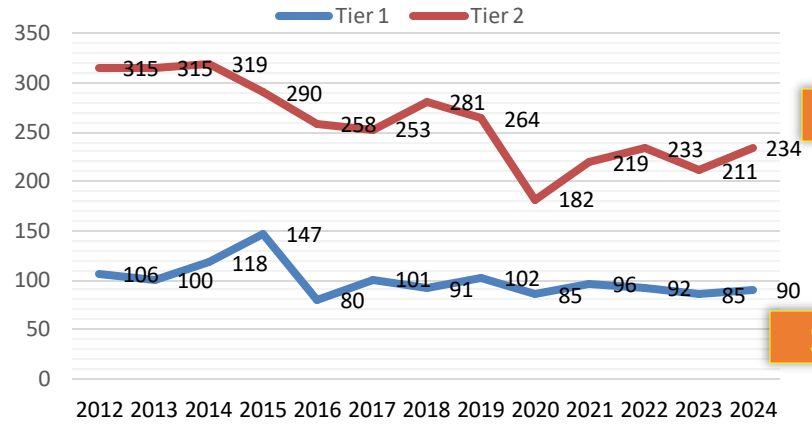
Preserve the CSB & Enhance Process Safety Through a Near-Miss Intelligence Hub

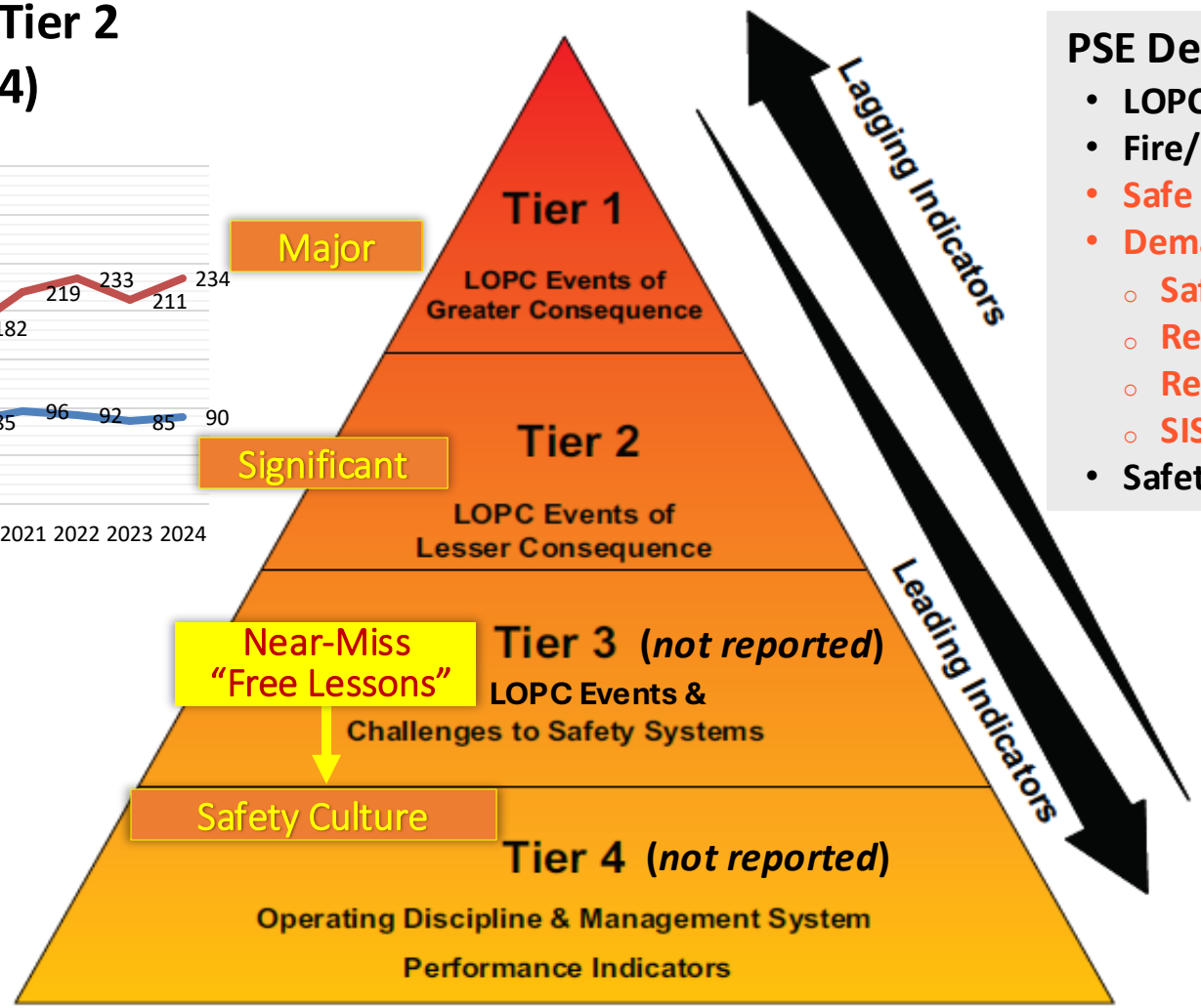
- Michael Marshall, PE (Purdue 1981)
- 40+ years in refining, midstream, petrochemicals
- Live in Indianapolis, IN
- Abstract focus:
  - Preserve CSB's investigative expertise
  - Establish neutral PSE Hub for near-miss learning
  - Use "AIM+PSM" in an AI-enabled PSE triage engine

API RP 754: Process Safety Event KPI Framework

Trend of Tier 1 and Tier 2 PSEs (2012–2024)



"Process Safety Performance Indicators for the Refining and Petrochemical Industries"



PSE Definition (Severity by Tier 1→ 4)

- **LOPC = Spill/Release** (by Threshold Quantity)
- **Fire/Explosion + Repair Cost + Injury/Fatality**
- **Safe operating limits exceeded**
- **Demands on Safety Systems**
  - **Safety system fails to activate**
  - **Relief to atmosphere**
  - **Relief to flare**
  - **SIS/ESD initiated**

  Near-Miss "Free Lessons"
- **Safety culture deficiencies**

Issued for refineries and petchem in 2010 with midstream and upstream added in 2016

- **101 refineries, 34 companies**
- **118 chemicals, 25 companies**
- **Many hundreds internationally**
- **Non-participating companies are out-of-conformance with RAGAGEP**

American Petroleum Institute

Why This Talk, Why Now

- API RP 754 Tier 1 & 2 PSE rates have plateaued since ~2015
- 2026 federal budget puts Chemical Safety Board (1998) future at risk
- Risk of losing investigative know-how and lessons-learned sharing
- AI/ML and LLM/NLP are now mature enough to automate PSE processes

Untapped Near-Miss Intelligence

Tier 3 near-miss events often outnumber Tier 1&2 by ≈ fifty to one…plants are overwhelmed

Tier 3 data stay inside the fence line → not publicly reported (but should be)

Near-miss data are “free lessons” for driving systemic improvements & uptime ($LPO → ROI)

Synergies of an asset integrity + PSM AI-enabled triage, decision support engine → “AIPSM” Model

No real commercial software → no OOTB SSOT VTC → still managed with spreadsheets

From Investigations to Predictive Analytics & Prevention

Now: CSB focuses on major incident deep dives, one incident at a time; redundant w/ OSHA/EPA + limited output

Future: Consolidate and AI-analyze tens of thousands of industry near-misses for sharing of systemic lessons-learned

Dual imperative

Preserve CSB's methods, taxonomies, and databank	Transform into predictive, AI-enabled triage/support engine

Vision: PSE Intelligence Hub & Process Safety Collaborative

Industry-wide, anonymized PSE Near-Miss Hub with RCFA Triage & Decision Support

Initially under CSB guidance, then a 501(c)(3) ‘neutral’ Process Safety Collaborative (PSC)

Powered by AI/ML + LLM/NLP to:

- Classify events consistently
- Detect precursors and systemic patterns
- Generate prioritized, actionable recommendations
- AI-engine designed, tested, managed, and continuously improved by academia (P2SAC??)

Data Rich & Insights Poor: Can AI help?

- Complex sites can experience hundreds of Tier 3 near-misses per year
- Humans can't process everything -- AI can:
  - Parse incident narratives (5W2H), RCFA, MOC, shift logs, equipment histories, and work orders
  - Link recurring, common cause failure modes across units / sites >> systemic analysis
- Suggest likely root-cause patterns and precursor chains
  - Triage with decision-support functionality → causes, contributing factors, remedial actions, and alerts
- Converts Tier 3 records from "filed and forgotten" into live early-warning signals
  - Move beyond the spreadsheet management of API 754 PSE data
  - Automating process will save 1-2 FTE per year

AI-Driven Use Cases for a PSE Intelligence Hub

Machine Learning (ML)

- Predictive Failure Modeling
- Risk Score Calibration
- Anomaly Detection & Benchmarking across Companies
- Time Series Forecasting (APR)

Natural Language Processing (NLP)

- Narrative Event Parsing
- Root Cause Analysis Assistance
- Auto-Triage of Near-Miss Tier 3 “Free Lesson” Findings

Human-in-the-Loop Checks/Learning

- SME Reality Check & Training

Large Language Models (LLM)

- Conversational Dashboard Assistant
- Recommendation Generation
- Policy Interpretation

Knowledge Graphs + AI Reasoning

- Enterprise + Industry Knowledge Graphs → API 754 Framework
- Process Simulations
- Digital Twins

AI-Augmented Reporting & Compliance

- KPI Report Auto-Generation
- Dynamic Audit Readiness

From Raw PSEs to Insight

Ingest & Normalize

- API 754 Tier 1– 4 with focus on near-miss events
- EHS/PSM, CMMS, AIM, SCE tests, MOC, PI/DCS tags, relief system data
- Mapped into a **common schema** with configurable RAGAGEP features

Clean, Standardize, & Enrich

- Equip. classes, units, release points, causes, contributing factors, $LPO
- Text preprocessing (acronyms, abbreviations, spelling, domain terms)
- 5W2H / hi order features, RAGAGEP like Heinz Bloch 7 cause categories

AI/LLM/NLP & ML Rules

- Multi-label classification, i.e., one event can be tagged with multiple truths
- Ad hoc queries “show me events like this” clustering, trend detection
- Triage scoring and predictive risk prioritization / drift detection

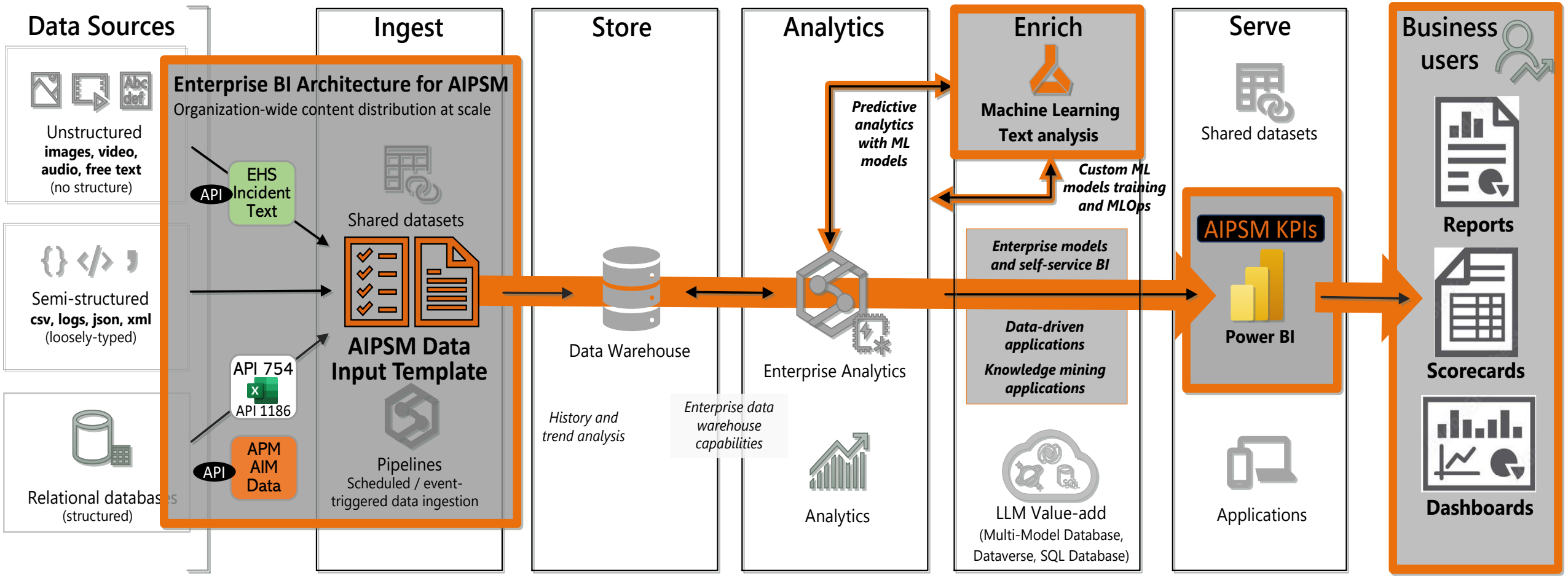
Risk & Economics Layer

- **Risk Intensity** and **Asset Health Indices** (a la Solomon Associates EDC)
- Mechanical availability, **lost-margin / lost-capacity** calcs for **ROI** ($LPO)

Outputs

- Prioritized CI themes, RCFA bad actors, “top 10 systemic issues” lists
- Feeds the PSE Hub and any PSM effectiveness / maturity model

AIPSM = AIM+PSM >> Expanding the data template



Implementation Path, AIPSM & Call to Action

AIPSM solution: Site-level implementation of approach

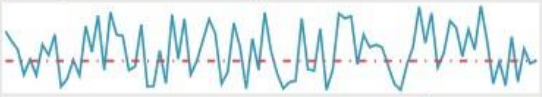
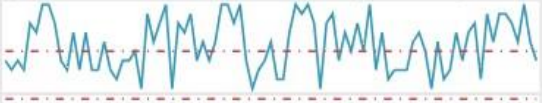
- Asset Integrity + Process Safety KPI dashboards and scorecards (cascade), reports, alerts, and notifications
- Near-miss triage scoring and risk ranking / prioritization
- “Control panel” for day-to-day KPI monitoring

What’s at stake:

- People: avoid preventable fatalities and injuries
- Economics: improve mechanical availability & margins
- Turn CSB’s work into living, evolving knowledge engine

Invitation to P2SAC & community:

- Help shape PSE Hub / PSC concept and architecture
- Sponsors volunteer pilot sites & anonymized data trials
- Partner on research, publications, and advocacy to preserve, modernize, & advance process safety science

BSC Aspect	KPI Name	KPI Status	Value	Target	Delta	Trends
Profitability & Risk (Finance)	Losses Due To Equipment Failures	+157 %	**770.0**	300.0	470.0	
	Maintenance Cost Per BBL	-15 %	**$3.0**	$3.5	-0.5	
	Cost of Breakdown Maintenance	+1 %	**$284.0**	$282.0	2.0	
	Actual Vs Budget Cost	-179 %	**-7.9 %**	10.0 %	-0.2	
Production & Operations (Customer)	Critical Equipment % Availability	-17 %	**80.0 %**	96.0 %	-0.2	
Improvement & Optimization (Internal Processes)	AIM Work Orders in Queue	+5 %	**21.0**	20.0	1.0	
	PSM Work Orders in Queue	-20 %	**4.0**	5.0	-1.0	
	% Preventative Maintenance Compliance	-89 %	**11.0 %**	100.0 %	-0.9	
	% Predictive Maintenance Compliance	-51 %	**42.0 %**	85.0 %	-0.4	
	% Downtime due to PSEs	-40 %	**9.0 %**	15.0 %	-0.1	
	Total PSE Count (5 yr avg)	+3 %	**155.0**	150.0	5.0	

0.06	432	98.50	400	540	1.00	293
Tier 1/2 Rate	LOPC Count	Avg Equip Availab...	Tier 3 Count	Tier 4 Count	% Actions Overdu...	Total Cost ($M)

Reset

Year, Qua...
- 2022
- 2023
- 2024
- 2025

Facility
- Refinery A
- Refinery B

Tier_Base
- Tier 1
- Tier 2
- Tier 3
- Tier 4

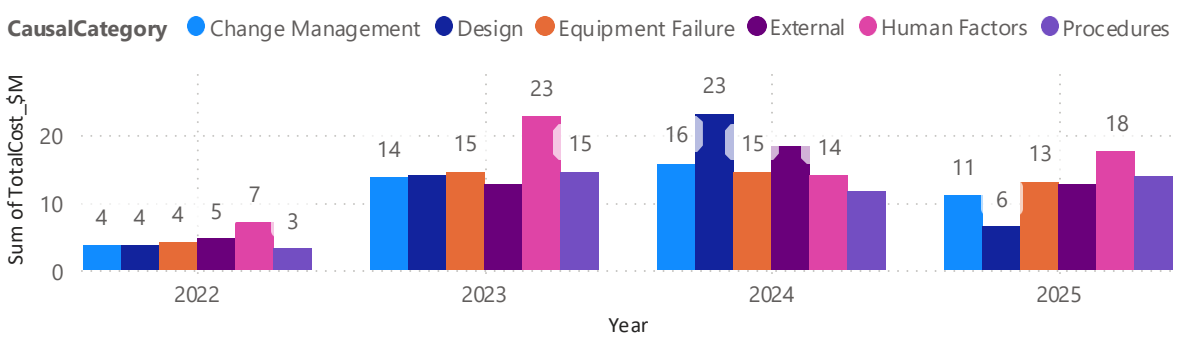
AIPSM_Element
- Equipment Strategy & Integrity
- Operations Discipline
- Reliability & Maintenance
- Safeguard Integrity (SIS/PRD)

ResponsibleDe...
- Engineering
- Inspection
- Maintenance
- Operations

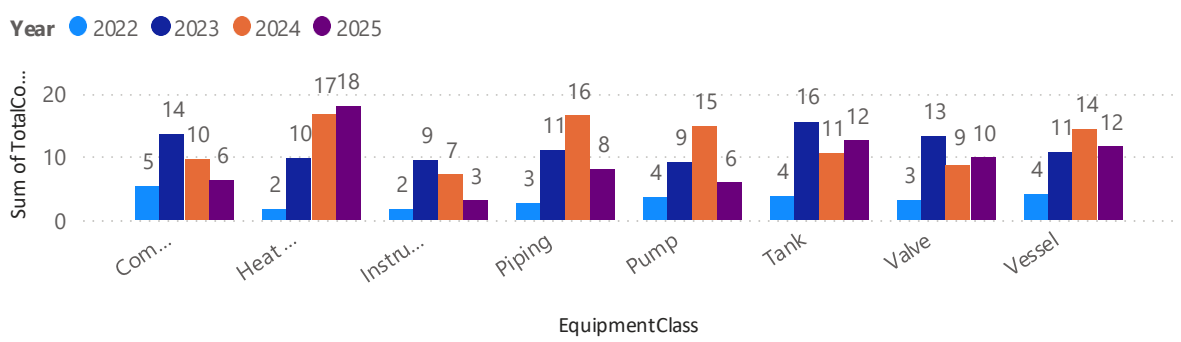
RCFA_Status
- Cancelled
- Closed
- In Progress
- Open

PSE_ID
- PSE-2022-0008
- PSE-2022-0009
- PSE-2022-0032
- PSE-2022-0047

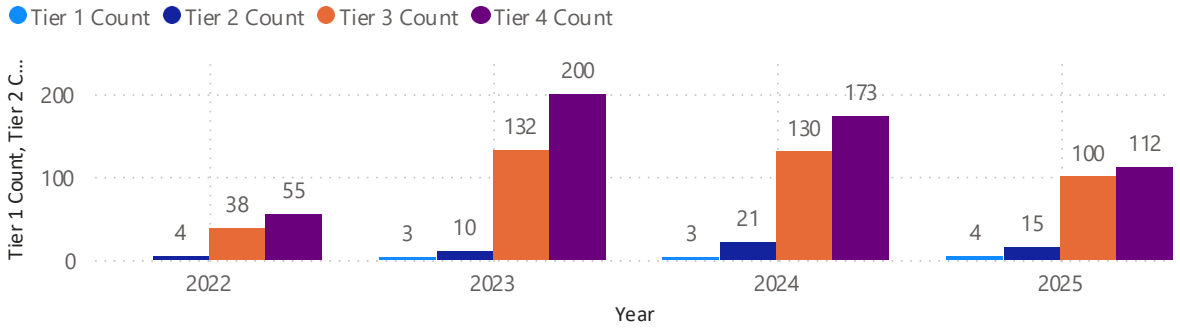
Sum of TotalCost_$M by Year and CausalCategory



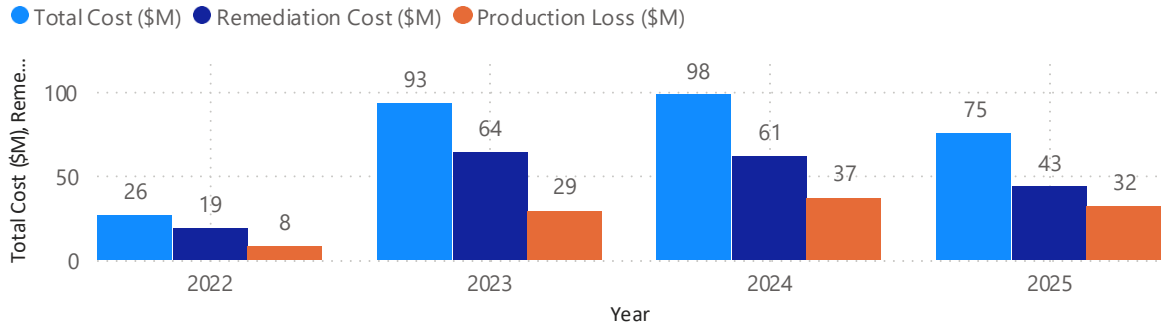
Sum of TotalCost_$M by EquipmentClass and Year



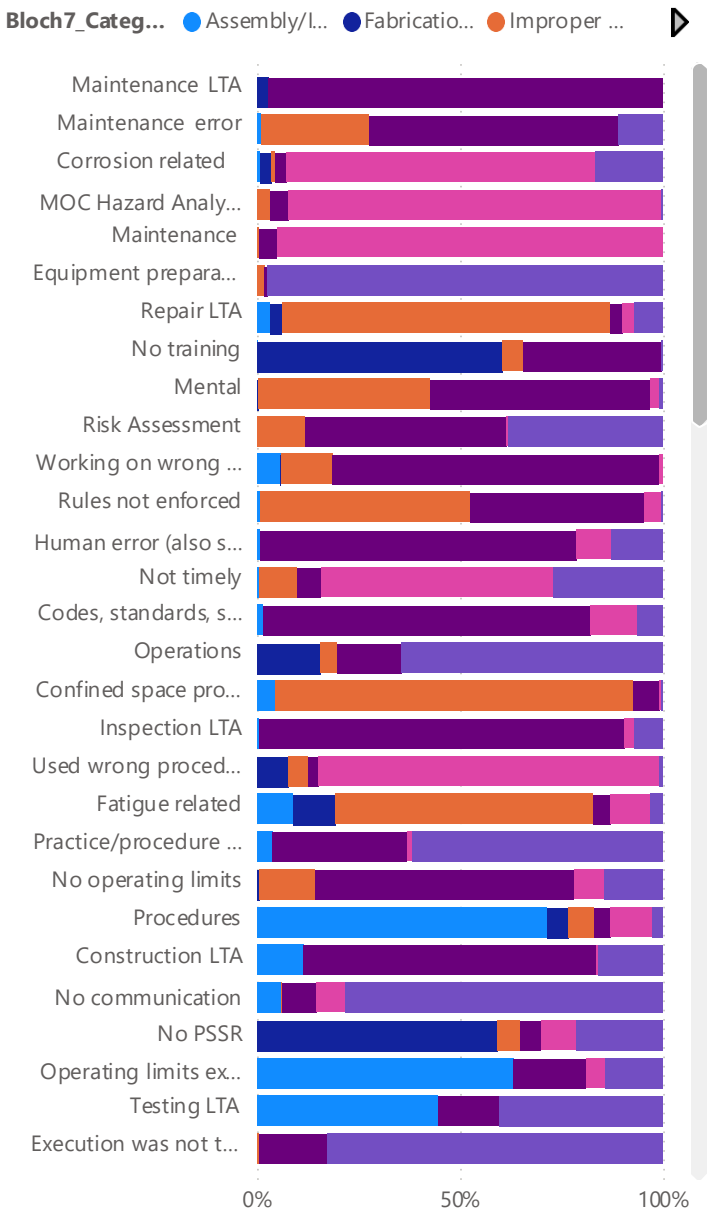
Tier 1 Count, Tier 2 Count, Tier 3 Count and Tier 4 Count by Year



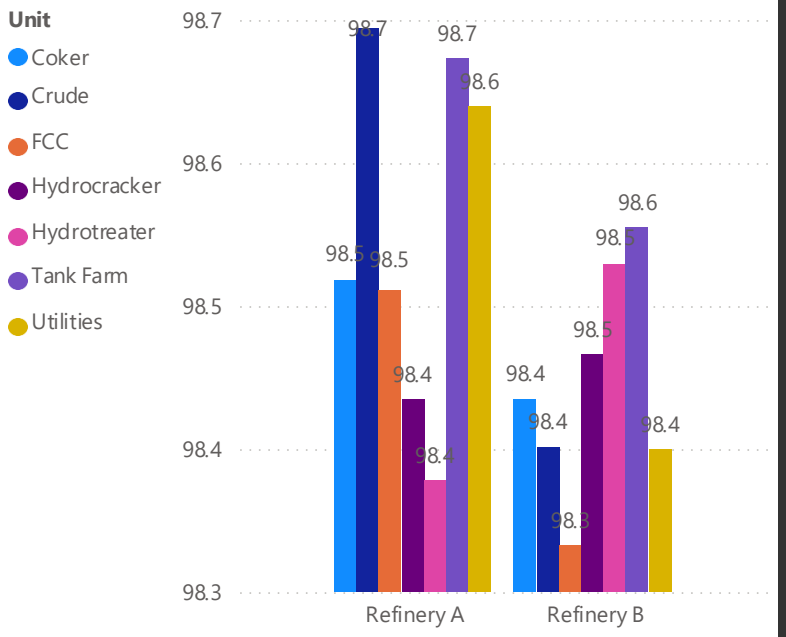
Total Cost ($M), Remediation Cost ($M) and Production Loss ($M) by Year



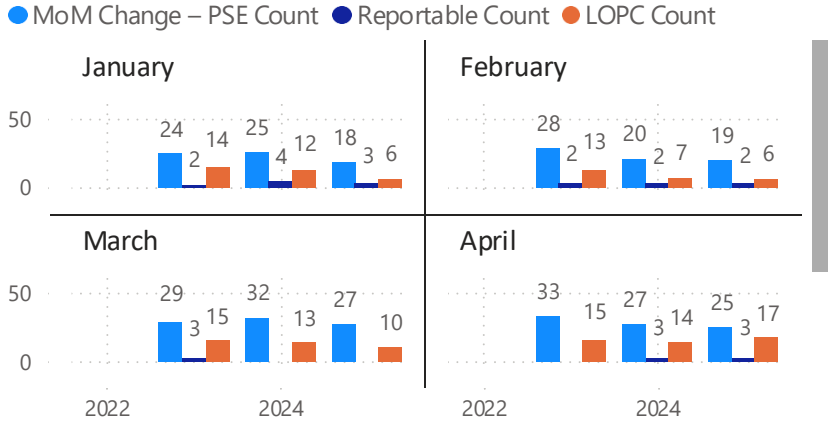
Sum of LostCapacity_$M by CausalFactor and Bloch7_Category



Avg Equip Availability % by Facility and Unit

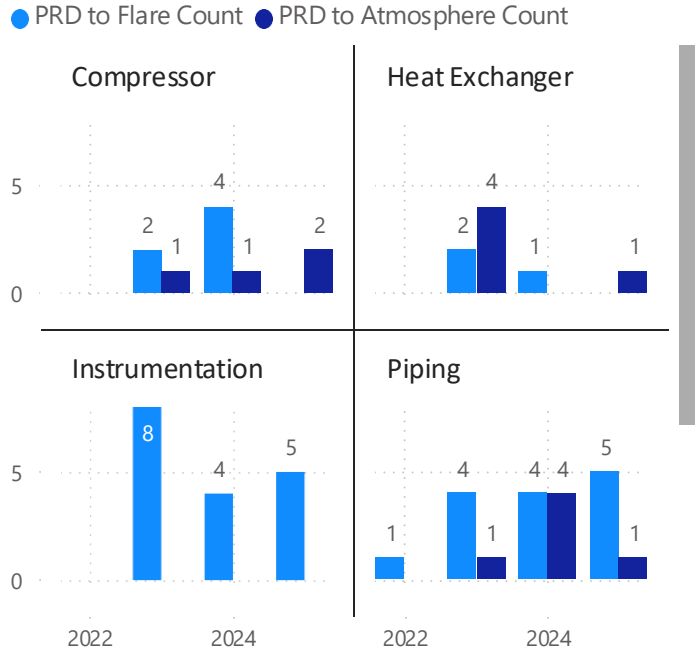


MoM Change – PSE Count, Reportable Count and LOPC Count by Year and Month



Reset

PRD to Flare Count and PRD to Atmosphere Count by Year and EquipmentClass



Month	PSE Count	P90 Severity	PRD to Atmosphere Count	PRD Lift Count
May	94	57.00	1	5
October	78	57.60	1	4
March	88	59.00	4	8
August	86	59.00	5	9
July	79	60.60	2	7
December	83	60.80	3	9
November	109	61.20	1	5
June	82	61.90	4	9
September	82	62.00	2	5
February	67	62.40	2	5
April	85	65.60	3	5
January	67	82.40	1	3
Total	**1000**	**62.00**	**29**	**74**

Role for P2SAC & Sponsors

Co-develop and validate AI/ML & NLP models for PSE analytics with actual PSE datasets

Act as a neutral host and custodian for industry, labor, regulators, vendors

Provide continuous improvement platform to:

- Refine data standards and taxonomies
- Run pilots and publish peer-reviewed results
- Train data-centric process safety professionals

PSE Intelligence Hub Features

AIPSM AI-Enabled Triage Engine

Prototype built in Excel / Power BI

- Predictive analytics specific to asset integrity and PSM *with ROI*
- RAGAGEP KPIs, dashboards, cascading scorecards, queries, reports, and alerts
- Normalizing PSE data by performance and process parameters -- not just manhours
- Failure modes and process safety decision support functionality at scale
- Categorizing, prioritizing, and risk ranking by economic loss $LPO
- AI LLM predictive modeling with PSE RCFA triaging, decision support, and reporting

Michael Marshall, PE is an oil & gas consultant with 40+ years' downstream, midstream, and petrochemical experience at Chevron, Marathon Petroleum, and as an independent SME. He conceptualized and field-tested the AIPSM approach—an API 754 and asset integrity–aligned KPI framework—now ready for software vendor partners to develop.

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AI-PSM