2	B1	B2	
H-05.01....	Pressure Hazards (Bottled Gases Und...	Loss of Containment	HS	Cylinder Projectile & Fragments	B4	B2	B0	B2	
H-05.01....	Pressure Hazards (Bottled Gases Und...	Loss of Containment	HS	Contact with Pressurised Gas	B2	B1	B0	B2	
H-05.02....	Pressure Hazards (Water under pressu...	Loss of Containment	HS	Projectile	C4	C1	C0	C3	
H-05.02....	Pressure Hazards (Water under pressu...	Loss of Containment	HS	Contact With Pressurised Water	B4	B1	B0	B3	
H-05.03....	Pressure Hazards (Non-hydrocarbon g...	Loss of Containment	HS	Projectile	C3	C1	C0	C1	
H-05.03....	Pressure Hazards (Non-hydrocarbon g...	Loss of Containment	HS	Contact With Pressurised Gas	C2	C1	C0	C1	
H-05.04....	Pressure Hazards (Air Under High Pres...	Release Under High Pressure	HS	Projectile/Skin/Fragments Impact	B2	B1	B0	B2	

- Management review of overall risks, or risk per location
- Sorting to order profile by category
- Allows a snapshot of the major exposure items

THESIS Action Tracking.....Ensuring Effective Hazard Management



- Generation of Shortfalls to log deficiencies in the Management System
- Create and track actions to recover Shortfalls – ensuring barrier effectiveness

Action Tracking

Show for all Locations Show for Location:

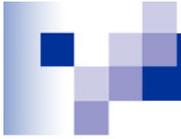
Show for all Hazards Show for Hazard:

Shortfalls: Show All Show Closed Only Show Open Only

Parent Hazard	Description	Type	Target	Completed	Priority	Closed	Notes
Hydrocarbon Gas	RSO-15 Informal process of ...	Control				No	Area 1 & Compression confirmed of the
Hydrocarbon Gas	SFH-019 Unable to test ESD...	Control				No	It is not possible to test all ESD for indi
Hydrocarbon Gas	SFH-020 All ESD valves on ...	Control				No	Testing of ESD valves will reduce the
Hydrocarbon Gas	SFH-029 Fire and gas overi...	Control				No	When overriding the fire and gas dete...

Remedial Actions:

Description	Action Party	Target	Completed	Closed
Demonstrate that a comprehensive regular "Fit-for-Purpose" testing schedule exis...	<None>	30/01/2009		No
Demonstrate that this schedule has been implemented (e.g. procedure and interv...	<None>			No
Ensure that actions from testing schedule are closed out and followed up...	<None>			No



Bow Tie Software Demo - Optional