Barrier Management

Nafiseh Reshadi, Oct 2016

Workshop Outline

- Hazardous Events and Major Accidents
- Rational behind Barrier Management
- Barrier Definition, Properties and Performance
- Implement Barrier Management System
  - Barriers - Integration with HSE Management
  - Barriers - Integration with Risk Analysis
  - Barriers - Integration with Maintenance
  - Focus Point - Safety-Critical Elements
  - Focus Point - Risk Reducing Measures
  - Proactive vs Reactive Barriers Management
- Barriers Performance Monitor and Verification
- Barrier Management in Day-to-Day Operation

Why barriers and barrier management?

- It is a well established topic in aviation and nuclear industries

- Grown as an important topic in petroleum industry

  - ❑ Since1970's, requirement for barriers in drilling and well operations in Norwegian Continental Shelf

- Essential in major accident prevention

  - ❑ Investigations findings
  - ❑ Researches
  - ❑ Requirements
  - ❑ Focus from petroleum safety authorities

Workshop Objectives

- To realize importance of barriers for safe operation
- To understand what is meant by barrier function, elements, and performance
- To understand principles of a systematic approach for barrier management, and its integration with company HSE-MS

Hazardous Events and Major Accidents

What? Why? How?

Major Accidents

A major accident is defined as an acute incident, which immediately or subsequently causes several serious injuries, loss of human life, serious harm to the environment, assets, or company reputation.

- Leaks of flammable gas or liquids; either ignited or unignited
- Well control incidents; either ignited or unignited
- Fire/explosion; could be critical areas of the plant causing escalation
- Collisions and other structural damage; including ship collision and dropped objects.

Year	Plant	Accident
2010	DwH Golf of Mexico	Explosion and fire killed 11. More than 4 million barrels of oil spill
2005	Texas City Refinery	Explosion killed 15 and injured 170
2004	Stockline Plastics	Explosion killed 9 and injured 40
2003	DSM Chemical Plant	Explosion killed 3
1992	Sodegaura Refinery	Explosion and Fire killed 10 and injured 7
1989	USA Philips 66	Explosion and Fire killed 23 and injured 130-300
1988	Piper Alpha	Explosion and Fire killed 167
1984	Bhopal Chemical	Released toxic gas killed 4000 and injured 500,000
1974	Flixborough Plant	Explosion killed 28 and injured 36

Major Accidents

Piper Alpha, 1988

Barrierer for å unngå storulykker

Norsk olje&

Hindre HC-lekkasje	Redusere mengde	Hindre antennelse	Hindre spredning	Sikre evakuerin
arrierer: esign este praksis ontroll/overvåkning valifikasjonskrav urs/kompetanse rbeidstillatelsessystem isikovurderinger tc.	**Barrierer:** Design Oppsamling Drenering Isolering Trykkavlastning/fakling Etc.	**Barrierer:** Design Tennkildekontroll Ventilasjon Overrisling (deluge) Nedstengning Prosedyrer/kompetanse Etc.	**Barrierer:** Design Passiv brannbesk. Aktiv brannbeskyttelse Ventilasjon Eksplosjonsbarrierer Etc.	**Barrierer:** Design Evakueringsvei Passiv brannbes Evakueringsmid Prosedyrer/kon Etc.

Prosjektet fokuserer kun på den første barrierefunksjonen: Hindre hydrokarbonlekkasje. Fokus på «prosesslekkasjer» (ikke brønnlekkasjer)

Har ikke hatt **antente** hydrokarbonlekkasjer på mer enn 20 år (1992)

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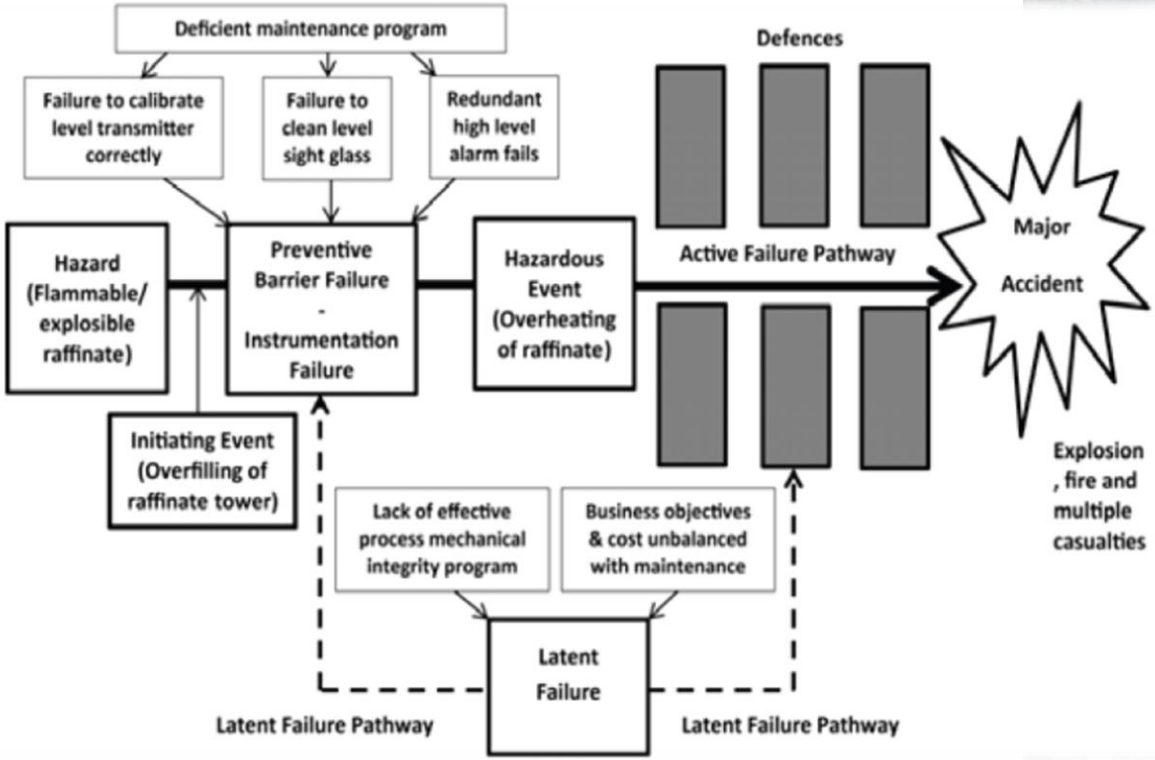
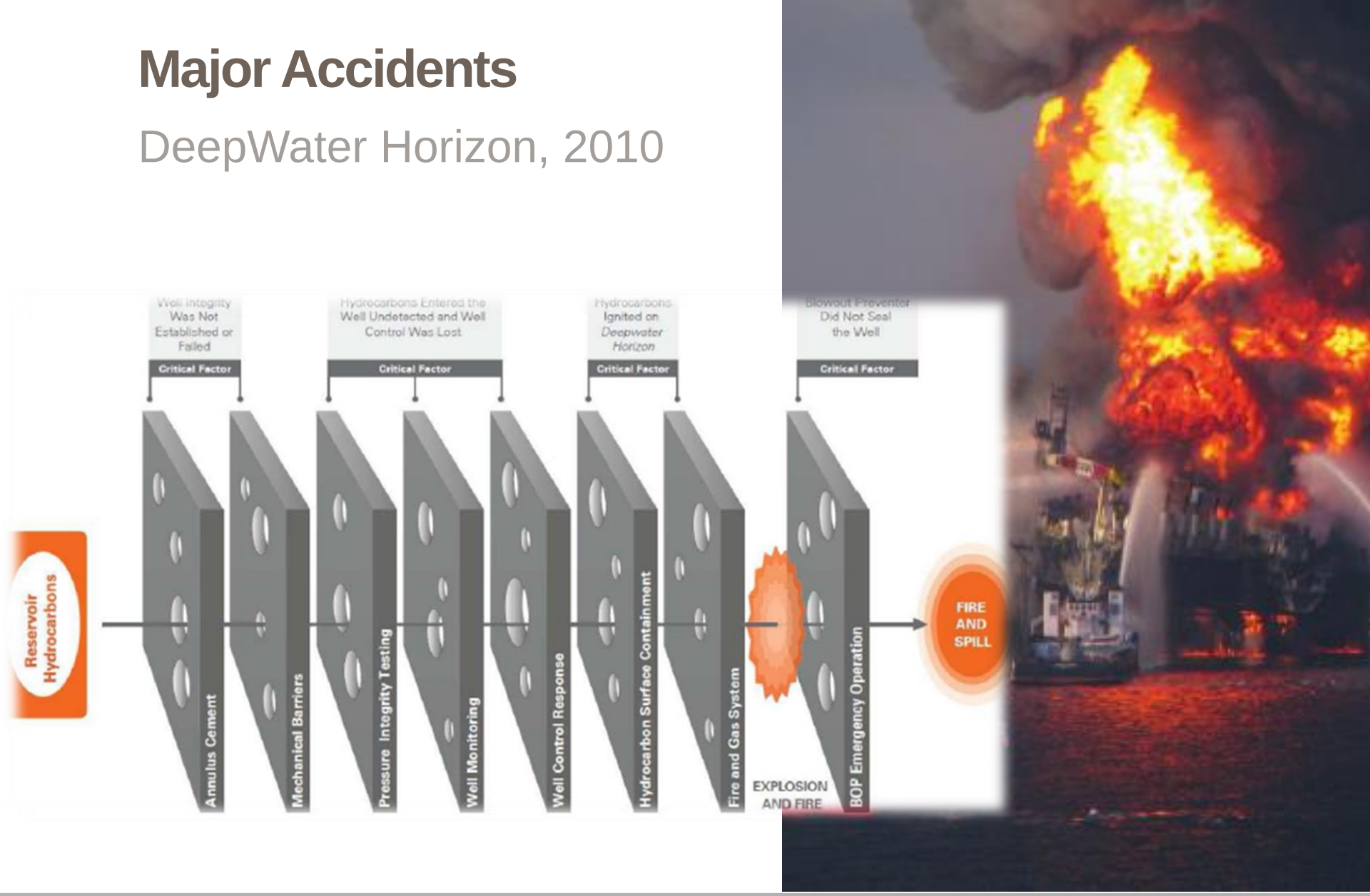
Major Accidents

Texas City Refinery, 2005



Major Accidents

DeepWater Horizon, 2010



Rational Behind Barrier Management

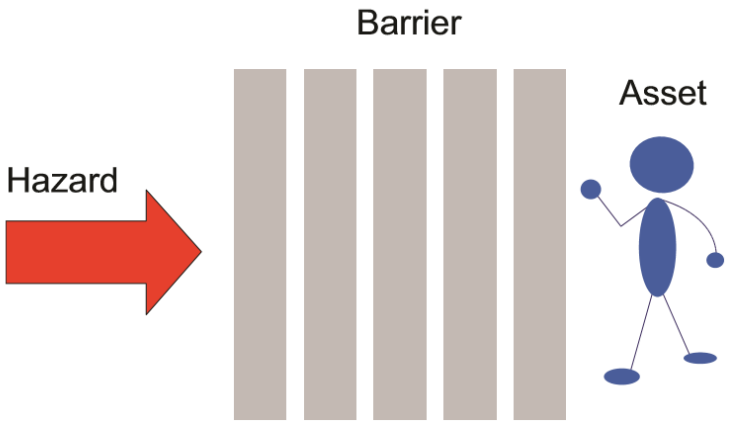
Rational behind Barrier Management

The energy-barrier principle (Gibson, 1961)

- Separate vulnerable assets from a hazard
- Hazard: A source of danger that may cause harm to an asset

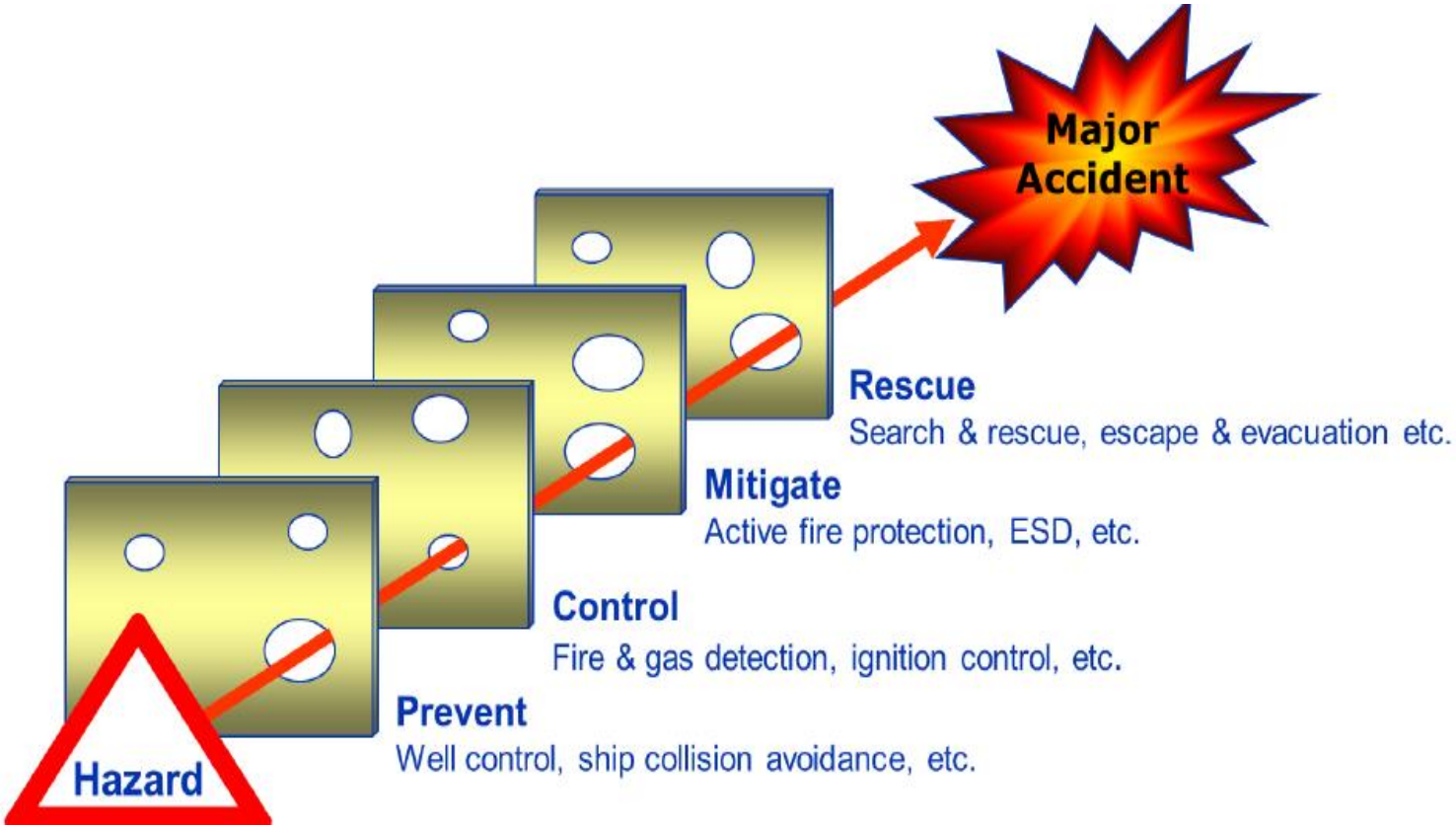
Defence in depth (IAEA, 1999)

- Failure of a single barrier should not lead to a major accident
- Multiple, redundant, and independent barriers



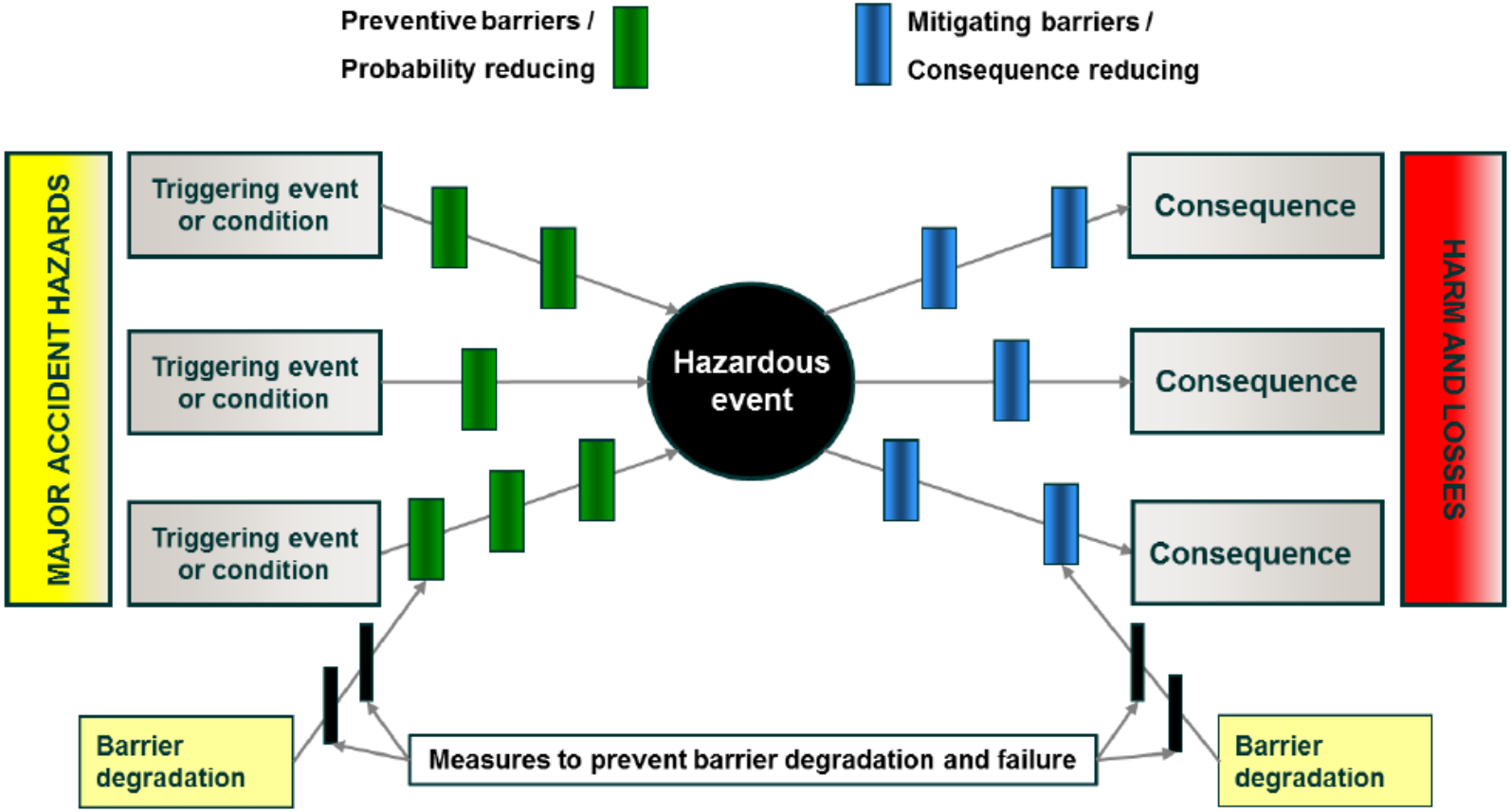
Rational behind Barrier Management

Swiss Cheese Model



Rational behind Barrier Management

BowTie



Rational behind Barrier Management

- Understanding the risk picture for a rig is imperative for managing major accident risk in planning phase as well as in daily operations.

- Decision makers in the company, both onshore and offshore, should know how and when the risk assessments tools can be used to make risk informed decisions.

- Barriers refer to measures established with an explicit purpose to:

  (1) prevent a hazard from happening
  (2) mitigate/limit consequences of a hazardous event

Barriers Definition, Properties and Performance

Barriers Definition

Barrier Function

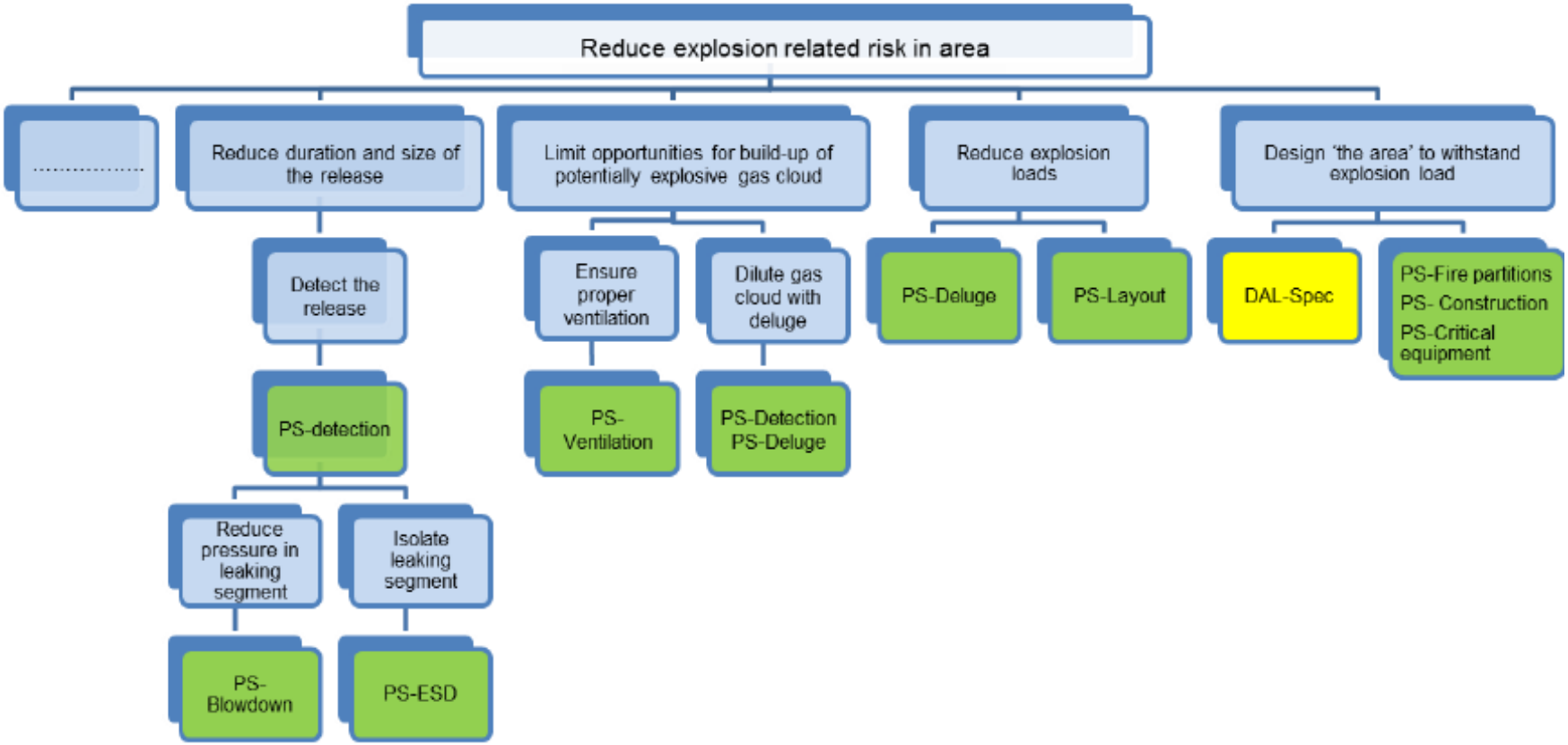
Purpose: Why is it necessary?
Role: How does it work?

Barrier functions		Purpose
Preventive barrier functions	Prevent impact	Prevent damage to installation and equipment by ships, dropped objects etc.
	Maintain position	Prevent potential major accidents caused by loss of position or stability.
	Prevent well kick	Prevent loss unintention
	Prevent blowout (topside or subsea)	Prevent hyc flowing unir environmer
	Prevent leaks	Reduce like

Mitigating barrier functions	Minimize leakage	Reduce size and duration of a leak.
	Prevent ignition	Prevent formation of an ignitable gas cloud. Remove or reduce intensity of ignition sources. Reduce probability of exposure (prevent contact between flammable material and the ignition sources that are required to remain in operation).
	Mitigate explosion effects	Mitigate the consequences of an explosion.
	Reduce fire load	Reduce duration and intensity of fire.
	Prevent escalation	Includes both internal (between equipment) and external escalation (between areas).
	Ensure effective escape	Enable quick, reliable and safe escape.
	Ensure effective rescue	Enable quick, reliable and safe rescue.
	Ensure effective evacuation	Enable quick, reliable and safe evacuation.

Barriers Definition

Barrier Functions in Different Levels



Barriers Definition

Barrier Element

(1)Technical, (2) Operational or (3) Organisational measures which alone or together realize one or several barrier

(1) Engineered systems, structures, or other design features which realize one or several barrier functions.

(2) A task performed by an operator, or team of operators, which realizes one or several barrier functions.

(3) Personnel responsible for, and directly involved in, realizing one or several barrier function.

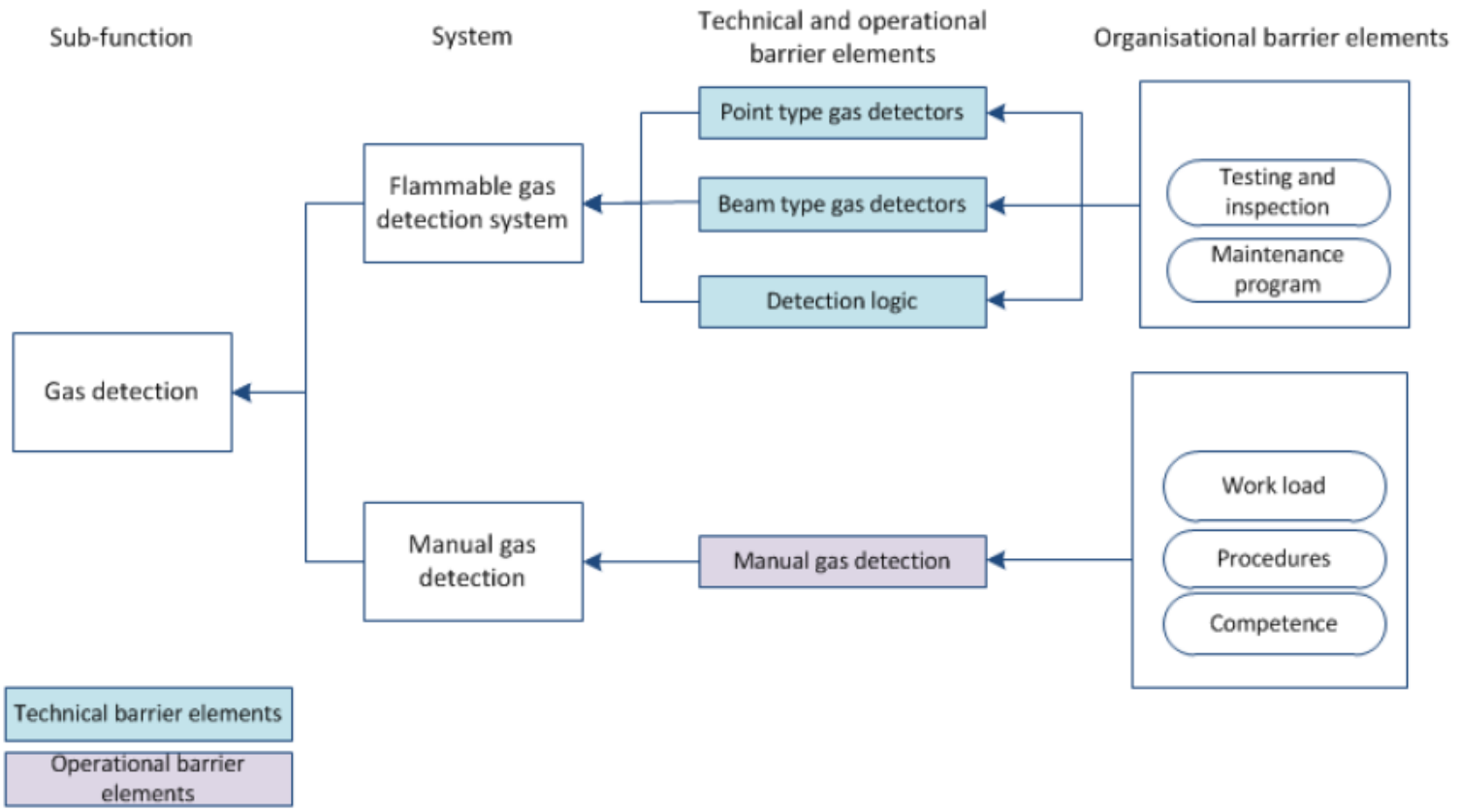
Barriers Definition

Barrier Element cont'd

Categories	Technical barrier elements (active)	Technical barrier elements (passive)	Operational barrier elements
Drilling	Mud pumps, de-gasser, BOP rams and preventers, choke & kill line incl. valves, control systems etc.	Wellhead, casing and liner, marine riser, drilling fluid (mud), cement, in-situ formation etc.	Monitoring and control of well pressures and volumes, kick detection, operating BOP and choke/diverter panel etc.
Topside	Fire and gas detectors, PA and alarms, ignition source control etc.	Fire walls, open and closed drains, layout arrangements, piping and flanges etc.	Search & rescue, operating firefighting equipment, etc.
Maritime	Ballasting system, thrusters, position keeping system etc.	Hull, water tight compartments, anchor lines etc.	Operate MOB boat, weather monitoring, emergency and controlled disconnect, ballasting operations, monitor and notify ships etc.

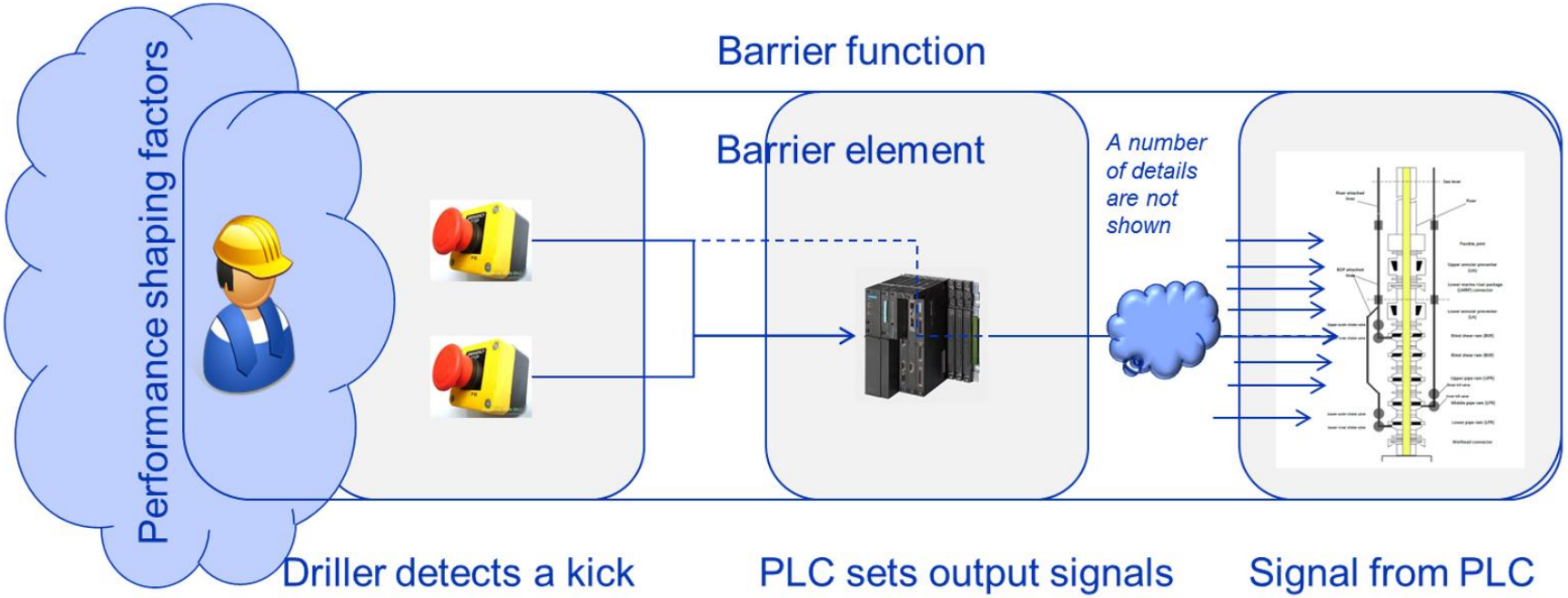
Barriers Definition

Elements Breakdown



Barriers Definition

Barrier Function by Different Elements



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Barriers Properties and Performance

- Functionality
- Reliability
- Specificity
- Capacity
- Durability
- Response time
- Robustness
- Audit-ability
- Independence

Implement
Barrier Management System

Implement Barrier Management System

- Barriers - Integration with HSE Management
- Barriers - Integration with Risk Analysis
- Barriers - Integration with Maintenance
- Focus Point - Safety-Critical Elements
- Focus Point - Risk Reducing Measures

Implement Barrier Management System

Main Steps

Barrier Analysis

- Describe major accident scenarios, incl. causes and consequences
- Identify barriers, both preventive and mitigating
- Link barriers to specific hazard and consequences
- Identify elements to realize the barriers main function
- Describe the interactions and interfaces between the different barrier elements
- Mapping which barriers are in place!

Question? Is there standard approach to barrier analysis?

Answer: No. Best practice is to use a combination of barrier diagrams and matrices.

Implement Barrier Management System

Main Steps cont'd

Barrier Performance Requirement

- Function
- Integrity
- Survivability

Requirement, Standards, Guidelines, Best Practices

It is important that performance requirements cover all barrier elements!

Barrier Scan and Improvement

- Verification activities; test, inspection, and maintenance
- Quality assurance
- Competence
- Planning

acceptance criteria

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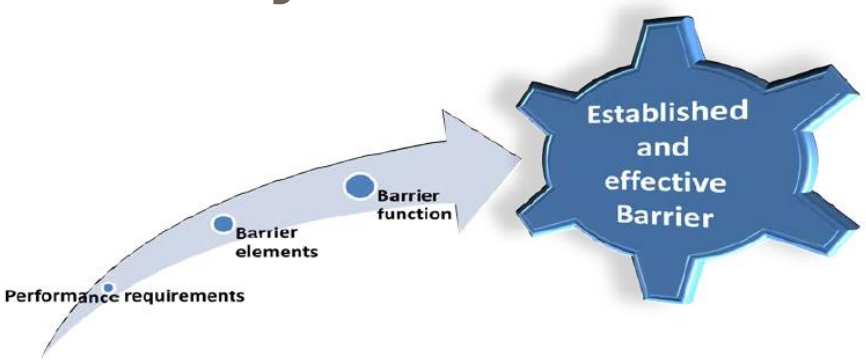
Implement Barrier Management System

Main Steps cont'd



- HAZID,
- Bow-Tie,
- Procedures & manuals etc.
- Workshops & interviews

Identify operational barrier elements

Task analysis

- Describe tasks
- Identify critical actions
- Identify PSFs
- Roles & responsibilities
- Work processes and systems

- Establish performance requirements, incl. assurance and verification activities
- Document in performance standards

Performance requirements

Implement and improve

- Verification & assurance act.
- Follow-up of employees
- Training & drills
- Task planning & execution
- Continuous improvement

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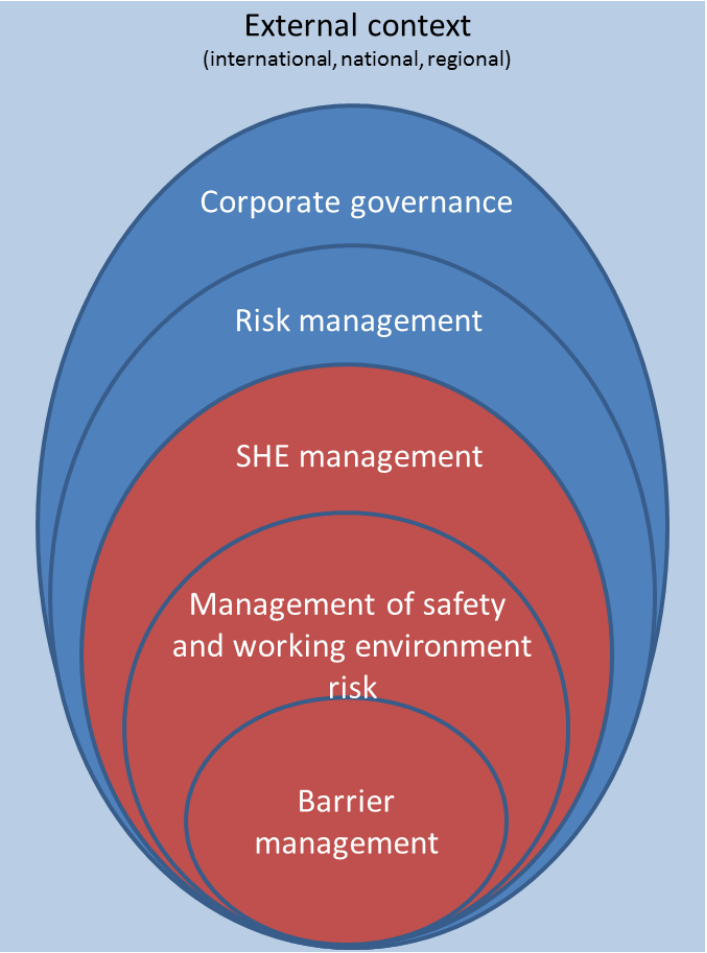
Implement Barrier Management System

Integration with HSE Management

Barrier management represents an integral part of the companies' health, safety and environmental (HSE) management system, which also forms an integrated part of their corporate governance.

Management Standards basis for Barrier Management
ISO:31000
ISO:9000



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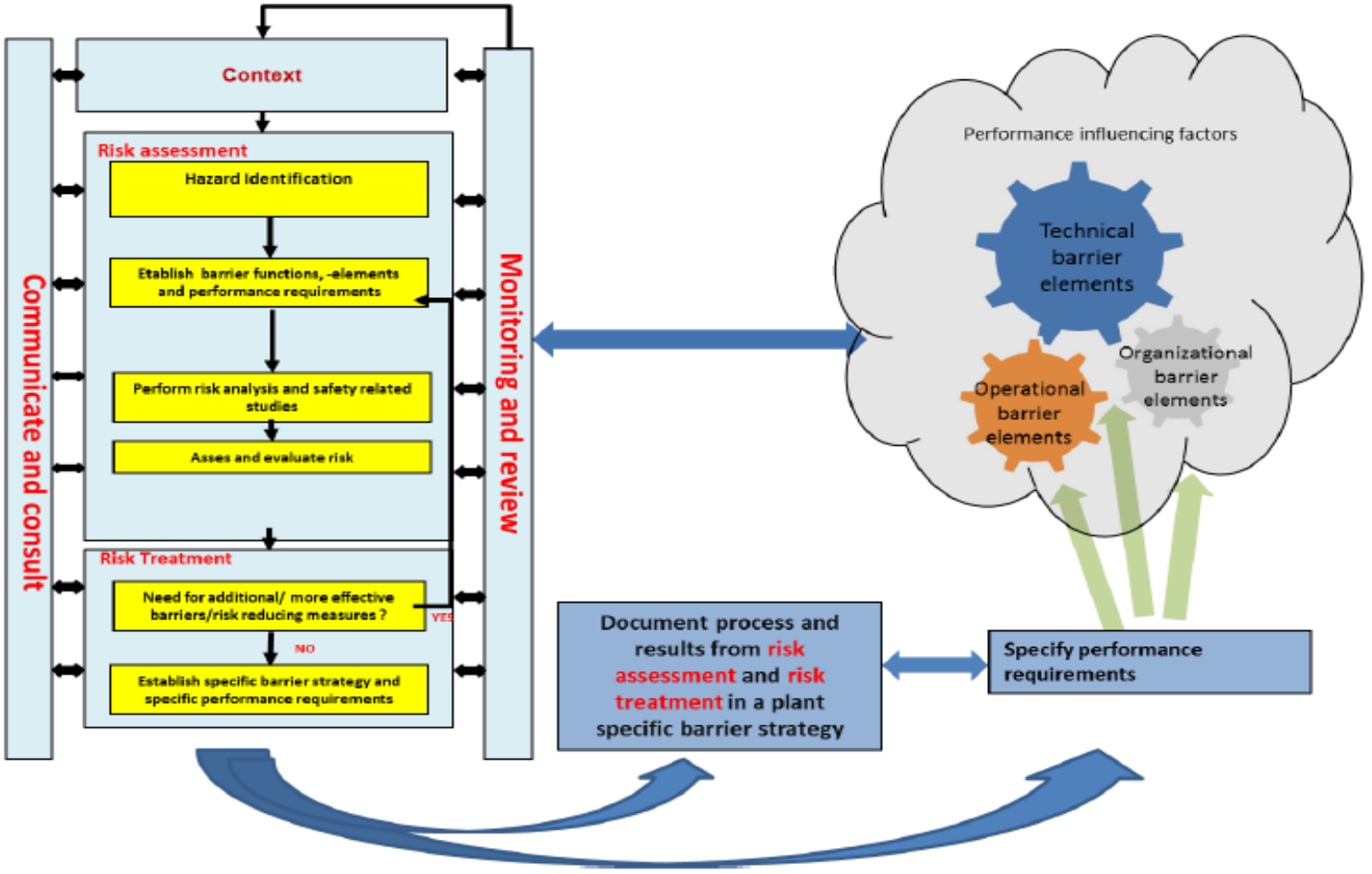
Implement Barrier Management System

Integration with Risk Analysis



Implement Barrier Management System

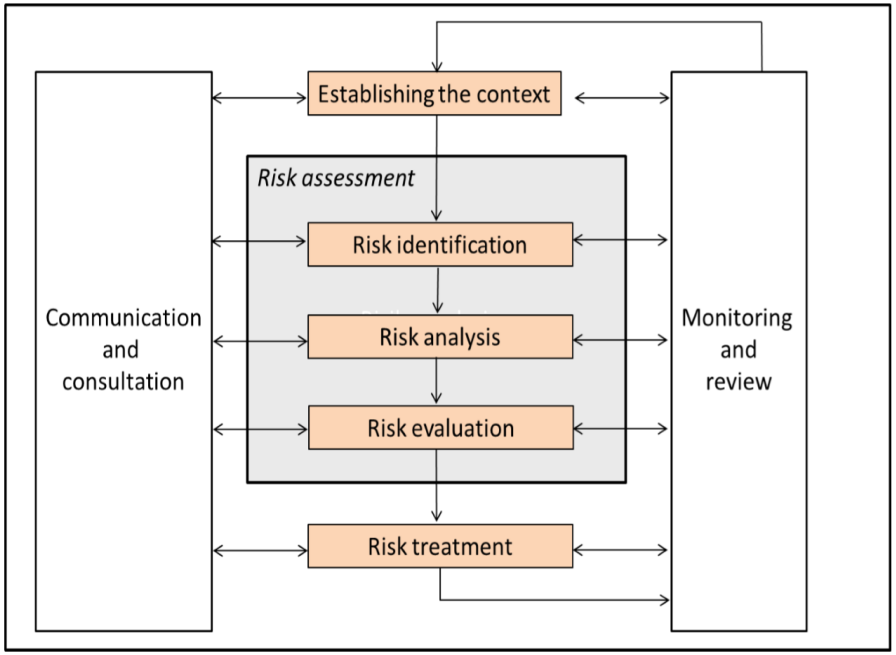
Integration with Risk Analysis

Modelling barriers in risk analysis

- Model complexity
- Operational and organizational barriers
- Proactive vs. reactive barriers

Establishing performance requirements

- Level of resolution
- Insensitivity to risk metrics
- Risk-based vs. descriptive approach



Implement Barrier Management System

Integration with Maintenance

Separated from other disciplines

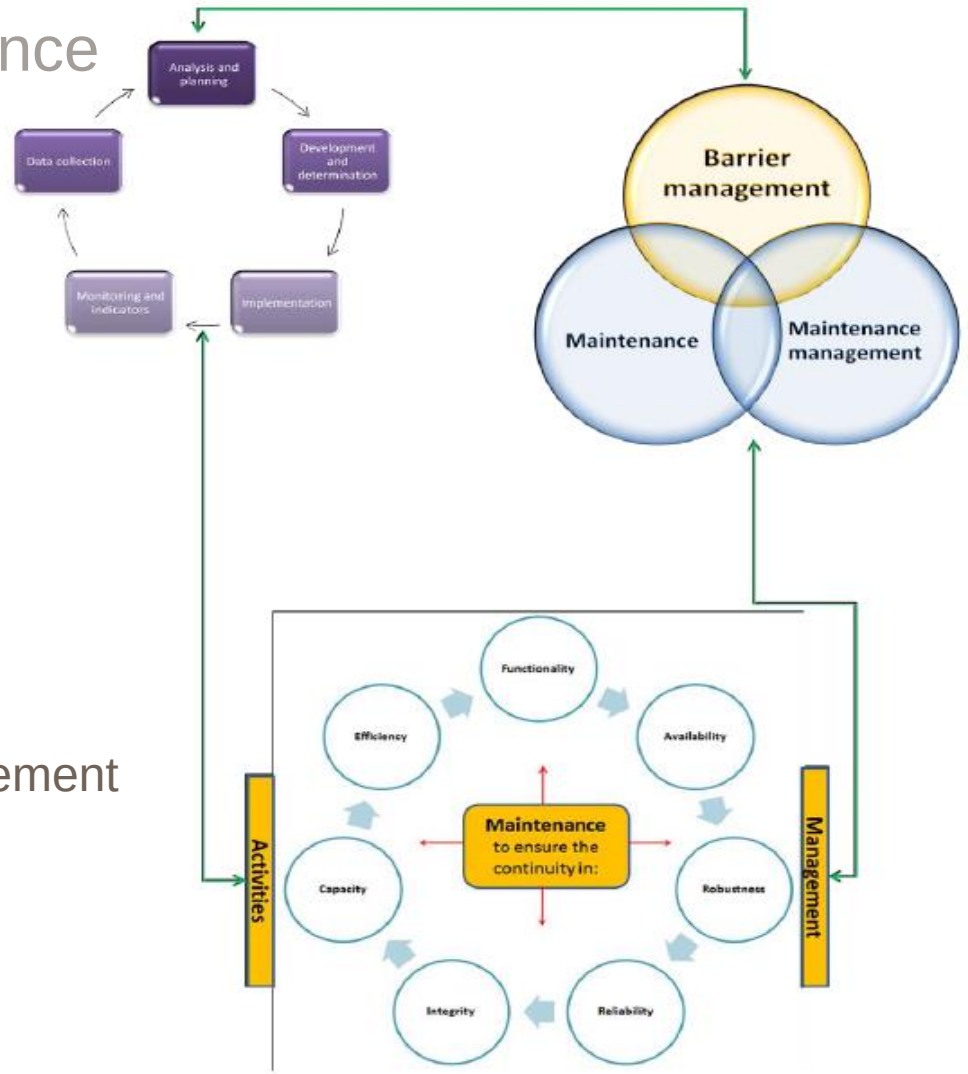
- Assumptions and requirements

Testing and verification

- Imperfect testing
- Other activities

Priorities for handling deviations

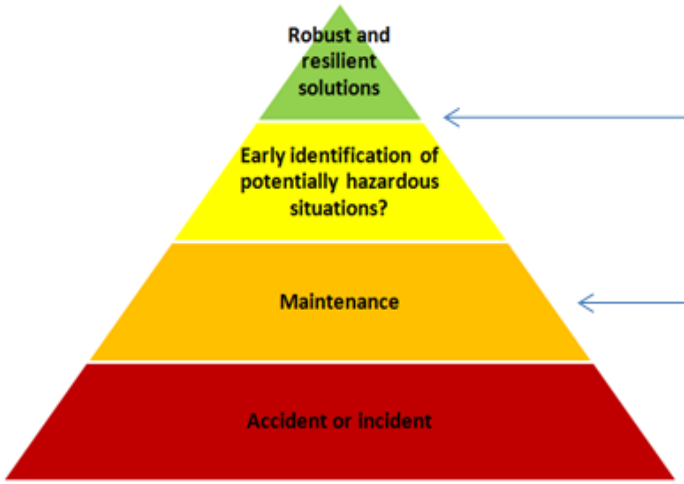
- Failure classification/ barrier element criticality
- Causes vs. symptoms
- Backlog



Implement Barrier Management System

Integration with Maintenance

Solutions of barriers and barrier elements



Barrier management

Maintenance

Implement Barrier Management System

Focus! Safety Critical Elements

- Safety critical elements are such parts of plant (including computer programs), or any part thereof:

a) the failure of which could cause or contribute substantially to major accident
b) purpose of which is to prevent, or limit/mitigate the effect of major accident

- Latent failures: Equipment degradation, incorrect configuration, or other failures which do not initiate an incident when introduced, but contributes to initiation or escalation of incidents in combination with other failures occurring at a later stage. k analysis.

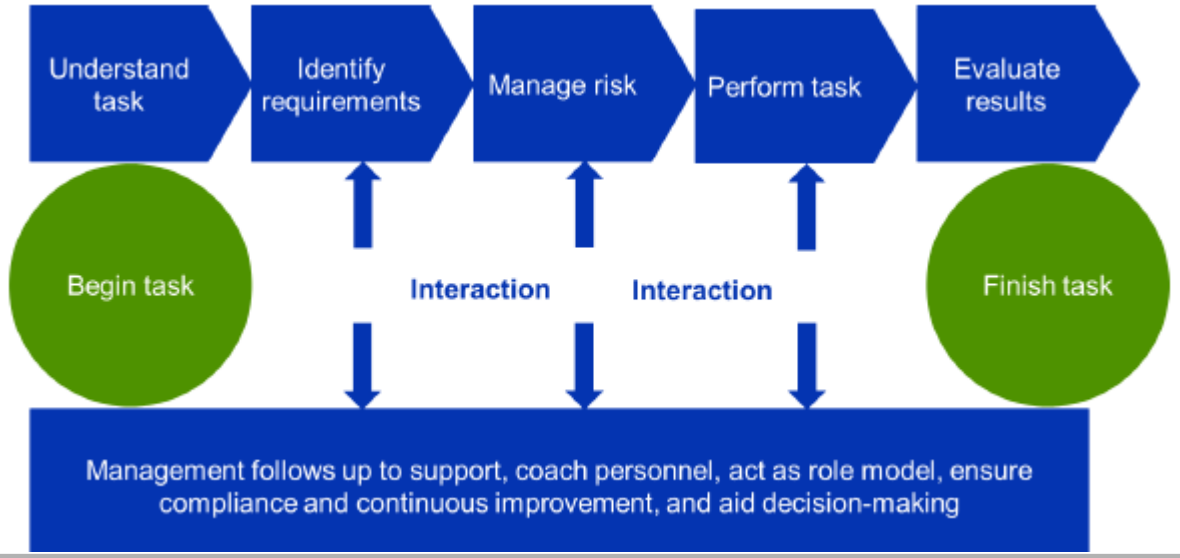
- Human error: Out-of-tolerance actions, or deviations from the norm, where the limits of acceptable performance are defined by the system.

Implement Barrier Management System

Focus! Safety Critical Tasks

Tasks where human performance contribute positively or negatively to major accident risk, through either:

- Initiation of events
- Detection and prevention
- Control and mitigation
- Emergency response



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Implement Barrier Management System

Focus! Safety Critical Failures

Unsafe actions represent the holes in the Swiss Cheese model caused by human error.

As for technical barrier elements, the most critical human failures should be identified so **risk reducing measures** can be implemented and followed up. This can be achieved through well-established methods such as:

- Safety critical task analysis (SCTA)
- Human error identification (HEI)
- Human reliability analysis (HRA)

Added value – This will increased safety: As a part of safety critical failures assessment, clearly define findings and practical risk reducing measures to be implemented.

Barriers Performance Monitor and Verification

Barriers Performance Monitor and Verification

Assure and maintain barrier performance

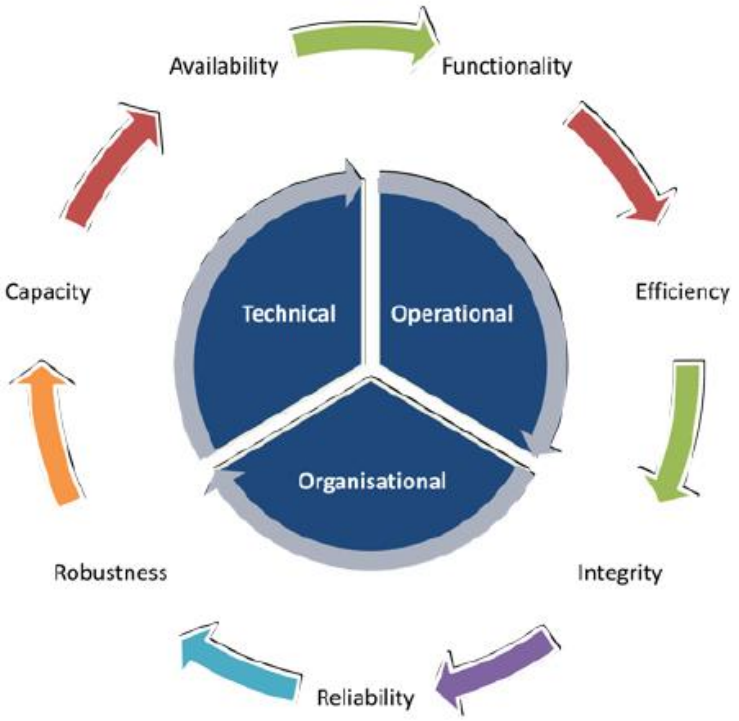
- Testing and inspection of barrier status
- Preventive maintenance for preventing barrier degradation
- Corrective maintenance for restoring barrier functionality

Barrier Status

- Failure and degradation of barrier
- Test frequency
- Real time data
- Costs

Indicators

- Leading vs lagging
- Investigation
- Risk influencing factors
- Audits



Barriers Performance Monitor and Verification

When developing a system for barrier status monitoring, the following principles can be applied:

- **Rating system:** Have clear criteria for the rating categories, with detailed descriptions for each category and for each indicator. This will enhance consistency in the evaluation and interpretation of it.

- **Aggregation:** Since aggregation of information not will give the full picture, there should be opportunities for drill down. In addition, information at several levels will be useful for different user groups.

- **Trends:** Trends compared to previous period, year etc. gives important information. This can be illustrated with e.g. an arrow downwards for deterioration, horizontal for unchanged and upwards for improvement.

Barriers Management in Day-to-Day Operation

Implementing barrier management in operational phase

- Conflict with existing systems
- Lack of holistic overview and approach
- Lack of experience with audits and systems

Using barrier and risk analysis in operational decision-making

- Unmanageability
- “Living” risk analysis

Decision making points:
- **SJA**
- **WP**
- **CCR**

Decision makers needs to have an overview of barriers status for correct decisions

Thank you

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