Generative **AI** in PHM applications

Where is the **W**in?

Panel Session #4

13th Annual PHM Society Conference

Moderator: Asma Ali

Panelists: Kai Goebel, Karl M. Reichard, Olympia Brikis, Sarah Lukens, Mark Roboff

Introduction

In this panel discussion, we will explore the potential of **ChatGPT/Generative AI** in **Industrial** use cases.

Our panel of experts will discuss the benefits, challenges and future opportunities

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Panel Guidelines

- This panel is not being recorded.

- Questions within the scope of the panel are encouraged! We have 2 options to submit:
    - Good old fashioned – raise your hand!
    - Whova App

- Please ensure your contributions are professional, thoughtful, and within the scope of the panel.

Moderator Intro | Who am I?

Asma Ali | GE Vernova | Sr Staff Analytics Engineer
Chicago, IL

Experience

Smart Signal, Navistar, General Electric (GE)

Education

MS: University of IL | Mechanical Engineering

BS: University of Connecticut | Biomedical Engineering

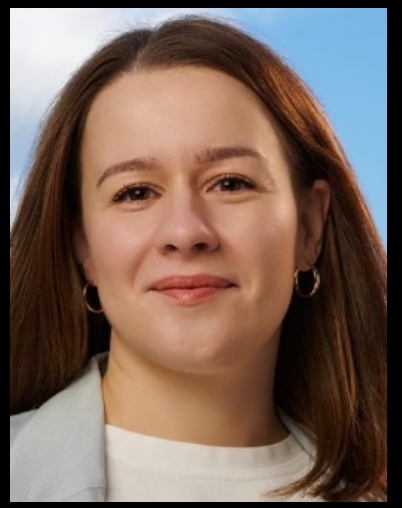
GE VERNOVA

GE Vernova is a global energy company (spin off from GE conglomerate), that aims to accelerate the energy transition to more sustainable, reliable and affordable sources.

Meet Our Panelists!

Sarah Lukens | LMI

Mark Roboff | Sky Thread



Olympia Brikis | Siemens

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Kai Goebel | Intelligent Systems Lab at PARC

Karl M. Reichard | Penn State University

Sarah Lukens

- 9 years industry experience at LMI, GE & Meridium
- Ph.D. in Mathematics in 2010 from Tulane University
- Related research interests:
  - Maintenance & Reliability analytics
  - Technical Language Processing
  - Data quality measurement & improvement frameworks

LMI is:

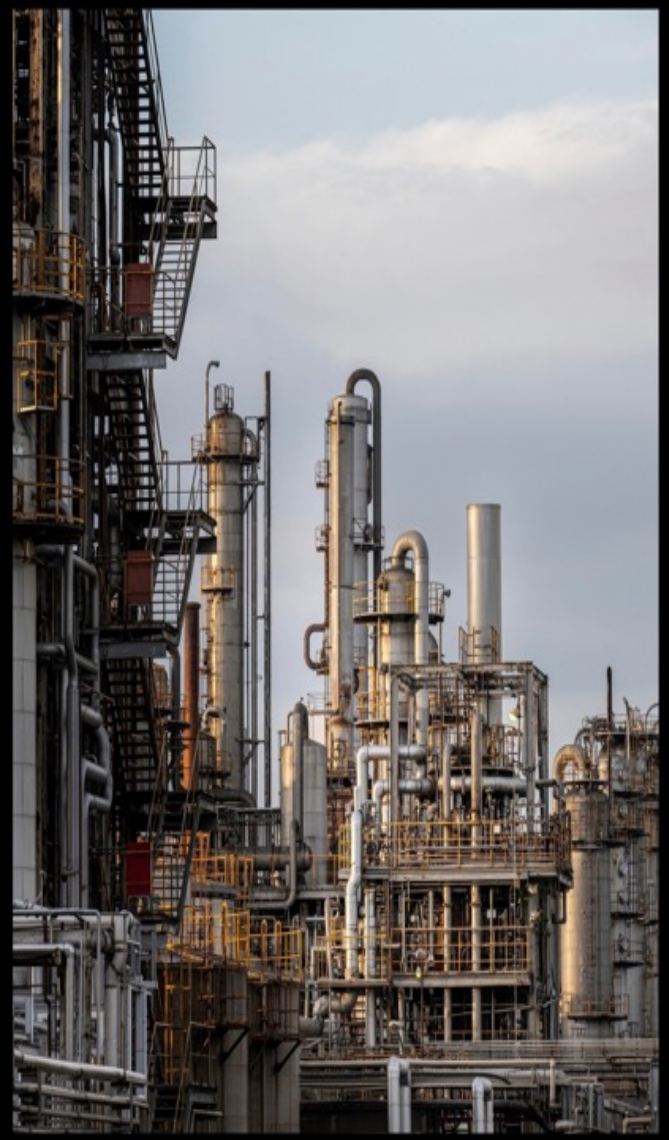
- Business consulting located in Northern Virginia serving **defense**, **federal & civilian health**, **homeland security**, **intelligence** and **space** markets.
- "Innovation at the Pace of Need"

LMI's Instruction-tuned Generative Resource

LIGER™

We're Hiring

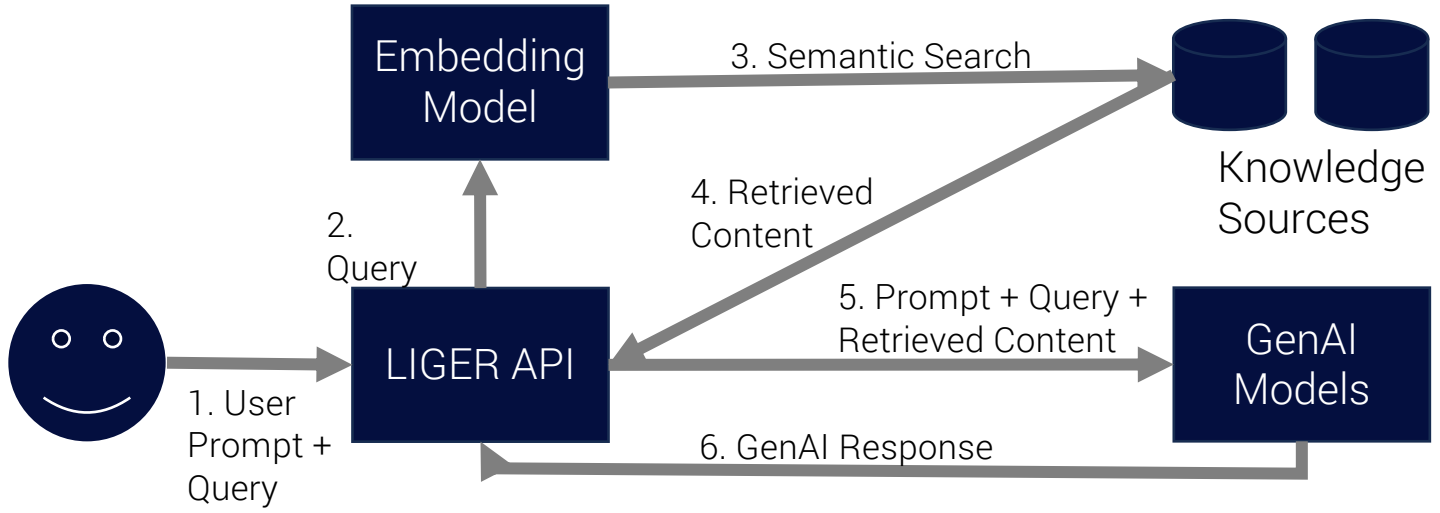
LMI



LLM | Commercial Solution

	Customer Challenges	LMI Solution
1	Security & Privacy of LLM's	LIGER uses language models we can use behind firewalls – ours, yours, GovCloud
2	Short term memory of training data	RAG allows us to give the LLM relevant information beyond what it was trained on.
3	LLM's are probabilistic and hallucinate	LLM is instructed to only return responses with location of citation so fact checking is straightforward.

LMI's Instruction-tuned Generative Resource (LIGER) is our Generative AI toolkit which focuses on **Retrieval-Augmented Generation** (RAG).



LIGER™ LMI

Kai Goebel

- Kai Goebel is Director of the Intelligent Systems Lab at PARC (recently fused with SRI International).
- **Other career stops:**
  - NASA Ames: Director of Prognostics Center of Excellence
  - GE Corporate R&D
  - Ph.D., UC Berkeley
- **Academic Credentials:**
  - ~20,000 citations; 400 publications; h-index: 69
  - Committee member of 17 Ph.D. students; adjunct
- Professor at LTU

SRI International®

Monetize Generative AI

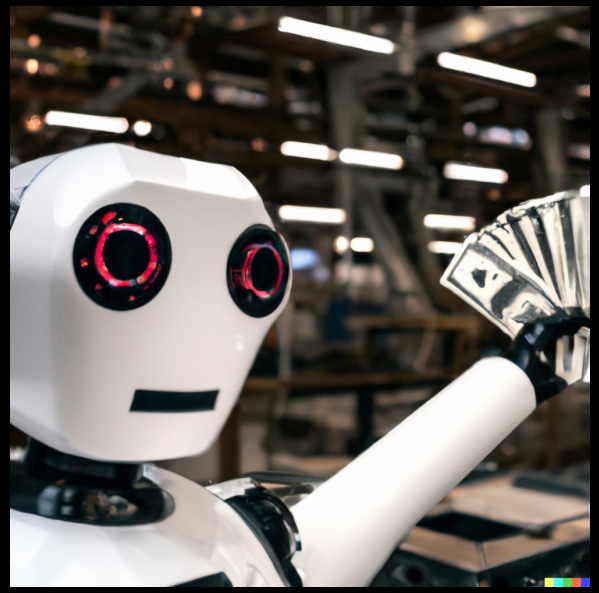


Image created with generative AI

Predictive Maintenance Algorithm Enhancement

Use generative AI to improve the accuracy and efficiency of predictive maintenance algorithms. Provide these enhanced algorithms to industries where equipment downtime is costly, such as manufacturing, aviation, or power generation.

Data Augmentation Services

Offer generative AI as a service to generate synthetic data to augment training datasets for PHM algorithms. This synthetic data can be used to improve the accuracy and robustness of predictive models.

Simulations and Testing Environments

Create generative AI-powered simulations or testing environments that replicate real-world conditions for equipment, machinery, or systems.

AI-Generated Reports and Insights

Develop generative AI models that can create detailed diagnostic reports, predictive maintenance recommendations, or real-time insights based on PHM data

SRI International®

Karl M. Reichard

- Associate Research Professor with the Penn State University Applied Research Laboratory (ARL) and Graduate Program in Acoustics
- ARL Technical Fellow and the chief scientist for the ARL's Systems Operations and Automation (SOA) Division.
- PHM Society Fellow
- 30+ years of experience in the design and development of advanced systems for sensing and controls.
- 50+ journal and conference publications.
- Teach courses in digital signal processing, active sound and vibration control, signal analysis, and prognostic health management.
- PhD and MS and PhD student advisor and committee member
- PhD in Electrical Engineering from the Virginia Tech

PennState
Applied Research Laboratory

Generative AI Opportunities and Challenges

Generate testing and training data sets

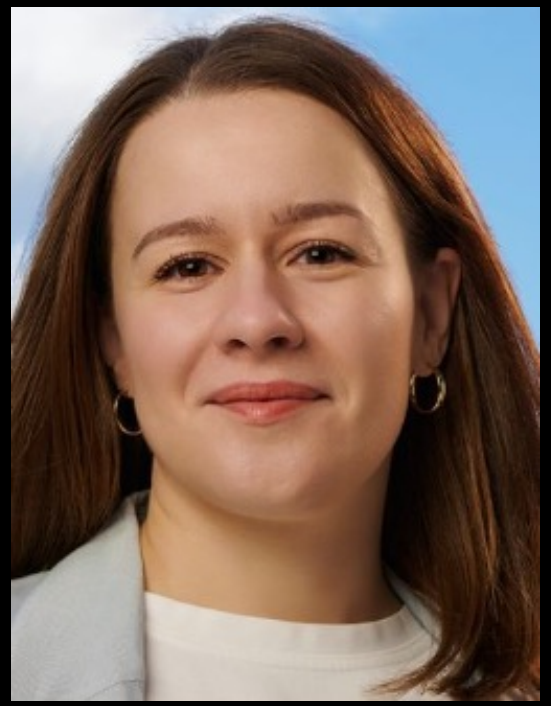
Create new data sets for testing and training diagnostic and prognostic algorithms and maintenance systems. The promise of Gen AI is to move beyond just adding noise to existing data. Collecting data is very expensive (especially faulty data if it must be collected separate from normal operation) and can result in *significant cost savings*. The use of Gen AI testing and training sets may have different considerations/risks that need to be considered.

Interpretation of monitoring system output and generation of maintenance recommendations

While may sound like using Gen AI to create user interfaces, but the promise is to connect diagnoses and predictions to actions with the best possible outcomes across multiple factors that may not be obvious to the UEX designer. We must exercise caution, because these recommendations can still reflect inaccurate capture of maintenance actions in the training data. If the use of Gen AI allows customizing recommended actions to customer policies and procedures this could *reduce development costs* and time to completion.

Capture and Report on Lessons Learned

Create lessons learned and conduct ROI analysis across multiple data sources. This presents the same challenges and rewards as other Gen AI applications.



Olympia Brikis

- **Director of Physics-Informed AI Research | Siemens**
  - 6 years of experience building the next generation of industrial-grade AI systems
  - M.Sc. Computer Science, LMU Munich/University of Warsaw

- **<u>Research Focus:</u>**
    - Physics-Informed AI
      - Embedding Physics-based Context and Domain Knowledge in AI Models
      - Data-Efficient Learning
      - AI-based Surrogate Models
    - Industrial Foundation Models
      - Multi-modal Learning
      - Edge Deployment of LLMs

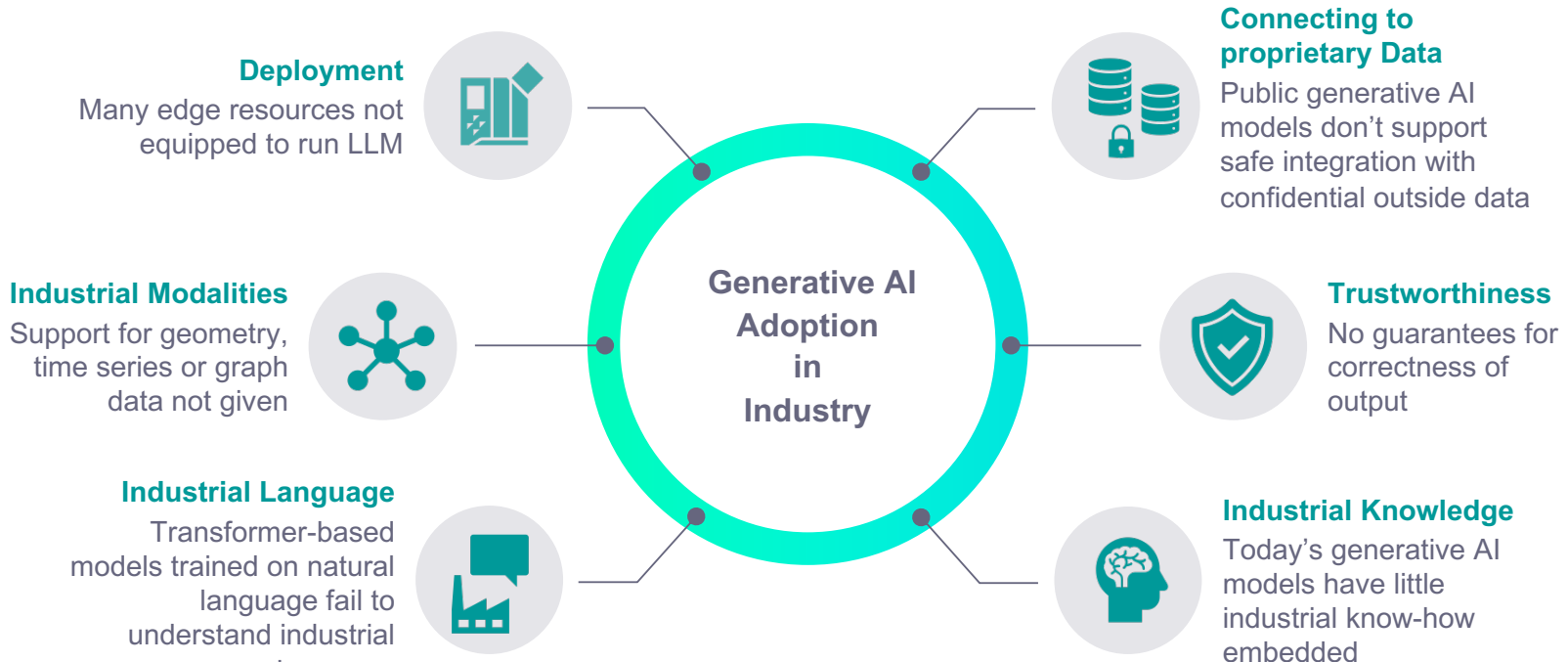
SIEMENS

Sample Applications for GenAI

Siemens Industrial Copilot (Automation Code Generation)

Knowledge Access

Co-pilots in Service, Maintenance, Engineering and Operations



SIEMENS

Mark Roboff

CEO of SkyThread.aero, a new venture building the future of digital connectivity for the aviation industry.

Founder and board member of Independent Data Consortium for Aviation (IDCA)

Chairman – SAE G34 / EUROCAE WG-114 Artificial Intelligence in Aviation Committee, building ARP-6983, a process standard to serve as a means of compliance for the certification of on-board, safety-critical ML

Formerly:

- Global Solution Leader, Aerospace, IBM
- Digital General Manager, Aerospace, DXXC

PHM Credentials:

- Past work with Airbus, Honeywell, and with airlines on five continents on predictive and prescriptive maintenance systems

SKYTHREAD

Role of GenAI in Aviation

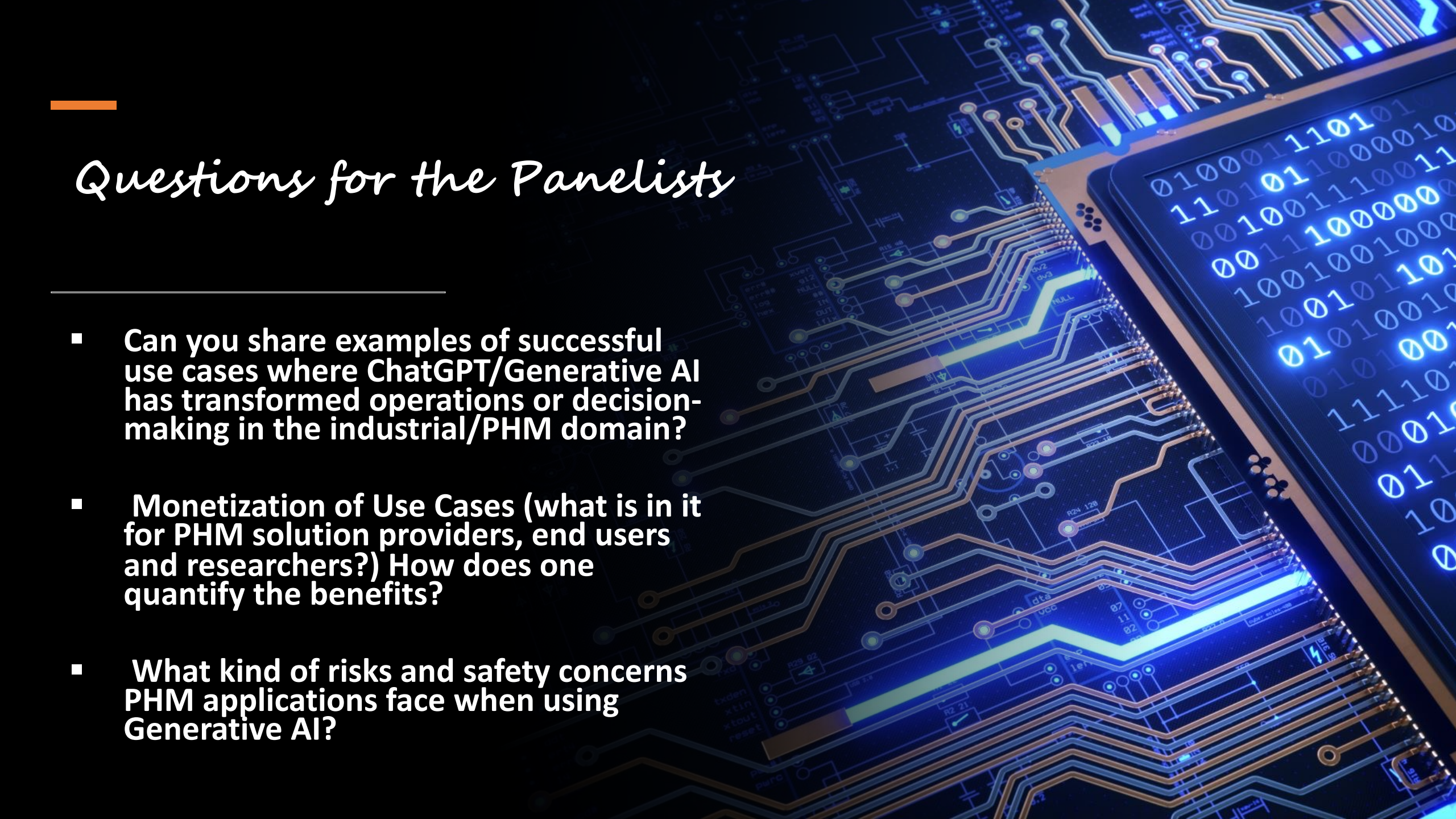
The role of Generative AI in unlocking aviation's highest-value digital asset: **Maintenance Records**

- The value of maintenance records in unlocking predictive and prescriptive insight
  - Uniform way of writing and controlled vocabulary
  - Written about all platforms and systems (no need for sensors, data collection off-aircraft)
  - Easier to obtain than QAR/DAR data
- Example of predictive insight
  - 737 Environmental Control System
    - Un-instrumented
    - Pilot Recordings of Duct Pressure
- Examples of prescriptive insight
  - Statistically comparing failure rates with repair actions
  - Finding most efficacious repair
- LLM potential to scale NLP capabilities and use-cases
  - What's needed: Secure train-and-deploy infrastructure
  - Cautions: The "Hallucination" problem. What it really means.

SkyThread

Questions for the Panelists

- Can you share examples of successful use cases where ChatGPT/Generative AI has transformed operations or decision-making in the industrial/PHM domain?
- Monetization of Use Cases (what is in it for PHM solution providers, end users and researchers?) How does one quantify the benefits?
- What kind of risks and safety concerns PHM applications face when using Generative AI?



Thanks!

Asma Ali GE Vernova

Please connect on LinkedIn!

Panel Generated Content

- Notes from the panel
- Whova App: questions asked and answers which were recorded in the Whova App. Note that there was additional verbal discussion not captured on Whova.

Notes from Panel Discussion

- Questions surrounding the US Executive Order on AI (which no one knew the answer to and I don't think anyone expected anyone to know – but there is interest in knowing)
- Interest in end-to-end examples with connections between spoken/written word and a physical part: eg asking LLM's to design a part, linking it to software to 3D printer and having a part made in your hand. Kai's lab did one test case with MATLAB, Karl's did one with a toy sailboat
- Monetization:
  - Saving time & efficiency
  - "Generative Design" – reimagining designs
  - Wrong question – should be thinking of LLM as a tool specific to solving problem, not how to monetize LLM specifically
  - Need to think about balancing cost and effort – right now, LLM's are free and easy to access but will they always be?
- Interest in pre-trained models for time series data
  - Wolfram has a plugin for classic time series analysis
- Topic of extracting text from images, like P&ID's
- End with "Let's not throw out our best practices in engineering just because we have a shiny new toy" (from Karl)

Whova Questions asked – Page 1 (3/12)

- How will the Executive Order from the President on AI enhance or detract from the implementation of Gen AI for the PHM community?
- How do you think we could go forward in formally making recommendations and considerations to the larger PHM community?
- Are there any concerns regarding OpenAI collecting data about what users ask ChatGPT? There has been trends in companies – employees have been told not to use ChatGPT.

Whova Questions asked – Page 2 (6/12)

- Generative Models are typically trained on vast amounts of data to achieve realistic performance. Even then, they struggle with finer details of generation, such as fingers/hands for image generation and hallucinations for text generation. With this in mind, what approaches can we use to train PHM signal or text generators?
- Monitoring the present decline in ChatGPT accuracy attributed to the model's evolving nature based on daily input data… What safeguards and independent validations are in place to ensure that ChatGPT's adoption in industrial settings for PHM is not causing unforeseen and potentially detrimental consequences?
- What are your recommendations or best practices for assessing how to deploy a foundational model internally in order to protect IP?

Whova Questions asked – Page 3 (8/12)

- What is the risk of giving away IP considering the questions that employees ask GenAI? For example, help with code, part design, requirements decomposition, etc. Our company firewall blocks it directly however my phone is clearly linked to me which can be clearly linked to my employer. My employer does not have a local version of a GenAI system.
- @Mark: Application of Gen AI on commercial aviation is easier than military aircraft in perspective of security issues. Since you mentioned F-35, could you provide specific cases how to gather input data of Gen AI and more detailed application examples in military platforms? And if it is applied appropriately, how much positive impact on maintenance, reliability, etc.?

Whova Questions asked – Page 4 (9/12)

- What are your thoughts about GenAI for safety-critical PHM systems?
  - Reply (Mark): It depends on if GenAI is used to help design the safety critical system or if it's used in the safety critical system. For the former, I think it's worthy of experiment today as part of a broader MBE strategy. The example General Baker talked about is a good one that should be explored en masse. For use in (i.e. the execution of) safety critical function, I think we are a long way off. The first certified ML models for use in the safety critical domain will be relatively simple supervised learning models, followed by reinforcement learning models. Methods to assure probabilistic, non-deterministic ML will need to be very well matured before Gen AI comes in.

Whova Questions asked – Page 5 (11/12)

- Do you know any ongoing proven use case/applications of Gen AI industry?
  - Olympia presented co-pilot used at Siemens, developed internally
  - Sarah presented a RAG model which LMI has successfully used for many use cases, including, for example:
    - Support in rapid identification of alternate supplier within supply chain (F-35 Joint Program Office)
    - Policy chat tool for Centers of Medicare and Medicaid Services: retrieve relevant information from hundreds of pages of policy documents in response to specific policy questions
- About the use case mentioned by Olympia in using Gen AI to guide user's questions to the best appropriate manual selection:
  - Did you use a pre-trained LLM?
  - If yes, how did you manage the limited size of the prompt?
  - How did you manage the transfer of Siemen's data to the LLM server?

Whova Questions asked – Page 6 (12/12)

- How do we contextualize natural language data in practice? For example, we have a big aero plane maintenance where multiple engineers are working on several different areas. The context will be different on different sections of the aeroplane.
  - Reply (Mark): I'm not sure I agree with this example. Maintenance records are written to a uniform standard regardless of the platform or component in question. This is due to having an industry standard taxonomy and writing structure as well as standardized maintenance workflows for maintenance execution, especially on the line. To answer your question broadly, contextualization and narrow workflows. As mentioned, maintenance logs for aircraft are standardized. Futhermore, the actions taken in a line maintenance situation are limited. Essentially, regardless of the component in question, one performs one of the following verbs: check, test, clean, remove, install. Deployed in this environment, context is self evident.
    - Sarah adding on to Mark: Work on Maintenance Action ontology has been developed and published by UWA: https://www.semantic-web-journal.net/content/ontology-maintenance-activities-and-its-application-data-quality . Maintenance actions are relatively straightforward entities to extract (compared to say failure modes and parts!) and they generalize across industry.