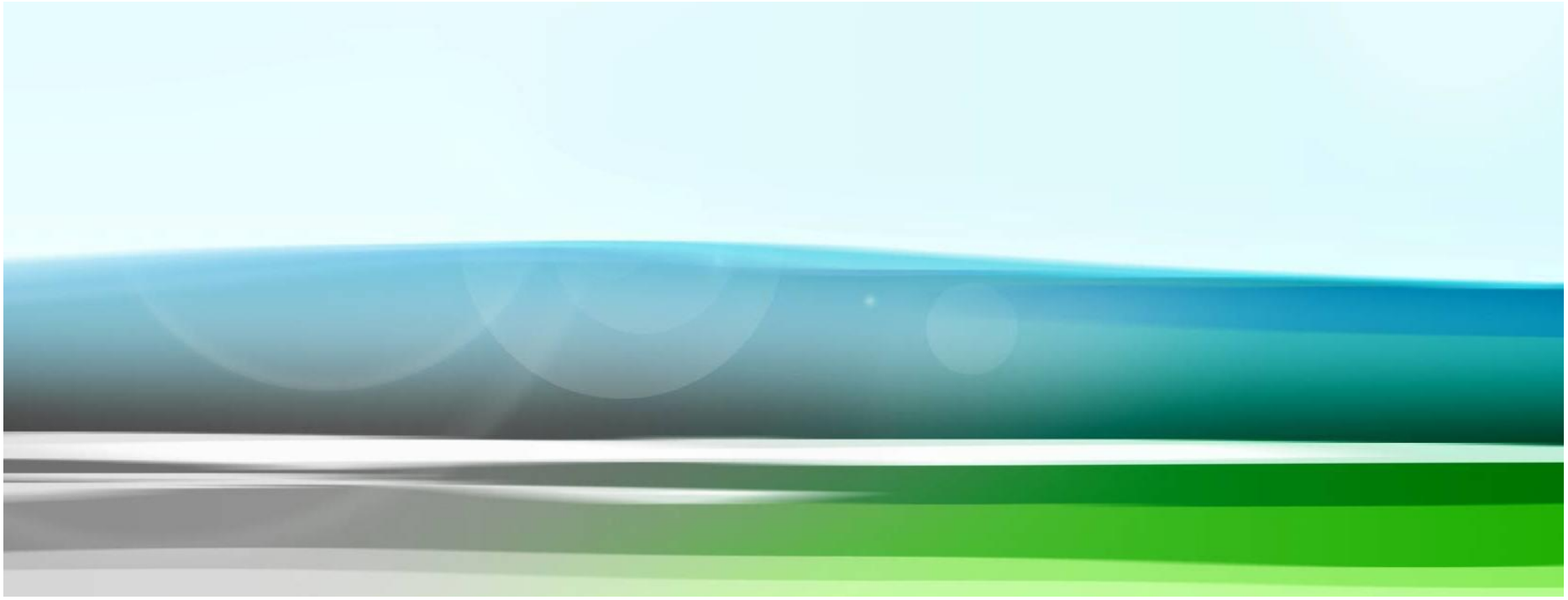


Defining and operationalizing the barrier concept

The human contribution

Sondre Øie
30 April 2013

MANAGING RISK

Introduction

- Sondre Øie
  - Human Factors & risk management consultant at DNV
- Topics & focus in this presentation
  - What is a barrier?
  - Operationalization
  - The human contribution
  - Focus on Human Factors, less on organisation
- Inspired by
  - Risk and reliability techniques
  - Nuclear industry
  - Old and recent developments within O&G
  - Human Factors methods
  - Project experience within Safety Barrier Management

Barriers on Google

Wikipedia: A barrier or barricade is a physical structure which blocks or impedes something.

Source: www.herasreadyfence.co.uk

A simple example to understand the complexity

Source: oblad.no

Operationalize the barrier concept

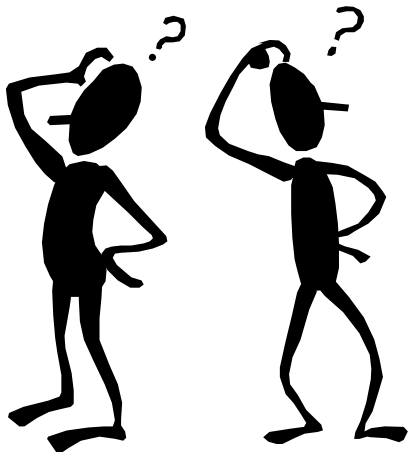
The need for operationalization….

From Wikipedia

- **Operationalization** is the process of defining a **fuzzy concept** so as to make the concept **clearly distinguishable** or **measurable** and to understand it in terms of empirical observations.
- In a wider sense it refers to the process of specifying the extension of a concept — describing what is and is not a part of that concept.

Bold statement (?!): Barriers and barrier management is a *fuzzy* concept

The “fuzzy” concept



HAZOP
Bow-Tie
Protection layer
Defence
Controls
Loss
Risk
Hazardous event
Consequence
QRA
Bow-Tie
Swiss Cheese
Barrier
Barrier function
Barrier system
Hazard
Initiating event
HAZID
Threat
Barrier classification
Barrier element
Triggering condition
Incident
Technical barriers
Organisational barriers
Operational barriers
Accident
Barrier strategy
Passive barriers
Active barriers
Performance shaping factor
Performance standards
Barrier decay mechanisms
Risk influencing factors
Human Factors
Structural barriers
Performance requirements
Failure modes
Barrier degradation
Human Error
Human Reliability

Barrier definitions

BARRIERS

- **Barriers** can be defined as measures that are designed/implemented with the *explicit* purpose (1) to reduce the probability of triggering a pre-defined hazards (loss) potential and/or (2) to reduce the consequence of a pre-defined hazardous event (Skjerve et al. 2003).
- A **barrier** is a physical or engineered system or human action (often based on specific procedures or administrative controls) that is implemented to prevent, control, or impede energy released from reaching the assets and causing harm (Rausand, 2011).

NORSOK Z-013

- **Barrier function**: Function planned to prevent, control, or mitigate undesired or accidental events
- **Barrier system**: System designed and implemented to perform one or more barrier function
- **Barrier element**: Physical, technical or operational component in a barrier system

Barriers as functions, systems and elements

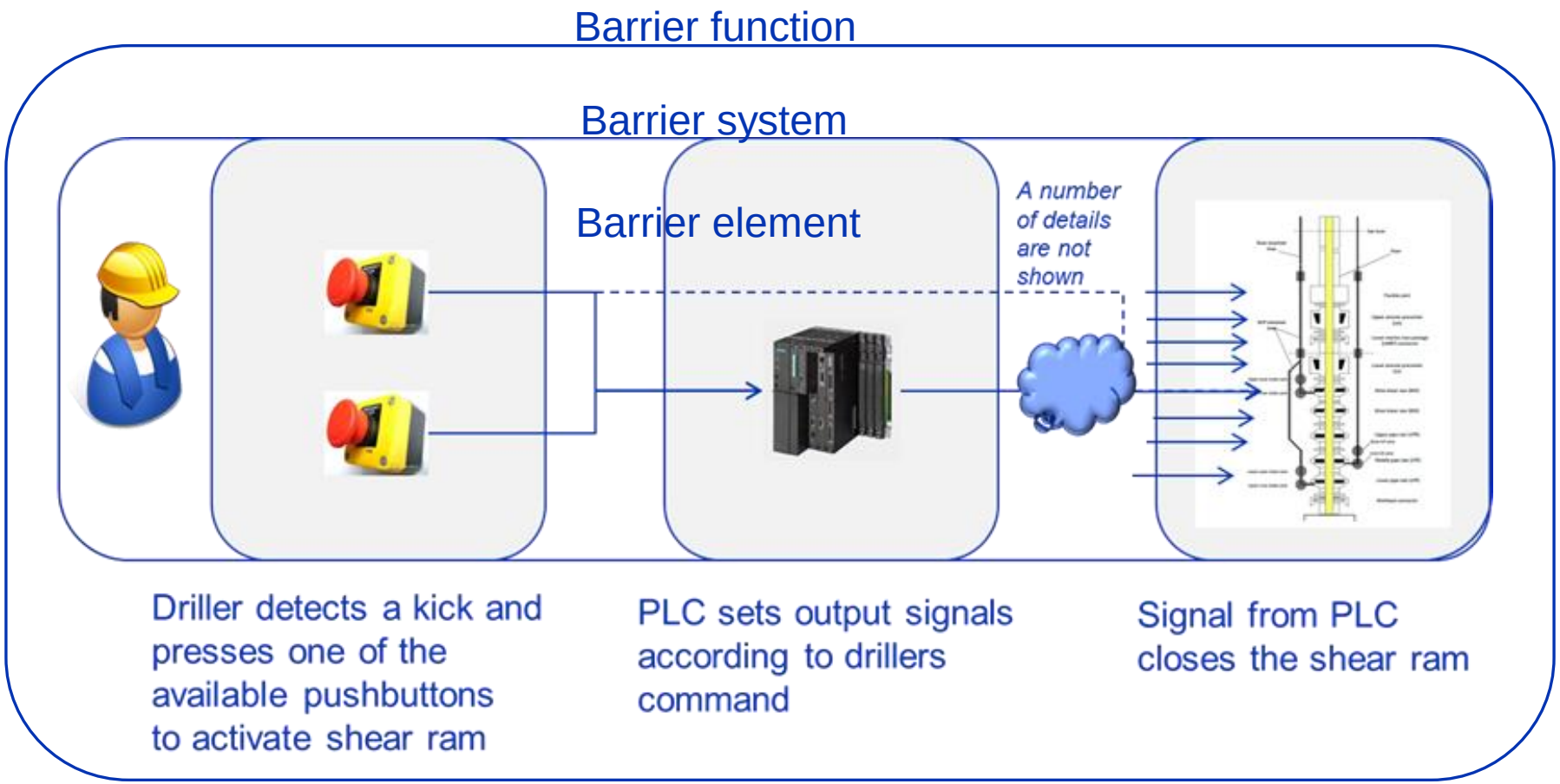
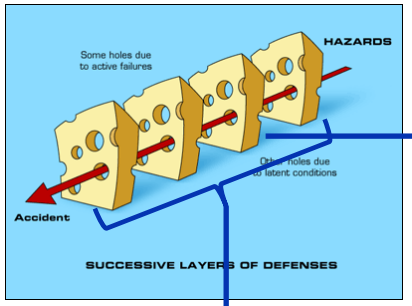


Illustration of how barrier systems and elements perform the main barrier function “prevent blowout”

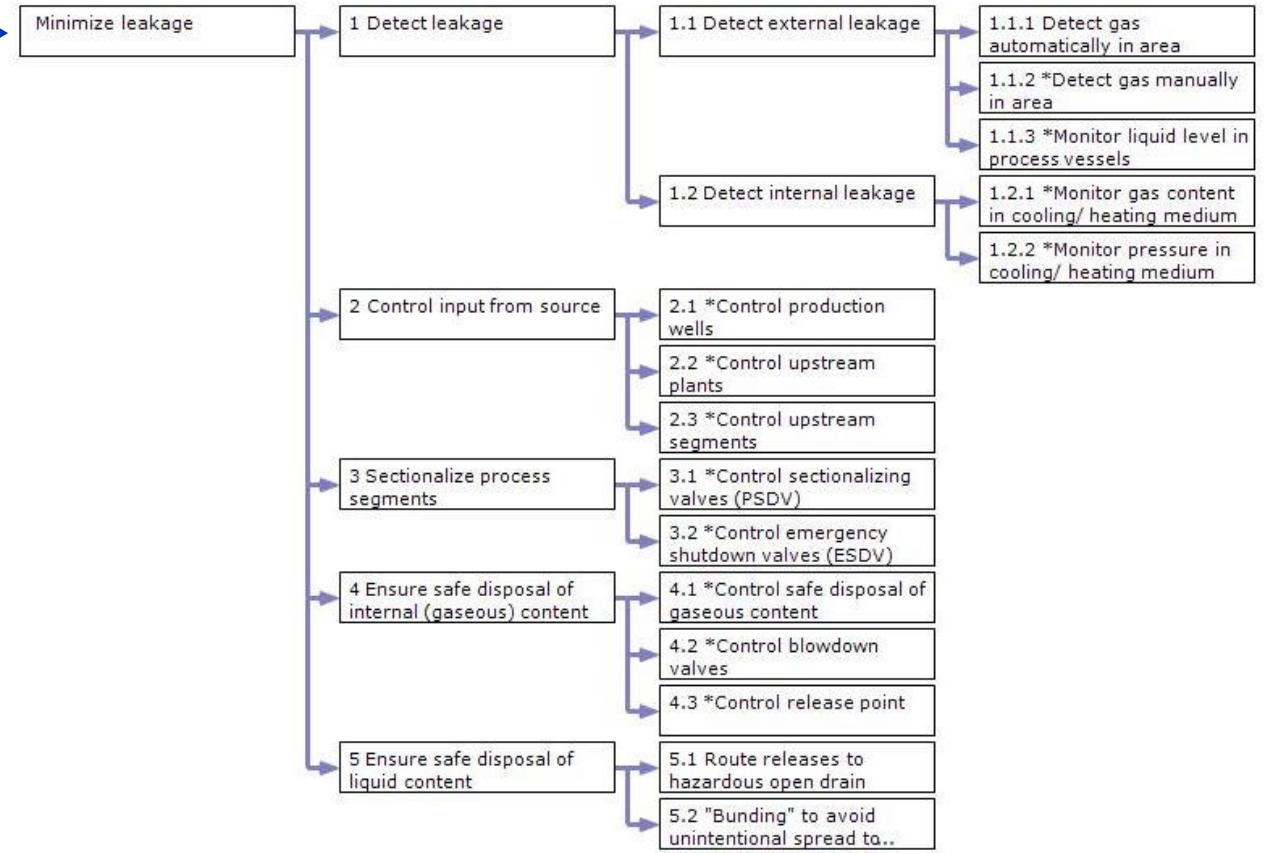
Example: “Minimize Leakage” barrier functions



Other barrier functions;
- Prevent leakage
- (Minimize leakage)
- Avoid ignition
- Mitigate explosion
- Reduce fire load
- Avoid escalation
- Protect personnel

Functions marked with * may involve or depend on **CCR operator tasks**

How?



Why?

Mapping barrier functions, systems & elements (incl. tasks)

#	Barrier functions	Description	Barrier systems/ elements	Operator tasks	Performance req.
Function level **1.0** **1.1** **1.1.1** **2.0** **2.1** **2.1.1** **Etc**	Name of functions, e.g.: ○ Prevent leakage ○ Minimize leakage ○ Avoid ignition ○ Mitigate explosion ○ Reduce fire load ○ Avoid escalation ○ Protect personnel ○ Etc.	Purpose of function and how it performs, e.g.: *"In order to prevent escalation of abnormal conditions into a major hazardous..."*	List of barrier systems and elements performing the function, e.g.: Emergency Shutdown ○ ESD valves ○ PSD valves ○ ESD alarms ○ Process HMI ○ Manual push-button ○ Etc.	Tasks necessary to perform barrier functions are mapped with regards to different operational modes, such as: ○ Normal operations ○ Shutdown/ start-ups ○ System upsets/ incidents	Barrier performance requirements, typically: ○ Availability ○ Functionality ○ Reliability ○ Robustness ○ Integrity ○ Etc.

- The barrier function hierarchy can be listed in a table for obtaining more information about how barrier systems, elements and operator tasks interact to perform barrier functions.
- Provides traceability from operator tasks -> barrier elements -> barrier systems -> and main barrier function presented in risk models, such as Bow-Tie's or Swiss Cheese
- Allows for barrier performance requirements to be reviewed on both detailed (element) and higher (system) levels

Human interaction with barriers

- Humans *primarily* interact with barriers in two ways;

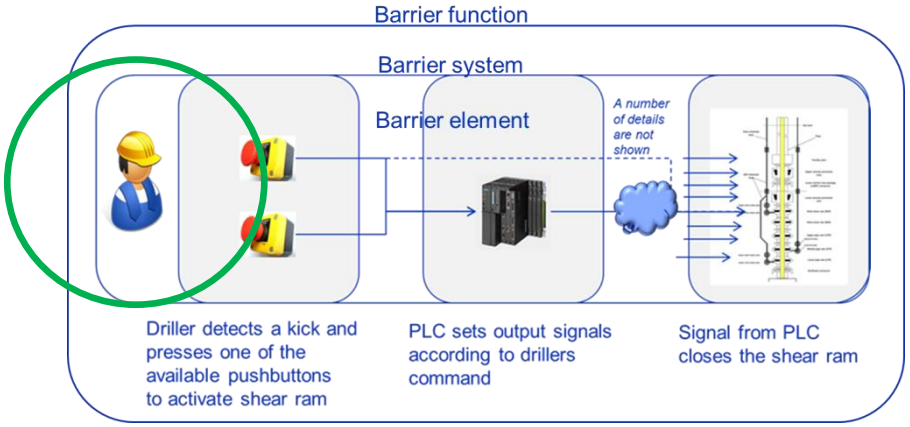
1. Monitoring tasks, control and activation of barriers
2. Maintenance, testing and inspection of barriers

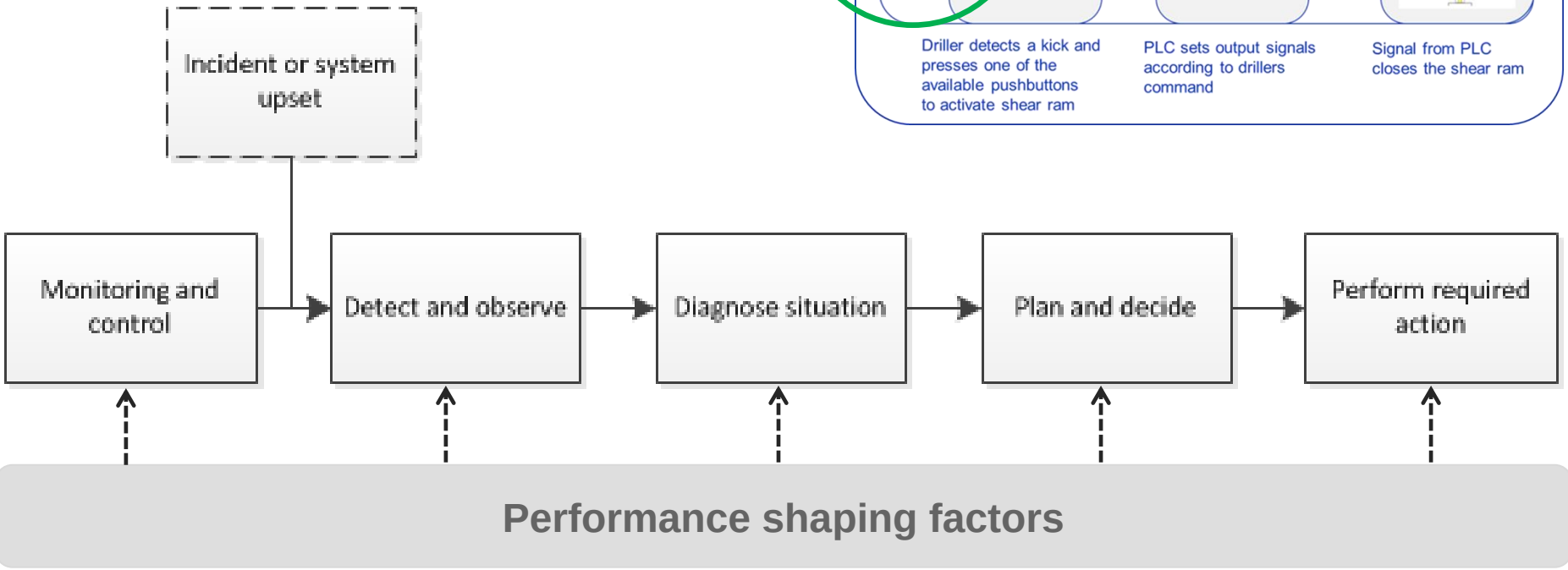
- Humans reduce risk by e.g.;
  - Discovering & correcting technical failures
  - Able to problem-solve and understand system status
- Humans increase risk by e.g.;
  - Introducing **"latent conditions"** such as incorrect maintenance
  - **"Unsafe acts"** initiating incidents, e.g. when working on pressurized HC piping or controlling barrier systems

- Human performance is influenced by **Performance Shaping Factors** (PSFs)
- PSFs affects *human reliability* and *human error* probability

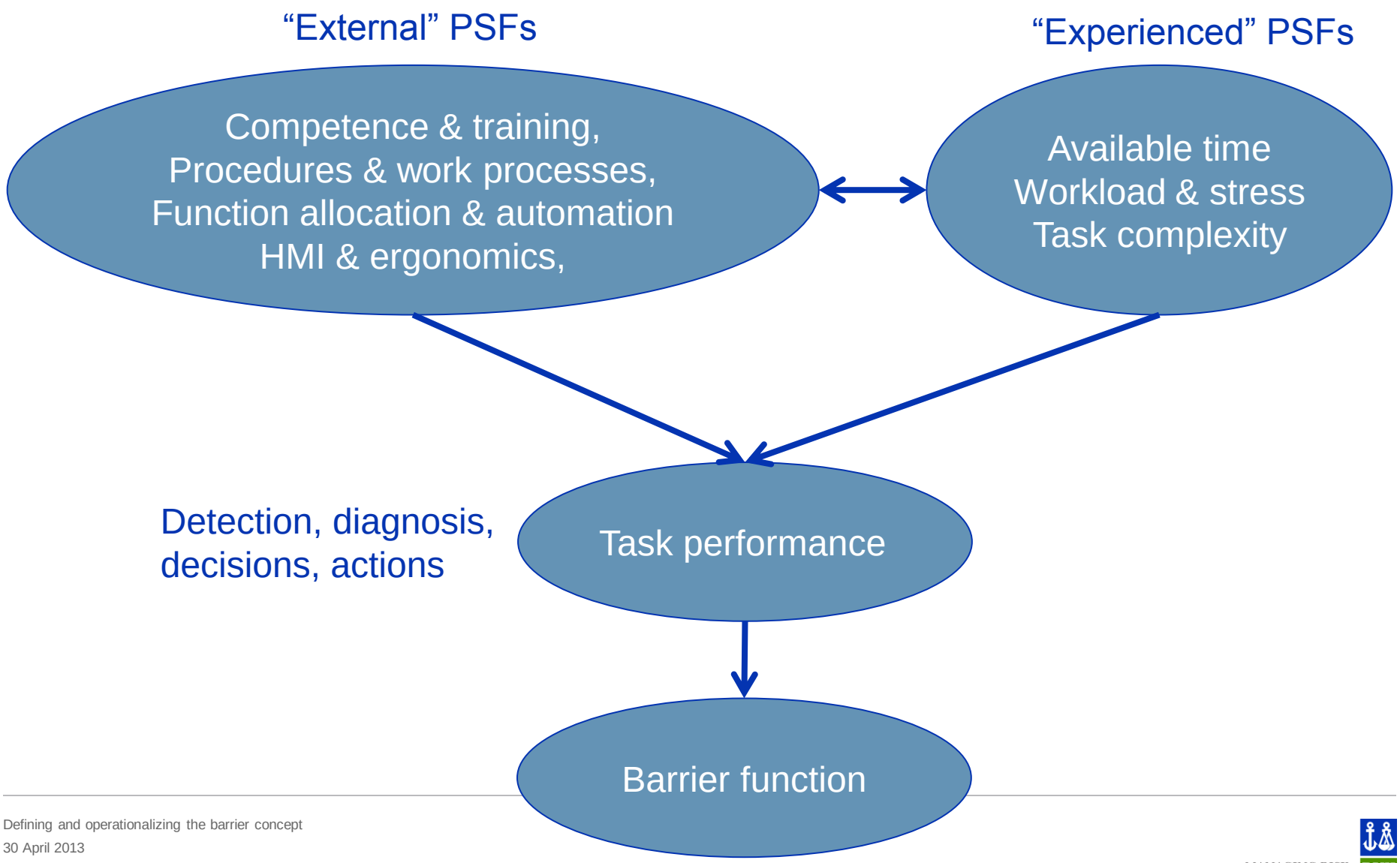
Monitoring, control and activation of barriers

Simple sequential model of operator tasks necessary to perform a barrier function (iteration not shown)





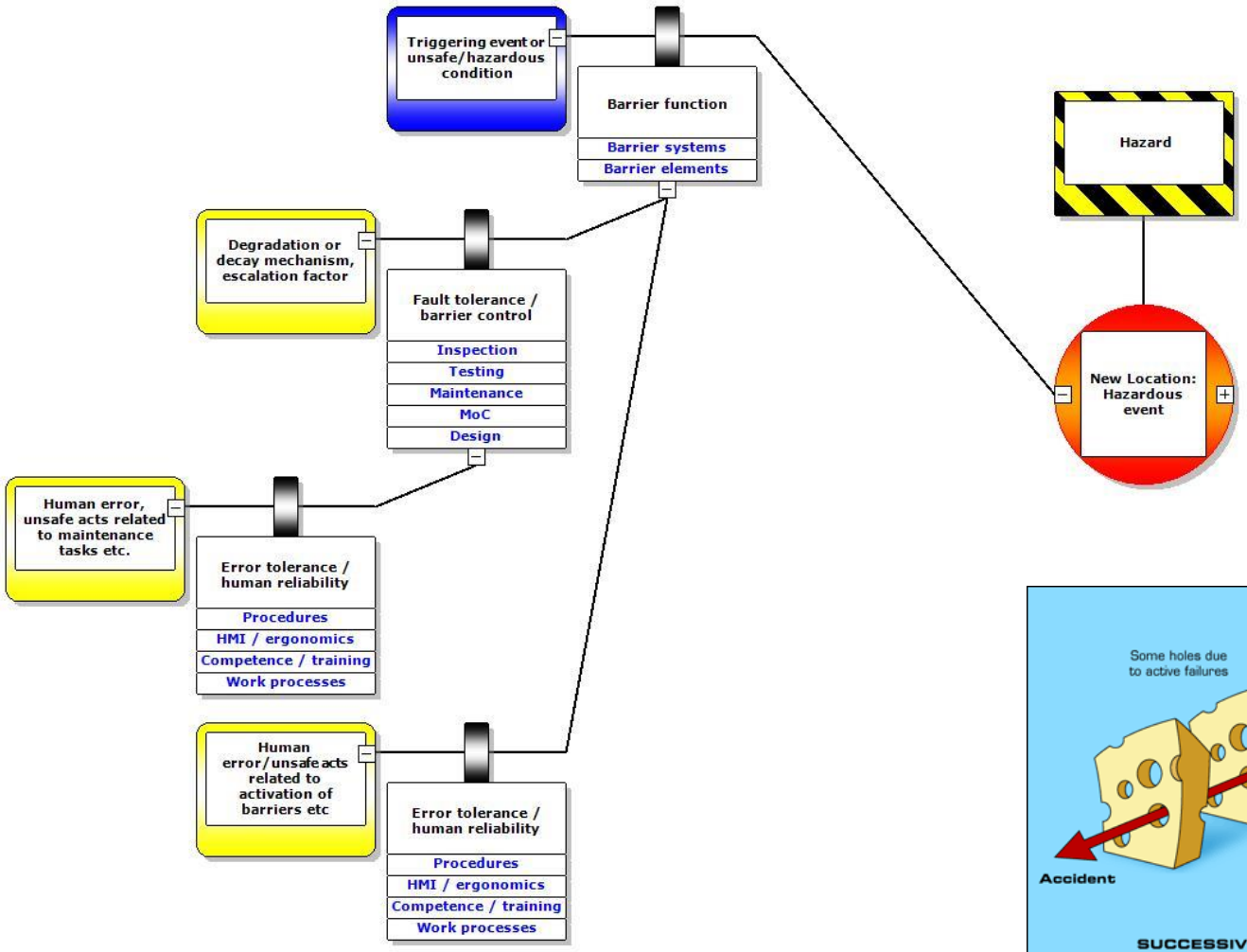
Performance shaping factors (PSFs)

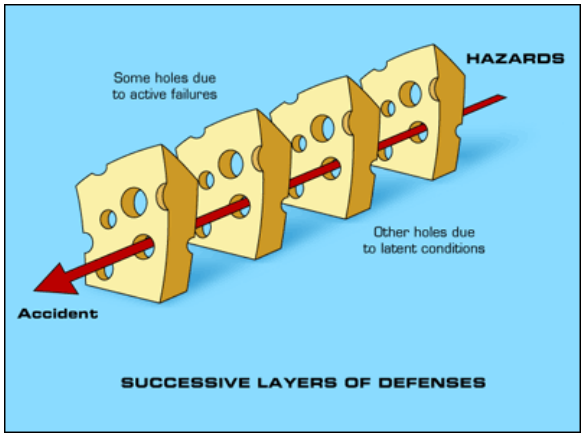


Performance shaping factors vs barrier elements

Examples	How PSFs may reduce risk of human error and increases human reliability	Common notions for why some PSFs are often considered "barrier elements"
Competence, training	Ensures that operator is confident with task at hand, creates less stress, reduces complexity	Competence specifically targeting tasks related to barrier functions, e.g. handling a gas leak
HMI, alarm system	Facilitates situational awareness, supports diagnosis and decision making, incorporates human error tolerance	Is the direct link between the operator and the barrier system, e.g. allows control and monitoring of barrier functions
Procedures	Available and good procedures provides guidance and support on how to perform tasks	Gives directions, often based on system safety philosophies, on how and when to act

Inspection, testing and maintenance of barriers





It's like plugging the "holes" in the Swiss Cheese model…

Task analysis to establish performance requirements

#	Task	Description	Performed by	Equipment and procedures	Performance requirements	References
2.1	Manually activate blowdown	In case of a gas leakage the CCR operators receive an alarm. They then have to detect this alarm, make a diagnosis of the situation and decide whether and how to activate blowdown.	CCR operators (Field operator) (Emergency Response Team)	Visual display unit (HMI) on operator station. UHF radio to communicate with field operator. DSHA procedure from the Emergency Preparedness manual.	The DSHA procedure shall support the operator in the blowdown sequence by clearly indicating steps, roles & responsibilities in handling the situation etc.	Barrier function 3.2.1 Performance standards QRA/HRA

- Essentially a breakdown of tasks associated with barrier functions
- Provides overview and details about operations and actions
- Can be used to address requirements for PSFs, e.g. whether HMI supports specific tasks
- Input to other analysis (e.g. HRA)

Explanations:

#: Task number,

Task: Name of task identified in the barrier function analysis

Description: Description of task in more detail

Performed by: Who is directly/(indirectly) involved in performing the tasks

Equipment and procedures: What the operator(s) use while performing the task (often referred to as barrier elements)

Performance requirements: Requirements for Performance Shaping Factors, minimizing the risk of human error and increases human reliability. Requirements are set for procedures, HMI, competence, work processes etc.

References: References to barrier functions and relevant documentation

Relevant techniques and methods

- **Human Factors Engineering**
  - Task analysis to capture system requirements necessary to ensure a human-centred design
  - HMI and alarm reviews to provide situational awareness and error tolerance
  - CRIOP to verify and validate Control Centres' ability to handle incidents
- **Risk assessments**
  - Human Error Analysis (qualitative) to identify error modes and eliminate error traps – similar to FMECAs for technical systems
  - Human Reliability Analysis (quantitative) to assess how human error probability is influenced by performance shaping factors – often combined with QRAs, LOPAs
- **Safety analysis**
  - Safety Critical Task Analysis to identify critical maintenance tasks vulnerable for introducing latent error conditions
- **Training**
  - Crew Resource Management (CRM) to train operator crews in teamwork skills facilitating early identification of threats and errors, so incidents can be avoided at early stages
  - Competence development within major accident risk understanding and barriers

Summary

- Barriers and barrier management is not necessarily complex – as long as you're faithful to your definitions, their operationalization and conceptual model
- So what's new? You'll need a modelling tool which ties it all together
- In order to understand how barriers performs it is necessary to;
  - identify the functions of the system, on both system and element levels (incl. tasks!!)
  - know what functions different systems and elements performs in various scenarios
  - understand the interaction and interfaces between the different systems and elements
- Keep in mind the **tasks** performed by operator(s) and associated PSFs
- The building bricks are already available – just make sure to bring a proper drawing
  - Requirements can be found in recognized standards
  - For risk reduction beyond what is provided by standards, traditional safety-, HF studies and risk assessment techniques will suffice
- Draw upon established safety and risk management frameworks
  - Various standards for safety & risk management can be adapted, e.g. ISO31000

References and recommended reading

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Questions?

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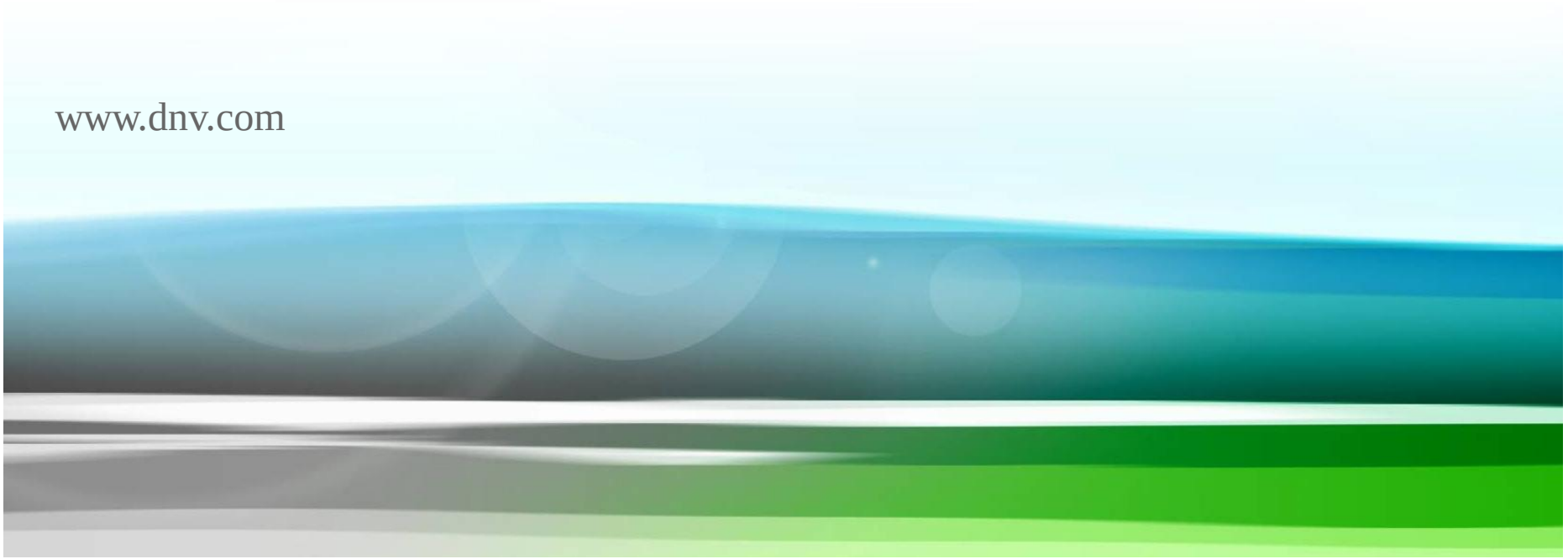

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