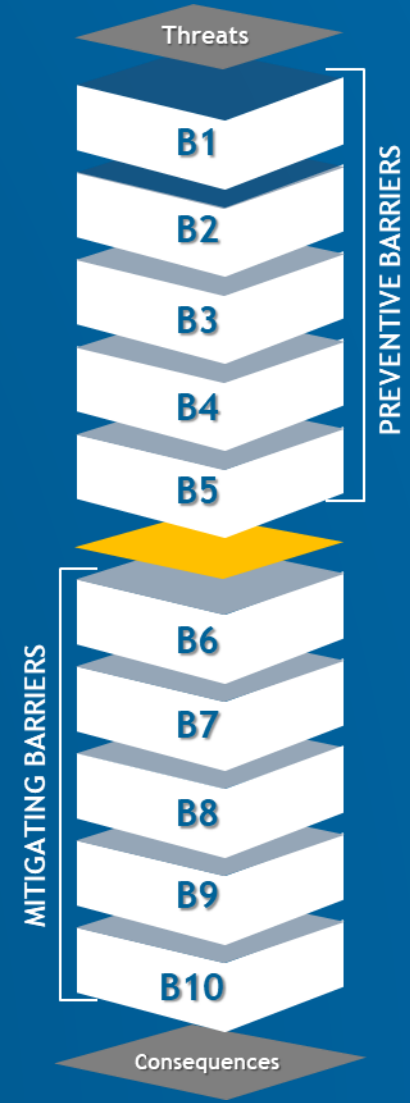


Dynamic Process Safety Barriers Management at Petrobras

Fábio Rossi
Rafael Armada



Dynamic Process Safety Barriers Management at Petrobras

Petrobras at a glance (2022)

Revenue

US\$

124,47

Billion in 2022

Investments

US\$

9.8

Billions

Daily production

Total Capacity of

2.15

Millions boe per day

Employees

Total of

46.416

Refineries

11

Platforms

56

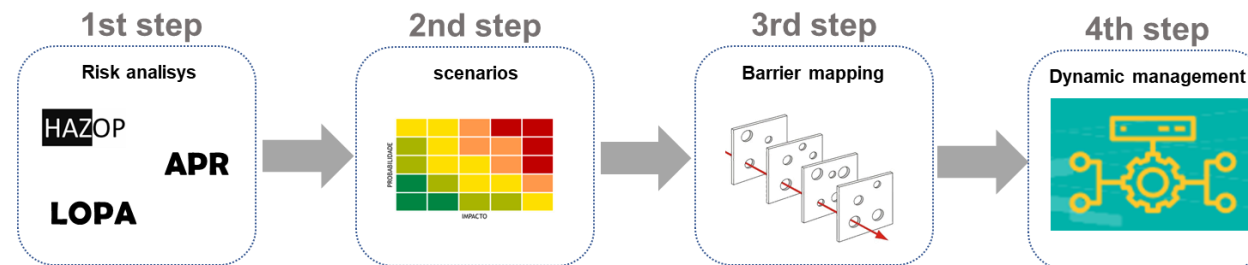
Thermoelectric

14

Dynamic Process Safety Barriers Management at Petrobras

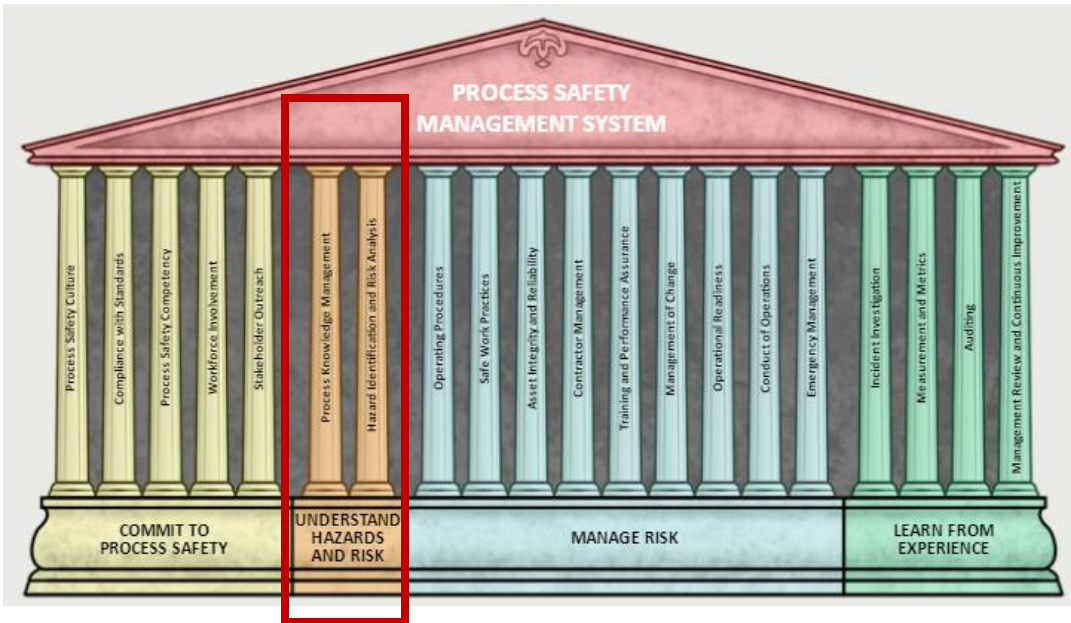
The Project purpose is to enhance **understanding of specific scenarios** and provide **clear indication that the safeguards** (risk-control measures) are in place and performing properly.

Summarizes and **communicates the health** (effectiveness) **and importance** (criticality) **of these safeguards** to support the **decision-making**.



Dynamic Process Safety Barriers Management at Petrobras

Understand Hazards and Risks



	Level 1	Level 2	Level 3	Level 4	Level 5
1	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Take immediate action	Take immediate action	Take immediate action
0.1	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Take immediate action	Take immediate action
0.01	No further action required	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Take immediate action
0.001	No further action required	No further action required	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives
0.0001	No further action required	No further action required	No further action required	No further action required	Evaluate risk reduction alternatives
0.00001	No further action required	No further action required	No further action required	No further action required	No further action required
0.000001	No further action required	No further action required	No further action required	No further action required	No further action required

↑ Increasing Frequency (in company determined units)
 → Increasing Severity (in company determined scale)

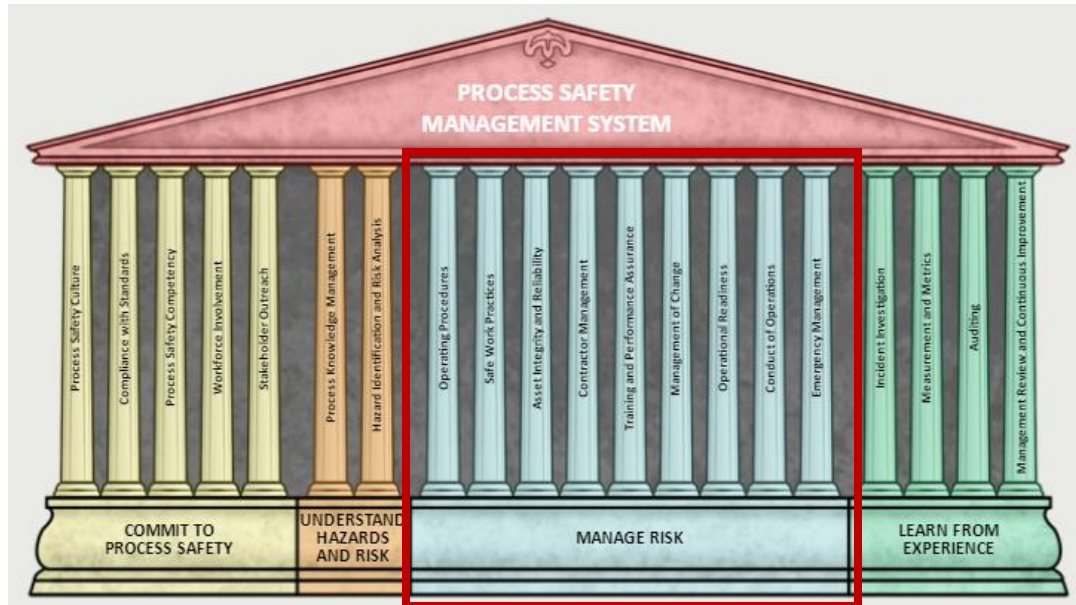
Preliminar Risk Analysis

		APR		Associated MOC:					
Unit:		Title:		Analysis Leader:					
System:		Reference Drawings:		Date:					
Subsystem:		Node:							
Hazardous Event	Causes	Possible effects	Detection (D) / Safeguards (S)	R	Freq.	Severity Category SP P E I T	Risk Category SP P E I T	Observation / Recommendation	N°
Large Release of Toxic Gases	Reactor Temperature Control Failure	Toxic Gas Cloud with Multiple Fatalities	Failure in reactor water flow control (FV) Failure in reactor cooling control Operational failure to temperature alarm (TAH) Failure in cooling outlet valve (improper closure) Toxic gas detection system		B	V V N I	HT HT HT M		

Hazard and Operability Study

		HAZOP		Associated MOC:				
Unit:		Title:		Analysis Leader:				
System:		Reference Drawing:		Date:				
Subsystem:		Node (session):						
Deviation	Causes	Consequences	Detection (D) / Safeguards (S)	R	Freq.	Severity Category SP P E I T	Risk Category SP P E I T	Observation / Recommendation
Temperature high	Loss of control in water flow for the reaction (Failure in the FV) or Opening of the FV due to temperature control failure (TC)	Loss of reaction control resulting in increased pressure, rupture disk opening, and formation of a toxic gas cloud with consequent fatalities	(S) Toxic Gas Detection System (S) Water Flow Control (FV) (S) Operational Response to Alarm (TAH) (D) Toxic Gas Detector		S B	V V N I	V V N I	

Manage Risk



- Inspection
- Maintenance
- Operation
- Process
- Automation
- Emergency response

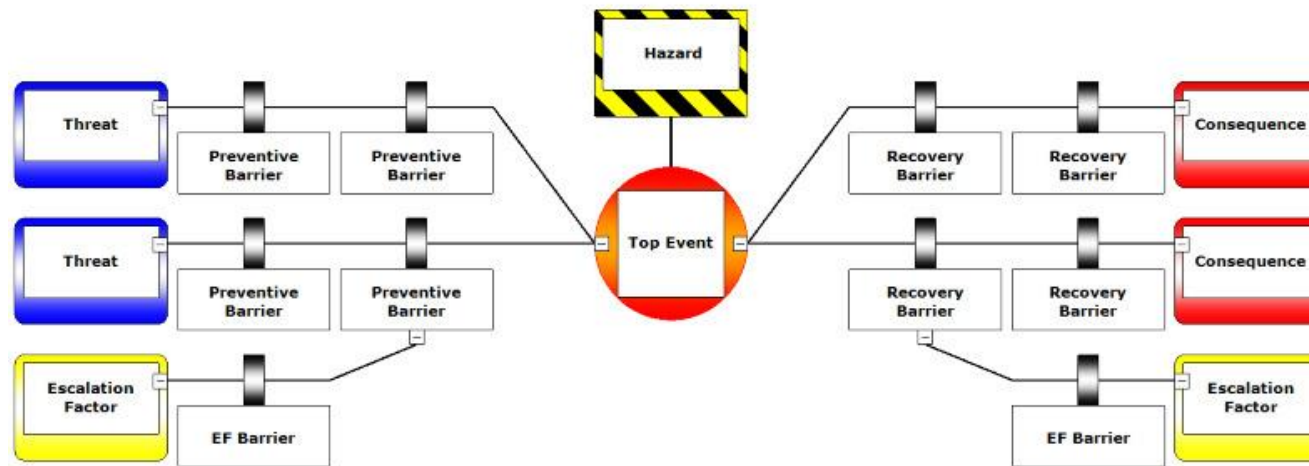
KPIs



Bowtie

Visual tool for assessing and managing the risks, causes, and controls of potential major accidents. It is capable of showing all the barriers and deployed degradation controls.

CCPS AiChe – Bow Ties in Risk Management, 2018 A Concept Book for Process Safety



Hazard and Operability Study

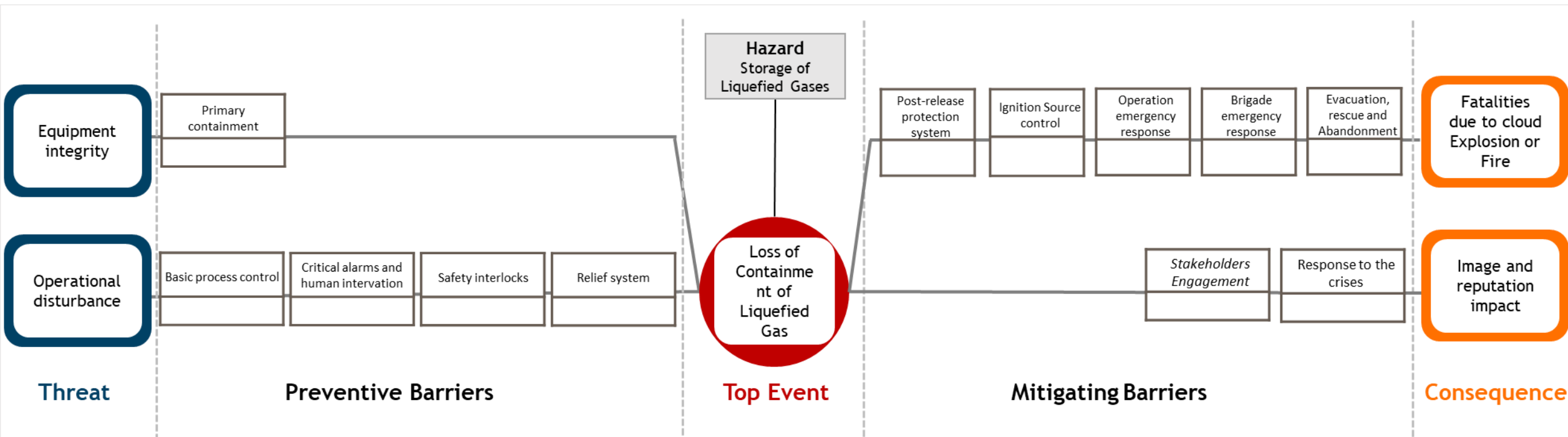
PETROBRAS		HAZOP	Associated MOC:					
Unit:	TEU	Analysis Leader:	Date:					
System:	Reference Drawing:							
Subsystem:								
Node (position):								
Deviation	Causes	Consequences	Detection (D) / Safeguards (S)	R	Pre	Severity	Risk Category	Observation / Recommendation
Temperature high	Loss of control in water flow for the reaction (F valve in the FV) or Opening of the FV due to temperature control failure (TC)	Loss of reaction control resulting in increased pressure, rupture risk opening, and formation of a toxic gas cloud with consequent fatalities.	(S) Toxic Gas Detection System (S) Water Flow Control (FV) (S) Operational Response to Alarm (OAS) (S) Toxic Gas Detector	5	0	High	High	Observation / Recommendation

Preliminary Risk Analysis

PETROBRAS		APR	Associated MOC:						
Unit:	TEU	Analysis Leader:	Date:						
System:	Reference Drawings:								
Subsystem:									
Node:									
Hazardous Event	Causes	Possible effects	Detection (D) / Safeguards (S)	R	Pre	Severity	Risk Category	Observation / Recommendation	N°
Large Release of Toxic Gases	Reactor Temperature Control Failure	Toxic Gas Cloud with Multiple Fatalities	Failure in reactor water flow control (FV) Failure in reactor cooling control Operational failure to temperature alarm (OAS) Failure in cooling outlet valve (impinger closure) Toxic gas detection system	5	0	High	High	Observation / Recommendation	

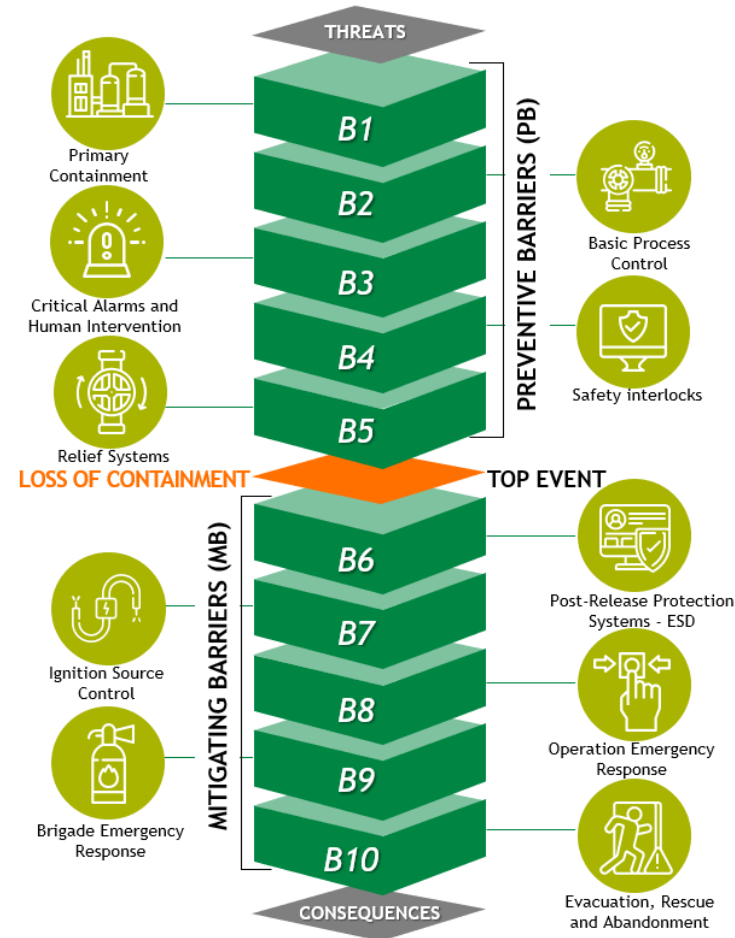
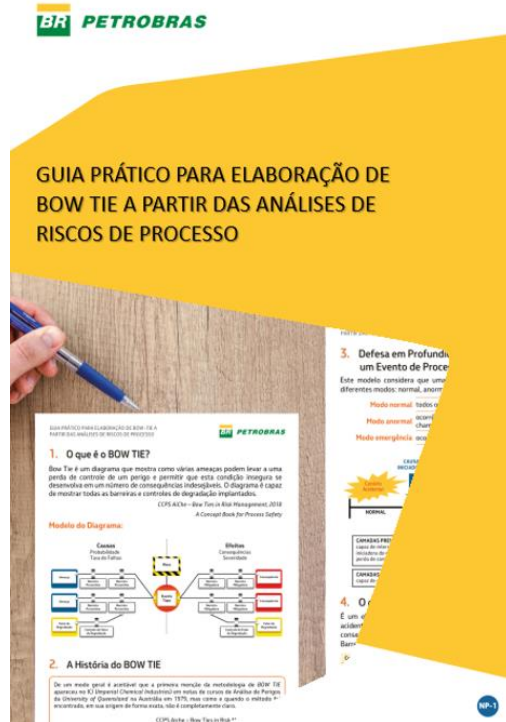
Dynamic Process Safety Barriers Management at Petrobras

Bowtie



Dynamic Process Safety Barriers Management at Petrobras

Bowtie

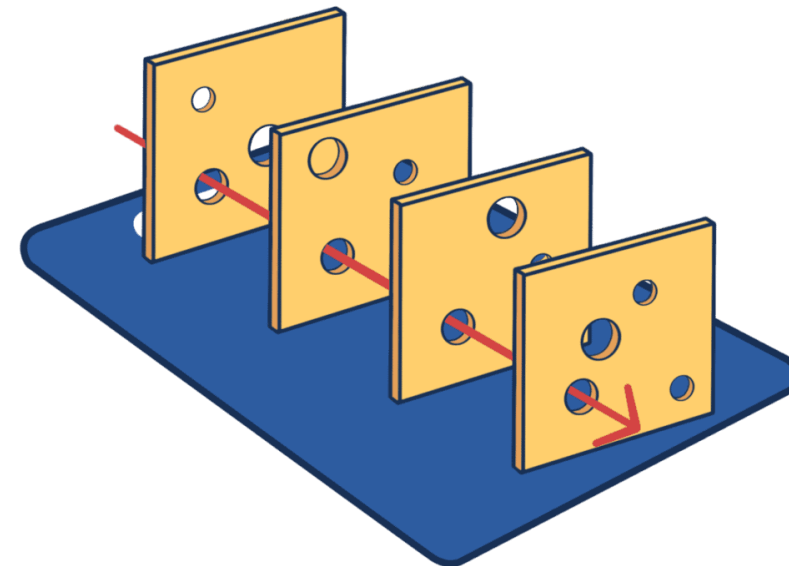


Dynamic Process Safety Barriers Management at Petrobras

Dynamic

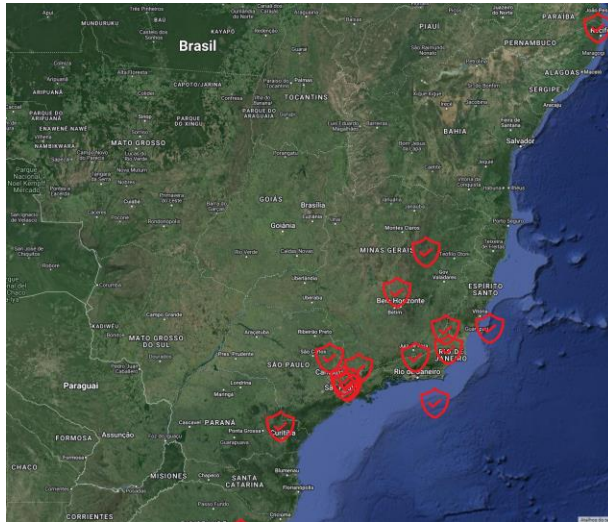
	Level 1	Level 2	Level 3	Level 4	Level 5
1	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Take immediate action	Take immediate action	Take immediate action
0.1	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Take immediate action	Take immediate action
0.01	No further action required	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Evaluate risk reduction alternatives	Take immediate action
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0.00001	No further action required	No further action required	No further action required	No further action required	No further action required
0.000001	No further action required	No further action required	No further action required	No further action required	No further action required

Increasing Frequency (in company-determined units) Increasing Severity (in company-determined scale)



Dynamic Process Safety Barriers Management at Petrobras

RiskPoynt



Regional Level Display Containing All Sites

UK English | 11/12/2021

- Brazil EP
- Brazil GE
- Brazil Refinery

	FPSO P-74	FPSO P-75	FPSO P-76	FPSO P-77	FPSO P-78
Initial	Mitigated	Mitigated	Mitigated	Mitigated	Mitigated
Primary containment					
Process Basic Control					
Critical Alarms and Human Intervention					
Safety Interlocks					
Relief Systems					
Protection Systems (after release)					

A1 - SOBRESSO	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
				A2 - BARRA ESPERADA	B1 - Contenção Primária
		A3 - PERDA DE CONTINGÊNCIA NA COMPRESSÃO DO FLUXO DE SOLAÇÃO PURIFICAÇÃO E COMPRESSÃO AQUECIMENTO	B1 - Contenção Primária	B3 - Alarmas Críticos e Intervenção Humana	B5 - Estímulos de alívio
		A4 - PERDA DE CONTINGÊNCIA NA FROTA DE SUPORTE ATRÁS DA SÁTIMA DE SECAGEM	B1 - Contenção Primária	B3 - Alarmas Críticos e Intervenção Humana	B5 - Estímulos de alívio
A5 - PRESSÃO MAIOR DEVIDO A TUBULAÇÃO 12001 EM 001 FC 1201 RECHAMADO A 01-12018	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A6 - PRESSÃO MAIOR DEVIDO AO RECHAMAMENTO INDEVIDO DA 01-12008	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A7 - NÍVEL MAIOR DO 0-1206 DEVIDO A FALHA NA 1-1208 OU 2-1208	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A8 - NÍVEL MAIOR DO 0-1206 DEVIDO AO RECHAMAMENTO INDEVIDO DA 01-12064	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A9 - NÍVEL MAIOR DO 0-1206 DEVIDO A FALHA NA 1-12084 OU 2-12084	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A10 - NÍVEL MAIOR DO 0-1206 DEVIDO A FALHA NA 1C-12084 E 1051C-12084 OU 1C-12084 OU 1051C-12084 RECHAMADO A 01-12027	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A11 - NÍVEL MAIOR DO 0-1206 DEVIDO A FALHA NA 1C-12027 RECHAMADO A 01-12027	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio
A12 - NÍVEL MAIOR DO 0-1206 DEVIDO AO RECHAMAMENTO INDEVIDO DA 01-12108	B1 - Contenção Primária	B2 - Controle Básico de processo	B3 - Alarmas Críticos e Intervenção Humana	B4 - Instrumentação de Segurança	B5 - Estímulos de alívio



Dynamic Process Safety Barriers Management at Petrobras

RiskPoynt



01 - Loss of Containment in the Gas Treatment System / H2S Removal Unit

- 1 Red Threat Lines
- 0 Amber Threat Lines
- 0 Red Cons Lines
- 3 Amber Cons Lines

02 - Loss of Containment in the Gas Treatment System / Sima 7- Gas Purification Safety K.O. Drum

- 1 Red Threat Lines
- 0 Amber Threat lines
- 1 Red Cons Lines
- 2 Amber Cons Lines

03 - Loss of Containment in the Flare / Sima System 16.1 Flare Gas Release Flammable, toxic and asphyxiating

- 1 Red Threat Lines
- 4 Amber Threat lines
- 0 Red Cons Lines
- 4 Amber Cons Lines

04 - Flammable atmosphere inside the flare tower piping / Sima 16.2 Flare Formation Explosive Atmosphere

BARRIERS	(MAN3) CORRECT. MAINT. 6	(MAN1) PM PAST DUE	(INSP1) INSP COMPLIANCE	(INSP2) INSPECTION RTI A	(INSP3) INSPECTION RTI B OVERDUE	(OP7) OPERATIONAL MODE MANUAL	(OP3) MOC OVERDUE	(OP10) ELASTIC SEARCH	(OP1) APLAT	(OP2) APLAT	(SEG5.3.1) APLAT	(SEG5.1.2) APLAT	(SEG6.2) APLAT	(SEG7.2) APLAT	(SEG5.1.1) SIRH+APLAT	(SEG6.1) SIRH+AP
B1 - Primary containment Systems	3	45	7	0	0	0	0	0	0	0	0	0	0	0	0	0
B2 - Process Basic Control Systems	18	327	3	0	0	13	1	0	0	0	0	0	0	0	0	0
B3 - Critical Alarms and Human Intervention	3	26	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Details

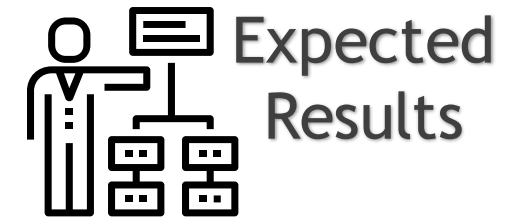
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Source Link	Service note	Work Order Description	Type	Note	Asset Number	Asset Name	Note Service Order Number	Note User S
🔗	000015206466	1 ^o -CNI-B3-2000 - VAZ LINHA ANTIESPUMANTE	CORRECTIVE :	MAINTENANCE	30100F.PSIQ.TUB.01.33	SISTEMA-1261.07	002028889531	INIT TRIA ANEX CONT

Introduction



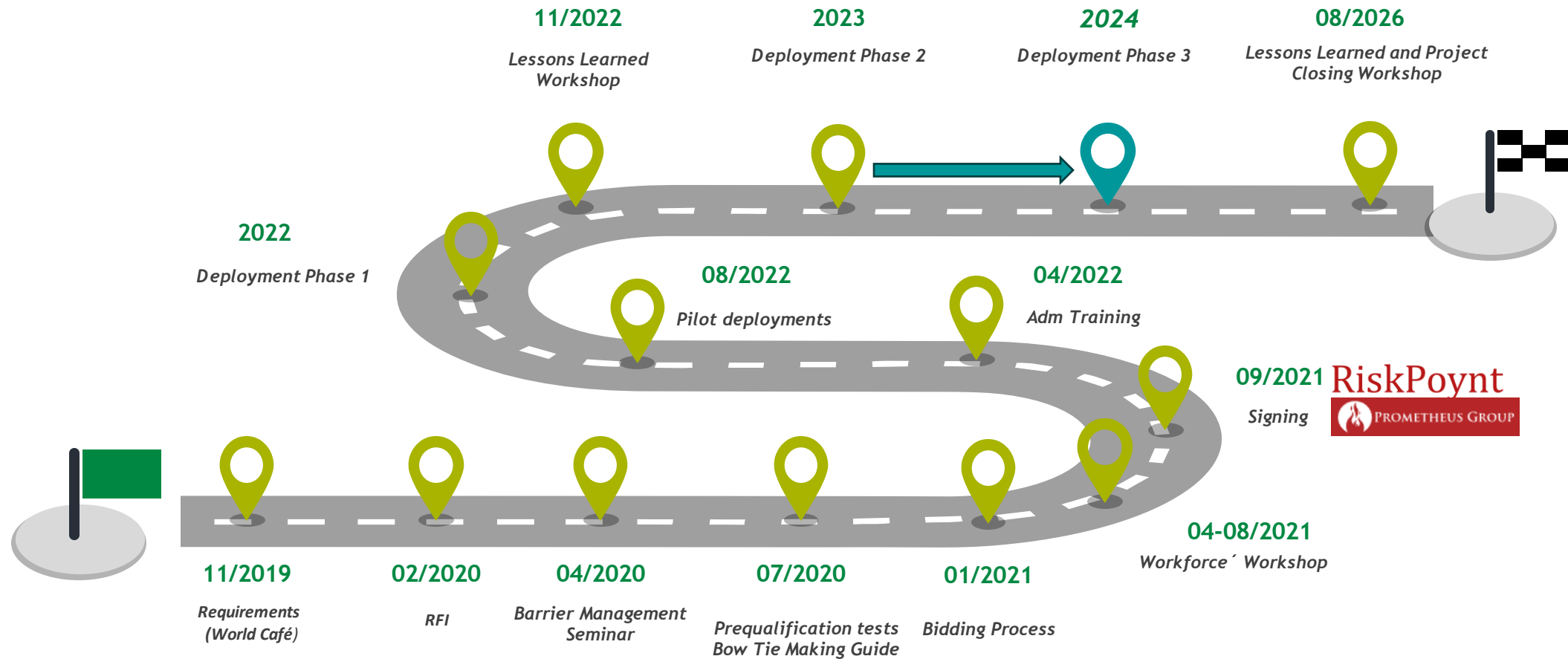
- Dynamic analysis of Process Safety Barrier integrity;
- Preventive identification of threats;
- Discipline integration - Operation, Maintenance, inspection, process and safety;
- Dynamic integrity assessment of Safety critical elements.



- Standard procedure;
- Data automation (quick response);
- Data reliability;
- Common language for risk communication;
- Effective management and control systems.

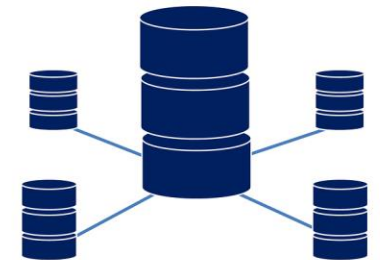
Dynamic Process Safety Barriers Management at Petrobras

Roadmap



Develop Software Communication with Databases

- Established remote connection between Petrobras' cloud and RiskPoynt's cloud;
- Integrate information from 30 different data sources;
- Translate 100 degradation criteria into queries for data acquisition
- 300.000 monitored equipment.



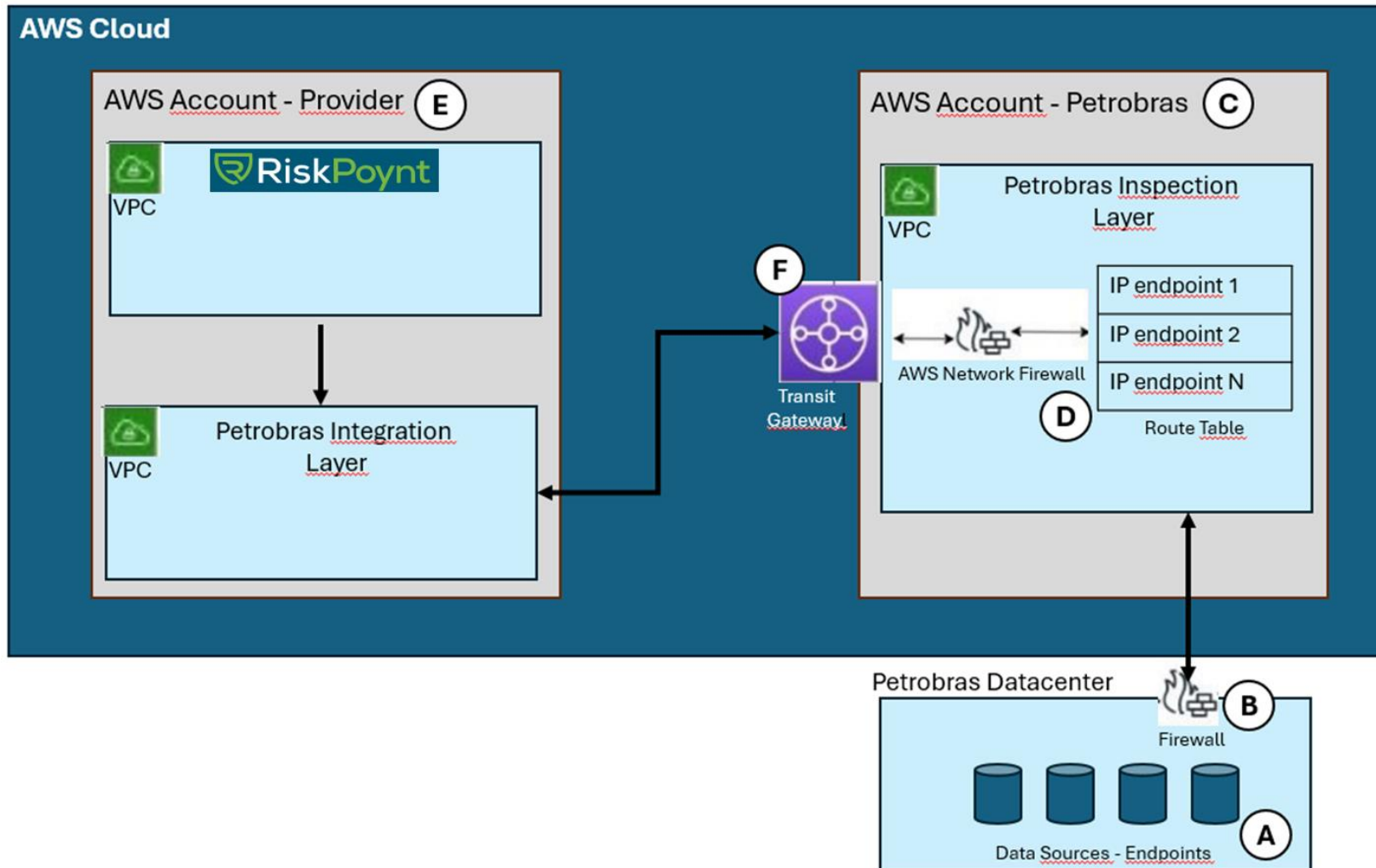
- Maintenance Mgmt. System.
- ERP System.
- Management of Change.
- Alarms Mgmt.

- Audit & Inspection.
- Risk Assessments.
- Permit to work.
- Licenses and compliance System.

- Learning Mgmt. System.
- Incident Mgmt. System.
- Distributed Control System.
- ...

Dynamic Process Safety Barriers Management at Petrobras

Cyber Security: Data Communication



- A - Petrobras Data Sources
- B - Petrobras network firewalls
- C- Petrobras AWS Account
- D - Access granted endpoints table
- E - RP AWS Account
- F - Transit Gateway - AWS security component

Dynamic Process Safety Barriers Management at Petrobras

Integrations big numbers: one day at RP application operation



30 SYSTEMS
CONSULTED



100 TABLES
QUERIED



1,000 COLUMNS
EXTRACTED



30,000
MAINTENANCE
ORDERS/MAINTENANCE
PLANS



100,000 RECORDS
OF MONITORED
ALARMS
INTEGRATION
JOBS



300,000 PIECES
OF EQUIPMENT
MONITORED



DAILY LOAD
PROCESSING OF
1H:30

Take Away



- Improve risk communication and stakeholder engagement;
- Optimizing resources allocation to strengthen controls;
- Adaptation to changing circumstances and evolving risks;
- PSM Critical Analysis across the company;
- Risk-based decision-making tool.

Challenges



Ensure High availability and minimal failures



Keep track of life cycle of data sources integrated to RP

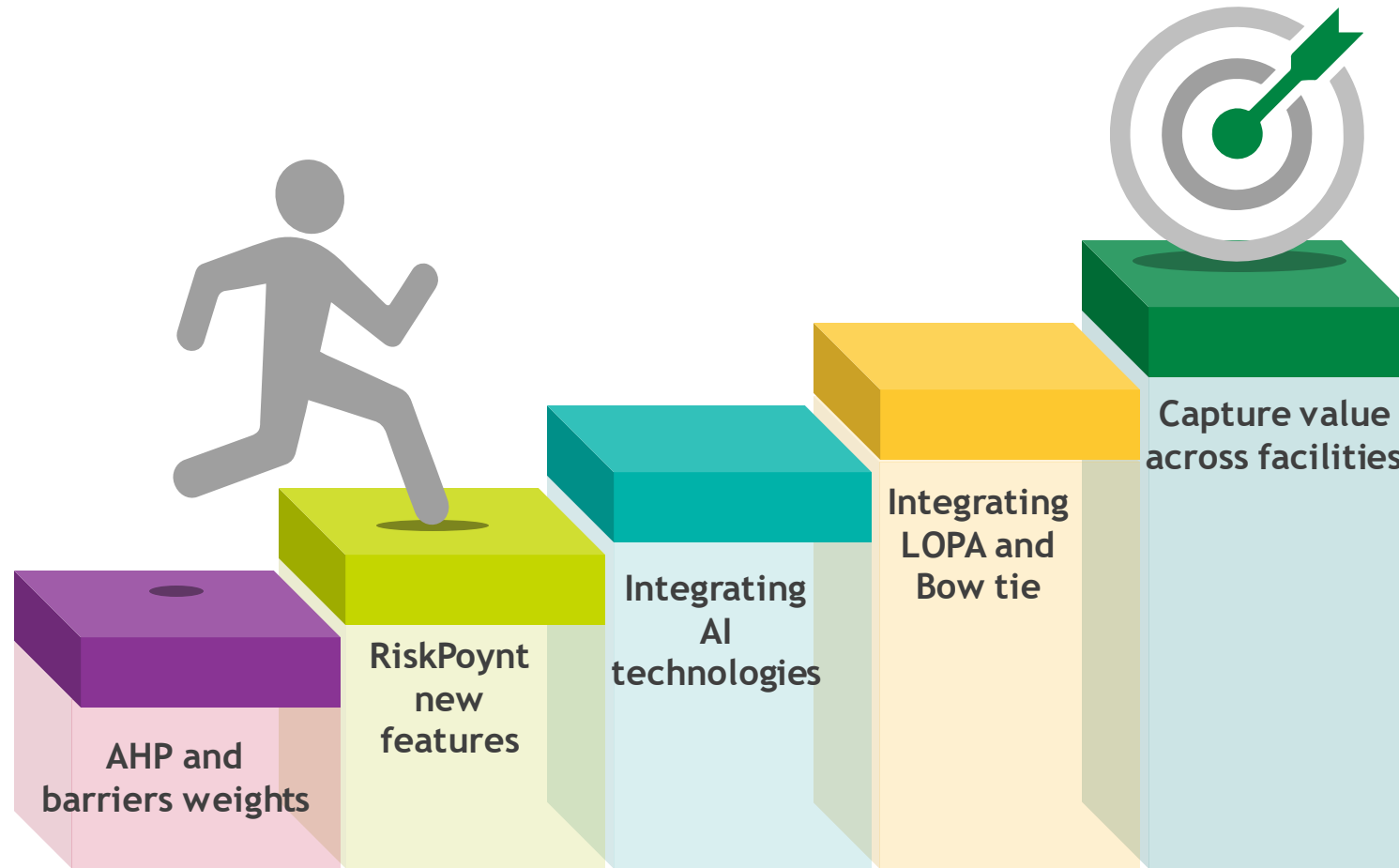


Review degradation criteria meeting business needs



Review and optimize data integration architecture

Way Forward



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