



*risk management and assessment for business*

# **Practical HSE Risk Management – An Introduction to the Bow-tie Method**

**Presentation to the International Conference for Achieving Health & Safety Best Practice in Construction, Dubai, UAE, 26<sup>th</sup>- 27<sup>th</sup> February 2007**

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# Purpose of presentation

- **Introduce bow-tie method**
- **Describe its practical uses and benefits**
- **Outline an example bow-tie**
- **Provide some tips for successful use**

# History of bow-tie method

- **Exact origins of bow-tie methodology are hazy – believed to originate from ICI in the late 1970's?**
- **Royal Dutch/Shell Group first major company to integrate bow-ties fully into business practices**
- **Use of bow-ties now widely spread between companies, industries, countries and from industry to regulator, e.g.:**
  - **Abu Dhabi National Oil Company (ADNOC)**
  - **UK Health and Safety Executive**
  - **French Government**
  - **Australian State Regulator**
  - **Land Transport Safety Authority of New Zealand**
  - **International standards (e.g. ISO 17776:2000)**
  - **International Association of Drilling Contractors (IADC)**

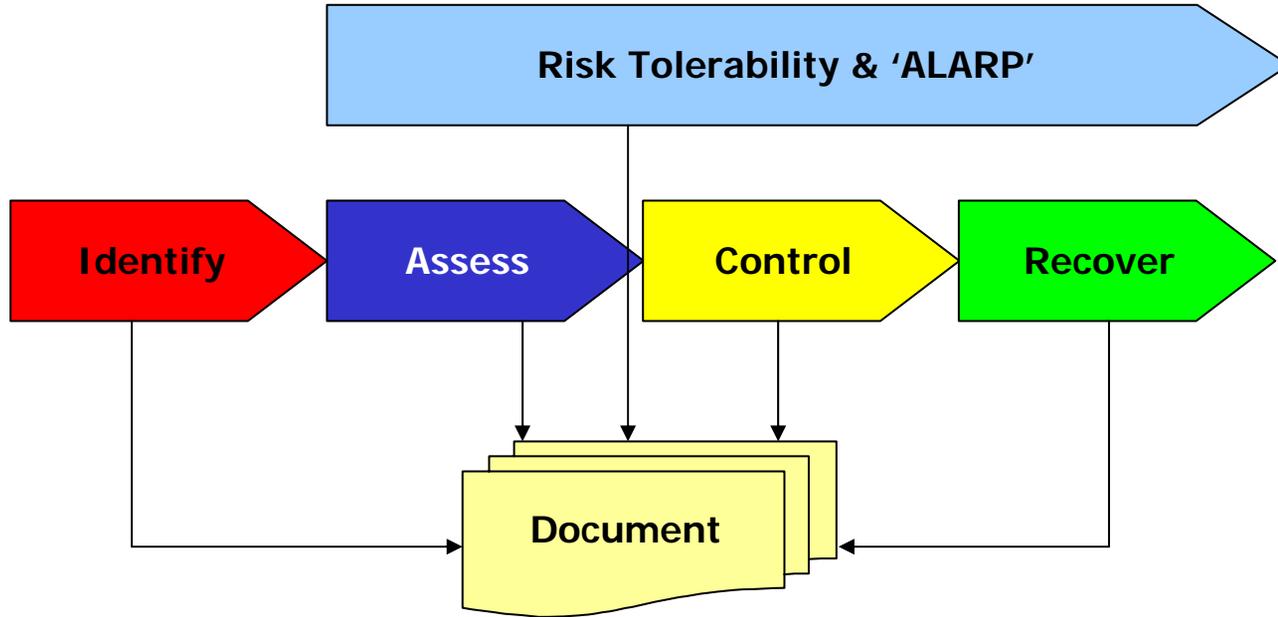
# Risk evaluation & management



## HSE Management System

An **HSE-MS** is a structured set of controls for managing HSE risk in a business

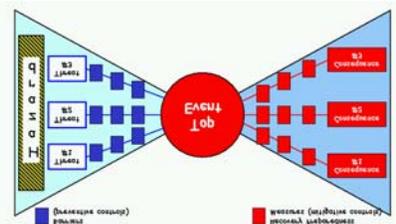
# Basic risk evaluation & management model



# Link with HSE-MS

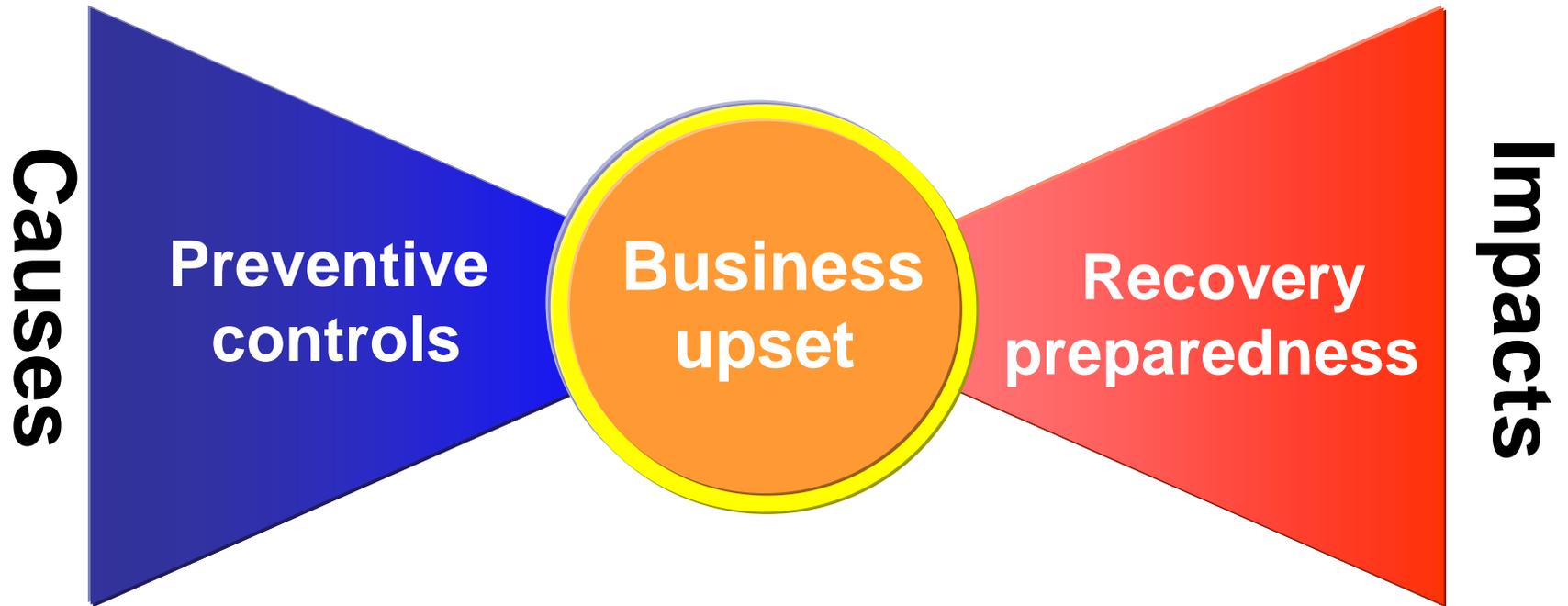
- Unlike traditional risk evaluation tools, the bow-tie method makes the link between risk controls and the HSE-MS:

Severity	CONSEQUENCE				FREQUENCY				
	People	Assets	Environment	Reputation	A	B	C	D	E
0	No injury	No damage	No effect	No impact	Never heard of in industry	Has occurred in industry	Has occurred in company	Occurs several times per year in company	Occurs several times per year at location
1	Slight injury	Slight damage	Slight effect	Slight impact	Manage for Continuous Improvement				
2	Minor injury	Minor damage	Minor effect	Limited impact					
3	Major injury	Localised damage	Localised effect	Considerable impact	Intolerable				
4	1-3 fatalities	Major damage	Major effect	National impact					
5	Multiple fatalities	Extensive damage	Massive effect	International impact					

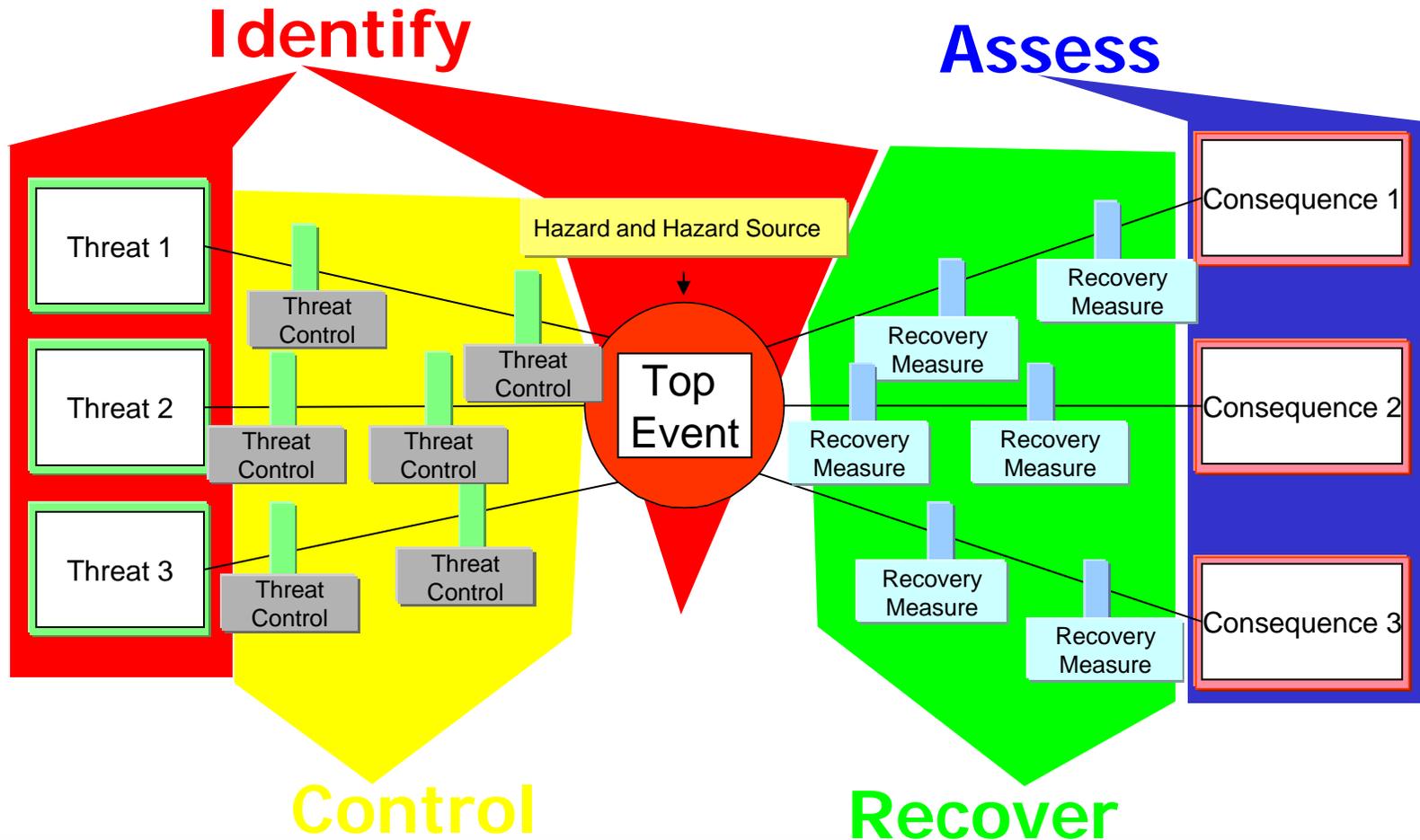


- Links are made via HSE-critical roles and responsibilities, HSE critical procedures, HSE critical equipment and systems, etc. identified on the bow-tie diagram

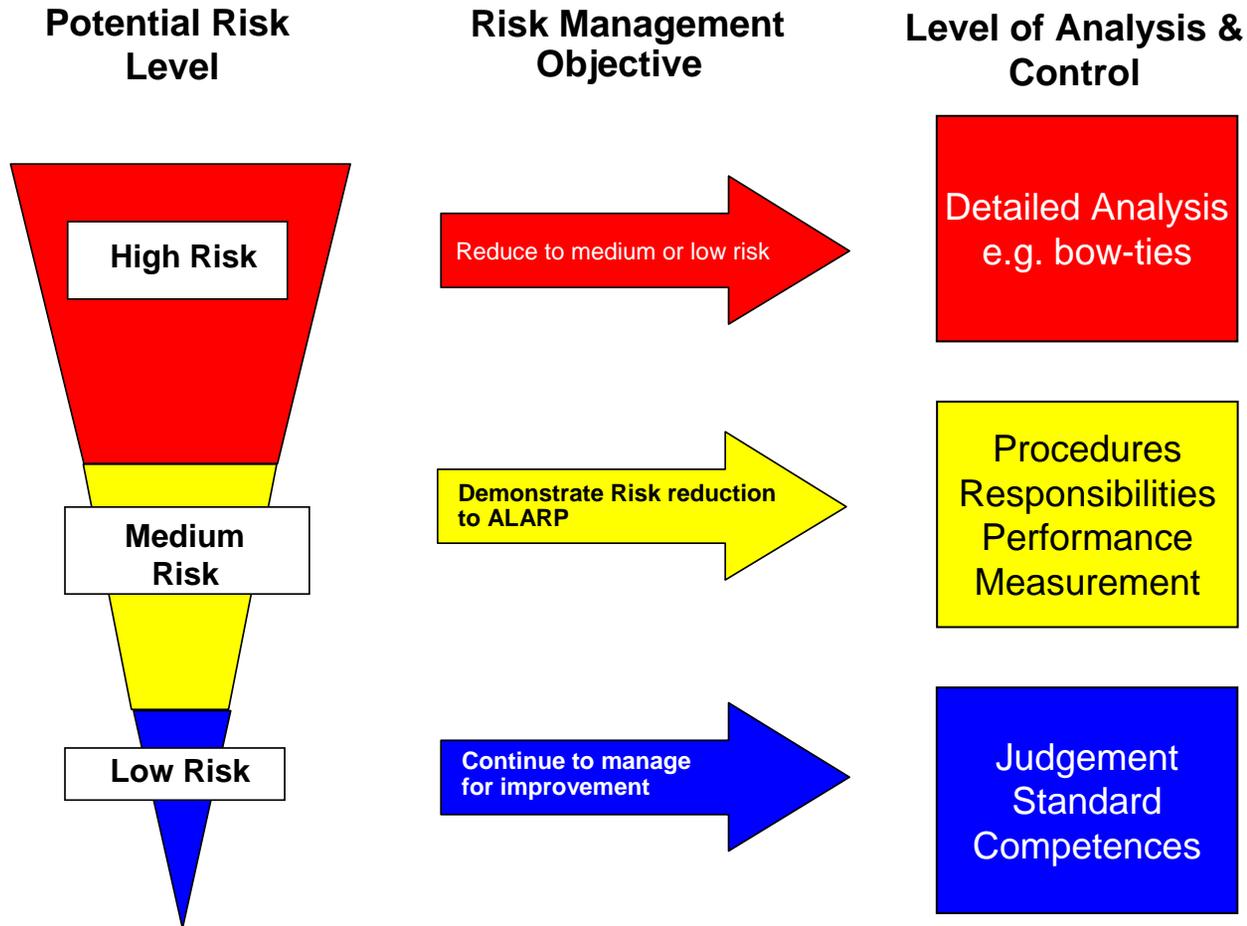
# Bow-tie diagram



# Bow-tie diagram



# Typical application of bow-tie method



**But method is equally applicable to routine risks as major risks**

# Practical uses

**Logical structured approach**

What are our major risks? Do we have any gaps in risk control?

**Communication**

How do we engage non-risk specialists?

**Formal demonstration**

Can we really demonstrate control of our risks?

**Specific risks**

Are these risks properly understood and controlled?

**Critical roles**

Do our people know what is expected of them?

**Competencies**

Are competence and control requirements aligned?

**Procedures**

Are they complete and effective?

**Auditing**

How can we focus audits on what really matters?

**Critical systems and performance standards**

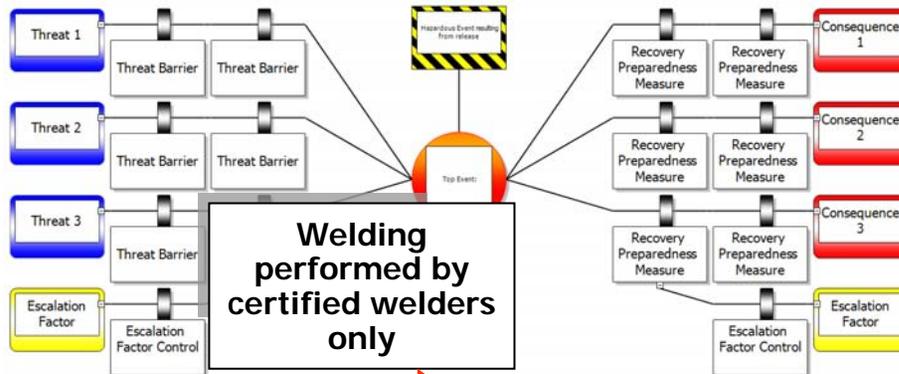
What are they?



# HSE-critical task catalogue

Client/Project Name		Senior Supervisor	
<b>Task 01.01</b>	Making live and Closing of Hot Work Permits	Ensure that all permits are signed out 'made live' and closed by the Authorised Person	Permit register Records of Hot Works Safety Meetings
<b>Task 01.02</b>	Ensure that Hot Work is in compliance with permit conditions	Ensure that permit is in compliance with MSN 102L and work is undertaken in safe manor	Permit register Walk round check/inspection of works Pre-job briefing sign off Safety meeting actions Daily records
<b>Task 02.04</b> <b>HSE-Critical task</b>	Ensuring that lifting gear is tagged and colour <b>HSE-critical procedure</b>	Ensure that lifting gear is coded as per procedure MSN 205L Ensure competence of certifying contractor	Audit and Inspection Sign off from certifying company. <b>Verification</b>
<b>Task 04.04</b>	Confirm portable electrical equipment is fit for purpose and in possession of integrity certification	Ensure that external electrical equipment is tested on a 3 month cycle and internal equipment is tested on a 6 month cycle as per MSN 23L.	Visual check Audit of Portable appliances

# Link between bow-ties and competence



Verify that competence and control requirements are aligned

Job Title: **Lead Production Operator (OPF)**      JG: 7

Building Block	Skill Element	A	K	S	M	Building Block	Skill Element	A	K	S	M
<b>Process System Description</b>	Describe purpose of system					<b>Equipment Operation Description</b>	Describe purpose of equipment				
	Provide sketch of product flow						Identify pressures, temperatures, flow rates				
	Identify process parameters						<b>Equipment Readings</b>	Take readings			
<b>Equipment Identification</b>	Identify subsurface completion equipment					Analyse readings					
	Identify surface equipment					Report anomalies					
	Identify facilities equipment					<b>Equipment Availability Optimisation</b>	Execute maintenance				
	Identify safety systems						Control running hours				
<b>Facilities (and Wells) Configuration</b>	Identify line-up					Analyse equipment failure					
	Identify availability of production system					<b>Rotating Equipment</b>	Describe different rotating equipment				
	Take levels of production tanks						Perform rotating equipment maintenance				
Calculate tank capacity					Analyse and correct machinery faults						
<b>Production Flow Regulation</b>	Identify production capacity					Maintain equipment history					
	Select well production					Test emergency equipment					
	Produce wells and facilities					Monitor rotating equipment					
<b>Product Delivery Commitments</b>	Communicate with marketing					<b>Static Equipment</b>	Describe different static equipment				
	Plan production						Perform static equipment cleaning and maintenance				
	Produce at required rate						Maintain equipment history				
						Monitor static equipment condition					
						<b>Failure Analysis</b>	Apply condition monitoring techniques				
							Analyse faults				
							Investigate possible shooting				

Typical Competence Assurance System Job Profile

# Accountability pack for each HSE-critical role

Accountability Sheet					
Role/Post :		<i>Maintenance Supervisor</i>			
Identified Safety Critical Role (Document OD-SA-03-46):		<i>Yes, Level 1 and 2</i>			
HSE Critical Task Specification Sheet					
Task Ref	Task Title	Input / Procedures		Task Verification	
BON-06.01.03	<i>Maintain, test and inspect cargo and crude export pumps, meters and protection systems</i>	<ul style="list-style-type: none"> <li>OPRM-2003-0304 : POPM Volume 4 - Oil Storage Handling and Ballast</li> <li>OPRM-2003-0305 : POPM Volume 5 : Oil Metering and Export</li> <li>OPRM-2005-0057 : Maintenance and Inspection Management System Manual</li> </ul>		Maintenance plan, maintenance records, test results checked and verified by Operations Supervisor	
BON-06.01.08	<i>Maintain, test and inspect the inert gas system</i>	<ul style="list-style-type: none"> <li>OPRM-2003-0319 : POPM Volume 19 - Inert Gas</li> </ul>		Maintenance Records. Reviewed by Ops Supervisor.	
Etc...					
Safety Critical Role Competencies (Document OD-SA-03-46)					
Competence Requirements	Prerequisites for Assessment	Assessment Format (Standard)	Assessor / Verifier	Re-Asses. Frequency	Maintenance of Competence
Skill at Validating PTW	Computer Based Training to Signatory standard	Computer Based Assessment	PTW Coordinator / Line Verifier	-	Maintained through ongoing daily activities and annual staff appraisal whilst in position
Skill at Supervising HSE	On the job exposure while completing OIM portfolio	Area Supervisor Competence Assessment Manual	Installation Manager / Line Verifier	-	Maintained through ongoing daily activities and annual staff appraisal whilst in position
Knowledge of the Nigerian Legislation (Mineral Oils (Safety) Regulations	Training Course	Demonstration of knowledge	Line Assessor / Line Verifier	-	Maintained through ongoing daily activities and annual staff appraisal whilst in position
Etc...					
I understand and accept the HSE Critical Tasks and Safety Critical Role Competencies assigned to me.					
Name			Signature		
Position			Date		

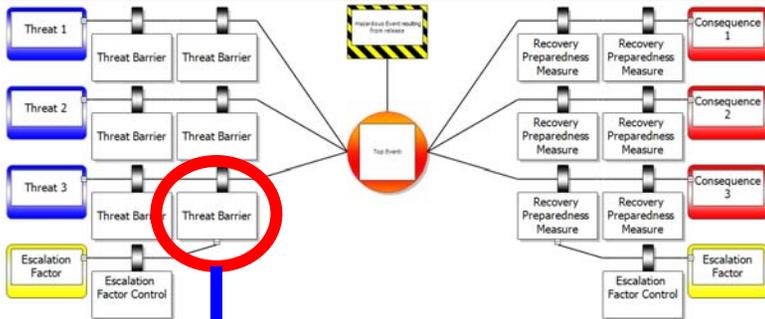
HSE-critical role

HSE-critical tasks, procedures & verification

HSE-critical competencies

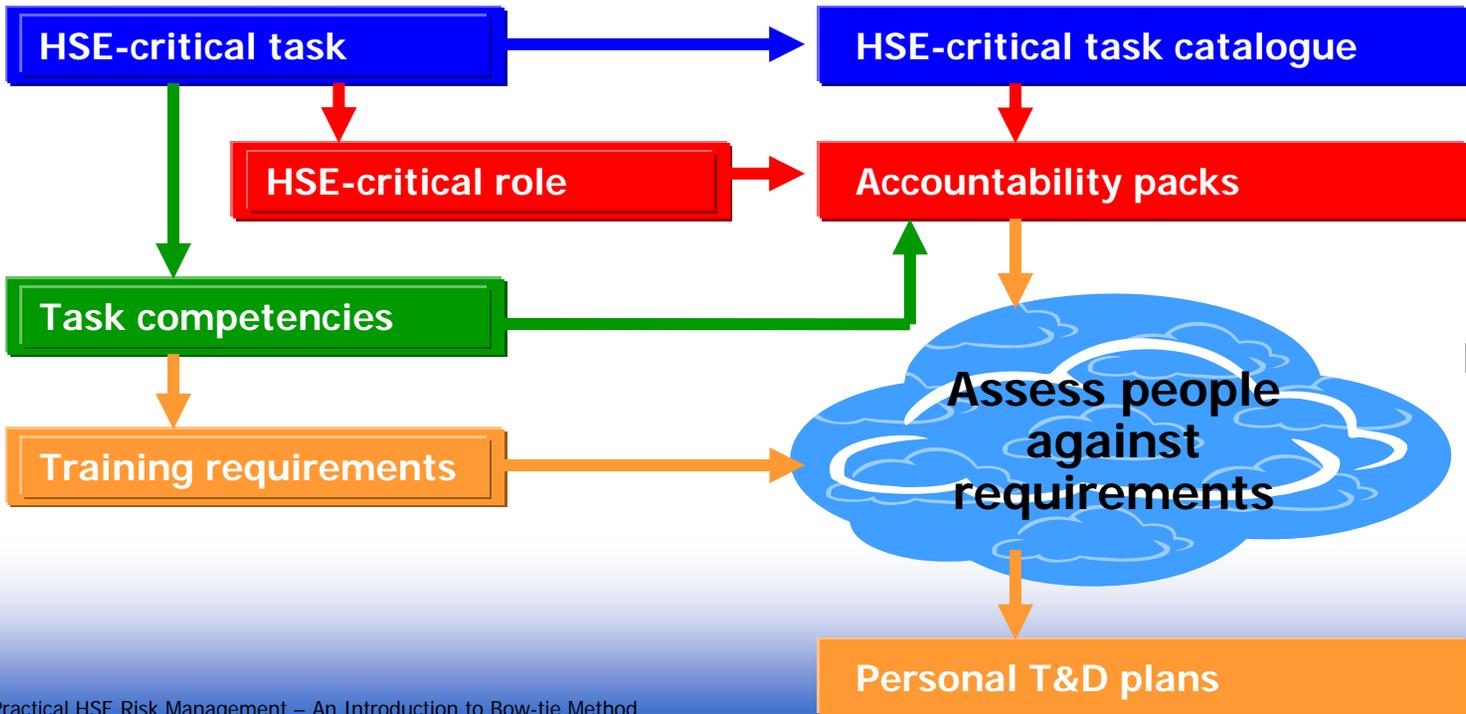
Sign-off

# Link between bow-ties and training & development



**Competent people provide resilience against major risks**

...to ensure each risk control works...



...use Competency Mgmt System



# Competency management system

CompetencyXP [Show Matrix]

File Add Records Security Maintenance Reporting Course Planning Tools Window About... Help

Select a Matrix  
 Matrix from definition  
 Dynamic matrix from role  
 Role: Roustabout

Expiry date: 27/2/2006  
 Core cost categories:   
 Comping:   
 Department incl sub:

Filter: 350 23.91 % 15,000.00  
 Expired: 10 0.68 % 25,201.00  
 Missing: 1,114 76.09 %

Legend:  
 Green: Valid  
 Red: Expired  
 Yellow: Planned date before selected expiry  
 Orange: Planned, in future

Sample training matrix

Name	Role	H2S Training	JSA	NR01 EPI	GVF	Rigging and Scaffolding	Scaffolding	SOP Method Safety Management	HSEIET	Survival	ISM Instruction	Field To Work	SEMS
CORREA DE LIMA, EVERTON	Roustabout								12/7/2007	11/23/2009			
CORREA GUEDES, WESLEY	Roustabout								10/14/2007	5/14/2007			
CORREIA DOS SANTOS, LUIZ ANTONIO	Roustabout			12/31/9999	12/31/9999			12/31/9999		6/24/2006		12/31/9999	
COUTINHO DE OLIVEIRA, RITA DE CASSA	Roustabout					8/23/2007		12/31/9999	10/26/2007	10/27/2006			
CRUZ DO NASCIMENTO, MARCOS	Roustabout	12/31/9999			12/31/9999	12/31/9999		12/31/9999	8/25/2006	7/5/2006			12/31/9999
DA COSTA MONTEIRO, RONALDO	Roustabout					8/5/2007			4/7/2006	8/26/2007			
DA CUNHA SILVA, FABIANO	Roustabout				12/31/9999	12/31/9999			12/12/2007	1/6/2008		12/31/9999	
DA CUNHA SILVA, FABIO	Roustabout							4/17/2009	2/7/2007		12/31/9999		
DA ROSA, JOSE LAELO	Roustabout				12/31/9999	7/22/2007		10/22/2006	3/31/2006	11/8/2009			
DA SILVA CORREA, ADILDO	Roustabout								12/9/2007	12/8/2010			
DA SILVA CORREA, CARLOS	Roustabout							12/31/9999	2/2/2007	2/5/2006			
DA SILVA CORREA, JOSE PAULO	Roustabout								4/28/2007	6/11/2006			
DA SILVA CORTES, JOAO MARCIO	Roustabout	12/31/9999	12/31/9999			12/31/9999		2/3/2006	5/14/2006	11/26/2006		12/31/9999	
DA SILVA ESTEVAO, ANSELMO	Roustabout					11/11/2007			11/12/2006	2/22/2006			
DA SILVA OLIVEIRA, JOSE EDUARDO	Roustabout	12/31/9999	12/31/9999			12/31/9999		10/11/2006	3/31/2006	2/5/2006			
DE ALENCAR SANTOS DA SILVA, HUMBERTO	Roustabout								12/1/2007	3/18/2007			
DE ALMEIDA COIMBRA, PAULO CESAR	Roustabout					12/31/9999		12/31/9999	11/18/2007	8/27/2006			
DE ALMEIDA RANGEL, MANOEL	Roustabout	12/31/9999	12/31/9999			12/31/9999		12/31/9999	2/23/2007	8/5/2009			
DE JESUS, DANIEL LUCIANO	Roustabout					12/31/9999			10/13/2007	10/13/2009			
DE LEMOS CASADO, SIDNEI	Roustabout									8/29/2009			
DE OLIVEIRA FREITAS, JOHNSON ROGERS	Roustabout									2/13/2006			
DE OLIVEIRA TALINA, CLAUDIO	Roustabout									8/30/2007			
DE PAULA DA SILVA, PAULO SERGIO	Roustabout	12/31/9999	12/31/9999					12/31/9999	1/19/2007	1/21/2009			
DE SA SANTOS, ALEXANDER	Roustabout								12/5/2007	8/6/2008			
DE SENA, ADILTON CATARINO	Roustabout		12/31/9999				12/31/9999		8/18/2006	4/6/2008			
DE SOUZA CALDAS, ROGERIO	Roustabout							12/31/9999	10/14/2007	2/26/2007		12/31/9999	
DE SOUZA MELO, PAULO ADRIANO	Roustabout					8/5/2007			4/26/2006	6/18/2006			
DE SOUZA PEREIRA, CRISTIANO	Roustabout							4/13/2006	12/3/2006	4/28/2007			
DE SOUZA PESSANHA, REGINA MARICA	Roustabout								11/26/2006	12/1/2010			
DE SOUZA SILVA, JOAO BATISTA	Roustabout			12/31/9999	12/31/9999				12/12/2007	7/22/2007		12/31/9999	
DE SOUZA TAVARES, CARLOS AUGUSTO	Roustabout									12/15/2006			
DIAS GUEDES, ROSSON	Roustabout									7/23/2009			
DOS ANJOS, WAGNER JORGE	Roustabout								10/14/2007	10/13/2009			
DOS REIS CORREA, FERRANDO ANTONIO	Roustabout								10/7/2007	10/3/2009			
DOS SANTOS ARAUJO DA SILVA, ANDERSON	Roustabout					3/13/2007			8/18/2006	8/20/2009			
DOS SANTOS, JOSUE LUIZ	Roustabout		12/31/9999					9/24/2006		3/20/2006			
DOW, WILLIAM MICHAEL	Roustabout					8/5/2007			4/7/2006	7/29/2009			
DUARTE DA SILVA, EDUARDO	Roustabout									1/10/2003			
FAPTA MACHADO, MARCOS ANTONIO	Roustabout								3/24/2006	3/29/2009			
FELIX DA SILVA, FRANCISCO CARLOS	Roustabout			12/31/9999		12/31/9999		12/31/9999		5/23/2007			
FERRERIA BARBOSA, ELY CARLOS	Roustabout								4/23/2006	12/23/2007			
FERRERIA BARBOSA, ESTACIANO	Roustabout												

Show report Export Close



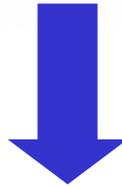
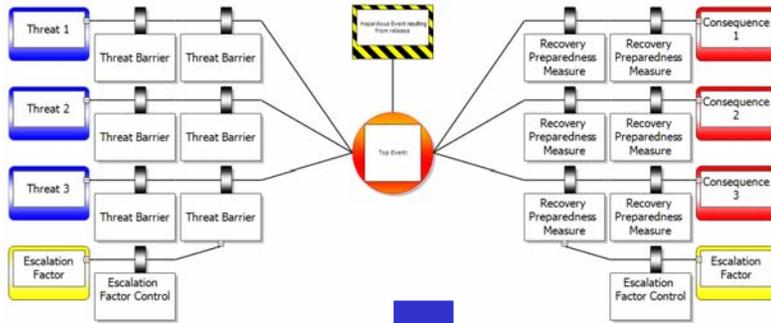
- Personnel information
- Training management
- Competency management
- Document management
- Reporting

# Link between bow-ties and procedures

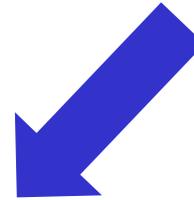
Task	Responsible Person/Task Description	Inputs/Documents	Verification
ABC-22.05	Area Supervisor – Maintain Safety Signage	<ul style="list-style-type: none"> <li>Ensure safety related signs are maintained up-to -date and in good order</li> <li>- escape routes</li> <li>- exit signs</li> <li>- fire equipment signs</li> <li>- life saving appliance signs</li> </ul>	- Inspection and Audit
ABC-12.03	HSE – Manager – Management of Hazardous Materials	<ul style="list-style-type: none"> <li>Ensure correct storage and handling of hazardous materials in accordance with the requirements identified in the MSDS</li> <li>- secure storage</li> <li>- segregation of incompatible chemicals</li> <li>- use of PPE</li> <li>- appropriate means of transport-</li> <li>inventory management</li> </ul>	<ul style="list-style-type: none"> <li>- HSE audit</li> <li>- area inspections</li> <li>- manifests</li> <li>- non compliance reports</li> </ul>
ABC-06.03	Site foreman – Weekly area Inspections of process facilities	<ul style="list-style-type: none"> <li>Carry out weekly inspections of all site areas:</li> <li>- housekeep</li> <li>- general co</li> <li>- general co</li> <li>- condition c</li> <li>- availability</li> </ul>	<ul style="list-style-type: none"> <li>- Inspection checklist</li> <li>- reports</li> <li>- reports</li> </ul>

**Verify procedures for conducting HSE-critical tasks are complete and effective**

# Link between bow-ties and auditing



HSE -CRITICAL TASK LIST	
<b>Responsible Person:</b>	<b>Supervisor</b>
Task 1: .....	
Task 2: .....	
Task 3: .....	

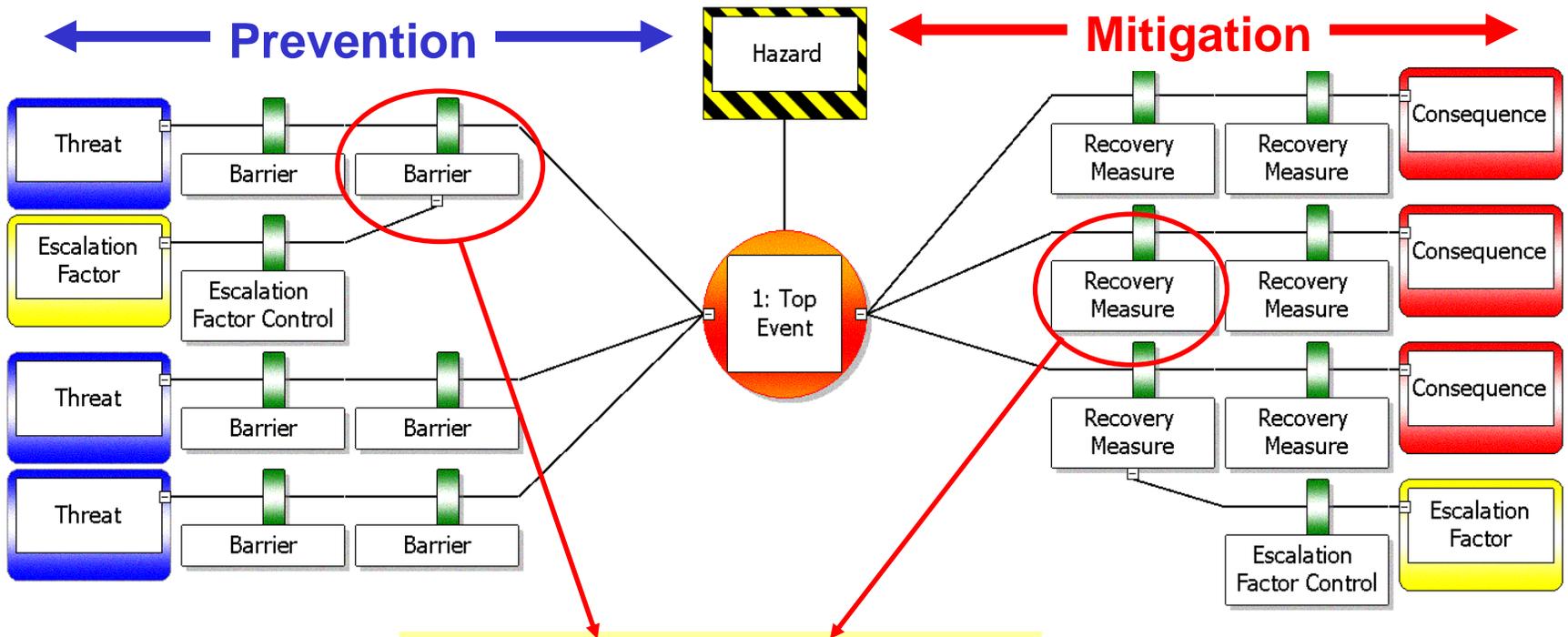


AUDIT CHECKLIST	
<b>Supervisor</b>	
Task 1 .....	<input checked="" type="checkbox"/>
Task 3 .....	<input checked="" type="checkbox"/>
<b>Foreman</b>	
Task 5 .....	<input checked="" type="checkbox"/>
Task 9 .....	<input checked="" type="checkbox"/>
Task 11 .....	<input checked="" type="checkbox"/>



**Audits can be focused on what really matters**

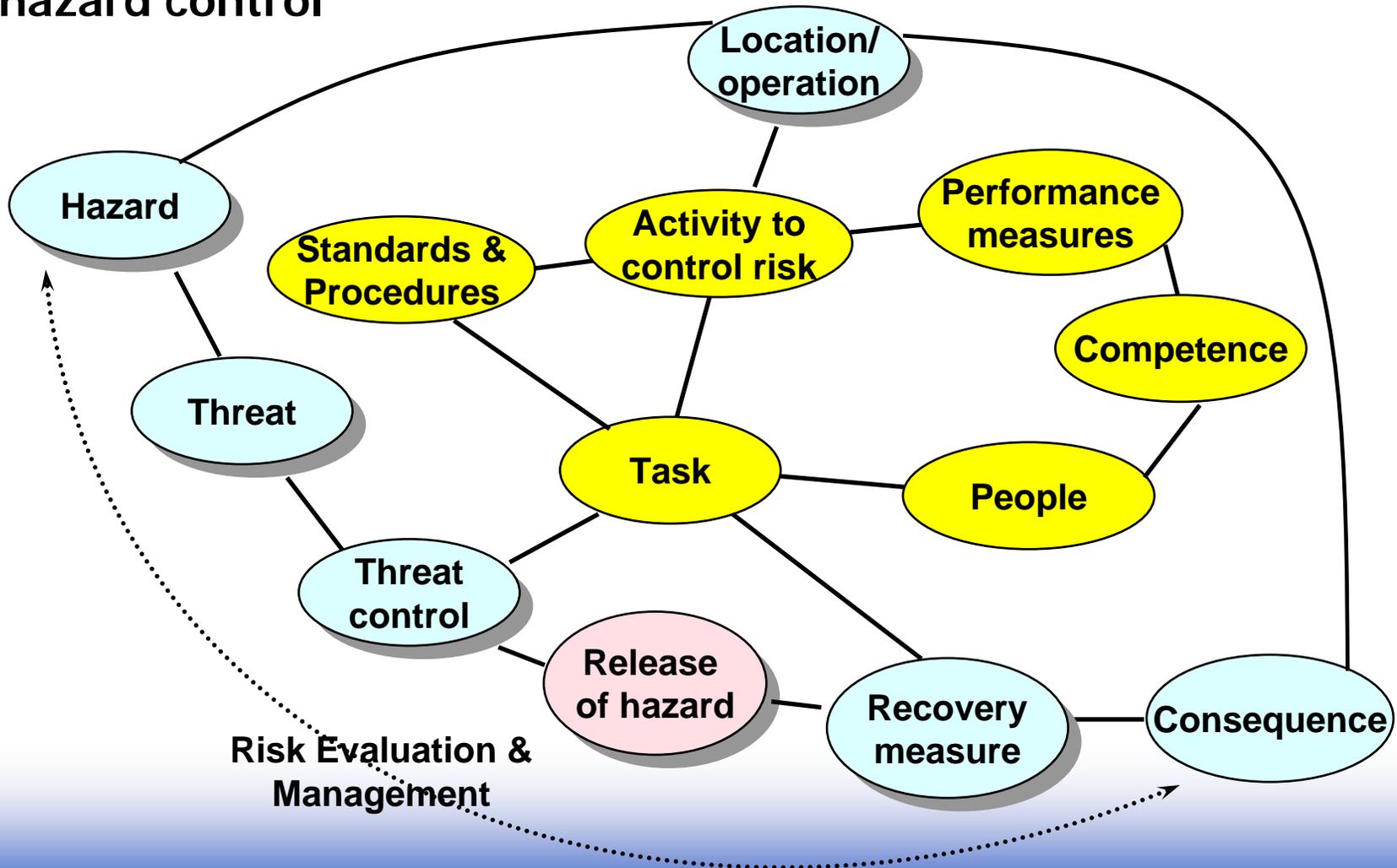
# Link between bow-ties and HSE-critical equipment & systems



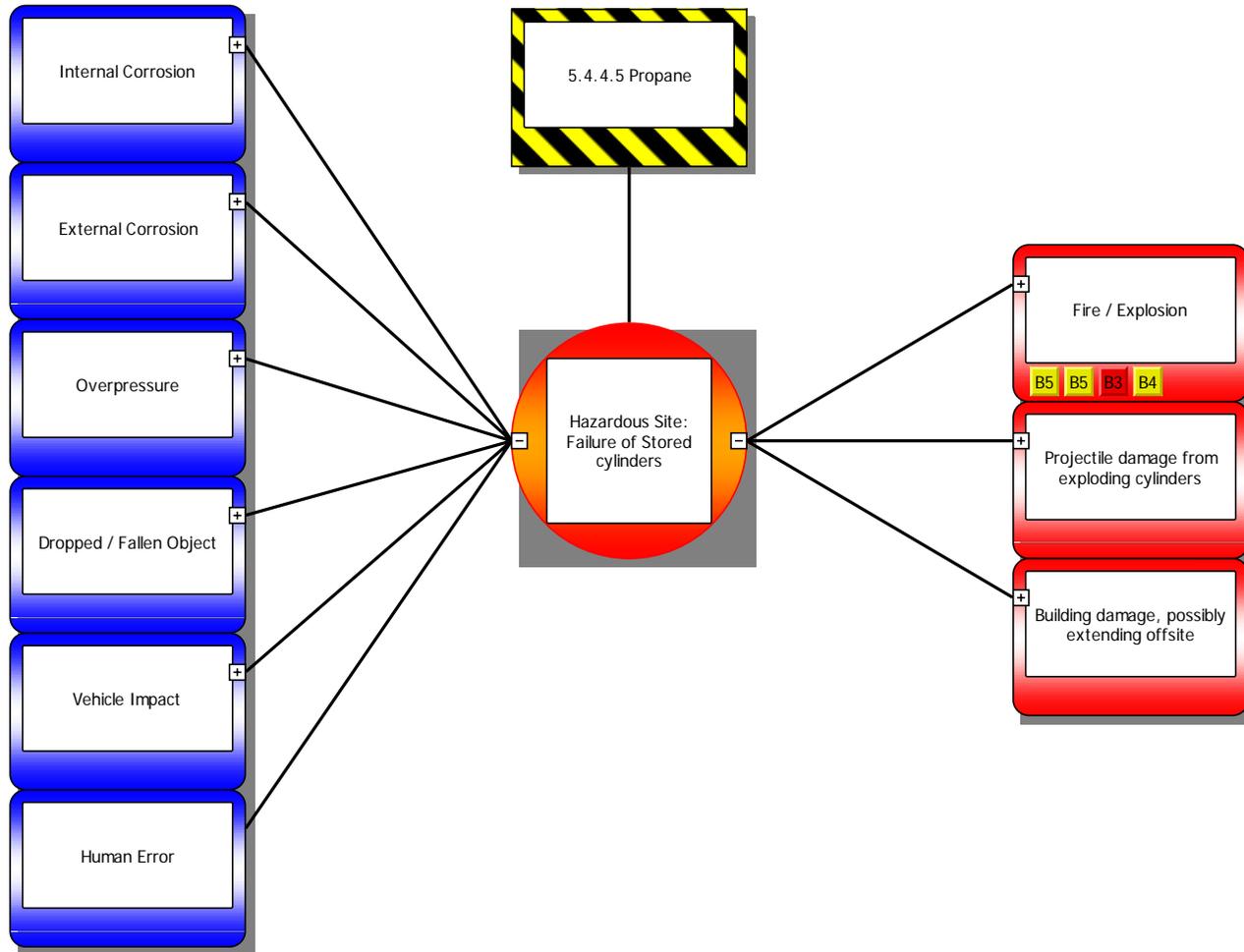
**Establish performance standards for these systems**  
**Maintenance management system should flag HSE-critical systems and tasks**

# Total hazard control

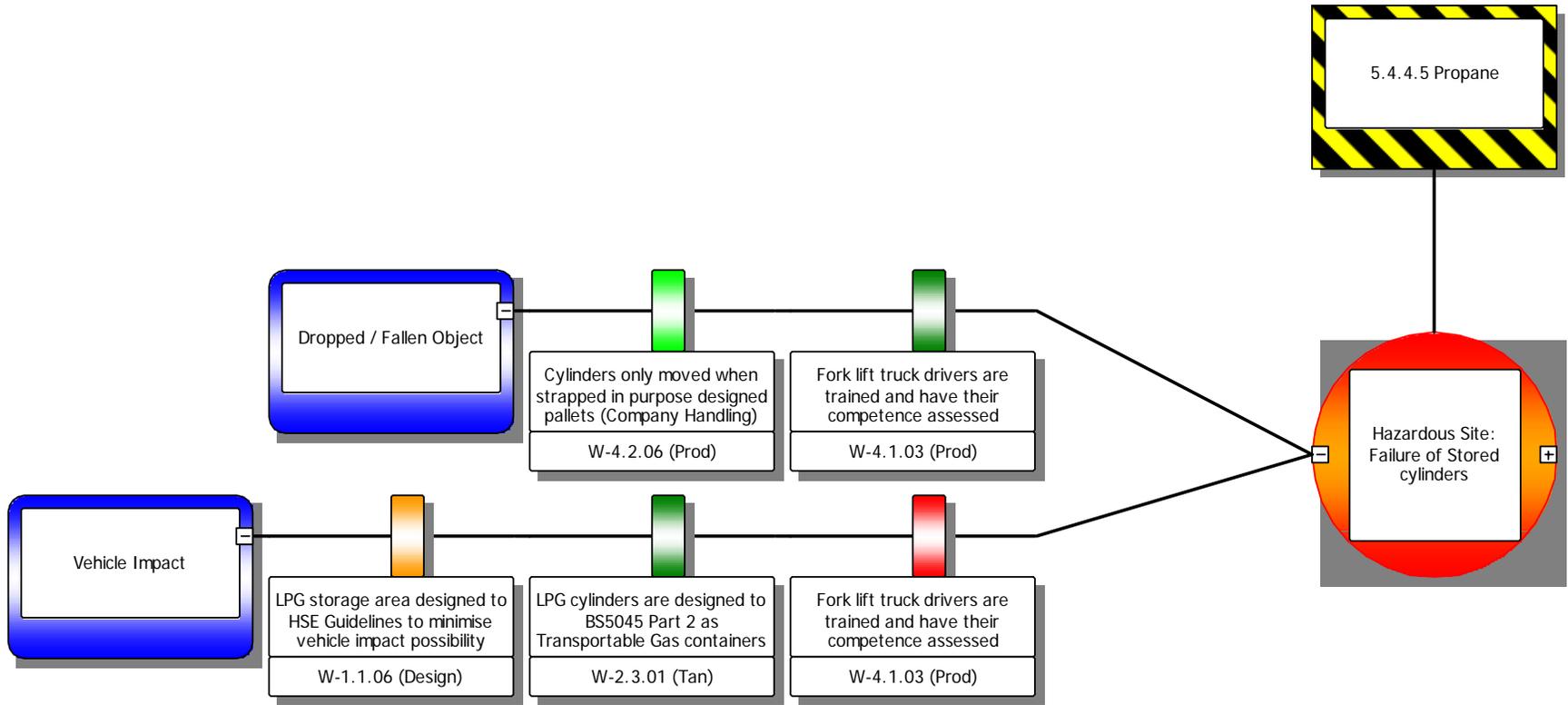
In the end you must have all connections in place for effective hazard control



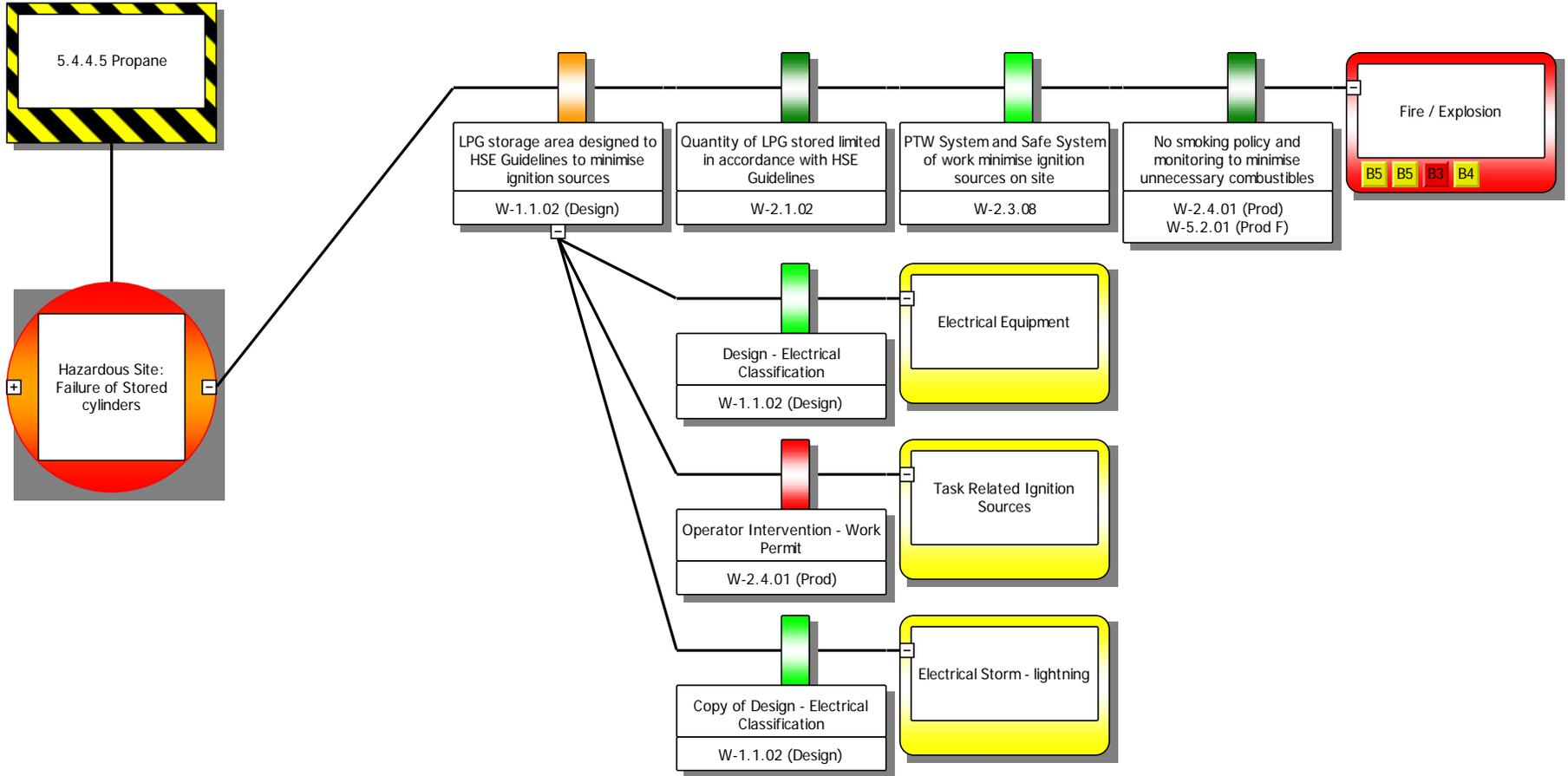
# Example bow-tie



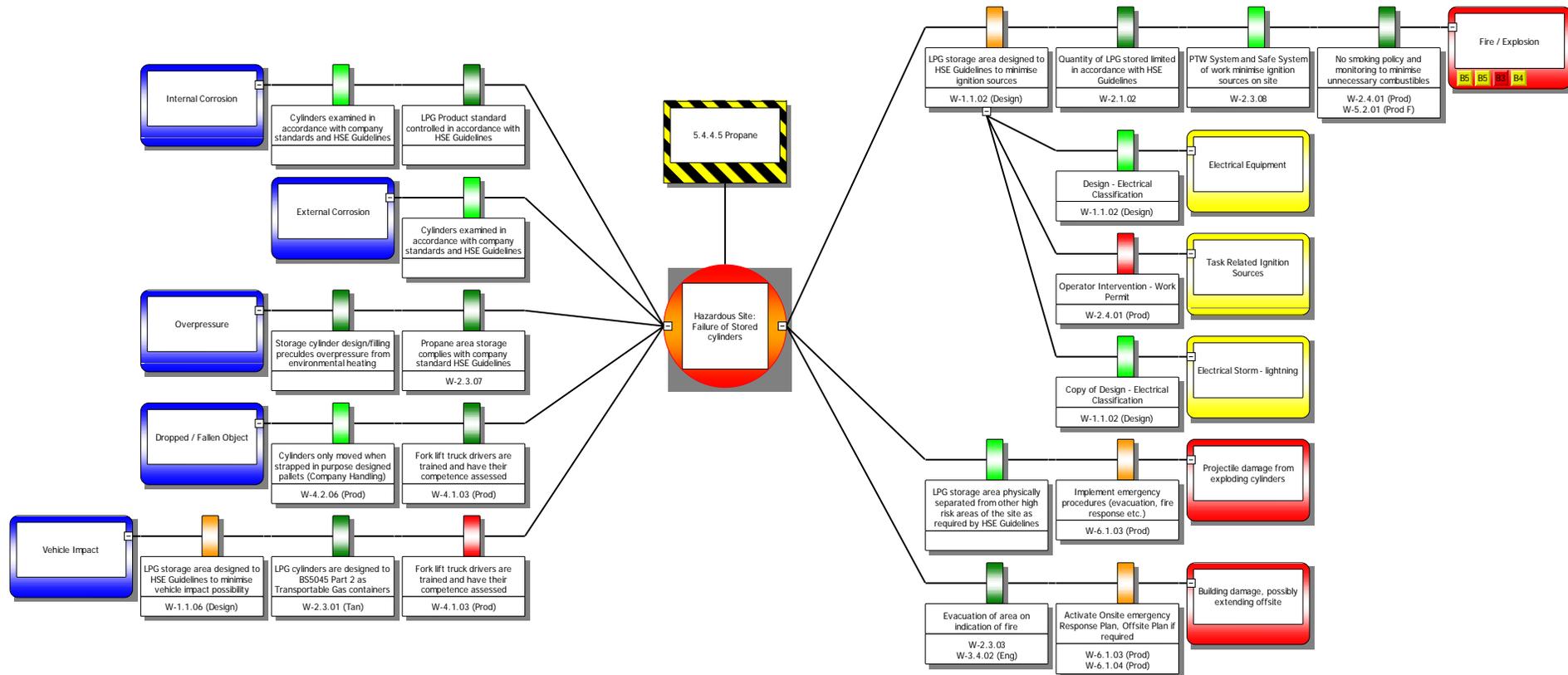
# Example bow-tie: threats



# Example bow-tie: consequence

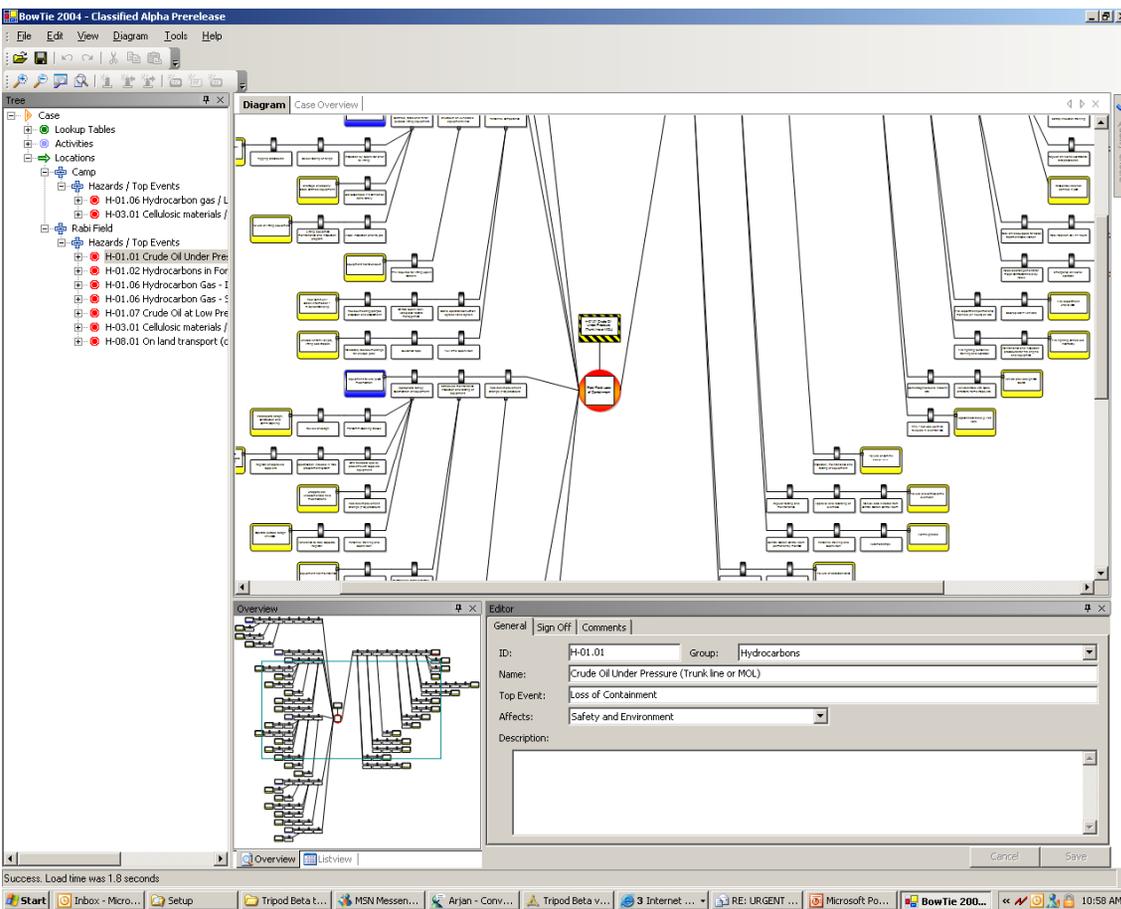


# Example bow-tie: complete



# Building bow-ties

Software helps but don't get hung up on it!  
Benefits are from approach and involving workforce



# Benefits of bow-tie method

- **Communication** – “a picture paints a thousand words”
- **Ownership** – involves people, gains buy-in, practical approach
- **International application** – overcomes language difficulties
- **All risks** – not just HSE
- **Risk reduction** - identifies where resources should be focussed for risk reduction, i.e. prevention or mitigation

# Benefits cont...

- **Fit for Purpose MS** – Links elements of the organisation's MS to specific control
- **Auditable Trail** – the diagrams and critical tasks provide protocol around which auditing by internal depts focuses on what people are actually doing rather than physical systems

# Limitations

- Entirely qualitative
- Does not replace other techniques (JSA, method statements, etc.) – is complementary to them
- Depends on experience of personnel and active workforce involvement
- Ensure controls in bowtie are truly independent

**But if you want to remove mystique of risk management and obtain insights into your risk controls that are easy to understand and easy to communicate, there is no better method than bow-ties**

# Tips for success

- 1. Keep end objective in mind - pitch at the right level**
- 2. Involve the right people**
- 3. Avoid barrier counting**
- 4. Use method to full potential**
- 5. Verify controls and tasks**

# Summary

- The **Bow-tie Diagram** is a user-friendly, graphical illustration of how hazards are controlled
- Effective risk management is only possible if people are assigned responsibilities for controls via **HSE-Critical Tasks**
- Visible links are made to **HSE-critical systems** and **competencies** and **auditing**
- The total methodology demonstrates not only what controls are in place **today**, but why they will still be there **tomorrow**