MFPT News Spring 2021

VI + MFPT: Diagnostics, Prognostics and Failure Prevention

"Where Theory Meets Practice"

Savannah, GA,

August 2nd – 5th, 2022

MFPT at VIATC 2022 Call for Papers & Presentations

The Society for Machinery Failure and Prevention Technology (MFPT) is proud to announce its call for papers and presentations for our 2022 annual conference, co-located with the Vibration Institutes annual meeting in Savannah, GA, August 2nd – 5th, 2022.

Call for Papers and Presentations

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Society for Machinery Failure Prevention Technology

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Chairman's Letter

It is my pleasure to note we had a wonderful in person conference July 13-16 in Arlington, TX. The conference was our first combined conference with the Vibration Institute. The conference sported papers from each of MFPT's focus groups including Data Management and AI, Diagnostics and Prognostics, Failure Analysis, Human Performance, Sensors, Signal Analysis, and Systems Engineering. If you attended the conference, you will find the proceedings here.

We are already looking forward to our 2022 MFPT and Vibration Institute combined conference, to be held August 3rd thru the 5th in Savannah, GA with 6 half day pre-conference workshops on August 2nd. When attending, you will benefit from sessions covering Vibration Diagnostics and Analysis, Failure detecting sensor technology, the use of AI in failure prevention, Signal Processing, Failure Analysis, Human Performance, Prognostics, Systems Engineering, and Fluid Systems analysis. On August 3rd and 4th, each day begins with two exciting keynotes hand selected by the Vibration Institute and The Society for Machinery Failure Prevention Technology.

We are now accepting abstracts for papers and presentations. For a description of our presentation categories, and to submit your abstract, please visit: https://www.mfpt.org/mfpt-2022-call-for-papers/ .

In the short term, please enjoy our quarterly newsletter and references to our online materials. You may also consider joining the Vibration Institute here, and benefit from discounted attendance at the conference, a subscription to Vibrations magazine, and access to a wealth of technical articles and videos in the member portal. When you do join, please edit your profile to include MFPT as one of your two chapter choices.

We look forward to your participation in our Society, and our discussion forum on LinkedIn.

Best Regards,

Preston T. Johnson

Preston Johnson, Chairman, MFPT

Articles

Are you ready for the Digital Twin?

We hear the term “Digital Twin” often in the context of the Industrial Internet of Things, Digital Transformation, or just going digital. What should we be doing to prepare for and to leverage the digital twin for machine failure prevention? Can the Digital Twin help us beyond machinery failure prevention? How about process optimization, lowering the cost of production? How about lowering the carbon footprint of the enterprise as part of process optimization? These are indeed some of the benefits of a contextualized holistic view of our plants that the Digital Twin offers.

Business Objectives:

So where do we start? We first need to define our critical manufacturing processes. From a business perspective, what drives our profits? By understanding our profit drivers, we can focus any digital efforts on those that impact business profits (or risk or costs).

Next, we need to identify the critical assets and components in the plant. What data is available from these assets? We are typically interested in engineering data including performance specifications, process and instrumentation diagrams (P&ID), repair and maintenance manuals, operational manuals, and drawings (both two dimensional and three dimensional). We are also interested in machinery and equipment data. Can we pull data from the equipment controllers in real-time? What network infrastructure is in place or can be added to connect the data to our digital twin? Do we need to add sensors and instrumentation to obtain the data we need to make decisions that will drive our business Key Performance Indicators (KPIs)?

What performance metrics are valuable? How about Overall Equipment Effectiveness (Availability * Performance * Quality)? What Operator tools are available that allow the operator to see a holistic picture of the equipment they operate and manage?

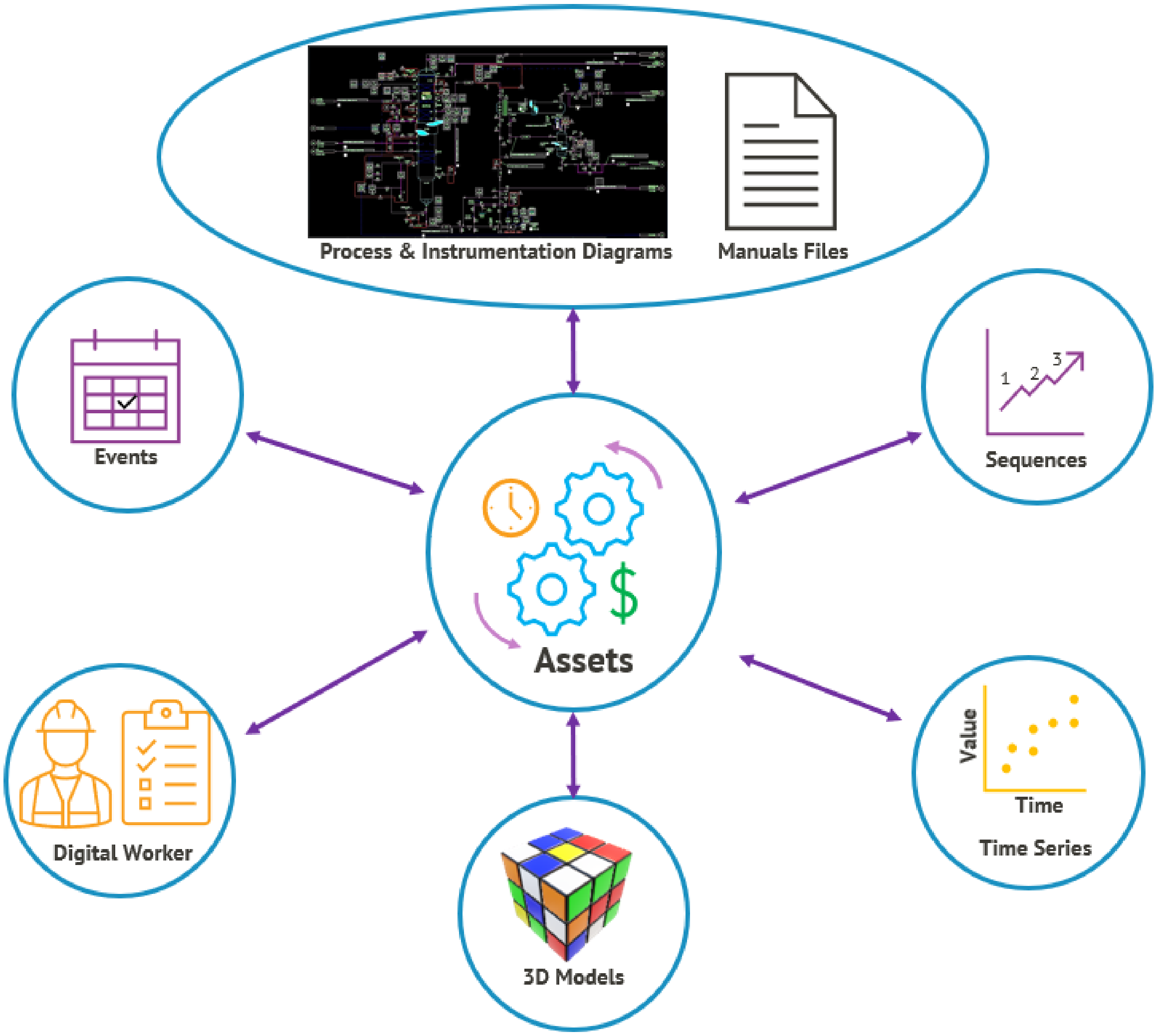
As you can see there are many questions, we should review on our digital twin journey.

Digital Twin Components:

In the end, our individual equipment assets, the subsystems they form, the systems, the plant units or lines, and the plant all have a digital twin. Each layer in the digital twin builds upon lower elements in an asset hierarchy oriented twin network. An individual asset is connected to a wide range of data about itself, both real-time data, and static document data.

As noted in the following diagram, the asset (equipment or system) is at the core of the digital twin. There is a range of real-time data including time series, maintenance and operation events, and worker operator activity associated with the event. There is static data including engineering documentation, manuals, and three-dimensional drawings.

As an example, a feed pump may be part of a distillation column, and is listed on the P&ID. A digital operator notes his production schedule event and starts the feed pump. The feed pump automatically executes a series



of start-up steps and checks. This is the start-up sequence. Motor current and vibration data from the pump is logged along with temperatures, pressures, and flows. These are time series data. The operations manuals provide limits on any of the data, sequence timing, etc. Our three (or two) dimensional models provide any visualization that is helpful to the operator or to management.

<u>Data Connectivity:</u>

It may seem obvious, yet our digital twin needs access to core data. Data resides in our control system and data historian. Data resides in our maintenance management and operator management systems. Data resides in our engineering archives. It is likely, that the data and systems are provided by multiple vendors, each with their own application programming interface. We need to identify where the data is, that will empower our digital twin.

We will also need to address our networking and security parameters as well. For example, we can use OPC UA to pull data from the control systems. OPC UA gives us security layers and can work across firewalls. OPC UA will allow us to see time series data, some sequence related data, and data that maps to events.

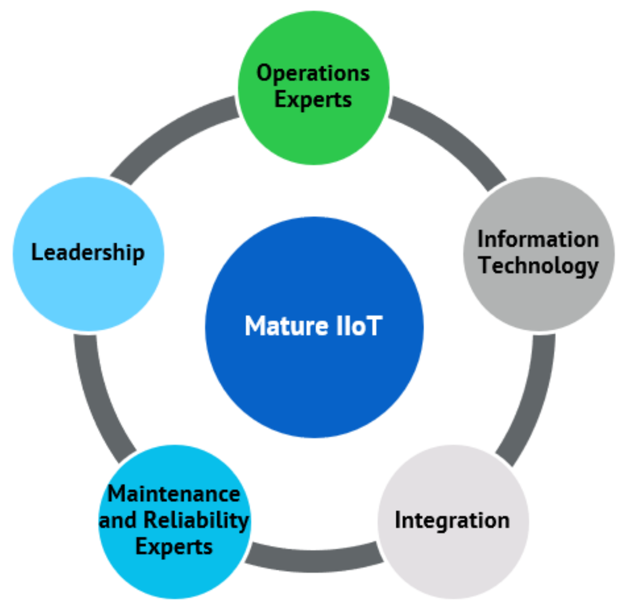
In other cases, we will need to access or implement digital versions of our management processes. These are business and process sequences we may wish to automate. We will need to access and manipulate our engineering data, those manuals, and P&IDs. It is likely we will need some help from natural language processing, or similar tools to interpret the engineering data. In the case of multi-dimensional drawings and models, we may need augmented reality resources that can bring the drawings to life. Lastly, we will want to bring our plant field personnel into the digital twin by adding smart devices for digital workflow, and access to digital twin information.

Bringing it all together:

Participating in the new digital industrial environment requires digital thinking, that is digitizing and automating many of our manual processes. However, these are often a two-to-three-year journey. For this journey, we will need support at the top of our organization, which may include cultural and change management efforts.

Of course, we start with our business justification. What areas of the business should we improve to solidify or increase our competitiveness in the market? This list gives us low hanging fruit and smaller bite size projects we can work with initially, as we build out our digital roadmap.

The process is a team sport, requiring representation from leadership, information technology, operations, maintenance, and of course a team to perform the integration. With the right team in place, it is possible to prioritize the business opportunities, with a focus on impactful and measurable initiatives that can be implemented quickly. A technology roadmap should be implemented to address all or most of the business objectives.



To keep the effort moving, it is recommended that companies partner with integration teams with expertise in operational technology (OT) and information technology (IT) and that have expertise in the company's manufacturing process. Experience yields the ability to anticipate and overcome challenges that are likely to arise.

As the journey continues, communication is paramount. Newsletters, and other status updates should be shared with all stakeholders, so everyone is included. Always ask for feedback to help refine the journey.

With these implementation elements in place, the team is ready to scale and ultimately transform the organization into a new digital entity. Machines will be more reliable, processes more efficient, energy consumption lower, and ultimately a more profitable and competitive enterprise.

About the Author:

Preston Johnson is a Senior Solutions Manager with CB Technologies, Inc. (CBT). CBT is a domain expert systems integrator with deep knowledge in IT and OT systems and integration. As a solutions manager, Preston focuses on Monitoring and Analytics as he assists clients begin their digital journey. Preston is also the Chairman of the Society for Machinery Failure Prevention Technology (MFPT). Preston is MFPT chair of the Data Management and AI focus group, and a fellow of MFPT. Preston can be reached at preston.johnson@cbtechinc.com

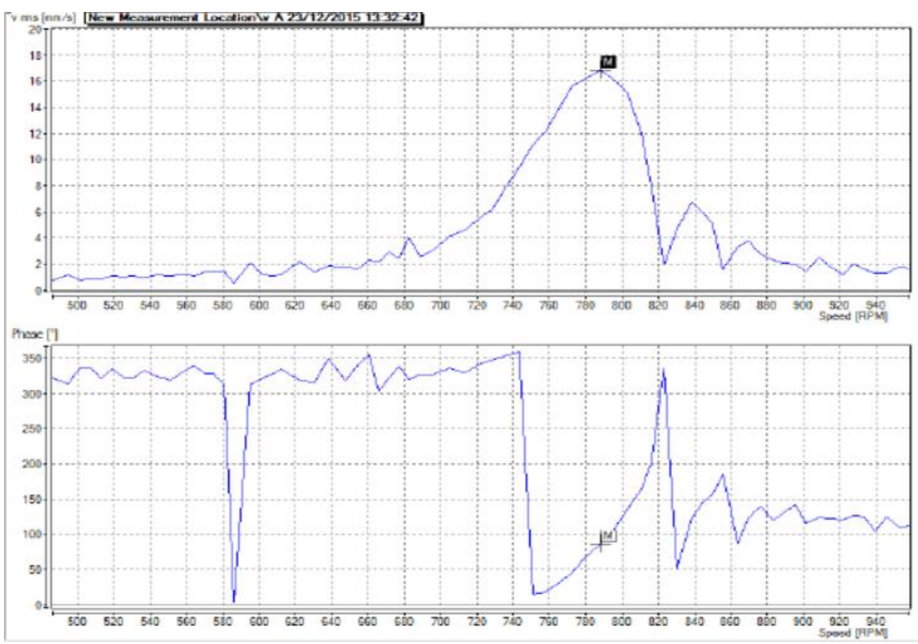
Use the features at test bed simulating site operating conditions

Problem statement - High Vibrations reported at a very remote site in VSD Motor / Gear box in all four Quintuple high pressure Plunger pumps at operating regime (65-80% of full RPM).

Pump maximum operating frequency – 15.3 Hz.

Actions taken –

Several attempts were made to undertake all possible corrective actions, but with no favorable results. A complete vibration survey was undertaken which indicated possible base plate resonance. The vibration response during Vibration survey run up clearly showed the motor going through a resonance at 65-80% of full rpm. Resonance was identified by the phase angle of the vibration changing by 90 degrees at resonance and then by 180 degrees once through the resonance as shown below -



However, OEM site representatives indicated installation issues, improper shimming and incomplete grouting as shown below –

A check list was prepared and provided to site and End users, before commencing bump tests and ODS survey of units.

Post-processing was done using industry recognized software
The tests and wireframe animation confirmed that deflection modes of all three pumps are similar.

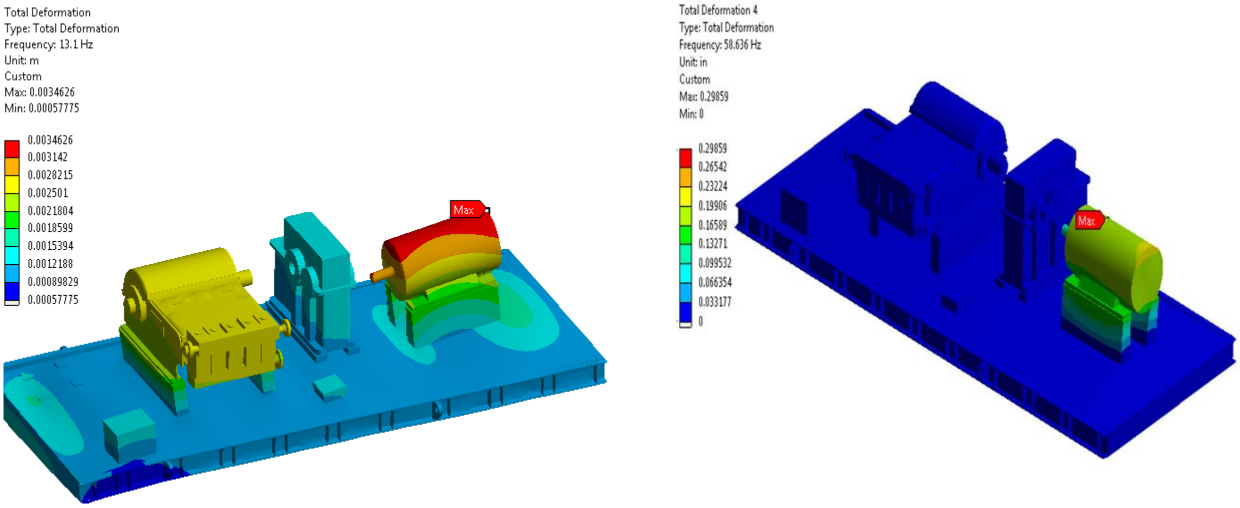
Based on Pitching of Motor and Rocking of gear box at @12 Hz and @30 Hz, it was clear that cross beams incorporated into the baseplate structure below motor and gear box appear to be too flexible.
Two solutions were proposed -

1. increase the stiffness of these beams, an additional support structure should be installed to reinforce each cross beam by fixing them directly to the concrete floor. Classical solution.

2. stiffening the whole baseplate by filling the internal cavity of the baseplate with cement grout and high pressure injecting an epoxy grout to fill remaining voids. This option would be a more failsafe method of ensuring that the whole of the bedplate is stiffened significantly, and natural frequencies of the individual components are driven away from the forcing frequencies of the motor.

Based on current requirement of pumps and complexity of job, it was realized that it is not easy to modify the base frame (to increase the natural frequency of the base frame) due to quantum of work associated to carry out the same. The second option was considered with prudence after obtaining no objection from end user engineering team.

It took simulation of exiting model based on as found results and further simulation with fully grouted design.



FE simulation results – As found (Left ABOVE) Motor pitching mode 13 Hz within 5% of calculated ODS and after grout (Right Above)

We tried to find the reason why such vibration was not detected in complete unit test at OEM test bench. Internal investigation revealed that such anomaly could not be detected because complete unit with VSD drive was never tested at various speed, in fact valve throttling was carried out to verify flow condition.

Remarks and Lesson learnt -If the units were tested as per site operating conditions, a considerable amount of money, time would have been saved.

About the Author:

Mantosh Bhattacharya is a Subject Matter Expert in Turbomachinery located in UAE and certified CAT IV vibration analyst. As a Subject Matter Expert, Mantosh focuses on selection, review of technical features of mission critical turbomachinery. Mantosh is in advisory board member in ATPS (Asia Turbomachinery and Pump symposium - Texas A&M TEES) Mantosh is also the Chairperson Failure prevention focus group of the Society for Machinery Failure Prevention Technology (MFPT). Mantosh can be reached at mantosh.b@petrofac.com

The Value of Systems Engineering (SE)

Greetings from Cleveland, Ohio! In this ever-changing environment we find ourselves in today, pandemic, economic turmoil, climate change and social unrest, I find some comfort in things that are steadfast and sure. Unfortunately, there also exist “sure things” that are unpleasant, such as, all machinery will fail at one point or another. That’s where we come in to save the day, hopefully. Our efforts to minimize failures is a huge undertaking. Once a machine, or system of machines is in service, the ability to make changes is very costly and time consuming, not to mention the resistance from conventional practice. Therefore, it is best to include risk mitigation and health monitoring for failure prevention at the beginning of a project/program to minimize cost and schedule problems.

Many of you may think, “Where does systems engineering come into play for failure prevention?” Well, let me elucidate with a little background first. Systems engineering as defined by the International Council on Systems Engineering (INCOSE) is: *“…a **transdisciplinary** and **integrative** approach to enable the successful realization, use, and retirement of **engineered systems**, using **systems principles and concepts,** and scientific, technological, and management methods.”* Where engineered systems are defined as, “…*composed of any or all of people, products, services, information, processes, and natural elements.”* Typically, projects take off running on a design solution without this upfront work, costing the organization and the public in general, much more than it would be if initial processes were followed properly.

So, as you can see, SE incorporates all aspects of a project or program. Our efforts to include machinery failure prevention technology must be a subset of these and, indeed, should be included in all aspects of these engineered systems, i.e., people, products, services, information processes and natural elements, not only hardware. Historically, MFPT has addressed products and information processes, but recently we have included Human Systems Monitoring as a Focus Group. In this vein of thought, I would like to include “natural elements” as an informal area of focus, for now. Isn’t the flow of air into a gas turbine part of the system? Or the flow of water through a pump? With this line of thinking, wouldn’t acoustics be another natural element of consideration? And in fact, Congress has mandated in the FAA Reauthorization Act of 2018, Pub. L. 115254, § 188, requiring the Federal Aviation Administration (“FAA”) to “evaluate alternative noise metrics to current average day-night level standard, such as the use of actual noise sampling to address community airplane noise concerns.” I won’t go into detail how the FAA has responded to this mandate. However, this is a real problem and aircraft noise, or any other machine generated noise is considered pollution and inevitably a “failure” in design to evaluate and mitigate this pollution in the first place.

As we learn more about SE and the development of new tools and methods to help with avoiding failures, the ability to design these systems away from potential problems is improving. At MFPT we encourage and foster these discussions to help all that want it.

I am hoping to see you at our 2022 annual conference, co-located with the Vibration Institutes annual meeting in Savannah, GA, August 2nd – 5th, 2022, where we can discuss these ideas further in person.

MFPT Website Call for Papers and Presentations Discussion

About the Author:

John Lucero has an advanced degree in mechanical engineering and has worked in government for 34+ years. His experience includes: aerodynamic and propulsion testing of subsonic, supersonic and hypersonic vehicles and components; theoretical and experimental aero-elasticity of fans and turbines in jet engines; experimental and theoretical tribology of materials and rotor dynamics of oil-free turbomachinery; Lead Systems Engineer for large space test facilities and space launch vehicles development including advanced composites technologies; test facilities engineering and management; and theoretical and experimental acoustics as a branch manager. He has served in the past for Machinery Failure Prevention Technology (MFPT) as the Tribology Focus Group Chair, and the MFPT Society Chair. He is currently the Systems Engineering Focus Group Chair for MFPT. John can be reached at mstar1960@sbcglobal.net

Recap on the MFPT/VIATC workshop: The complexities of selecting and installing a new wireless CBM (vibration) system

The objective of the workshop was to educate maintenance professionals regarding the complexities of selecting and installing a new wireless CBM (vibration) system. Various aspects of the system performance and features were discussed, helping to inform the questions to ask when investigating options that are the best fit for a particular facility and maintenance model.

Aspects of the system discussed included sensor technology and performance as it impacts measurement accuracy, features of concern including battery life and transmission distance, edge data processing, network installation, data access and display. We also spent an hour on data analysis, including a comparison of the difference between classical physics-based vibration signal processing versus data driven approaches to derive asset Health Indexes and the exercise of machine learning for Predictive Maintenance (presented by David Siegel, CTO Predictronics Inc).

Lastly, an experienced CBM solution installer and reliability expert (Dustin Morris, I-Care) reviewed practical considerations when selecting and installing a wireless CBM (IIoT) system.

About the Author:

Ed Spence is the Founder and Managing Director of The Machine Instrumentation Group, a collaborative network of contract engineering service providers helping clients define and develop new sensors for novel machine health applications.

Previously, Ed was the Marketing Manager for Analog Devices MEMS Sensor Technology Group, where he defined the MEMS accelerometer roadmap for vibration based Condition Monitoring, winning an Innovation Award at Sensors Expo 2017 for the flagship ADXL1002 MEMS accelerometer. Ed has been engaged in the development of Condition Monitoring sensor solutions since 2008. Ed has published or presented on the subject of sensors for CBM on numerous occasions.

Ed serves on the Board of Directors for The Society for Machinery Failure Prevention Technology, and is a member of the Vibration Institute, The Society of Maintenance and Reliability Professionals and The Society for Prognostics, Health and Maintenance. Ed also volunteers for non-profit IBEC Ventures, providing business consulting to small business startups overseas. Ed holds a B.S.E.E from University of Massachusetts, and a certificate in Strategy and Innovation from MIT Sloan Business School. Ed can be reached at ed.spence@machineinstrumentation.com

MFPT Focus Group Areas: https://www.mfpt.org/focus-groups/

The Society's mission (of providing an interchange of technical information for the benefit of owners and operators of mechanical machinery) is facilitated within our focus groups. The focus groups include:

All the focus area disciplines interact with each other. For example, systems engineering identifies functional requirements of equipment and their likely failure modes in the application. This engineering work drives human inspection tasks as well as automated inspections. Sensors give us quantifiable data about the physical world, and signal analysis transforms that data into condition and performance indicators about our equipment. Exploring and interpreting these indicators are diagnostic, prognostic, multivariate data analytics, and analysis of failures. In each of these areas, the performance of the human is always an element of success and efficiency.

Thru discussions in our focus groups, participants gain knowledge that helps drive towards failure prevention within the participant's organization. Our discussion forum (see link above) makes it easy to post a question, comment, article, etc., for all the MFPT community to see.

Each year, we host sessions in each of these areas at our annual conference and our webinars. Join our mailing list to stay informed.

Systems Engineering

FG Chair: John Lucero, NASA, Glenn Research Center

The Systems Engineering Focus Group (SEFG) provides a forum to foster the development and application of a systems approach to complex technical problems. Due to the interdisciplinary technical structure of MFPT, technical processes representing System Design, Technical Management and Product Realization are instrumental in the development and integration of new technologies into mainstream applications. The SEFG will encourage the application of these Systems Engineering tools to problems posed by the MFPT community.

Sensors

FG Chair: Ed Spence, Machine Instrumentation Group

The Sensors Focus Group (SFG) facilitates the discussion of sensors for Machinery Failure Prevention. Discussions include new sensor technologies and the means to connect them, data driven approaches to data analysis, and developments under the Industrial IoT umbrella.

Ed Spence, our Sensors Focus Group Chair, hosted a tutorial:

- Accelerometers for Machine Health Monitoring and Diagnostics

And we hosted several sessions with sensors as the focus:

- Complimenting acceleration measurements with advanced strain gauge technology
- Miniature Solid-State Batteries for High Temperature Industrial Sensors
- Combining Wear Debris and Vibration for a More Complete Understanding of Machinery Health

Signal Analysis

FG Chair: Suri Ganeriwala, SpectraQuest

The Signal Analysis Focus Group (SAFG) facilitates the discussion of data acquisition, signal analysis, diagnostics, artificial intelligence, logicians, etc. A core focus is signal processing (of all sensor type data) to assess the condition of components, subsystems, systems accurately and reliably in enough time to maximize reliability and minimize costs.

Data Management and AI

FG Chair: Preston Johnson, CBT

The Data Management and AI Focus Group (DM&AIFG) supports the discussion of data management tools, capabilities and standards that facilitate the detection and measurement of failure modes; that facilitate monitoring machinery and structural health; and that facilitate maintenance decision making. Participate in discussion of best practices and options for collection, advanced analysis, and dissemination of technical information for all sensed parameters.

Diagnostics and Prognostics

FG Chair: Hoffy Hoffmeister, Ridge Top Group

The Diagnostics and Prognostics Focus Group (D&PFG) provides a forum to foster professional collaboration in the practice and technology of Prognostics and Health Management (PHM). The D&PFG provides and entry point for members new to the field of PHM and a forum for experienced professionals to collaborate on the most pressing problems. D&PFG encourages the use of standards and the application of PHM techniques across multiple domains.

The MFPT D&PFG is a group of professionals working to advance the field of PHM by collaborating on technical issues and sharing relevant industry information. Sample discussion areas include: Mechanical and electronic PHM, Prognostic methods and technology, PHM Standards, PHM case studies.

Failure Analysis

FG Chair: Mantosh Bhattacharya, Petrofac

The Failure Analysis Focus Group (FAFG) fosters the development, utilization, and enhancement of failure analysis techniques and methodologies. Lessons learned are conveyed to the MFPT Community, to prevent recurrence of failures, saving precious resources. The FAFG engages with other MFPT Focus Groups to show why failure analysis is an integral part of the product life cycle.

Human Systems Monitoring

FG Chair: Mark Derriso, US Airforce

The mission of the Human Systems Monitoring Focus Group (HSMFG) is to create an international forum where academia, industry and government agencies can discuss the state of the art in the area of human monitoring systems technologies. Topics of interest include but are not limited to wearable sensor technologies, data acquisition and management architectures, data analytics and assessment methodologies and health, fitness, and human performance monitoring techniques for industrial and military applications.

The MFPT HSMFG is a group of professionals working to advance the field of human systems monitoring by collaborating on technical issues and sharing relevant methodologies and approaches from academia, industry, and government to advance the state of the art.

Publications:

MFPT members have published several books on failure prevention technology subjects. These include:

- "Prognostics and Health Management: A Practical Approach to Improving System Reliability Using Conditioned-Based Data", co-authored by James P. Hofmeister

  Prognostics and Health Management provides an authoritative guide for an understanding of the rationale and methodologies of a practical approach for improving system reliability using conditioned-based data (CBD) to the monitoring and management of health of systems. This proven approach uses electronic signatures extracted from conditioned-based electrical signals, including those representing physical components, and employs processing methods that include data fusion and transformation, domain transformation, and normalization, canonicalization and signal-level translation to support the determination of predictive diagnostics and prognostics. Written by noted experts in the field, Prognostics and Health Management clearly describes how to extract signatures from conditioned-based data using conditioning methods such as data fusion and transformation, domain transformation, data type transformation and indirect and differential comparison.

- "Condition Monitoring Algorithms in MATLAB®": Offering the first comprehensive and practice-oriented guide to condition monitoring algorithms in MATLAB®, by Adam Jablonski. This book is available from Springer at the above link.

  This book offers the first comprehensive and practice-oriented guide to condition monitoring algorithms in MATLAB®. After a concise introduction to vibration theory and signal processing techniques, the attention is moved to the algorithms. Each signal processing algorithms is presented in depth, from their basics to the applications, including extensive explanations on how to use the corresponding toolbox in MATLAB®. In turn, the book describes several techniques for synthetic signals generation, as well as vibration-based analysis techniques of large data sets. Finally, it shows readers how to directly access data from industrial condition monitoring systems (CMS) using MATLAB® .NET Libraries. Bridging between research and practice, this book offers an extensive guide on condition monitoring algorithms to both scholars and professionals.

Other Publications

The MFPT and VIATC Conference 2021 Proceedings are here.

Sessions include:

- Data Management and AI_Leverage AI for Zero Downtime
- Signal Analysis_Dynamic_Operating_Condition
- Diagnostics_Gas turbine and compressor control
- Diagnostics_Structural Vibrations in Long Shaft Pumps
- Human Performance_AthleteEngineering
- Human Performance_ClosingWearableGap
- Human Performance_Comfort&FitVersusEffectiveness
- Sensors_TD ROSS Rotating Optical
- Diagnostics and Prognostics_CBE Life Curve
- DataMgmt and AI_Model Monitor Analyze to Optimize
- Human Performance_Enhancing Work Execution
- Human Performance_Organizational Performance and RCA
- Sensors_Fluid Sys Analysis & Diagnostic Technolgies
- Human Performance_ Management of Stress
- Signal Analysis_A Pedagogical Approach To Mechanical Vibrations
- Failure Analysis_Cold Spray
- Prognostics_Human Machine
- Diagnostics_Monitoring of Motor Gear

MFPT's 2020 Conference Proceedings are located here. Many of these sessions are listed in the focus group area.

MFPT offered several webinars between our 2020 conference and our 2021 conference. These include

Digitally Enabling Maintenance and Reliability
Model, Monitor, and Analyze a Digital Twin Foundation
Induction Motors and Motor Current Signal Analysis
Using Motion Magnification for Machinery Diagnostics

You will find many of our additional conference publications at MFPT Publications We are working to improve the listing and indexing, yet feel free to search today for your key words.

Going Forward

The Society for Machinery Failure Prevention Technology (MFPT) continues its mission of providing a technical interchange of MFPT topics. We look forward to our conversations, and our in person meeting the week of August 2nd to August 5th, 2022 at the Marriott Riverfront in Savannah, Georgia.

Please also follow MFPT

at MFPT

and on our LinkedIn discussion forum at MFPT: Society for Machinery Failure Prevention Technology

MFPT Discussion Forum

and on Twitter

MFPT on Twitter

join our mailing list at

Mailing List

become a formal member of MFPT by selecting MFPT as your VI-Institute chapter

MFPT Membership