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Distinguished Lecturer Program

A step change in traditional Risk Assessment Techniques for Process Safety and Asset Integrity Management

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eni e&p

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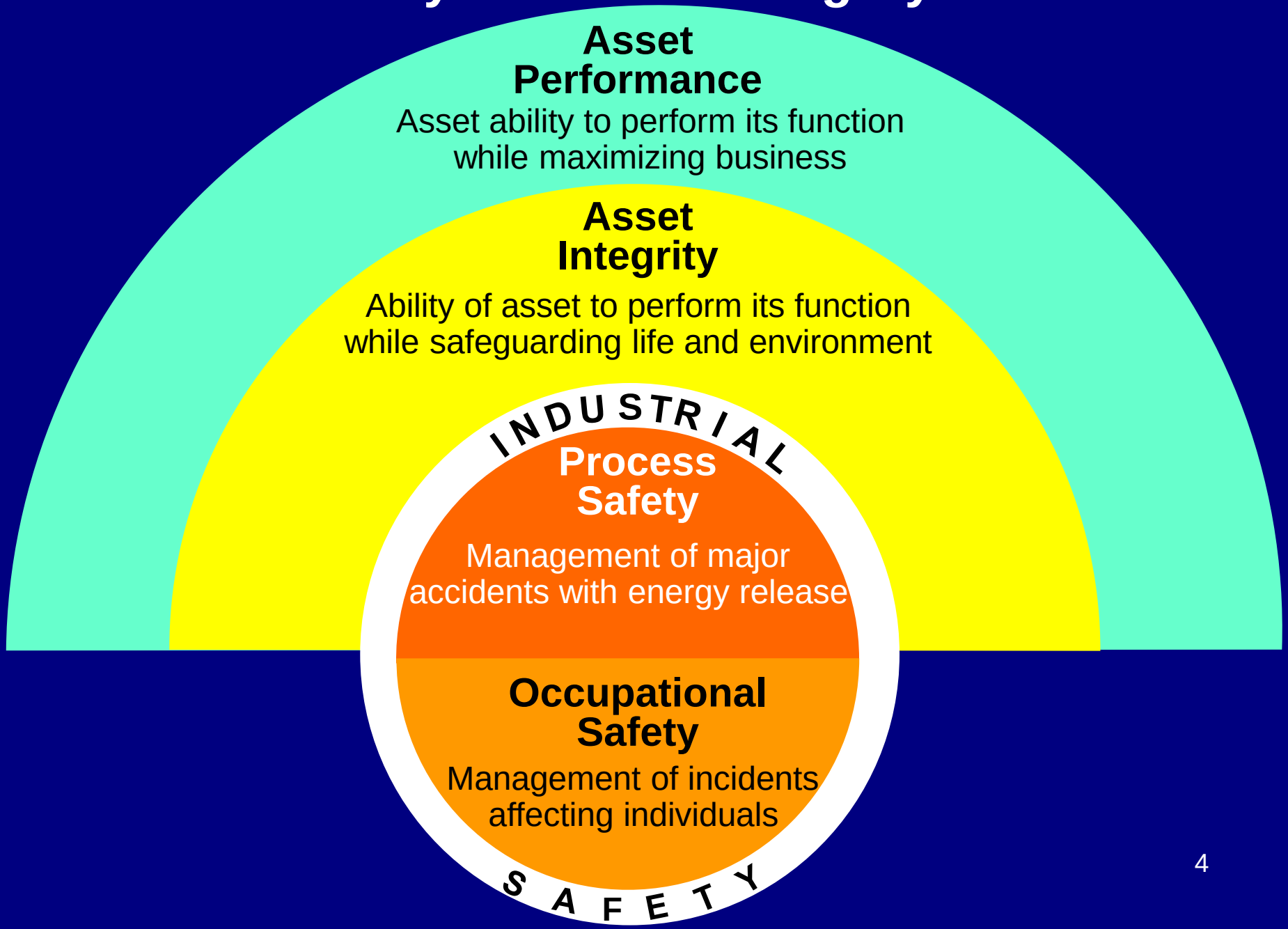
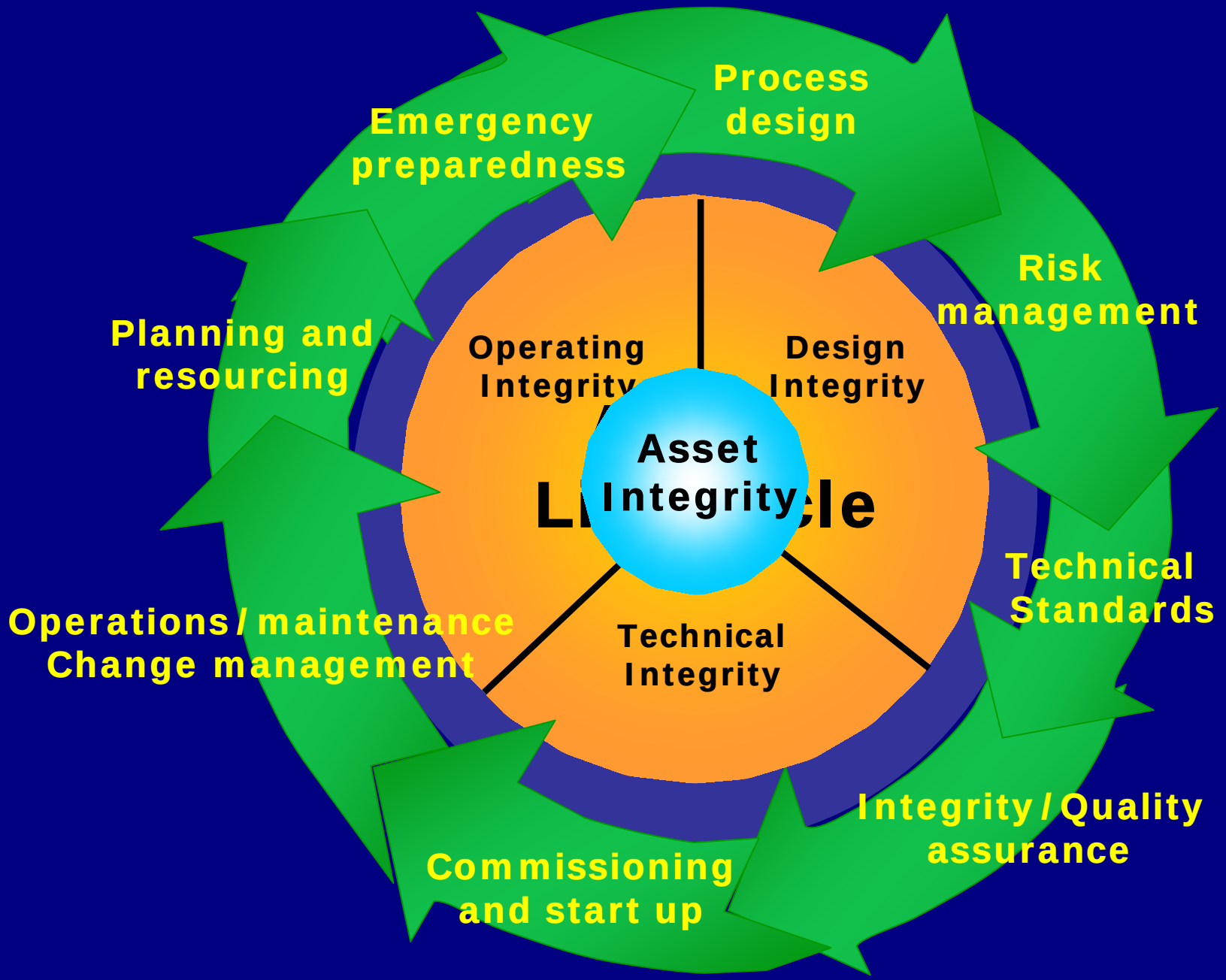
Agenda

1. Process Safety and Asset Integrity: definitions
2. Process Safety Management during asset lifecycle
3. Occupational Safety vs. Process Safety
4. The Barrier Concept
5. Risk Analysis tools for Process Safety
6. B.A.R.T. BAseline Risk Assessment Tool
7. Conclusions

Process Safety and Asset Integrity: Definition



Process Safety Management during asset life cycle



Occupational Safety vs. Process Safety

Occupational Hazard

- Single Injuries / fatalities
- Recurrent Root Causes:
  - Poor supervision
  - Human error,
  - Lack of attention

Process Safety Hazard

- Multiple Injuries / fatalities
- Recurrent Root Causes:
  - Malfunctions
  - Human error,
  - Deviation from operating procedures

DANGER

Occupational Safety Risks

Related to the violation of Golden Safety Rules

Safe Driving → **Safety Belts, Speed Limits, Defensive Driving etc.**

Track the Changes → **Changes reported & understood By-Pass approved**

Operating Lifting Safely → **Operators trained Lifting device certified**

Prevent Fires → **Firefighting Equipment, Fire Team in place, ER plan**

Mind the Height → **Scaffolding properly erected, Fall Arrestor Devices,**

Isolate Energized Systems → **Qualified de-energizer /team Work Permits**

Stabilize excavations → **Work Permit Proper Slope Benches,**

Handle Permits to Work (PTW) → **PTW System in place and understoo**

Apply HealthCare Solutions → **Safety Data Sheets Medical Certificates**

Protect Your self → **Head, eyes, hand feet and ears protection**

Occupational Safety vs. Process Safety

An operator walks through a process unit and slips and falls to the ground and suffers a days away from work injury.

The slip/fall is due to weather conditions, “chronic” oily floors and slippery shoes.

A maintenance contractor opens a process valve and gets sprayed and this results in a severe burn and days away from work

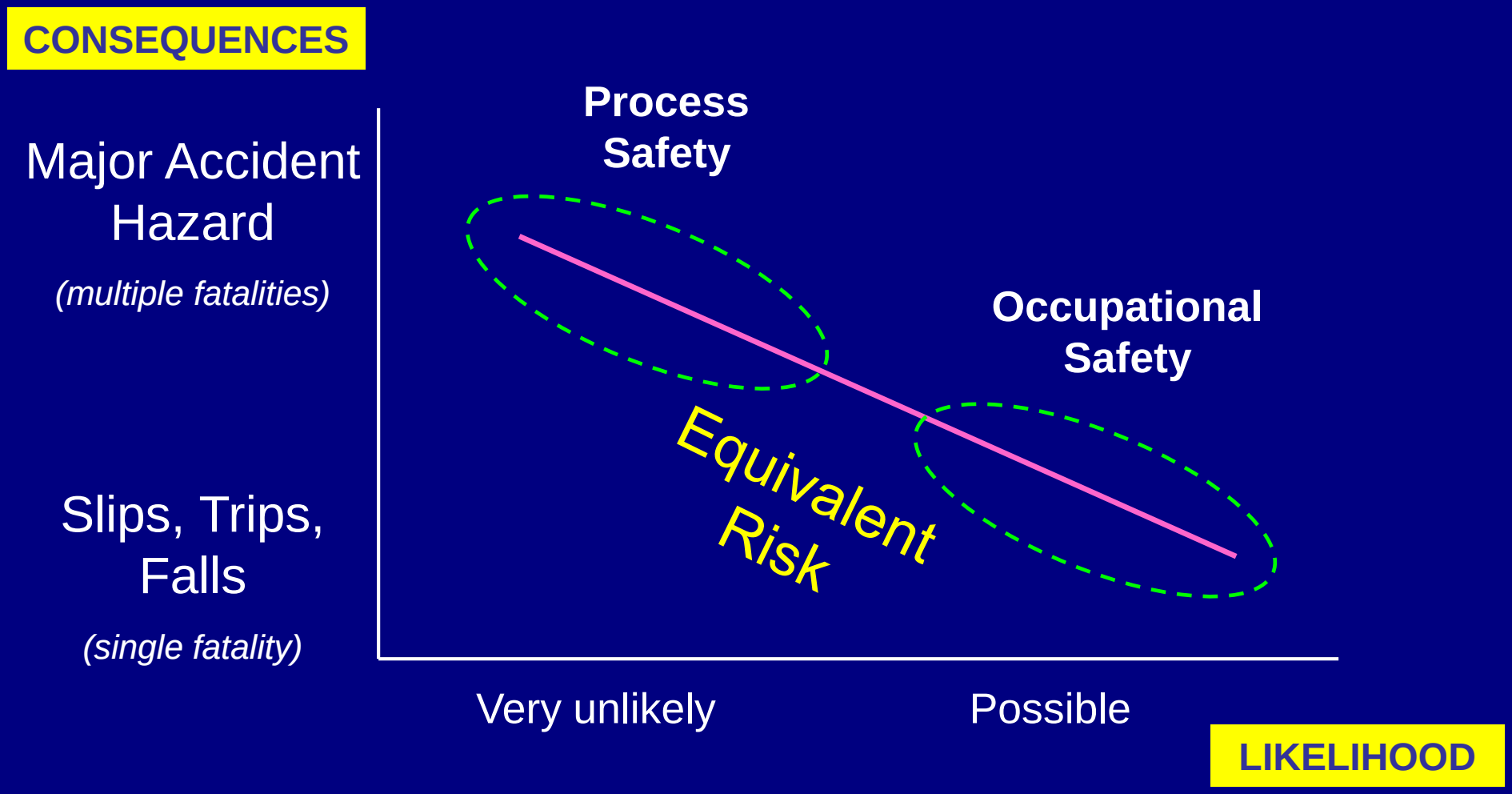
This is an

Occupational Safety Accident

This is a

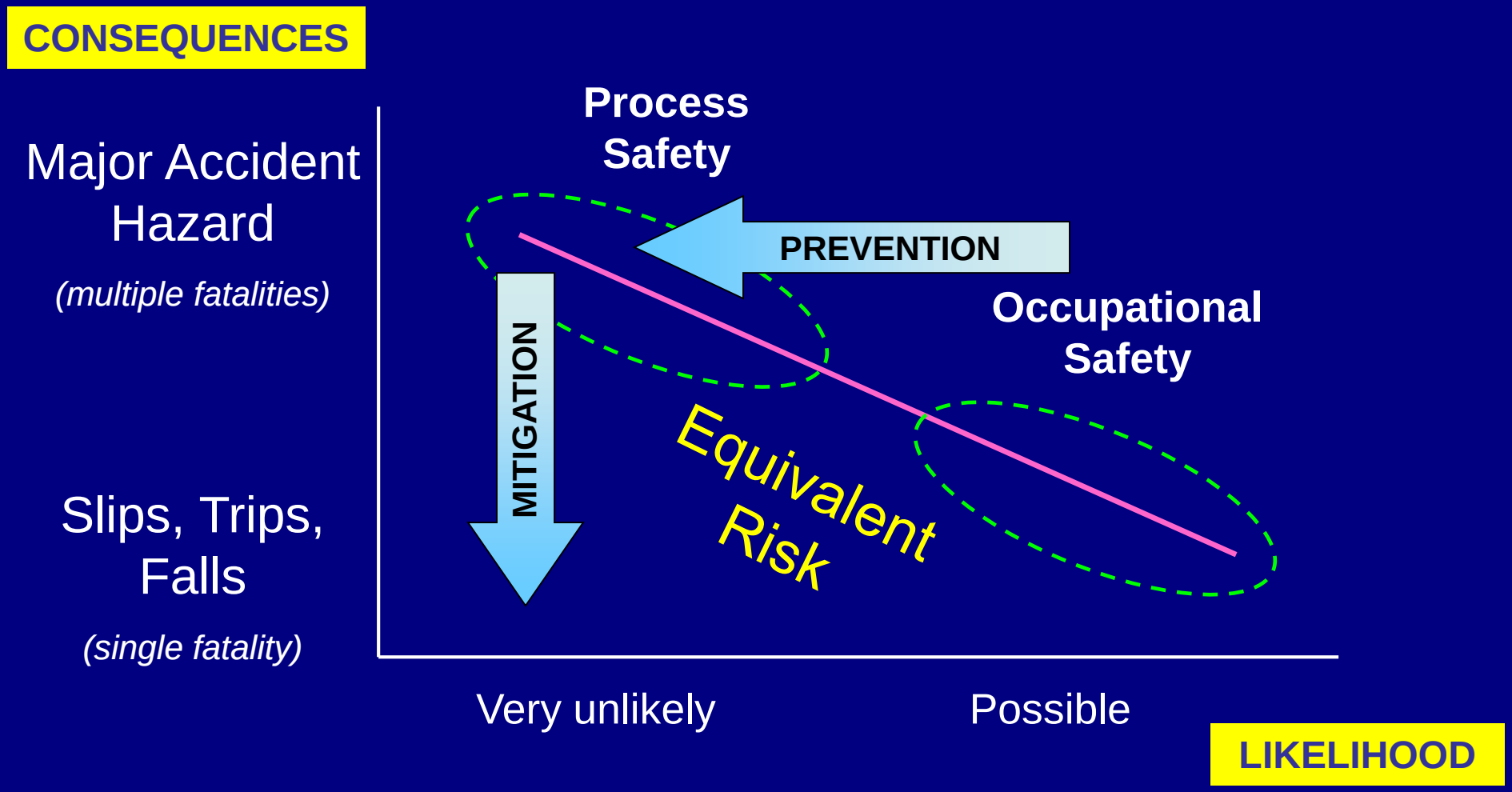
Process Safety Accident

Occupational Safety vs. Process Safety



The Barrier Concept

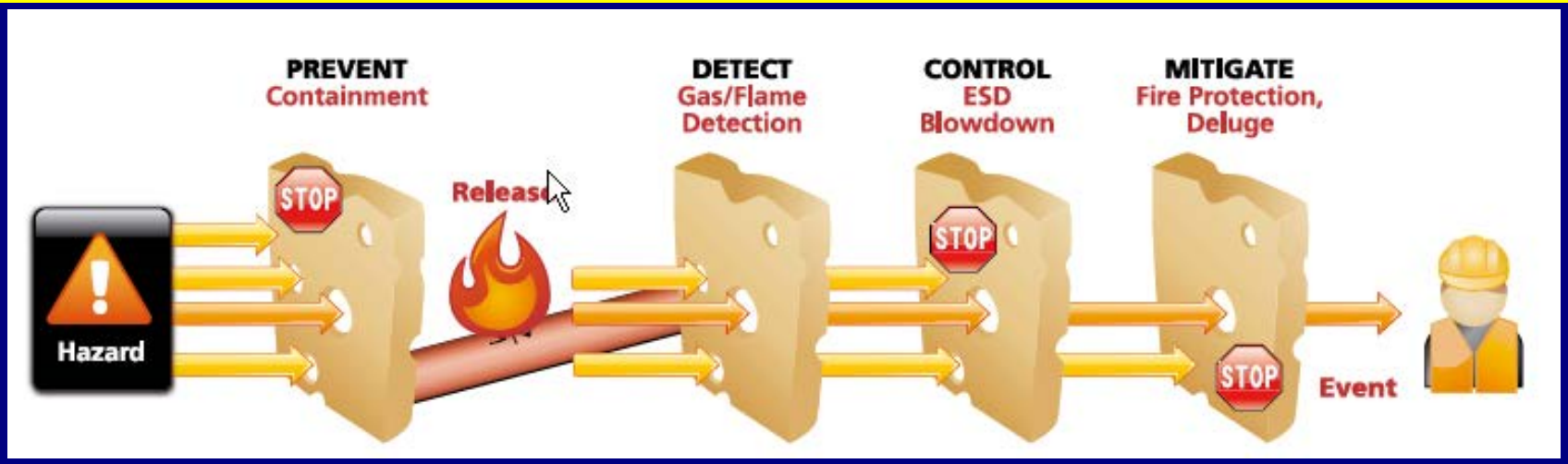
In order to prevent or mitigate a hazard, **Barriers** are required.



The Barrier Concept

A **Barrier** is a functional grouping of safeguards and controls selected to prevent the realization of a hazard

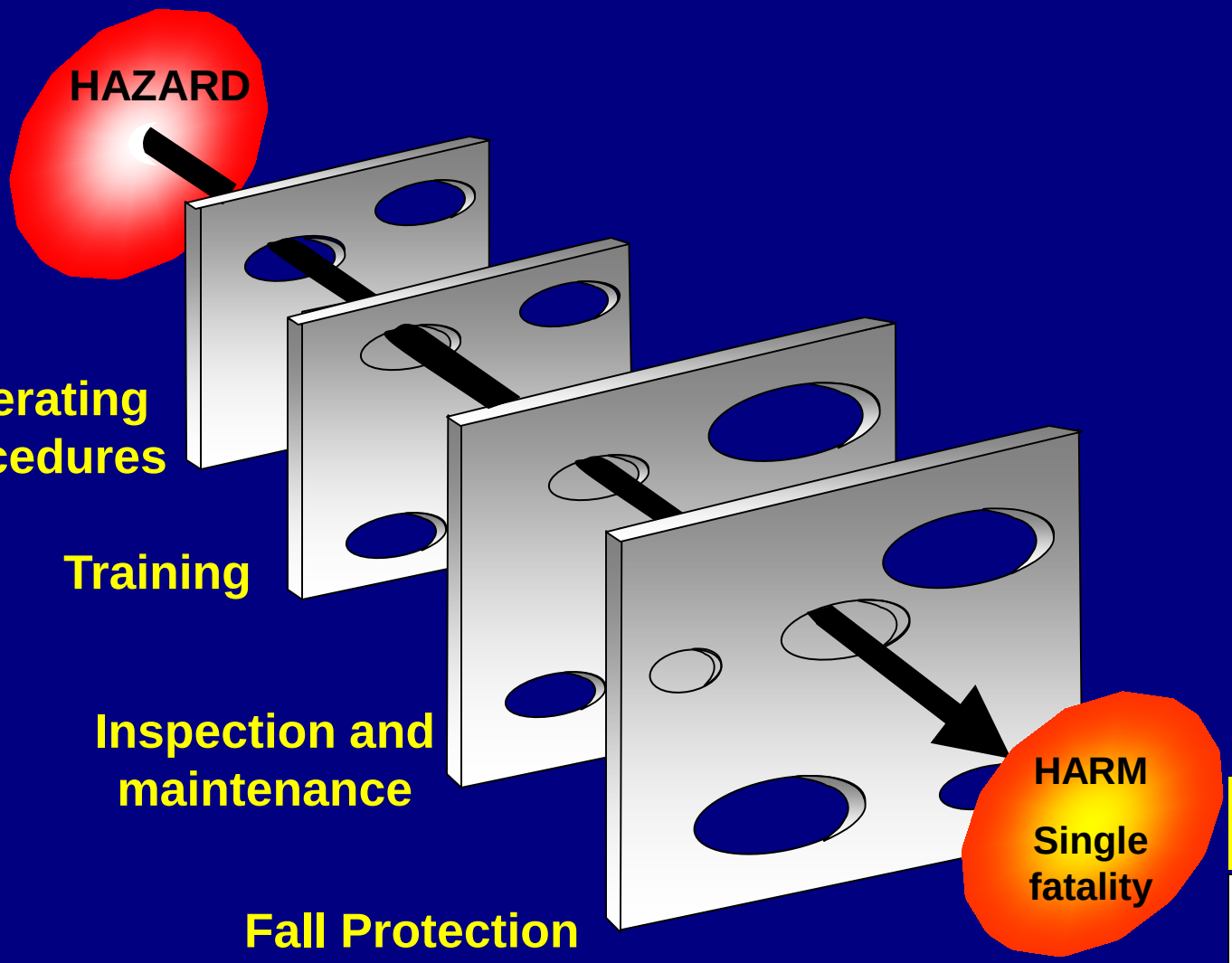
Swiss Cheese Model



Incidents occur when one or more holes in each of the slices become aligned, allowing for 'a trajectory' of accident opportunity

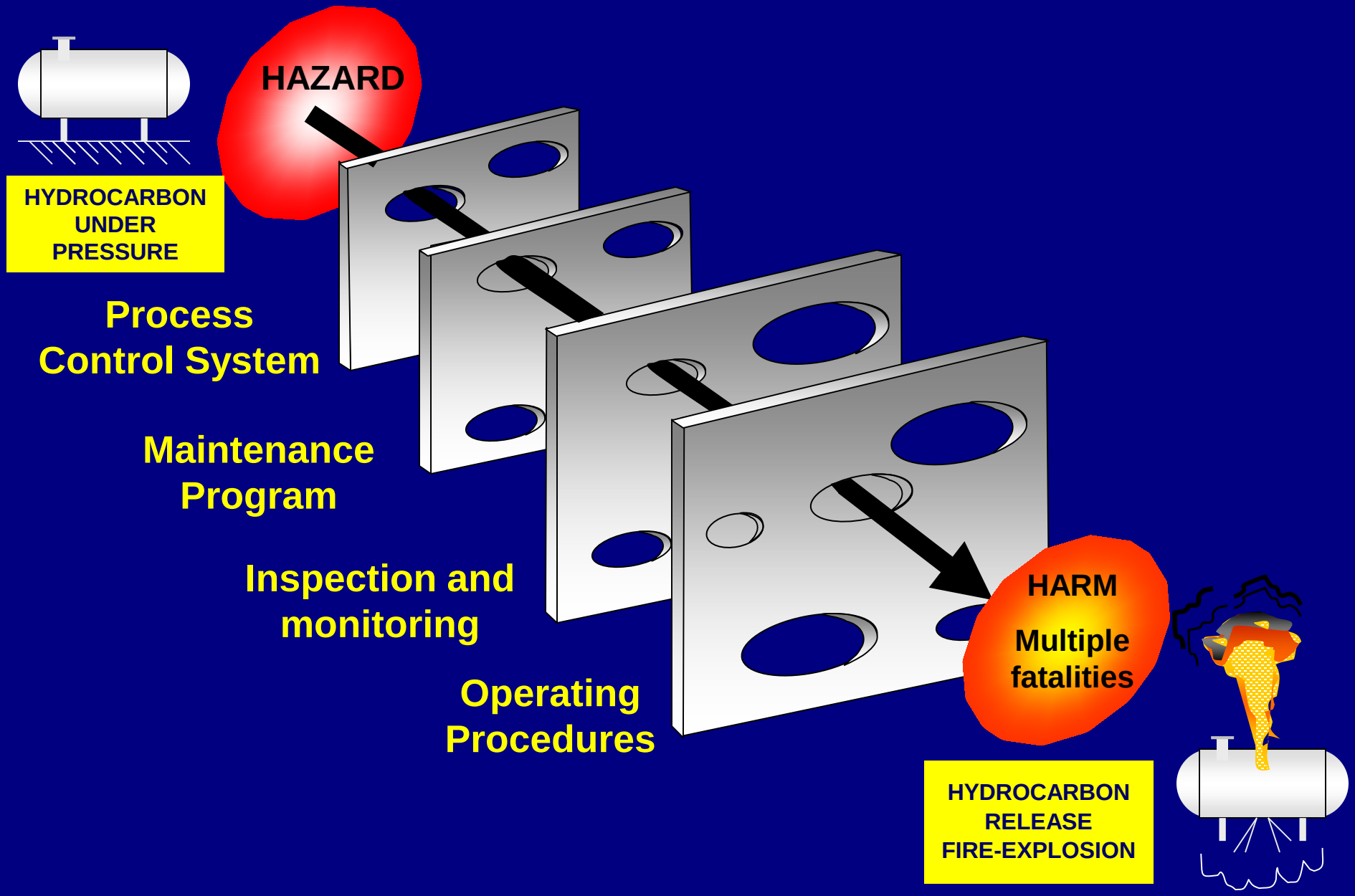
The Barrier Concept – Occupational Hazard

WORKING AT HEIGHT



FALLING FROM HEIGHT

The Barrier concept – Process Safety Hazard



Risk Analysis Tools for Process Safety

Early Design Phases

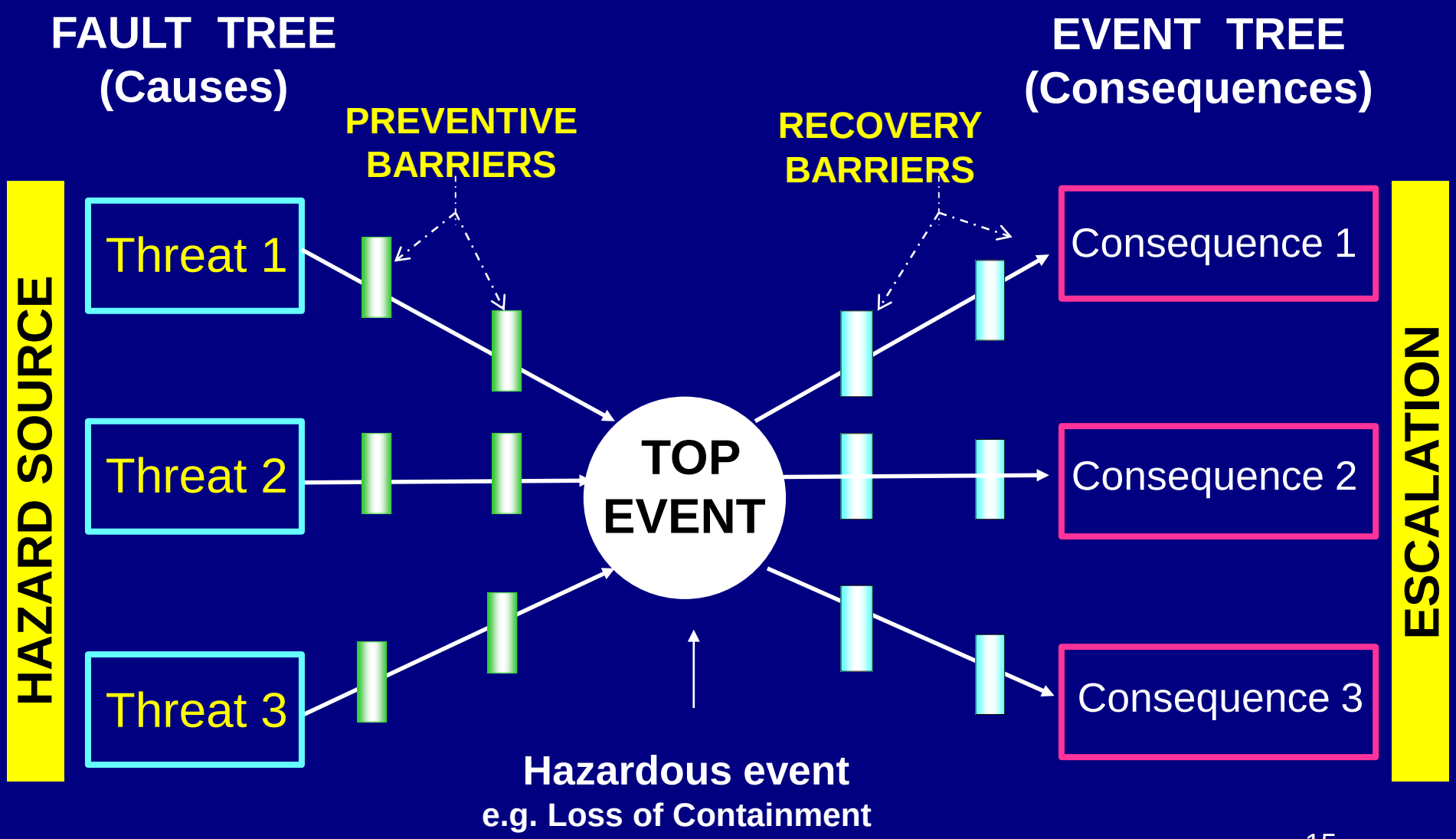
- Experience and Judgment
- Checklists Analysis
- Codes and Standards
- Preliminary Process Screenings
- Preliminary Hazard Identification

Later Design Phases

- RBI
- FMECA
- RAM
- Root Cause Analysis
- What-if Analysis
- HAZOP
- Quantitative Risk Analysis

Risk Analysis Tools for Process Safety

BOW TIE



Risk Analysis Tools for Process Safety

- **Bow tie**: good way to establish relationships between Hazard, Top Events, Threats and Consequences

- **Preventive Safeguards** reduce **the likelihood of** occurrence of the loss event (e.g. primary containment systems)

- **Recovery safeguards** reduce **the severity** of consequences (e.g. detectors)

Risk Analysis Tools for Process safety

Qualitative Risk Analysis

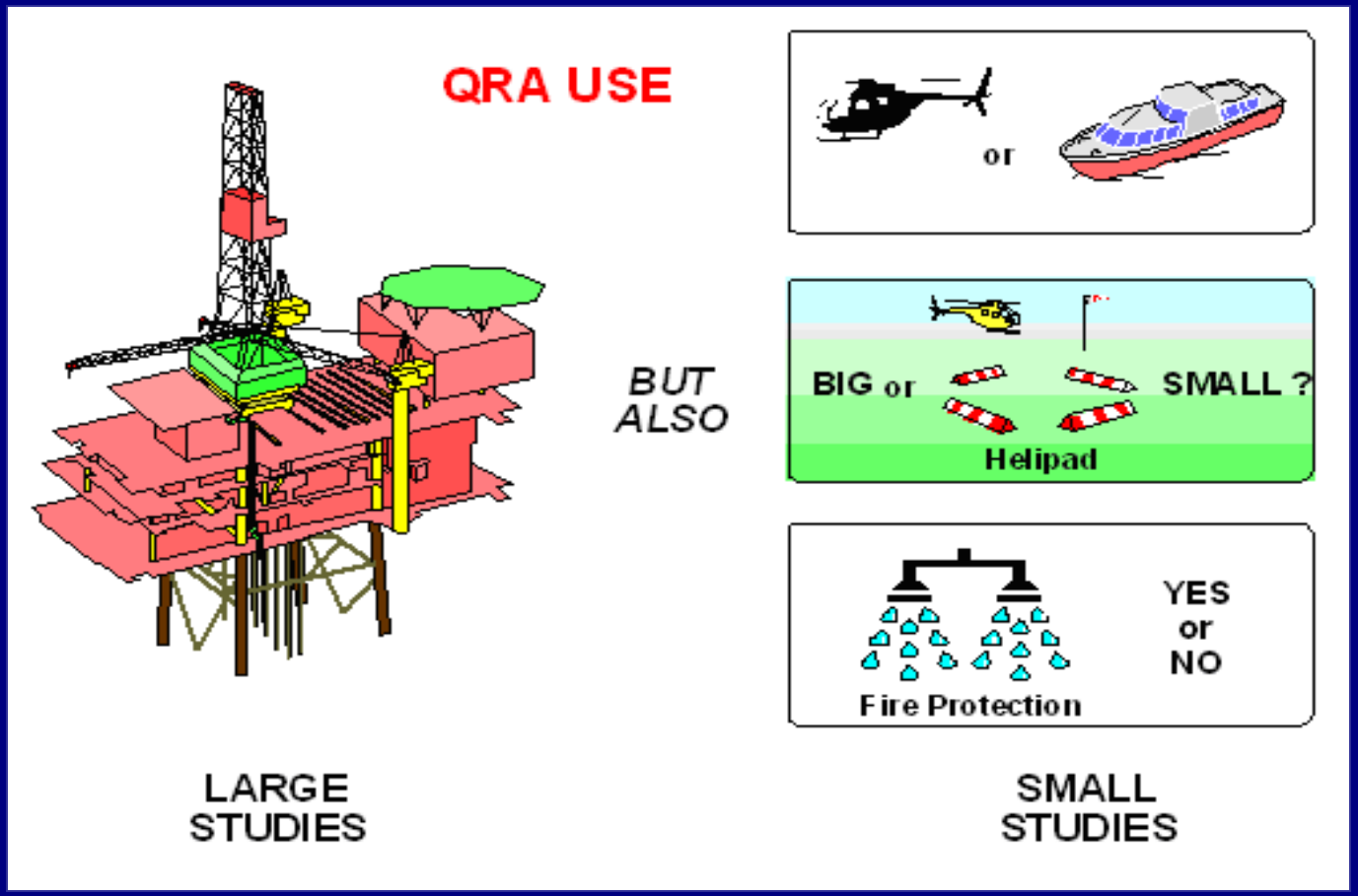
- Structured approach for Qualitative evaluation of Frequency and severity

Consequence					Increasing Annual Frequency					
Severity	People	Environment	Assets	Reputation	0	A	B	C	D	E
					Non-credible	Rare	Unlikely	Credible	Probable	Frequent
					Could happen in E&P industry	Heard in E&P industry	Has occurred at once in Company	Has occurred several times in Company	Happens several times/y in Company	Happen several times/y in one location
1	Slight injury	Slight effect	Slight damage	Slight impact	Continuous Improvement					
2	Minor injury	Minor effect	Minor damage	Minor impact				Risk Reduction Measures		
3	Major injury	Local effect	Local damage	Local impact						
4	One fatality	Major effect	Major damage	Major impact				Intolerable Risk		
5	Multiple fatalities	Extensive effect	Extensive damage	Extensive impact						

Risk Analysis Tools for Process safety

Quantitative Risk Analysis (QRA)

- Structured approach to Quantify Frequency and Severity
- Powerful tool during design phase and for ALARP demonstration



Risk Analysis Tools for Process Safety

QRA methodology limitations

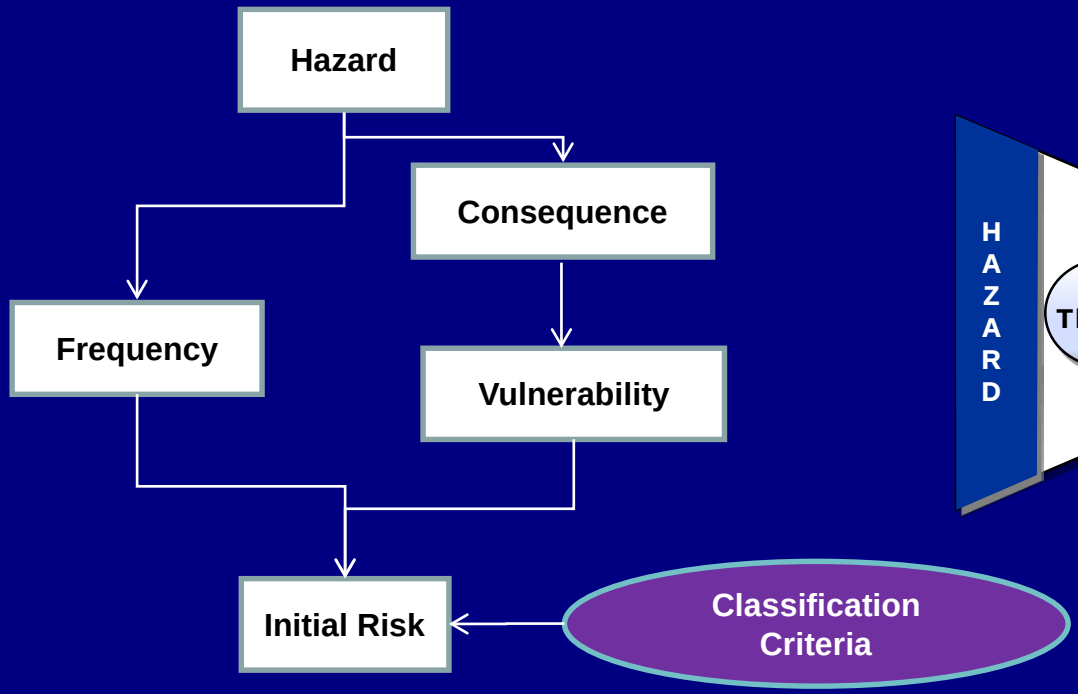
- **some hardware barriers** (e.g. the ESD) not considered
- **contribution of operational barriers** not quantifiable
- need of clear definition of working **time spent by operators**
- easily **misused** to justify deviation from standards
- **Uncertainties in input** resulting in unrealistic outputs

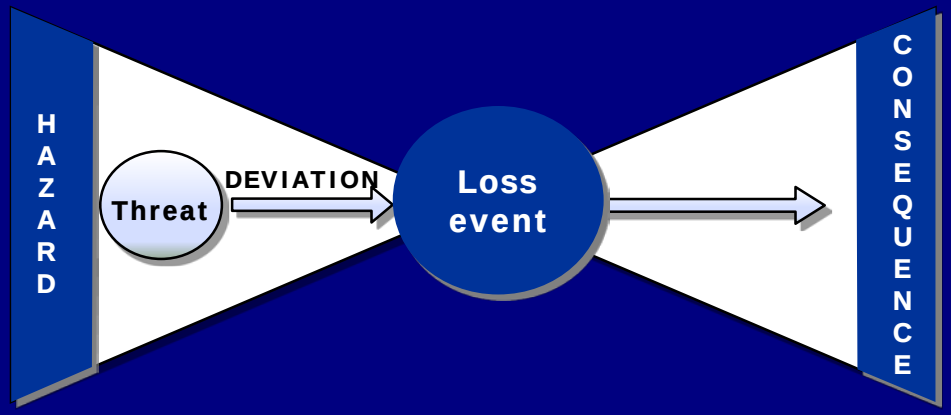
B.A.R.T. BAseline Risk Assessment Tool

Combination of a simplified QRA with a Bow-Tie Method

- **Simplified QRA**:
  to estimate the Initial Risk level of each functional unit, assuming no barriers in place.

- **Bow-Tie Methodology**:
  assess the Risk level taking into account the safety barriers and their effectiveness in prevention and mitigation.





B.A.R.T. BAseline Risk Assessment Tool

- BART project started in 2008; first trial on site in 2009
- Result of the cooperation between eni e&p safety department and eni engineering company (Tecnomare)
- Subjected to a Critical review by DNV
- Successfully applied so far to over twenty installations
- Presented at international conferences[1] workshops[2] and on technical journals[3]

1. SPE 146845 - ATCE 2011, IPTC 2011; SPE 156521- APPEA 2012; AIChE 6th Global Congress on Process Safety),
2. 5th Annual HSE Excellence Europe – London; Asset Integrity Workshop Stavanger
3. AIChE Process Safety Progress- Volume 30

B.A.R.T. BAseline Risk Assessment Tool

BART is a Risk Assessment Methodology to:

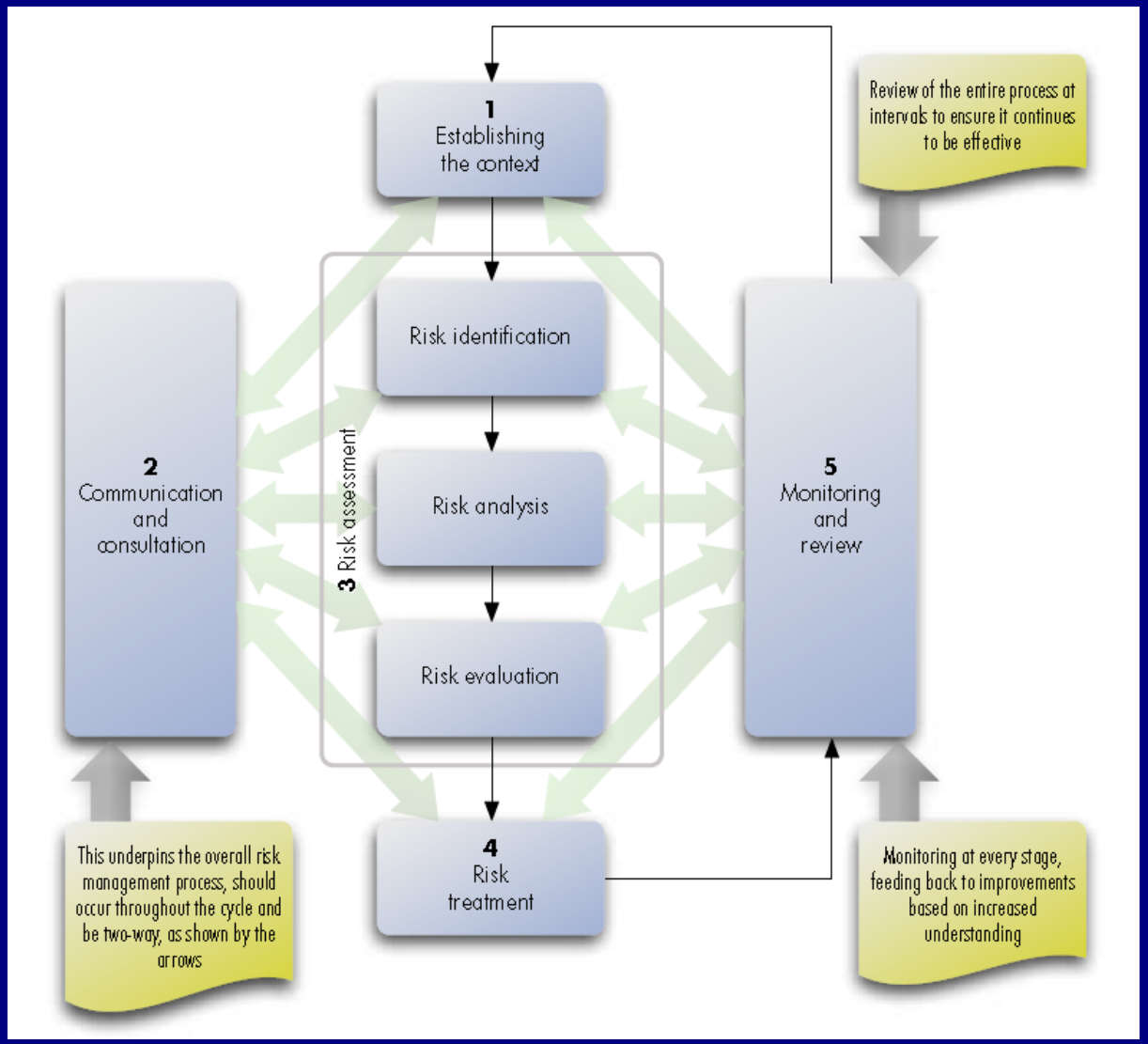
- identify and analyze all potential process safety hazards that can lead to major incidents
- determine the current level of process safety risk and define controls aimed at reducing it ALARP
- Establish effective Risk Reduction measure and support Management in the Decision Making Process

The methodology applies to both **onshore and offshore installations**

*(ALARP: **A**s **L**ow **A**s **R**easonably **P**racticable)*

B.A.R.T. BAseline Risk Assessment Tool

- BART methodology is consistent with the Risk Management process outlined in the OGP Asset integrity Report:



B.A.R.T. BAseline Risk Assessment Tool

Four Main Steps

Risk Identification	Risk Analysis	Risk Evaluation	Risk Treatment
Plant Configuration *Process Characteristics*	*Major Incident Scenarios* *Incident frequencies and consequences*	*Major Incident Scenarios* *Preventive and recovery safety barriers*	*Action Plan* *Risk Reduction strategy*
1st Step **Plant Modelling**	***2nd Step*** **Initial Risk**	***3rd Step*** **Current Risk**	***4th Step*** **Future Risk**

B.A.R.T. BAseline Risk Assessment Tool

1st step: Plant Modelling

Plant Layout:

- Functional Units
- Safety Distances

Process Characteristics:

- Equipment List per Unit
- Fluid Properties
- Operating Conditions

Safety Distances:

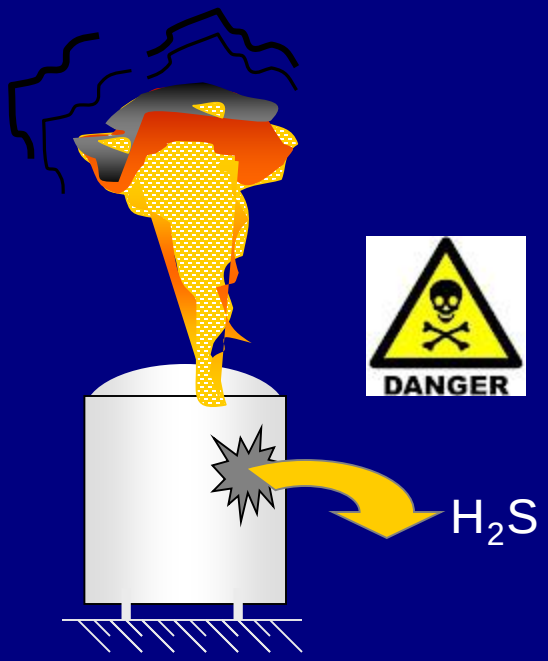
- Unit Length and Width
- Minimum dimension of the functional unit
- Minimum distance from other plant units and permanently manned areas

B.A.R.T. BAseline Risk Assessment Tool (6/16)

2nd Step: Initial Risk

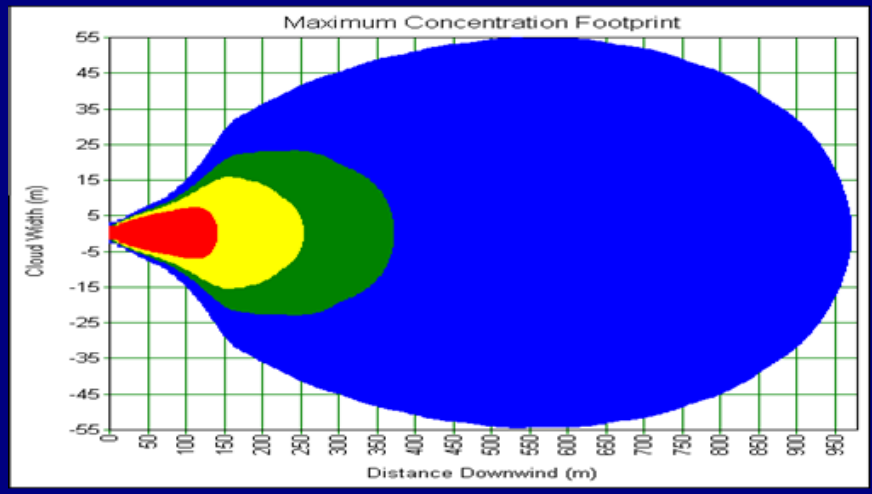
Determine the initial release frequency and estimate consequences with a simplified QRA. The major incident scenarios considered are:

- Jet Fire
- Pool Fire
- Flash Fire
- Explosion
- Toxic Release



Release Frequency evaluation

Consequence modelling



B.A.R.T. BAseline Risk Assessment Tool

Scenario frequencies and consequences are recombined, assessed and displayed in a **Risk Screening Matrix**

Consequence		***Increasing Annual Frequency***					
Seve-rity	**People**	**0**	**A**	**B**	**C**	**D**	**E**
		Non-credible	**Rare**	**Unlikely**	**Credible**	**Probable**	**Frequent**
		Could happen in E&P industry	Heard in E&P industry	Has occurred at once in Company	Has occurred several times in Company	Happens several times/y in Company	Happen several times/y in one location
1	**Slight health effect**	***Continuous Improvement***					
2	**Minor health effect**				***Risk Reduction***		
3	**Major health effect**						
4	**One fatality**					***Intolerable Risk***	
5	**Multiple fatalities**			**INITIAL RISK**			

B.A.R.T. BAseline Risk Assessment Tool

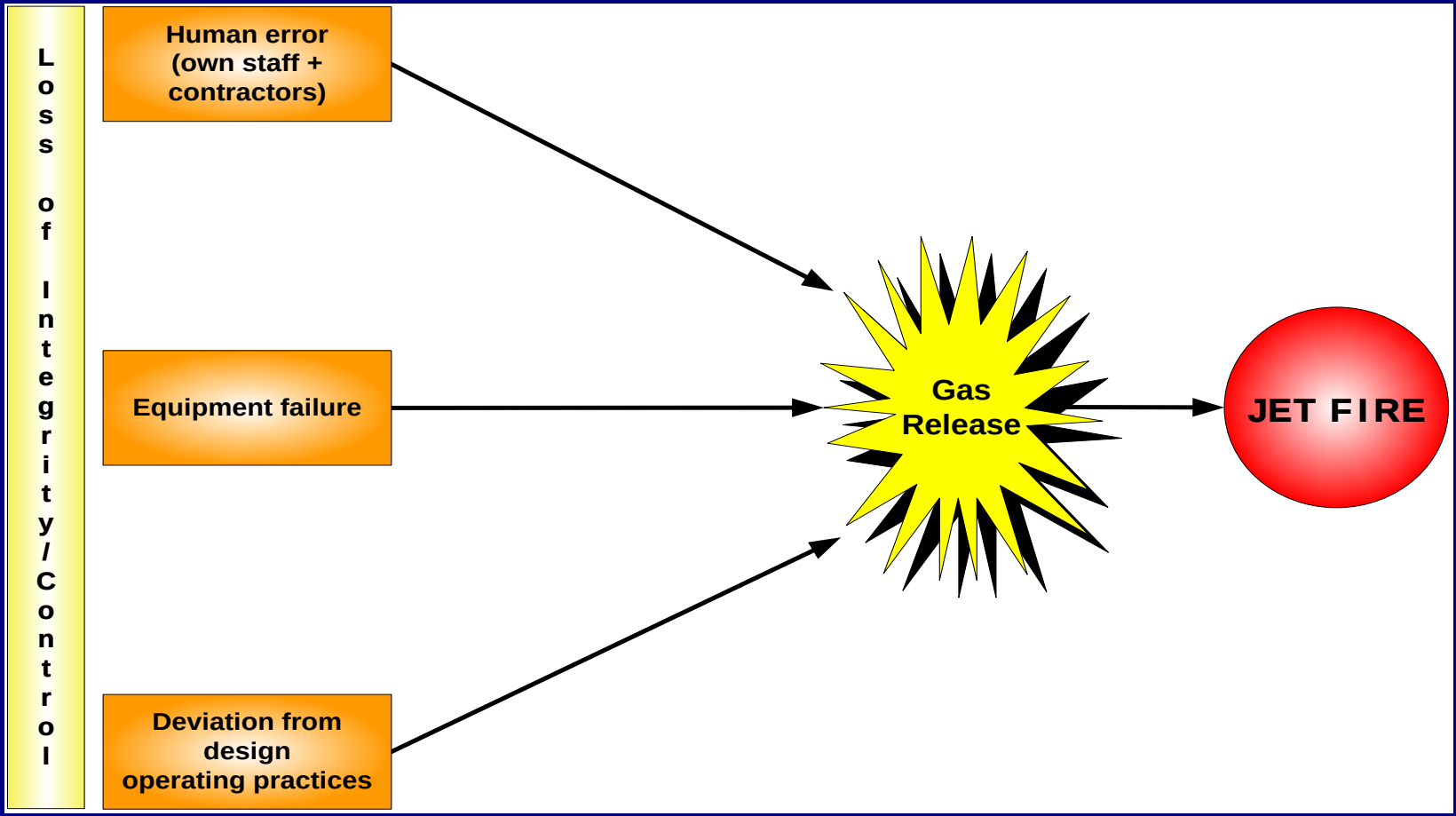
3rd Step: Current Risk

- Identify and select the controls forming an “independent barrier”.
- Evaluate the reliability of the barriers in place with dedicated checklists and interviews on site
- Assess current risk for each unit
  - Reduce likelihood of initial Risk with Preventive Barriers
  - Reduce consequences of initial Risk with Recovery Barriers

B.A.R.T. BAseline Risk Assessment Tool

Threat Identification

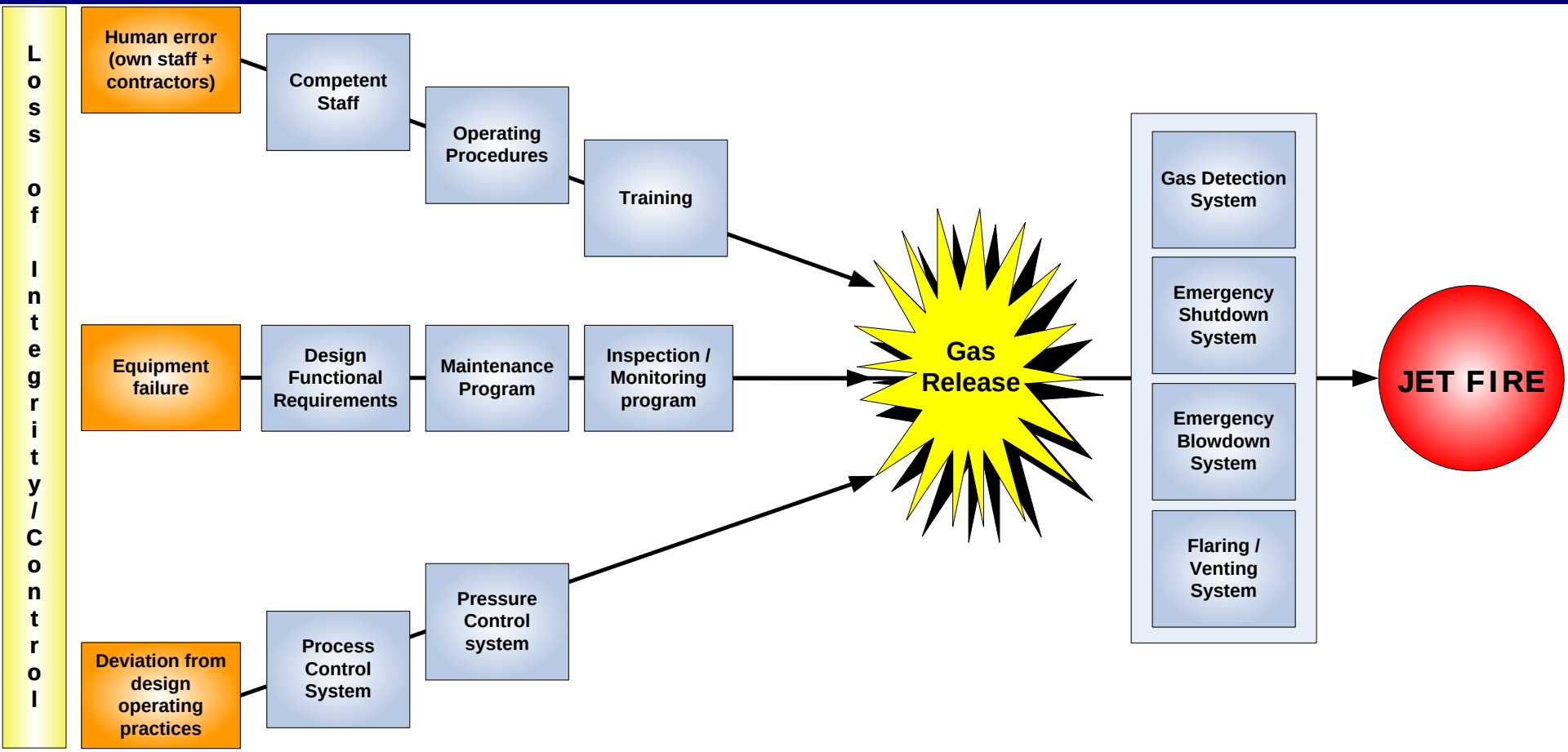
- What causes the hazard to be released?
- How can control be lost?



B.A.R.T. BAseline Risk Assessment Tool

Identification of Preventive Safeguards

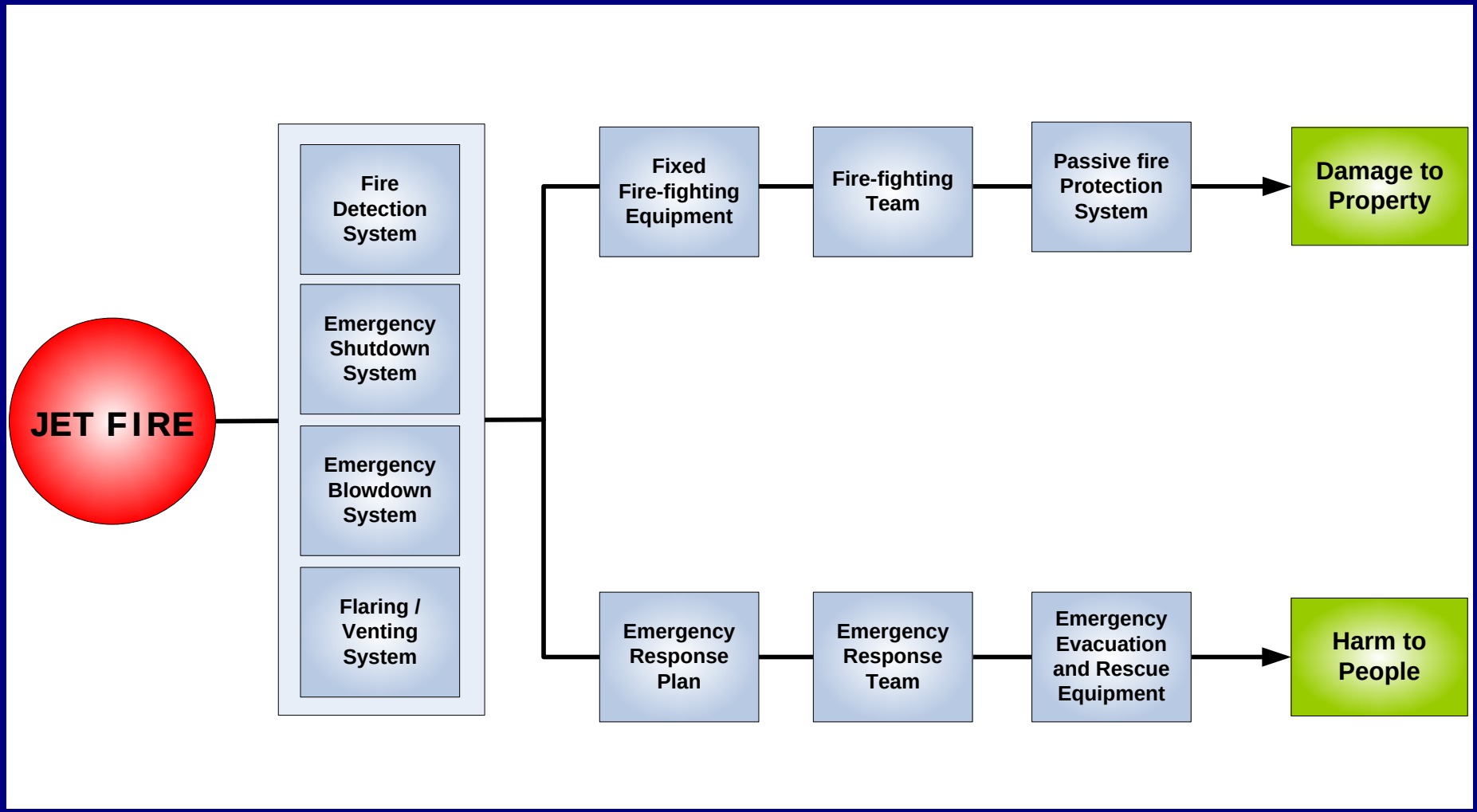
- How do we prevent the hazard from being released?
- How do we keep control?



B.A.R.T. BAseline Risk Assessment Tool

Identification of Recovery Safeguards

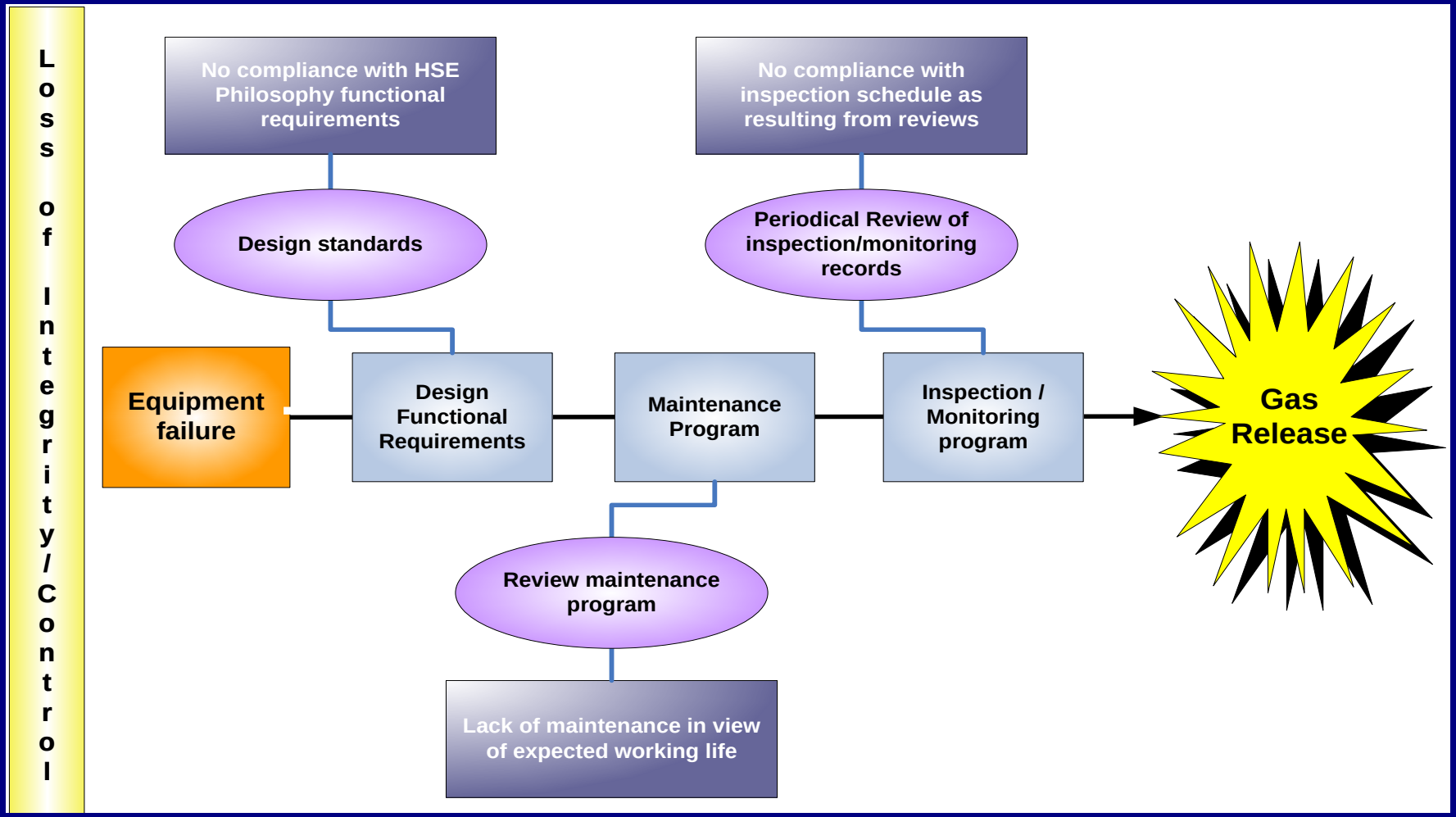
- How do we limit the severity of the event?
- How do we minimise the effects?



B.A.R.T. BAseline Risk Assessment Tool

Escalation Factors and Controls

- How might controls fail? How do we make sure they don't?
- How could their effectiveness be undermined?



B.A.R.T. BAseline Risk Assessment Tool

Barrier Name	Reliability	Basic Controls	Reliability
Equipment Functionality	MEDIUM	Equipment Integrity	MEDIUM
		Inspection and testing	HIGH
		Maintenance Management system	MEDIUM
Task Management	LOW	Staff competence training and awareness	LOW
		Contract HSE Requirements	LOW
		Process Safety Rules for Operations	HIGH
		Management of changes	LOW
		Operating Procedures	LOW
Process Safety Management System	MEDIUM	Process Safety Leadership & commitment	MEDIUM
		Process Safety Culture	MEDIUM
		Process Safety Audit	LOW

Barrier Reliability- Preventive Barriers

B.A.R.T. BAseline Risk Assessment Tool (10/16)

Barrier Name	Reliability	Basic Controls	Reliability
Fire Management	MEDIUM	Fire-fighting Team	HIGH
		Fixed fire-fighting systems	MEDIUM
		Mobile and portable fire fighting system	HIGH
Plant Layout	MEDIUM	Plant Layout	MEDIUM
Emergency Response System	MEDIUM	Contingency and Emergency Response Plan	HIGH
		Communication Systems	HIGH
		Emergency Response Team	HIGH
		Emergency Power Supply System	HIGH
		Escape evacuation and Rescue Equipment	MEDIUM
Temporary Refuge	LOW	Temporary Refuge	LOW

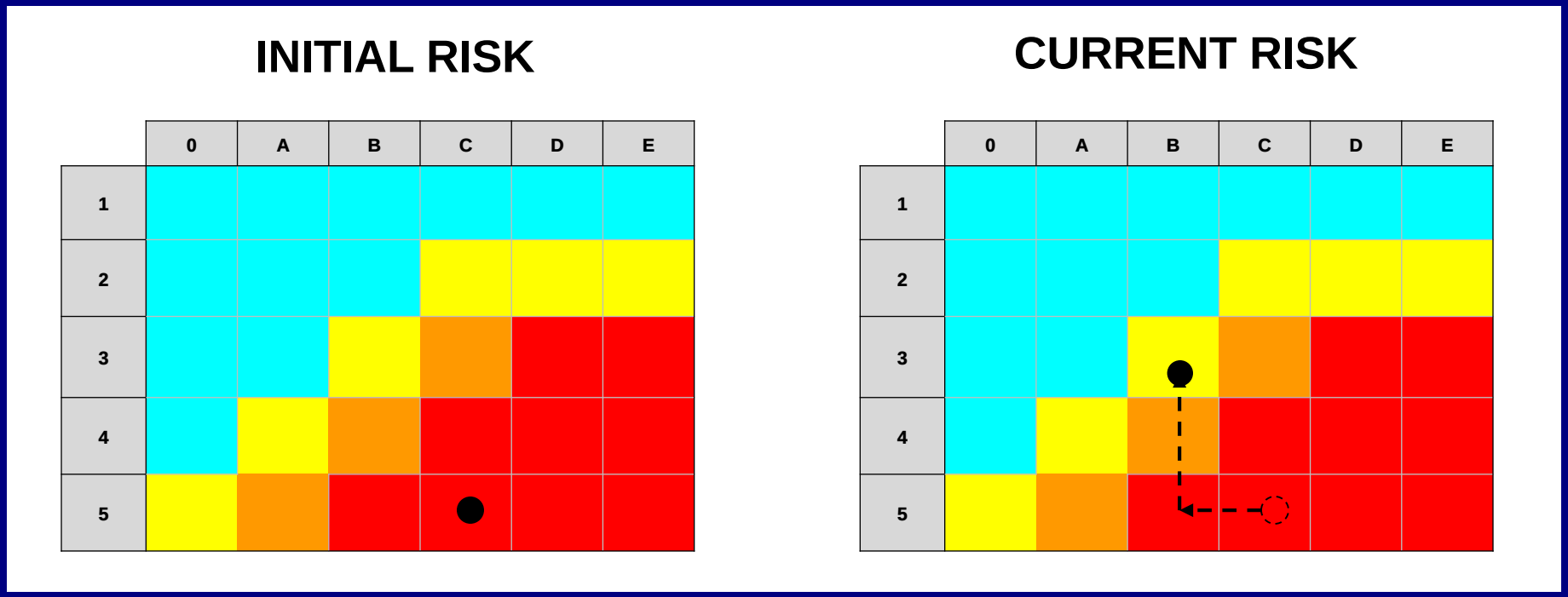
Barrier Reliability - Recovery Barriers

B.A.R.T. BAseline Risk Assessment Tool (11/16)

BART Checklist

ID	EMERGENCY RESPONSE TEAM	Score	Y/N	Notes
1	Are emergency response team trained on contingency and emergency response and evacuation procedures?	**2**	**Y**	ER training has been provided
2	Are emergency response team fully aware of their roles and responsibilities on emergency?	**1**	**N**	ER roles & responsibilities are included in training
3	Are emergency response team properly equipped and trained on the use of emergency devices and tools?	**2**	**Y**	The fire/rescue contractor has trained and experienced staff.
4	Is available a documented training programme for the emergency response team members and training records are kept?	**2**	**Y**	The fire/rescue contractor has records of all training to staff conducted
	TOTAL	**7**	**6**	**86%**

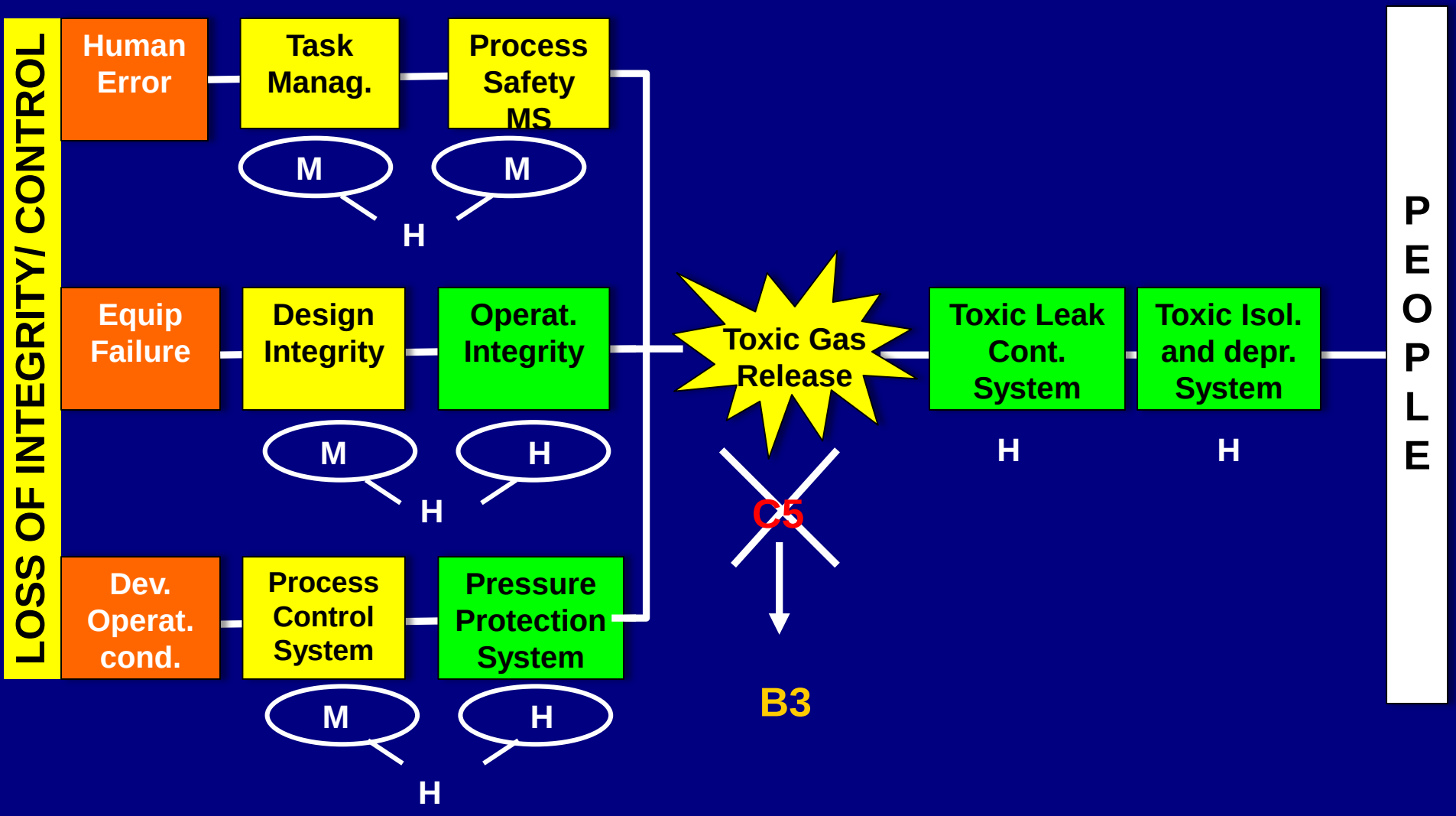
B.A.R.T. BAseline Risk Assessment Tool



Once Known number and reliability of all barriers in place, the initial risk frequency can be decreased:

- Each HIGH-reliability preventive / recovery barrier reduces the initial frequency / consequence by **one order of magnitude**
- LOW - or MEDIUM-reliability barriers if combined can act as HIGH-reliability barriers.

B.A.R.T. BAseline Risk Assessment Tool



B.A.R.T. BAseline Risk Assessment Tool

Unit	Event	Current Risk		
		Human Error	Equipment Failure	Deviation Process
AGP Heaters	FF	A4	A4	A4
	JF	A4	A4	A4
	PF	A5	A5	A5
Compression	EX	B4	B4	B4
	FF	C4	C4	C4
	JF	C5	C5	C5
Dehydration	FF	B4	B4	B4
	JF	B5	B5	B5
Emulsion Heaters	FF	A5	A5	A5
	PF	B3	B3	B3
Inlet Separators	FF	A5	A5	A5
	JF	A4	A4	A4
	PF	A4	A4	A4
LP Separators	FF	A5	A5	A5
	PF	A4	A4	A4

Significant Risk Scenarios – Current Risks

B.A.R.T. BAseline Risk Assessment Tool

4st step: Future Risk

Recommended Actions:

- identified for each preventive and recovery control, whose poor reliability affect the whole barrier effectiveness
- aimed at improving the reliability of existing barriers

Future Risk Reduction Scenarios

- Simulation of different “scenarios” to reduce overall risk implementing one or more recommended actions
- facilitates the decision process in selecting the most appropriate risk-reduction strategy.

B.A.R.T. BAseline Risk Assessment Tool

Recommended Actions

CASE	RISK REDUCTION SCENARIO	CONTROLS	HIGH Risk Reduction	
			PEOPLE	ASSET
1	**Prevention of Equipment Failure**	• Maintenance Management • Inspection & Testing • Equipment Integrity …	**- 33%**	**- 33%**
2	**Revamping of Isolation & Depressurization System**	• Gas Detection System • Fire Detection System • Emergency Blowdown …	**- 50%**	**- 78%**
3	**Mitigation of Fire Scenarios**	• Fixed Fire-fighting System • Mobile/portable fire-fighting • Spill containment System …	**- 38%**	**- 67%**

Simulation of risk reduction scenarios

B.A.R.T. BAseline Risk Assessment Tool (16/16)

Unit	Event	Future Risk		
		Human Error	Equipment Failure	Deviation Process
AGP Heaters	FF	04	04	A4
	JF	04	04	A4
	PF	04	04	A4
Compression	EX	A4	A4	A4
	FF	B4	B4	B4
	JF	B3	B3	C3
Dehydration	FF	A4	A4	B4
	JF	A4	A4	B4
Emulsion Heaters	FF	04	04	A4
	PF	A3	A3	B3
Inlet Separators	FF	04	04	A4
	JF	04	04	A4
	PF	04	04	A4
LP Separators	FF	04	04	A4
	PF	04	04	A4

Significant Risk Scenarios – Future Risks

Conclusions

- **Process Safety** and **Occupational Safety** as key drivers in E&P Operations
- **Effective barriers** needed to prevent major hazards
- Need for **innovation** in traditional risk assessment methodologies

Conclusions

- **B.A.R.T** proposed as a **step change** for **Process Safety** Risk Assessment
- **Methodology and dedicated software** based on the combination of QRA and Bow Tie
- It offers **Risk Reduction Strategies** to assist the management in the **decision making process.**

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