TotalEnergies

Critical Barrier Management

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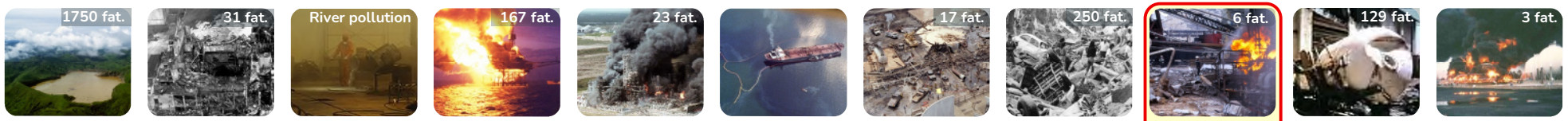
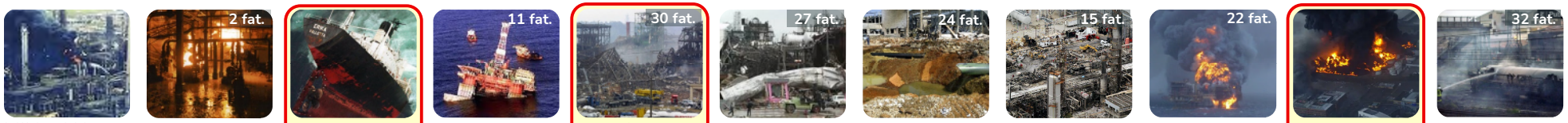
Management of Critical Barriers: Why is it Important?

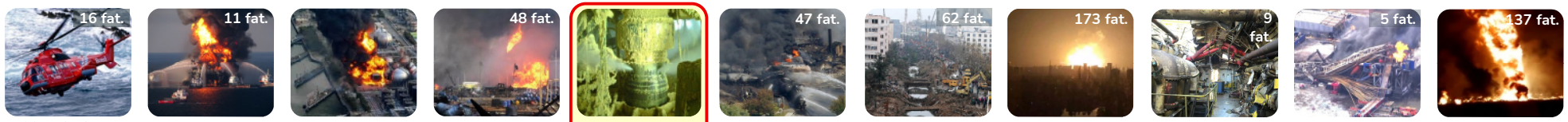
Texas City 1947 | **Feyzin 1966** | Flixborough 1974 | Antwerpen 1975 | Seveso 1976 | Umm Said 1977 | Los Alfaques 1978 | **Bantry Bay 1979** | Alexander Kielland 1980 | Bhopal 1984 | Mexico City 1984



Lake Nyos 1986 | Chernobyl 1986 | Sandoz (Bale) 1986 | Piper Alpha 1988 | Pasadena 1989 | Exxon Valdez 1989 | Arco (Channelview) 1990 | Guadalajara 1992 | **La Mede 1992** | Dakar 1992 | Belpre 1994



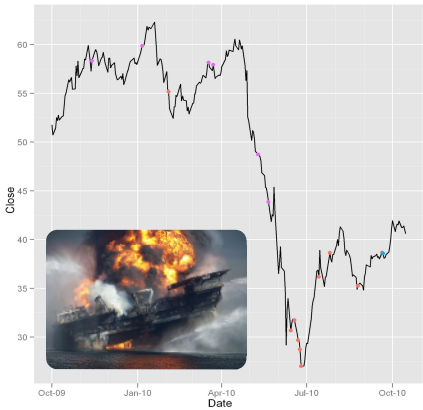
Milford Haven 1994 | Longford 1998 | **Erika 1999** | Petrobras 2001 | **AZF 2001** | Skikda 2004 | Ghislenghien 2004 | Texas City 2005 | Mumbai 2005 | **Buncefield 2005** | Viareggio 2009



North Sea 2009 | Deepwater 2010 | Fukushima 2011 | Amuay 2012 | **Elgin 2012** | Lac Megantic 2013 | Qingdao 2013 | Tianjin 2015 | FPSO Cidade Sao 2015 | Patterson Rig 2018 | Tlahuelilpan 2019

Beirut 2020 | Visakhapatnam 2020 | Aqaba 2022 | Conakry 2023 | Shandong 2025

Deepwater Horizon (April 2010)



Dramatic impacts

- Environment
- Casualties
- Property destruction
- Wealth destruction

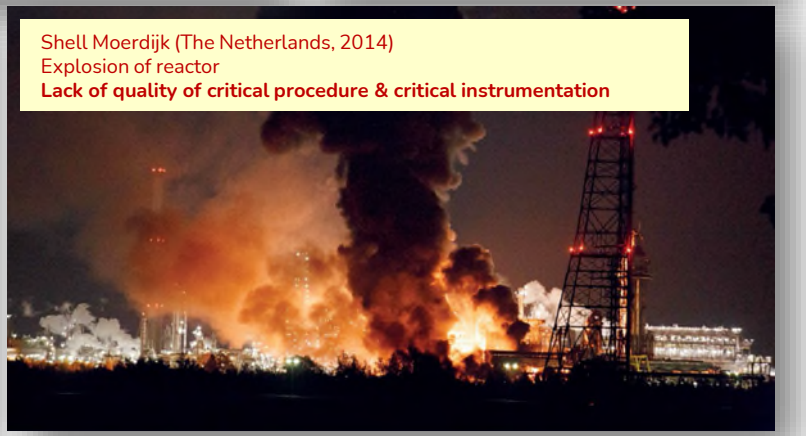
(-55% in 2 months)

«A major accident is the only thing which prevents me from sleeping. The explosion of the BP platform Deepwater Horizon, in the Gulf of Mexico, turned out to be a major event. Nobody imagined that an oil well could cost 60 billion dollars to a company. It is the Achilles' heel of big groups as ours, more than the geopolitical events. This is why I decided to make safety a value of TotalEnergies because we make no compromise for a value! »

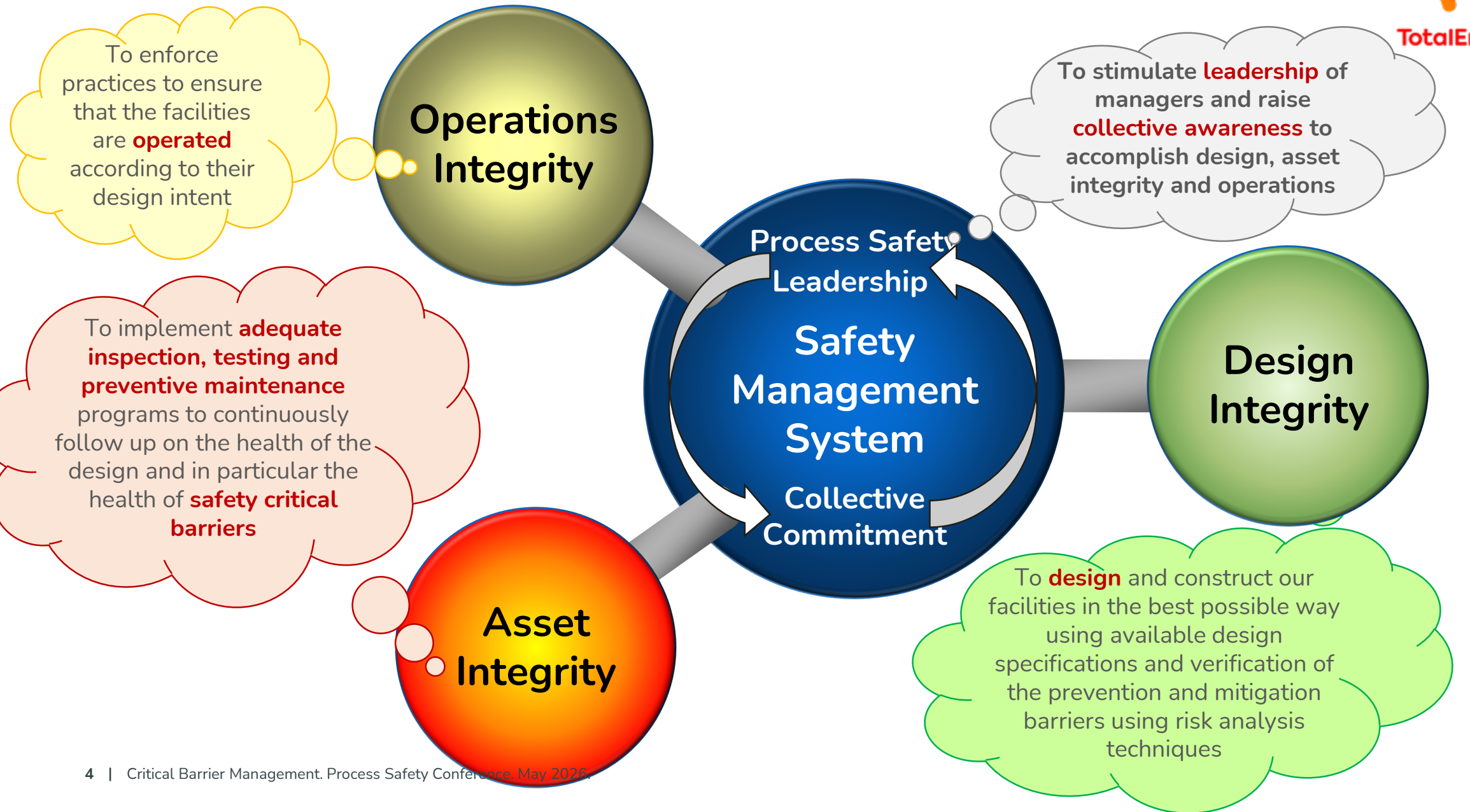
Management of Critical Barriers: Why is it Important

- Many major accidents in our industry are related to poor critical barrier management.
- These accidents can be avoided if:
  - The possibility of these events is properly identified.
  - Their critical prevention and protection barriers are properly selected, designed, maintained and operated.

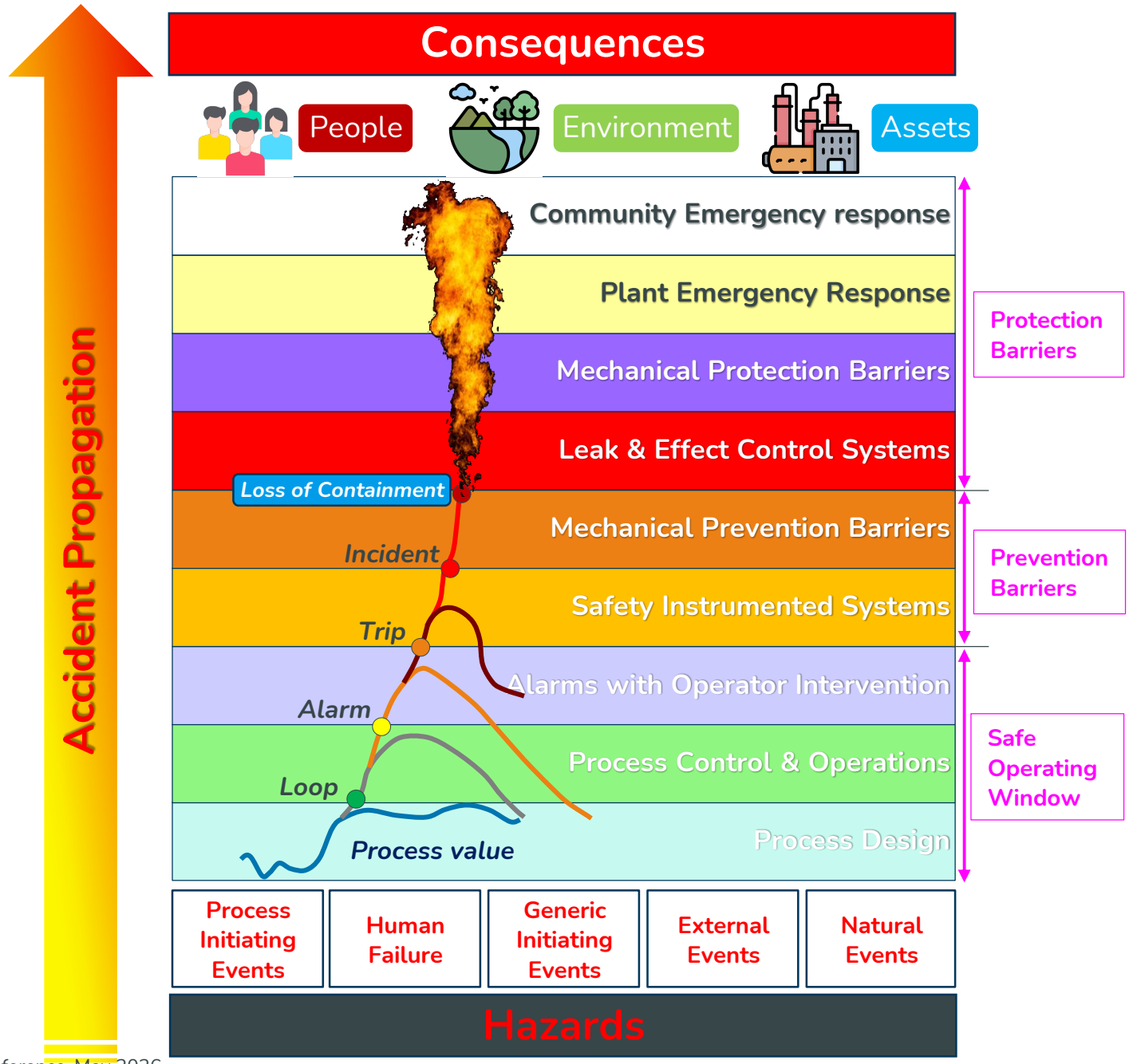
The **management of critical barriers is of vital importance for the prevention and control of major accidents !**



Critical Barrier Management Principles

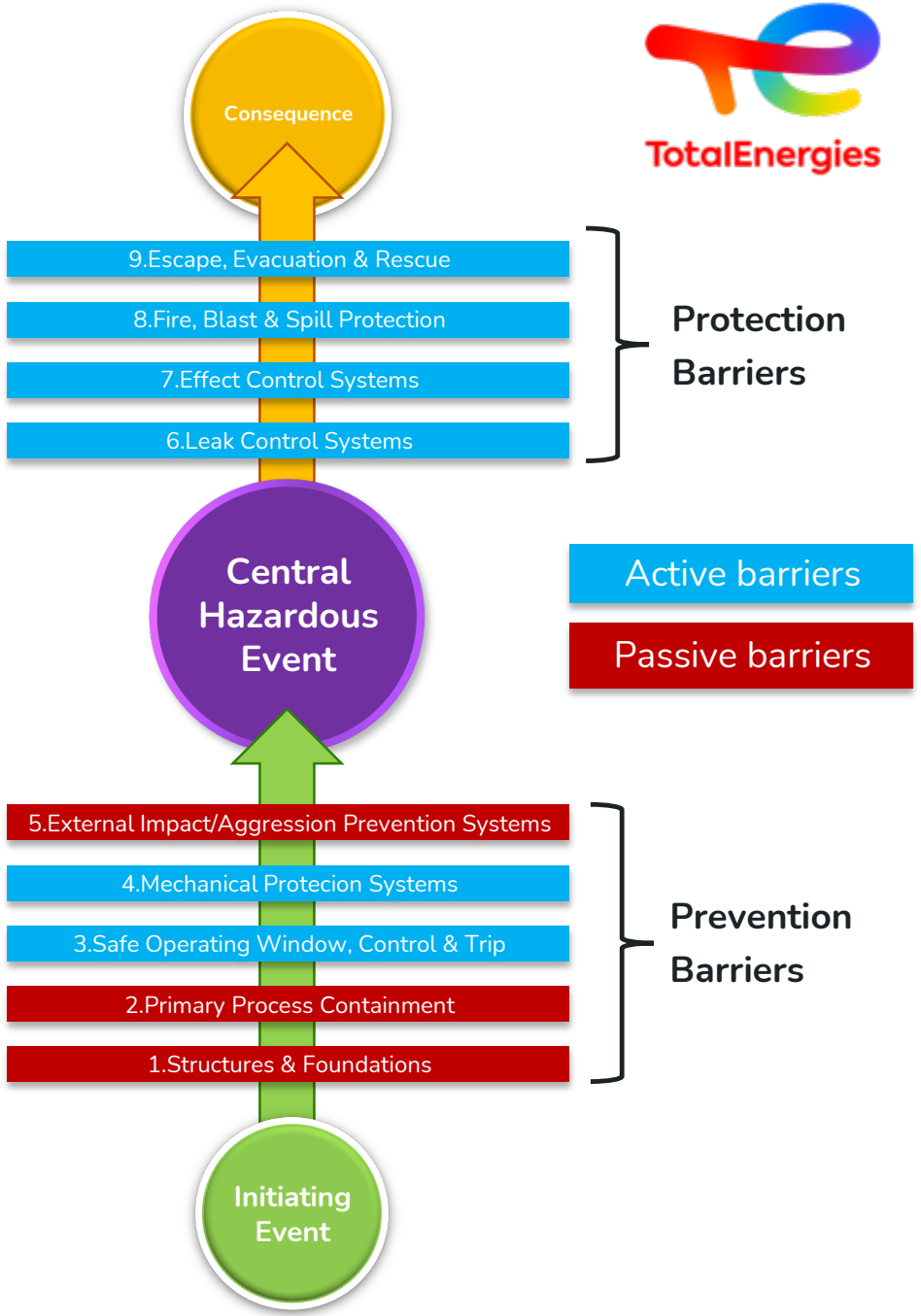


Barriers


Consequences
People
Environment
Assets
Accident Propagation
Community Emergency response
Plant Emergency Response
Mechanical Protection Barriers
Leak & Effect Control Systems
Loss of Containment
Mechanical Prevention Barriers
Incident
Safety Instrumented Systems
Trip
Alarms with Operator Intervention
Alarm
Process Control & Operations
Loop
Process Design
Process value
Protection Barriers
Prevention Barriers
Safe Operating Window
Process Initiating Events
Human Failure
Generic Initiating Events
External Events
Natural Events
Hazards

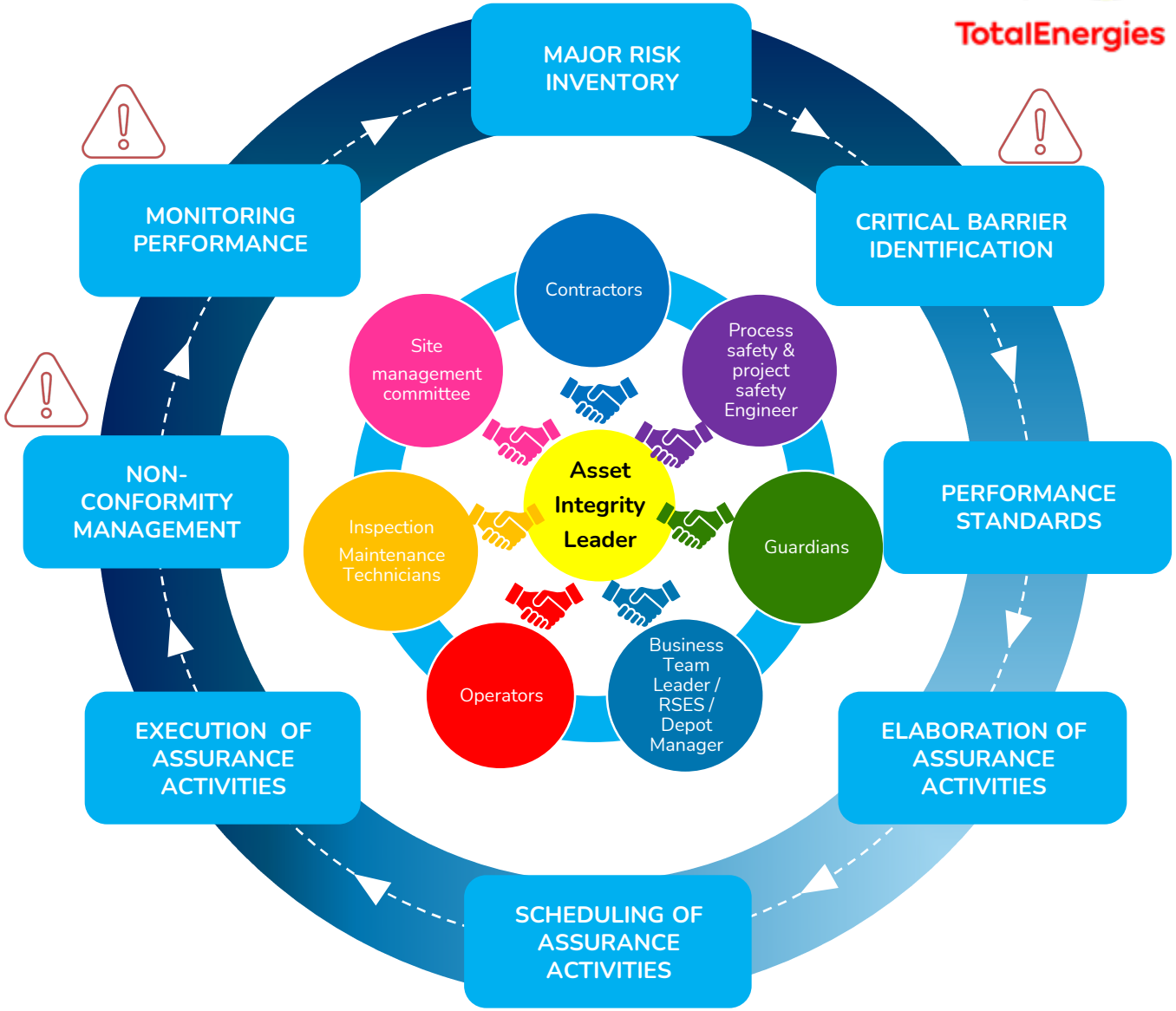
Barriers Categories: Examples

Nr	Critical Barrier Category	Examples
1	Structures and Foundations	o Supporting structures
2	Primary Containment Systems	o Storage vessels o Process vessels o Piping o Pipelines
3	Safe Operating Window, Control & Trip	Safety Instrumented Systems. Examples include: o Overfill protection o Overpressure protection o High temperature protection o Reaction killing systems
4	Mechanical Protection Systems	o Pressure relief devices (2-way pressure/vacuum valves, RD,...) o Mechanical interlocks and mechanical safety systems
5	External Impact & External Aggression Protection	o Riser protection o Cathodic protection o Building pressurization
6	Leak Control Systems	o Detection with operator action o Emergency shutdown & isolation systems o Blowdown & emergency depressurization systems o Rapid dump systems o Fire detection systems (with automatic action) o Gas detection systems (with automatic action) o Liquid detection systems (with automatic action) o Breakaway system or coupling
7	Effect Control Systems	o Ignition prevention systems o Secondary containment systems
8	Fire, Blast & Spill Protection Systems	o Firewater systems (including pumps, headers, nozzles...) o Explosion mitigation systems
9	Escape, Evacuation & Rescue Systems	o Lifeboats o Other rescue & evacuation systems

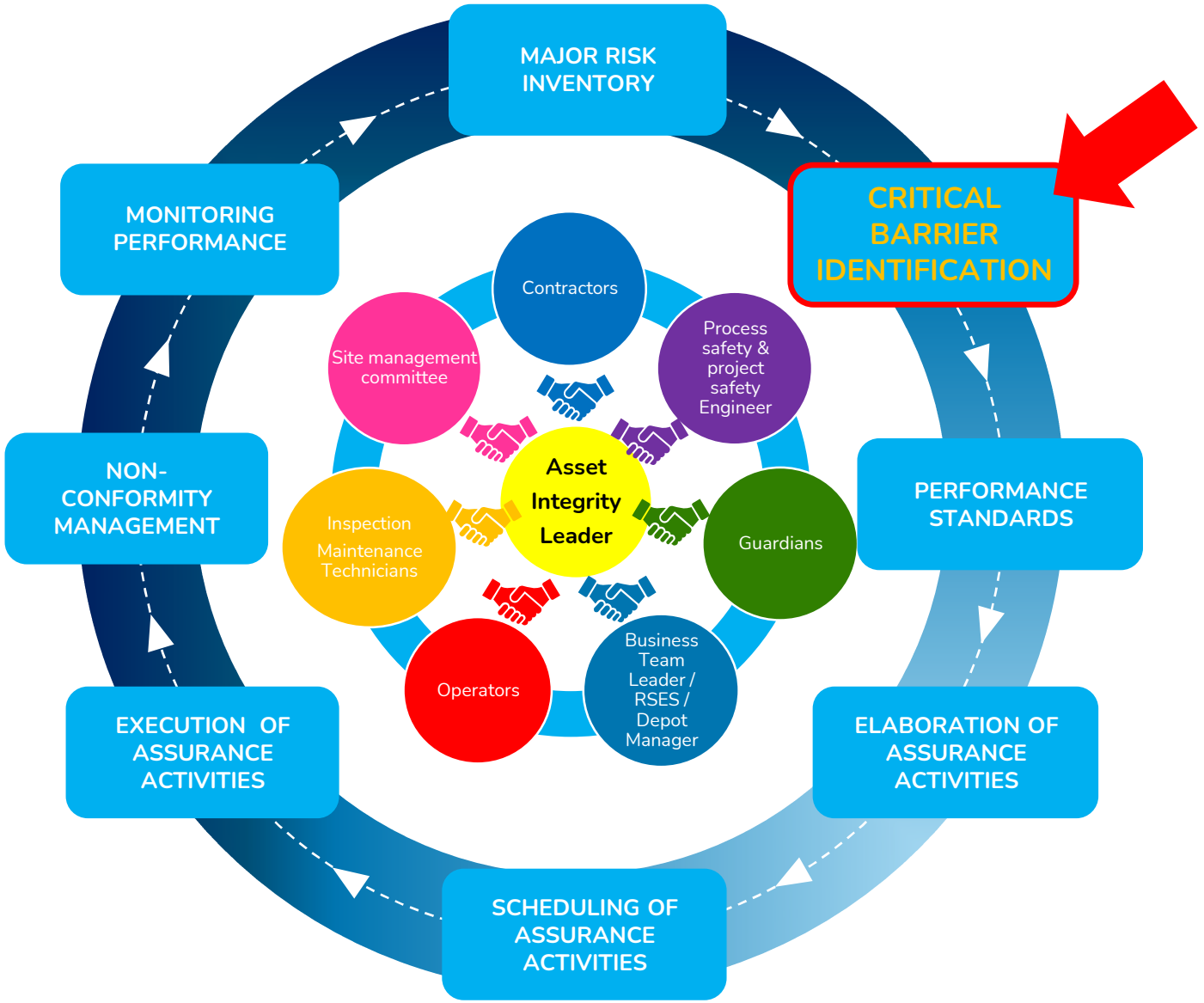


Critical Barrier Management Process

- The overall process for critical barrier management is given in the picture on the right
- The successful implementation of this process will depend on the collaboration between several disciplines and roles in the organization, with the Asset Integrity Leader playing a pivoting role
- In this presentation, the following aspects of the barrier management cycle will be highlighted
  - ✓ Critical barrier identification
  - ✓ Non-conformity management
  - ✓ Monitoring of performance



Critical Barrier Identification

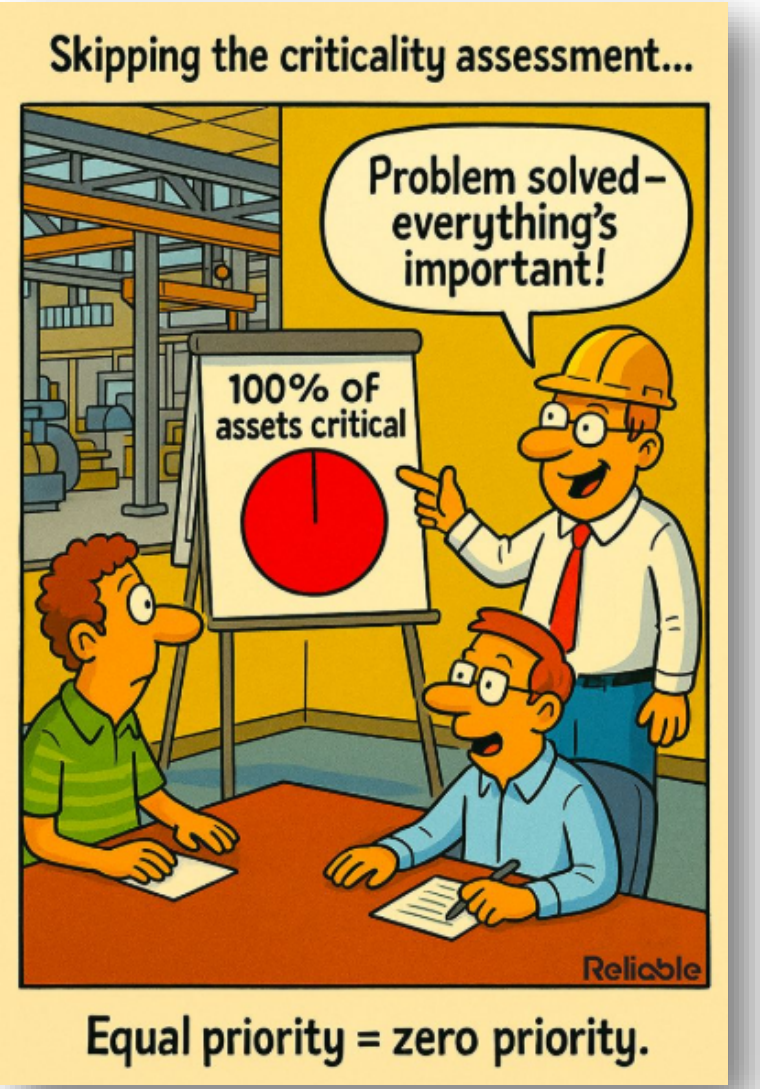


Identification of Critical Barriers

- In large industrial sites, many thousands of barriers are installed !
- Ensuring the 100% reliability and availability of all these barriers without important backlog in their maintenance and/or inspection can be a challenge.

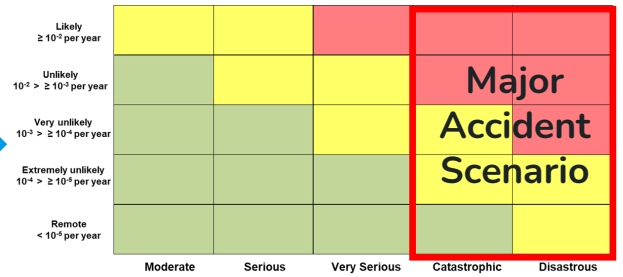
Objectives:

- **Focus efforts where it matters most !**
- **Simplify for everything else !**
- **Putting a focus does not mean “forgetting about the rest” !**



4 Step Process for Selection of Critical Barriers

Step 1: Select Major Accident Scenarios

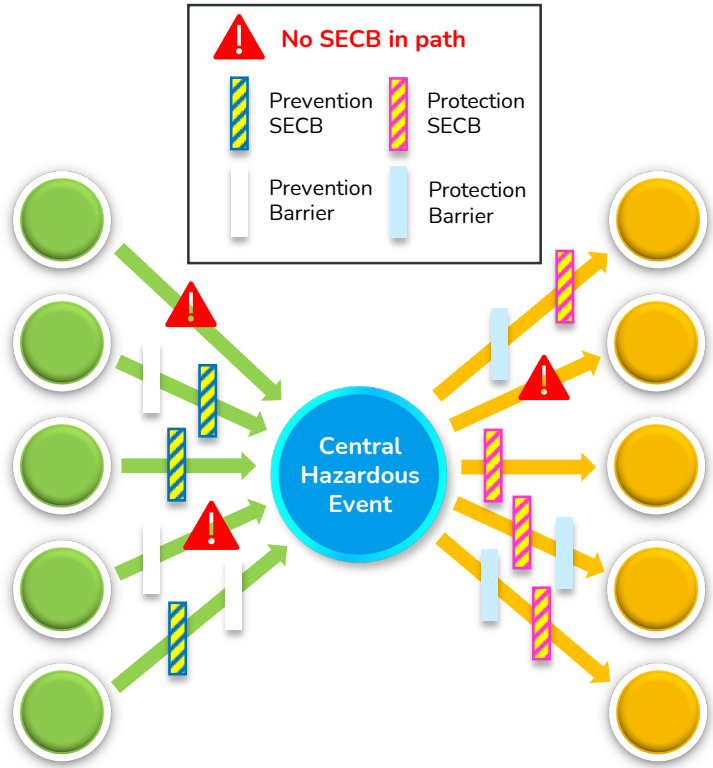


Major Accidents
- Multiple fatalities
- Long lasting pollution of sensitive environment
- >10 M€ damage to assets

Step 2: Select Mandatory Critical Barriers

Mandatory Critical Barrier Category
1. Primary Containment Systems (for corrosion and/or erosion as initiating event !)
2. Safe Operating Window, Control & Trip
3. Mechanical Protection Systems
4. Leak Control Systems
5. Fire, Blast & Spill Protection Systems
6. Offshore Specific Barriers

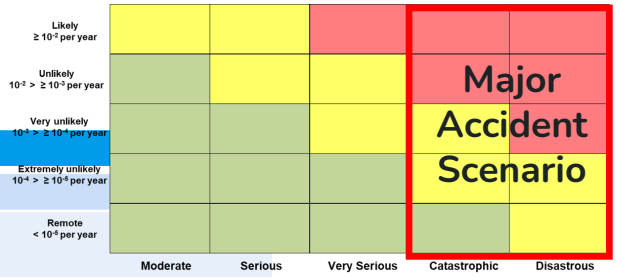
Step 3: Verify whether all paths (upstream and downstream) in the Major Accident Bowtie are covered by at least 1 Mandatory Critical Barrier



Step 4: If Step 3 is negative, Critical Barriers must be selected in additional barrier categories (fulfilling 4 basic requirements) to ensure that all paths in the Major Accident Bowtie are covered by at least 1 Critical Barrier in every path at both sides of the CHE

Additional Critical Barrier Category
1. Structures and Foundations
2. Primary Containment Systems (for other initiating events besides corrosion/erosion, e.g. vibration, fatigue, mechanical failure,...)
3. External Impact & External Aggression Prevention Systems
4. Effect Control Systems

Barriers Categories



- **Mandatory critical barriers for all business units in TotalEnergies**
- **Mandatory critical barriers for corrosion/erosion as initiating events**
- **Additional barriers (when needed to protect all scenario paths)**
- **Mandatory barriers for Offshore only**

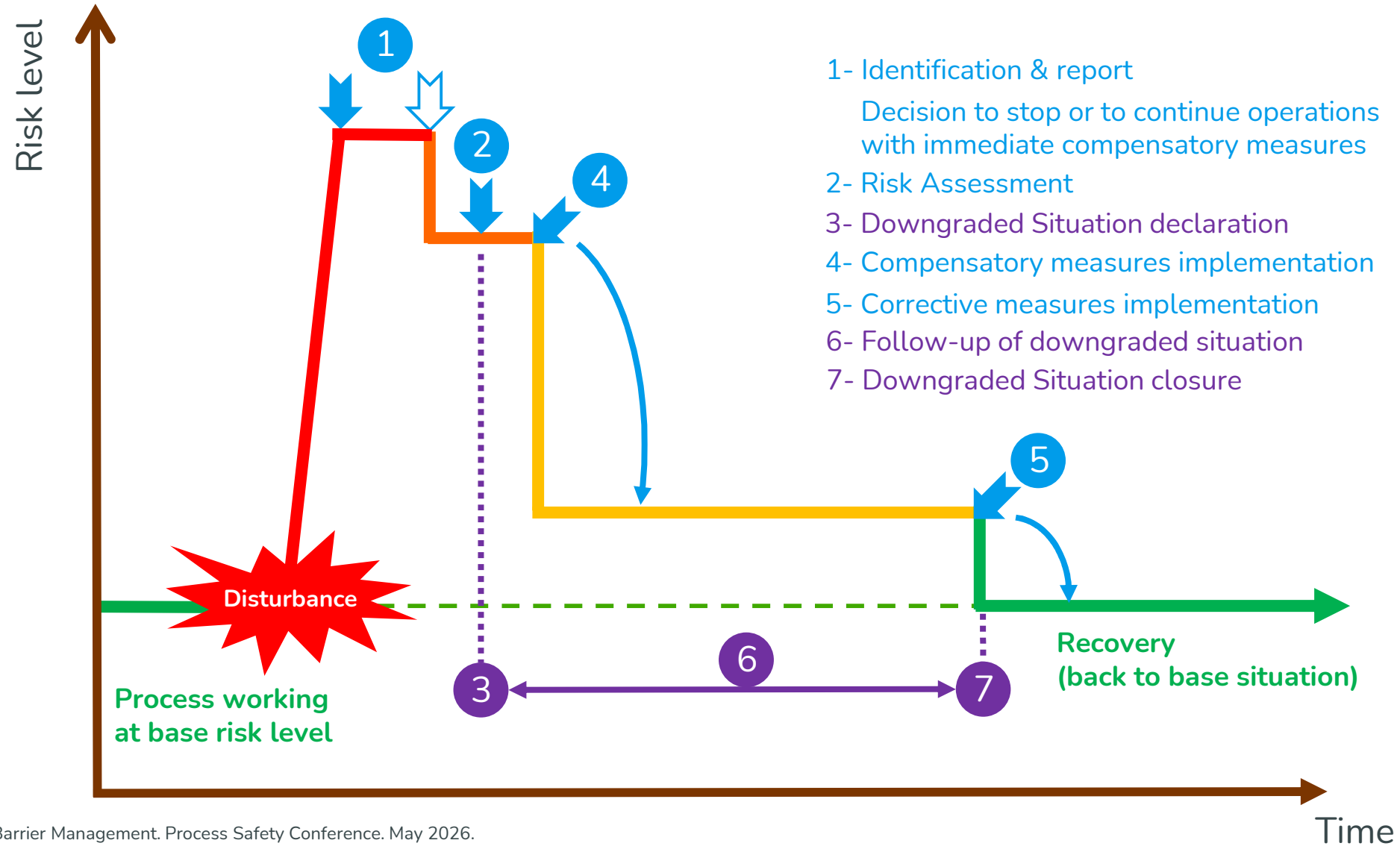
Nr	Critical Barrier Category	Examples
1	Structures and Foundations	o Supporting structures
2	Primary Containment Systems	o Storage vessels o Process vessels o Piping o Pipelines
3	Safe Operating Window, Control & Trip	Safety Instrumented Systems. Examples include: o Overfill protection o Overpressure protection o High temperature protection o Reaction killing systems o HIPS o Cathodic protection systems
4	Mechanical Protection Systems	o Pressure relief devices (2-way pressure/vacuum valves, RD,...) o Mechanical interlocks and mechanical safety systems
5	External Impact & External Aggression Protection	o Riser protection o Cathodic protection o Building pressurization
6	Leak Control Systems	o Detection with operator action o Emergency shutdown & isolation systems o Blowdown & emergency depressurization systems o Rapid dump systems o Fire detection systems (with automatic action) o Gas detection systems (with automatic action) o Liquid detection systems (with automatic action) o Breakaway system or coupling
7	Effect Control Systems	o Ignition prevention systems o Secondary containment systems
8	Fire, Blast & Spill Protection Systems	o Firewater systems (including pumps, headers, nozzles...) o Explosion mitigation systems o Pollution detection and associated equipment
9	Escape, Evacuation & Rescue Systems	o Temporary Refuge with HVAC / Fire Dampers o Mooring Systems, hull of floating systems (FPSO,...) o Equipment needed for the Escape Barrier (including routes, rescue systems, Emergency Lighting, Lifeboats,...)

Non-Conformity Management

Barrier Management

TotalEnergies

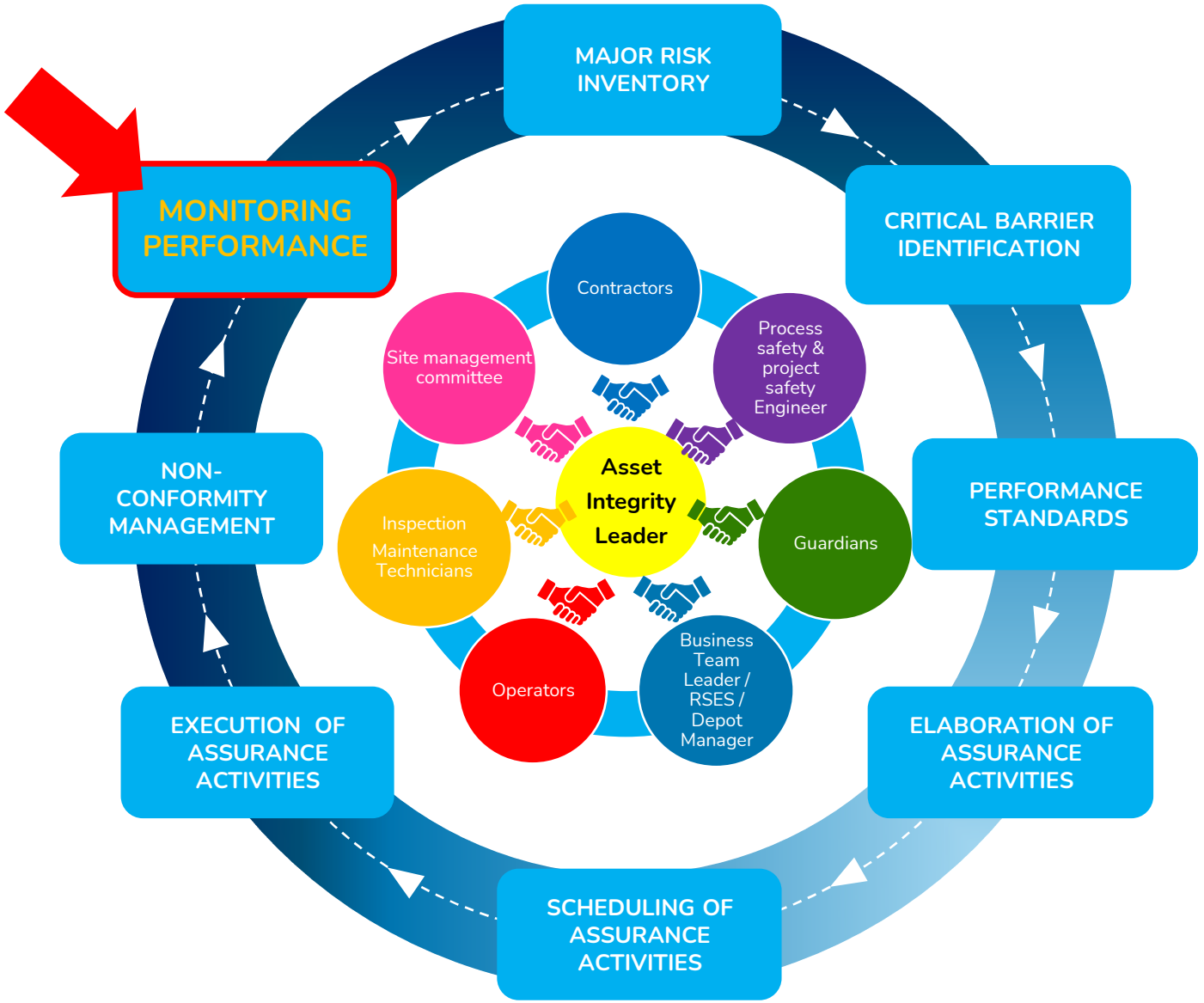
Non-Conformity Management: Downgraded Situations



1- Identification & report
Decision to stop or to continue operations with immediate compensatory measures
2- Risk Assessment
3- Downgraded Situation declaration
4- Compensatory measures implementation
5- Corrective measures implementation
6- Follow-up of downgraded situation
7- Downgraded Situation closure

Downgraded Situations

Monitoring of Performance



Need for Contextualization

Find a cross-branch digital solution that provides a **daily visual status of the safety critical barriers** in industrial sites with a **clear link to the major risk scenario**.

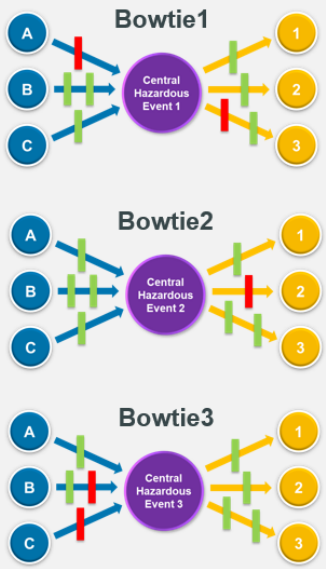
The table below gives a fictive example of the status of safety critical barriers in an industrial site

➔ In this case, only 2% of all critical barriers (5 out of 230) is not operational

➔ The site target is to have at least 98% of critical barriers operational.

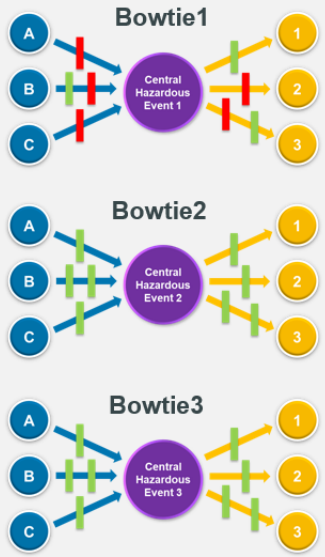
Is this situation as shown in the table below acceptable?

Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status	Critical Barrier	Status
SCB1		SCB24		SCB47		SCB70		SCB93		SCB116		SCB139		SCB162		SCB185		SCB208	
SCB2		SCB25		SCB48		SCB71		SCB94		SCB117		SCB140		SCB163		SCB186		SCB209	
SCB3		SCB26		SCB49		SCB72		SCB95		SCB118		SCB141		SCB164		SCB187		SCB210	
SCB4		SCB27		SCB50		SCB73		SCB96		SCB119		SCB142		SCB165		SCB188		SCB211	
SCB5		SCB28		SCB51		SCB74		SCB97		SCB120		SCB143		SCB166		SCB189		SCB212	
SCB6		SCB29		SCB52		SCB75		SCB98		SCB121		SCB144		SCB167		SCB190		SCB213	
SCB7		SCB30		SCB53		SCB76		SCB99		SCB122		SCB145		SCB168		SCB191		SCB214	
SCB8		SCB31		SCB54		SCB77		SCB100		SCB123		SCB146		SCB169		SCB192		SCB215	
SCB9		SCB32		SCB55		SCB78		SCB101		SCB124		SCB147		SCB170		SCB193		SCB216	
SCB10		SCB33		SCB56		SCB79		SCB102		SCB125		SCB148		SCB171		SCB194		SCB217	
SCB11		SCB34		SCB57		SCB80		SCB103		SCB126		SCB149		SCB172		SCB195		SCB218	
SCB12		SCB35		SCB58		SCB81		SCB104		SCB127		SCB150		SCB173		SCB196		SCB219	
SCB13		SCB36		SCB59		SCB82		SCB105		SCB128		SCB151		SCB174		SCB197		SCB220	
SCB14		SCB37		SCB60		SCB83		SCB106		SCB129		SCB152		SCB175		SCB198		SCB221	
SCB15		SCB38		SCB61		SCB84		SCB107		SCB130		SCB153		SCB176		SCB199		SCB222	
SCB16		SCB39		SCB62		SCB85		SCB108		SCB131		SCB154		SCB177		SCB200		SCB223	
SCB17		SCB40		SCB63		SCB86		SCB109		SCB132		SCB155		SCB178		SCB201		SCB224	
SCB18		SCB41		SCB64		SCB87		SCB110		SCB133		SCB156		SCB179		SCB202		SCB225	
SCB19		SCB42		SCB65		SCB88		SCB111		SCB134		SCB157		SCB180		SCB203		SCB226	
SCB20		SCB43		SCB66		SCB89		SCB112		SCB135		SCB158		SCB181		SCB204		SCB227	
SCB21		SCB44		SCB67		SCB90		SCB113		SCB136		SCB159		SCB182		SCB205		SCB228	
SCB22		SCB45		SCB68		SCB91		SCB114		SCB137		SCB160		SCB183		SCB206		SCB229	
SCB23		SCB46		SCB69		SCB92		SCB115		SCB138		SCB161		SCB184		SCB207		SCB230	



Case 1

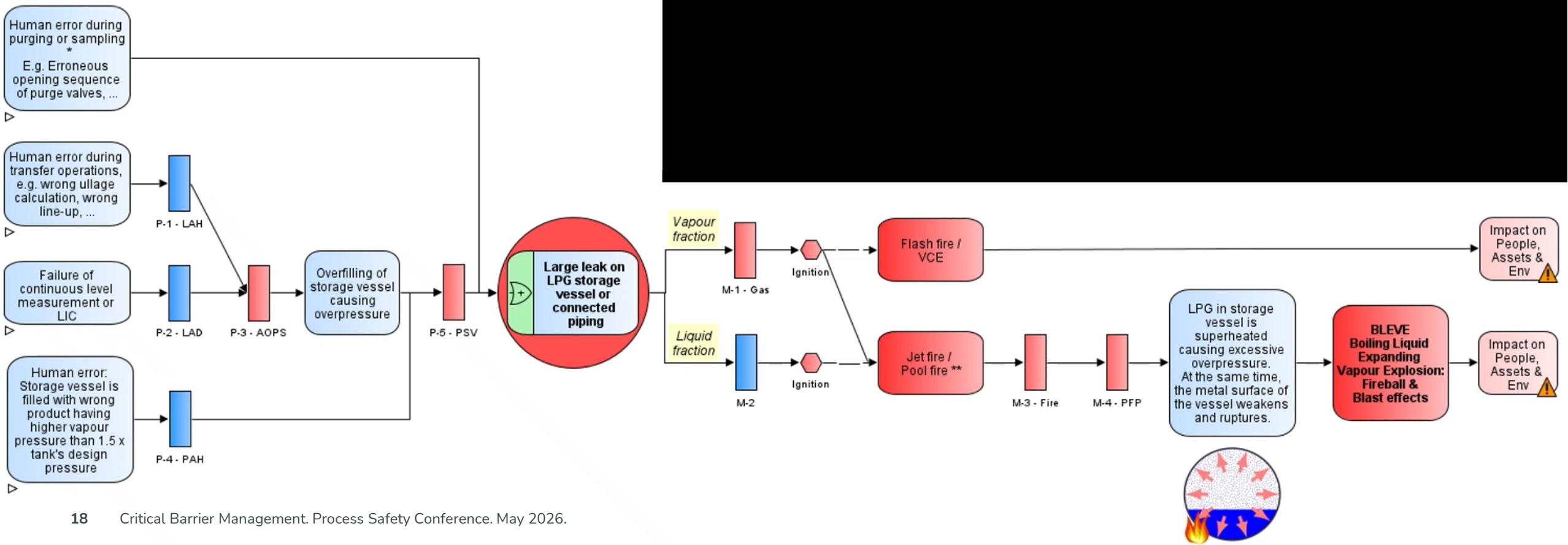
5 barriers KO but all paths of all major accident bowties **have at least 1 Safety Critical Barrier operational**



Case 2

5 barriers KO but 2 paths of Bowtie 1 (path A2 & C2) are **not protected by an operational Safety Critical Barrier**

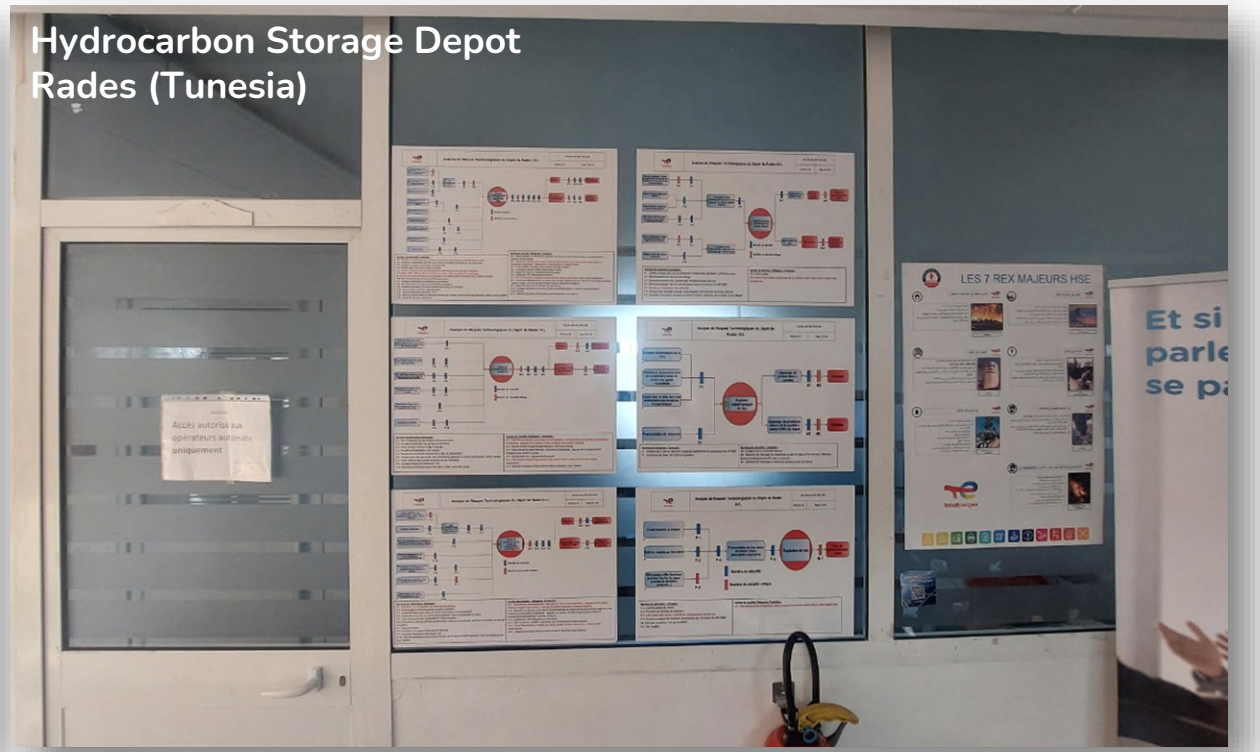
Typical LPG Bowtie BLEVE of aboveground LPG storage vessel



Management of Critical Barriers. Initiatives.

Display of simplified bowties of main major accident scenarios displayed in control room

Hydrocarbon Storage Depot
Rades (Tunesia)



Hydrocarbon Storage Depot
Rades (Tunesia)

Focus = People in Operations

Management of Critical Barriers. Initiatives.

Panel with description of main major accident scenarios displayed at the entrance of a unit

Focus = People in Operations

Management of Critical Barriers. Initiatives.

Training of operators on understanding of bowties.

Daily review of the status of critical barriers.

Training in the control room to all operational shift teams and to the maintenance personnel
Polypropylene site LaPorte (US, TX)

Daily review of downgraded situations on site to check status of safety critical barriers
Polypropylene site LaPorte (US, TX)

Focus = People in Operations

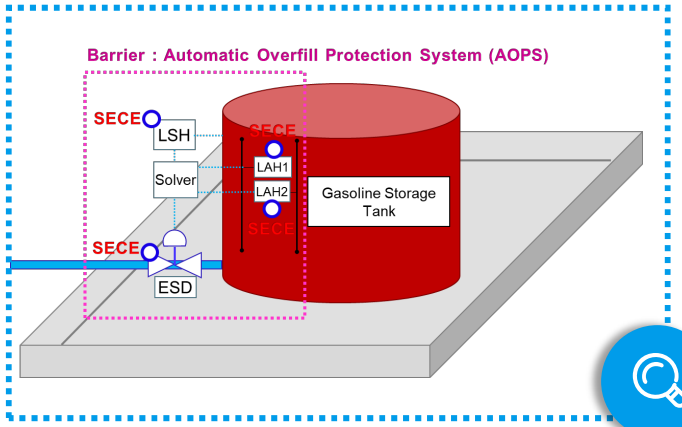
Management of Critical Barriers. Initiatives.

Identify critical safety barriers are clearly identified in the field (when possible)

example

Focus = People in Operations

Digital Tool for Follow-Up of the Status of Critical Barriers



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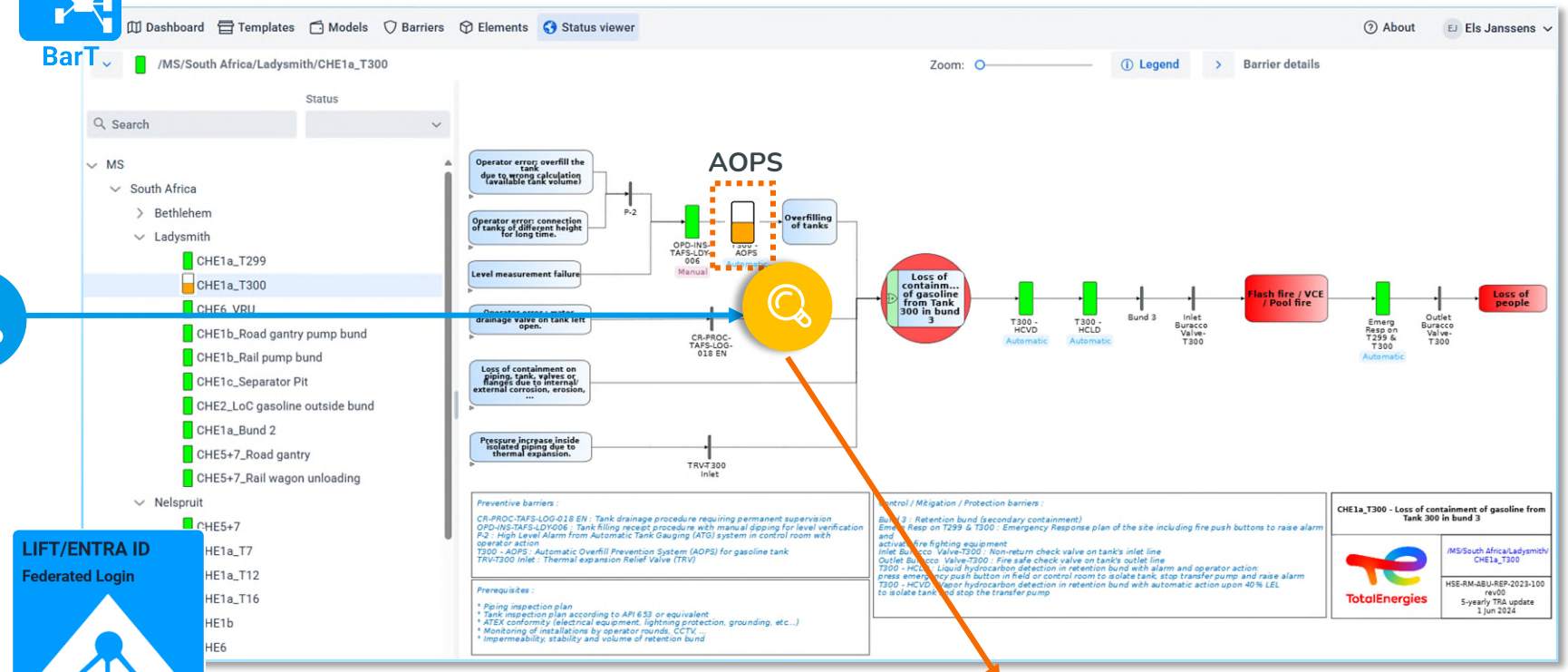


LIFT/ENTRA ID
Federated Login
Login

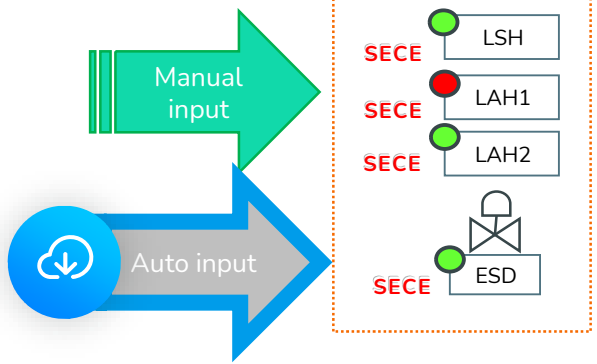
GRIF

Critical Barriers status

- Barrier is **fully operational** as required by its design and its performance standards
- There is a **delay in ITPM** activities of one or more SECEs that are part of the barrier
- The barrier is **impaired** with a performance deviating from its design intent and applicable performance standard
- The barrier has **failed** or is **not operational**

SECE status

- SECE is **fully operational** as required by its design. No delay on ITPM program, no degradation, no bypass.
- SECE **delay in ITPM** activities
- SECE **failed** or **not operational**



Thanks!

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