AI for Process Optimization, Reliability and Safety

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- Executive VP, Process Safety & Strategic Client Partnerships
- Professional ChE, AIChE Fellow
- AIChE CCPS Technical Steering Committee Member, S&H Division Member
- Texas A&M Mary Kay O'Connor Process Safety Center: Steering Team Member, Harry West Memorial Service Award Recipient (2008 and 2015), Trevor Kletz Merit Award (2019)
- International Society of Automation Excellence in Leadership Award (2016)
- AIChE S&H Division: Walton-Miller Lifetime Achievement Award (2020)
- Process Safety Consultant, Corporate Strategist, Leadership Training and Mentoring, Global and Site Management System Consultant, Lead Auditor, Incident Investigator, PHA/LOPA Facilitator
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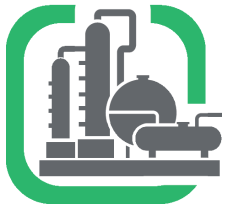
- Masters in Computer Engineering from GeorgiaTech
- Led product development in Web, IoT and Embedded Systems at National Instruments, Microsoft and Larsen & Toubro
- Highly interested human-centered design of technology
- STEM education for children and young adults with FIRST, Hyperloop and GirlScouts
- Early-stage startup investor and entrepreneur

Presentation Outline

- AI Vision for Process Safety
- AI and the Subject Matter Expert
- Maximizing Production & Improving Safety
- Proactive Health, Safety and Environment (HSE) Management
- Applying AI in your own Organization
- Open Discussion

What is your AI Vision for Process Safety



Advanced Automation
Safe Process Optimization
Intelligent MOC

Smart Operating Procedures
Human Performance Factors
Training Simulation & Feedback
Operating Discipline

IPL Demand/Cause
Tracking/ML
Preemptive Loss of Control
Predictive Maintenance

Incident Investigation
Lesson Learning
Emergency Response,
Evacuation and Rescue

Safe Work Locations
Bypass Management

Process Safety Metrics
Predictable Performance

AI and the Subject Matter Expert

In Industrial Environments, AI is augmenting SMEs to unlock higher quality and productivity

How AI Creates Value from Big Industrial Data:

- Operationalizes organizational information and tribal knowledge
- Surfaces patterns and insights in large volumes of data
- Enables SMEs to focus on high value decisions

Maximizing Production & Improving Safety

OIL & GAS UPSTREAM

One supermajor calculated that if they improved platform availability across their fleet by one percent, they could net an annual uplift in production of ~$300M.

PROBLEM

- Complexity in streaming data and managing alerts
- Inefficiencies around manually maintaining model accuracy

RESULTS/ROI

1-4% or ~$30M
Annual Improved Production

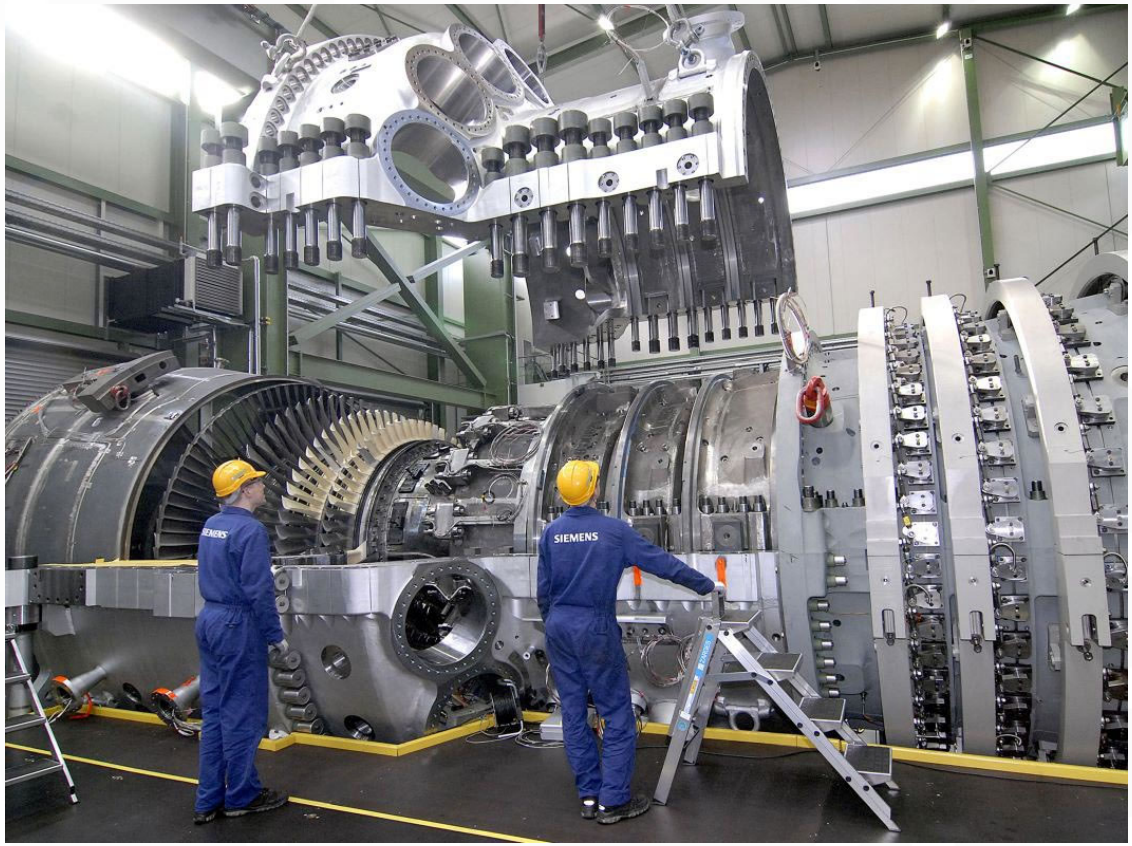
9 days
Failure Forewarning

Once deployed across fleet, the AI-powered solution will contribute a total economic impact of ~$800M annually.

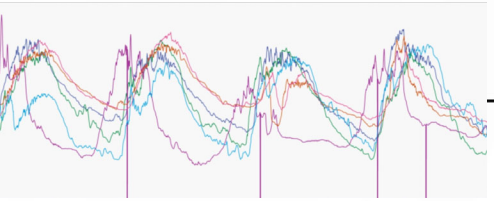
Simple Rules? Not for Complex Assets

Rules based thresholding, even with complex combinational logic is insufficient to capture system states

- Several 100 -1000s of moving parts in complex interaction
- System state drifts with operation, condition and environment
- Very few failures to learn from
- 500 - 3000 sensors/tags per asset
- 40-60 complex assets per production platform
- False positives are expensive to address for unmanned platforms



Novel Techniques to Analyze Time Series Data



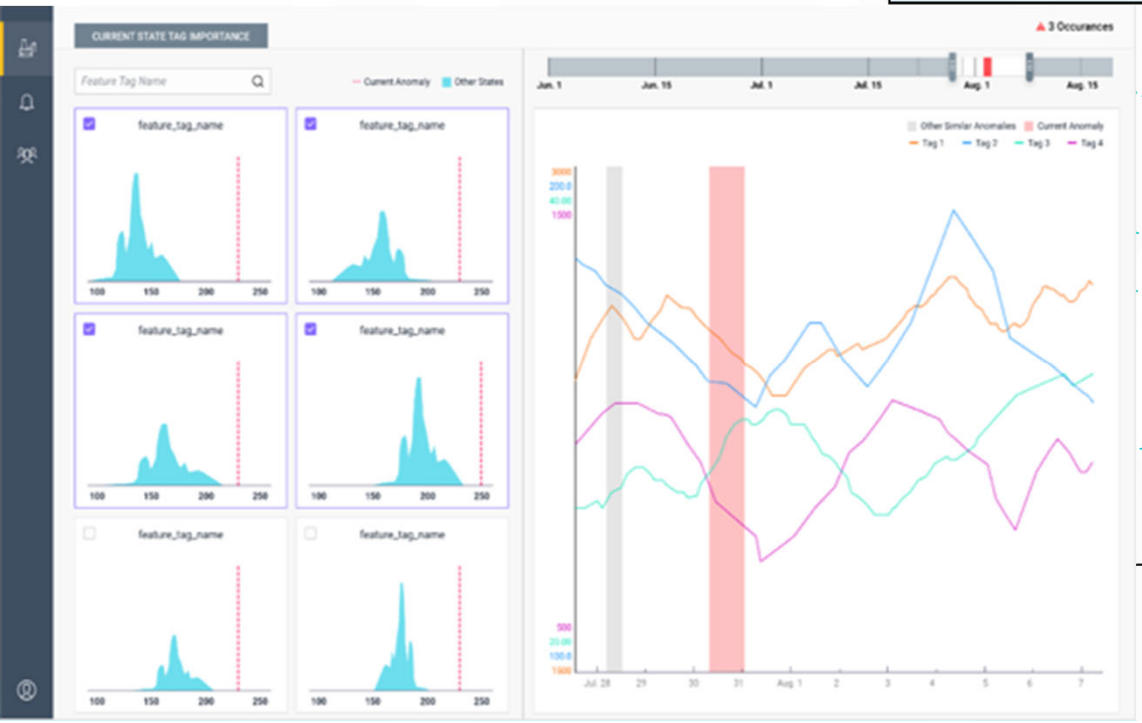
Data Preprocessing
Scaling
Imputation

Data Filtering

System mode filter → Data for mode of interest (e.g. ON/OFF system mode) → **Normal filter** → Normal data

Test Data

Training Data



Models

- NBM Model
- Clustering Model

→ Model Validation on **Test Data**

→ Tune Hyper-parameters

→ Run new model

KS2
KS3

Prescribing Optimal Maintenance for Aircraft Faults

INDUSTRIAL CONGLOMERATE

For commercial airlines, a one- or two-hour AOG delay can **cost between $10K-150K per instance**, not to mention damage to the airline's reputation.

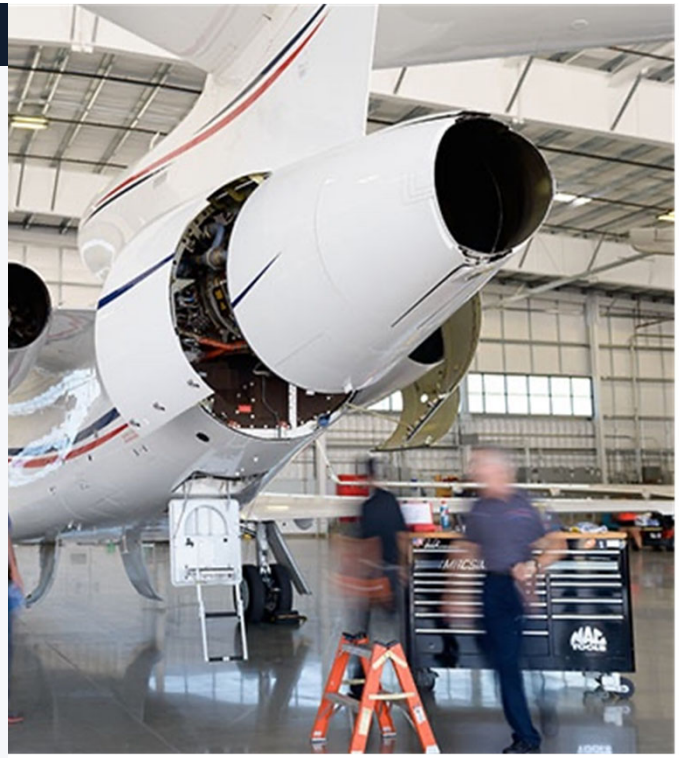
PROBLEM

- Isolating a root cause can take hours
- Extracting value from PDFs and long technical manuals is difficult
- Tribal knowledge is lost as experienced personnel retire or leave

RESULTS

73% (38.6K)
Unnecessary subsystem replacements found

120K (18 yrs.)
Work orders' worth of tribal knowledge captured



The prescriptive recommender reduced root cause analysis effort by 90%, resulting in a 20-min. decrease of aircraft on the ground (AOG) per incident.

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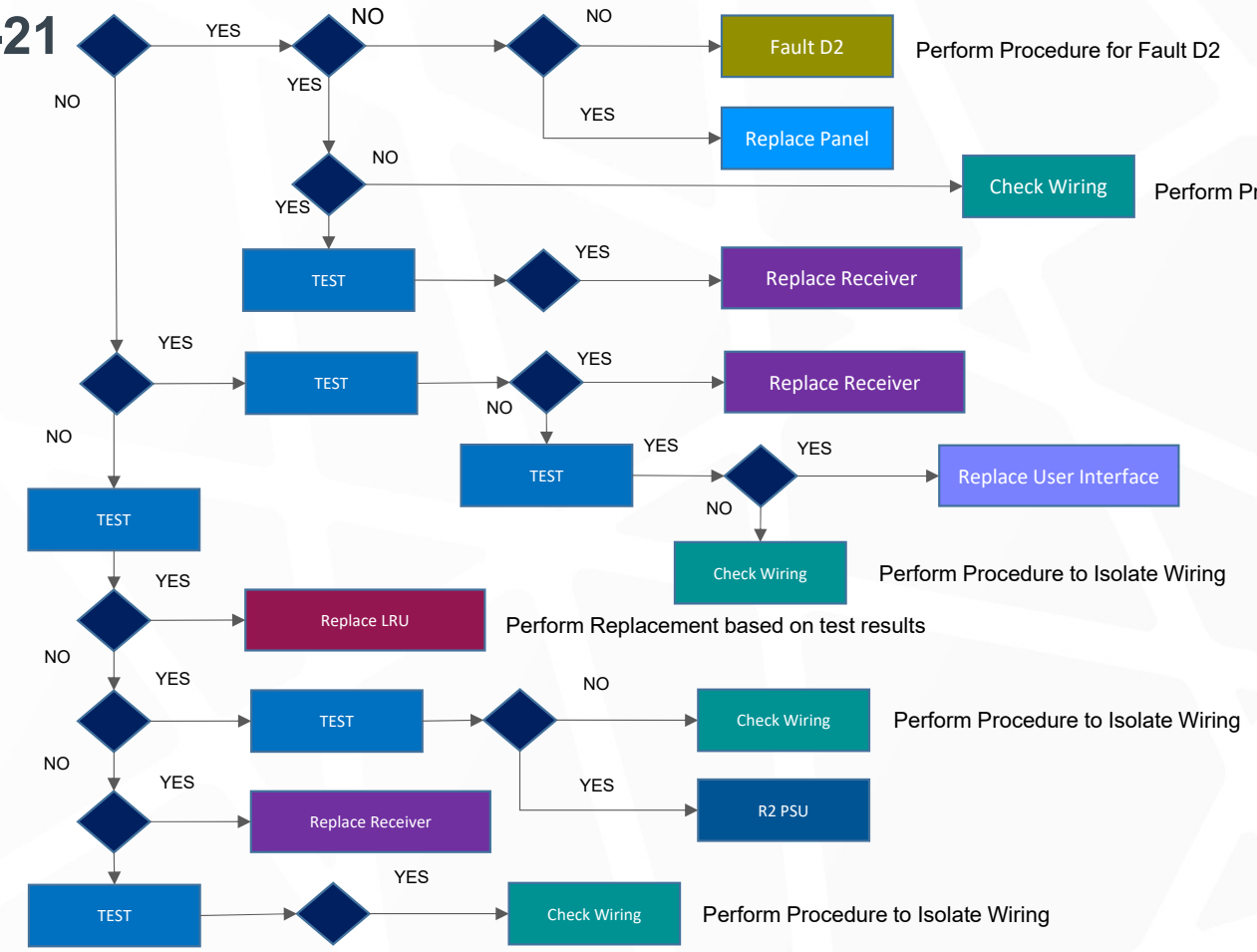
KS2 How did you create the Work Orders worth of tribal knowledge Value?
Kathy Shell, 5/13/2021

KS3 Can we draw a corollary to manufacturing; Possibly. Consider applications across a facility or major unit operation where extracting and digitalizing degradation indicators enables a prioritized maintenance plan for an unplanned or planned outage.
Kathy Shell, 5/13/2021

Troubleshooting can take hours, even for experienced maintainers

Fault 34-21



Extracting Actionable Prescriptions from Maintenance Records

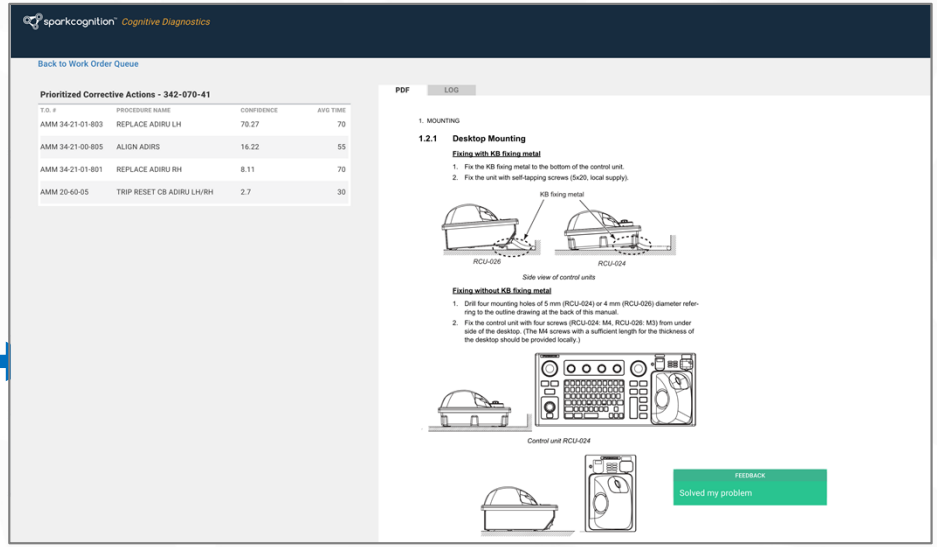
Maintenance records are not “natural language”

IT WAS PERFORMED IR FAILURE IAW FIM 34-21 TASK 803 REV 60, STEP E, ITEM 1 AND WAS PERFORMED ADIRS BITE PROCEDURE IAW FIM 34-21 TASK 801 REV 60, STEP B, ITEM 1-E AND WAS FOUND MAINTENANCE MESSAGE (34-21002 - IR FAILURE) AND (34-21007 - ADR DATA INVLD) AND (34-21020 - ADR FAIL). IT WAS PERFORMED INSPECTION IN ADIRU LH AND FOUND WATER ON ADIRU AND WAS REPLACED ADIRU LH IAW AMM 34-21-01/401 REV 60. IT WAS PERFORMED NEW ADIRS BITE PROCEDURE IAW 34-21 TASK 801 REV 60, AND MAINTENANCE MESSAGE DOES NOT SHOW ON THE CDU, THE STATUS CODE DOES NOT SHOW IN ISDU AND THE FAULT LIGHT ON THE MSU DOES NOT COME ON, AND WAS CORRECTED THE FAULT.

IT WAS FOUND FAULT COD 34-21002 (IR FAILURE) IAW FIM 34-21 TASK 801 REV. 60, PERFORMED FIM 34-21 TASK 803 REV. 60 , REPLACED ADIRU IAW AMM 34-21-01/401 REV. 60 ,SYSTEM OK IAW AMM 34-21-00-710-801 REV. 60.

IT WAS PERFORMED IR FAILURE IAW FIM 34-21 TASK 803 REV 60, STEP E, ITEM 1 AND WAS PERFORMED ADIRS BITE PROCEDURE IAW FIM 34-21 TASK 801 REV 60, STEP B, ITEM 1-E AND WAS FOUND MAINTENANCE MESSAGE (34-21004 - ALIGN FAULT). IT WAS PERFORMED ALIGN FAULT IAW FIM 34-21 TASK 805 REV 60, STEP F, ITEM 1 AND WAS PERFORMED STEPS FROM THE CDU AGAIN TO ENTER THE PRESENT POSITION AND THE STATUS CODE DOES NOT SHOWS ON THE ISDU AND CORRECTED THE FAULT. FLT 5617 ASSUMED BY ACFT PR-GXT.

- Fault Code
- Symptom
- Procedure Reference
- Effectiveness
- Corrective Action



Proactive Health, Safety and Environment (HSE) Management

GAS PROCESSING AT NATIONAL OIL COMPANY

In 2019, 48 O&G companies (and contractors) reported 21,899 days of work lost through injuries

PROBLEM

- Safety function is typically poorly staffed with 1-2 Safety Supervisors per plant
- HSE management is ”retroactive”, learning from historical incidents
- Truly catastrophic incidents are rare; limit learning opportunities

KS4

RESULTS

1.3% High Severity Risks

Correctly identified LOTO as root cause for high severity electrical risk despite minimal examples

2000+ Observations

Automatically evaluated with 75%+ accuracy

The HSE solution enables SMEs to train/fine tune models and automates weeks of manual work in minutes

Slide 13

KS4 What do you want to convey with this. As stated, it really isn't a problem. From our earlier conversations, maybe Incident learning must come from lower Tier events.

Kathy Shell, 5/13/2021

Natural Language Challenges

Operational records are functional and terse with high variability

Functional Language

“received a cwp diagnosis for ee. ee was termed on 1/23/2013.”

Non-standard grammar and vocabulary

“we have chemical store that contain different kind of chemical that we handle it in the area, employee may expose to them at any time, There is no CHB around that location for any craft to know the hazard of that chemicals.”

Terse

“Plug chute alarm”

Spelling/Typographical errors

“Box glass broking.”

“LADDER FOR PZV ON AIR RECEIVER TANK WHIT OUT SAFETY GUARD”

Technical jargon/colloquialisms

“breakers shut without LOTO”

“Several breakers found in OFF position and not locked”

“Breaker in OFF position but it was not locked and tagged out”

Keywords/ontologies and Off-the-shelf language models are ineffective on operational records

Natural Language Analysis of “Observations”

Observations

Safety Violations

Employee Suggestions

Unsafe Conditions

Historical Reports

Root Cause Analysis

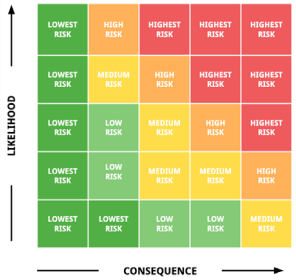
Incident Reports

Near Misses

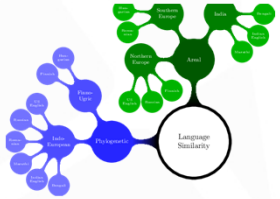
Hazard Type

- Fire
- Explosion
- Falling Heights
- Electrical
- Slips, Trips

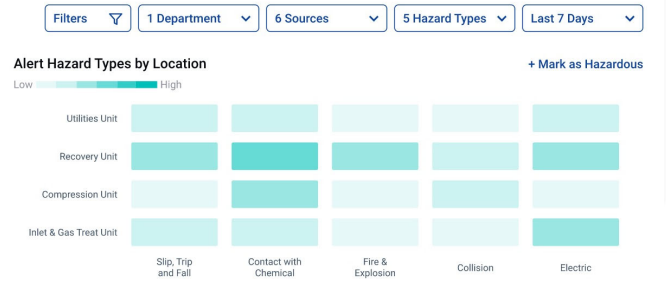
Risk Analysis

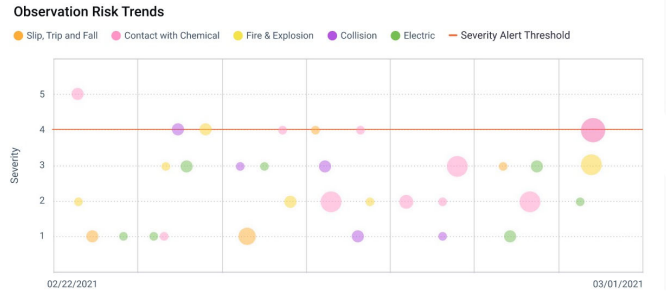


Language Similarity



Time-based Patterns





Getting Started with AI in your Organization

1. Explore un-utilized/underutilized data sources in high cost/tedious/critical processes
2. Consult SMEs to understand current process, gaps, desires
3. Utilize development accelerators from discovery → operationalization – DS is an iterative process

Data Type	Common Source	Application
Time series sensor data for vibration, temperature, strain, pressure, current, voltage etc.	OSI PI	**Predictive Maintenance**
Maintenance records	Maximo, Oracle	**Prescriptive Maintenance**
Safety observations, MOCs, PHA Recs, Incident Records	SAP/Custom/Excel	**HSE Management Incident Anticipation**
Service tickets – disruptions, IT requests, call centers	SAP, EMC2, JIRA, ORACLE	**Operational Analytics, Business Process Automation**

Where does AI fit in your Process Safety and Operational Excellence Vision?

Thank you for your attention!

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