Condition Monitoring & Condition Based Maintenance
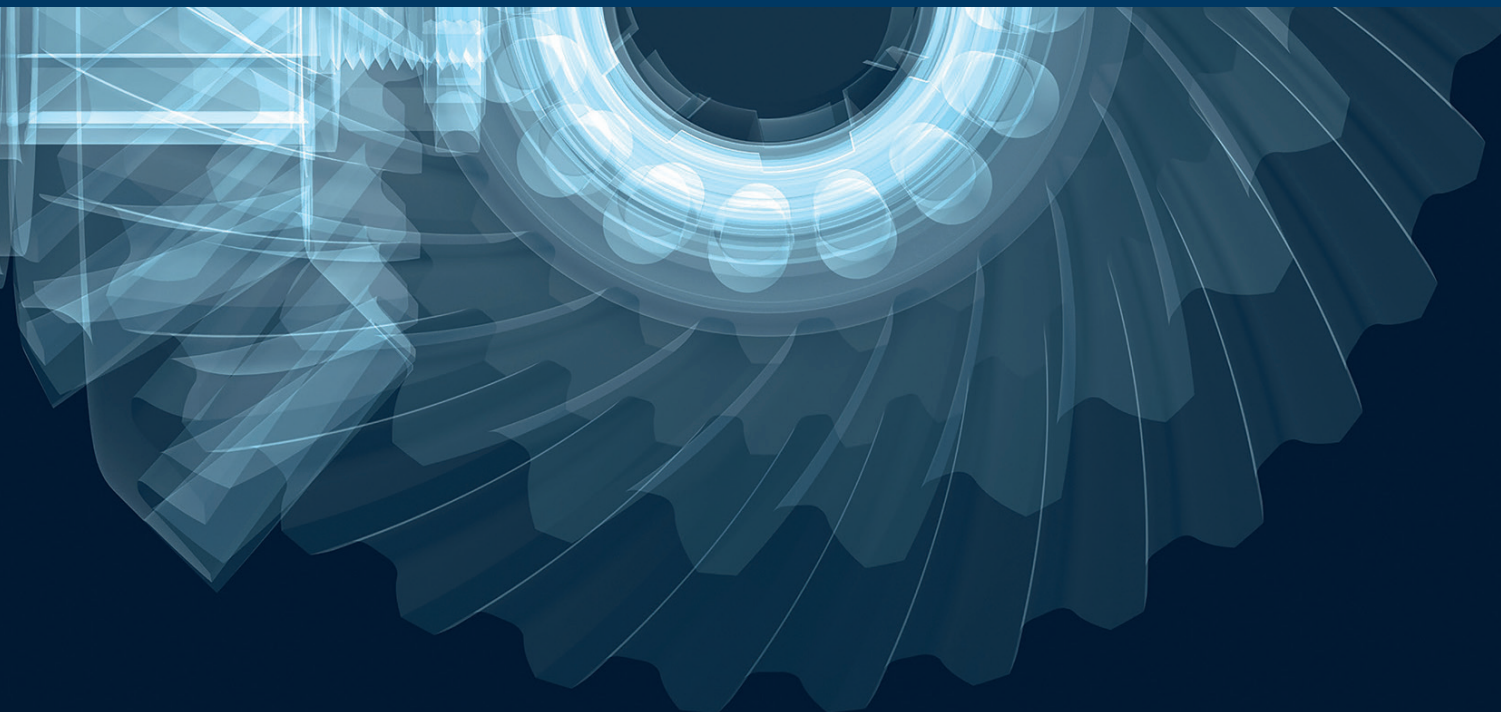
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KRISTIANSAND KOMMUNE

VRIAgder

World-class competence on CBM

Teknova is proud to present some of the world's most regarded specialist on condition monitoring and condition based maintenance in a specialist workshop in Grimstad, Norway.

For two days, we aim to bring forward the technical and economic aspects of condition based maintenance (CBM) and prognostics and health management (PHM) to the oil and gas industry, by exploring knowledge already developed in other industries. The workshop will be punctuated by technical and economical talks.

The targeted audience includes managers, executives and chief scientists in the oil and gas sector. The communication level at the workshop will be adapted to non-specialists on CBM and PHM.
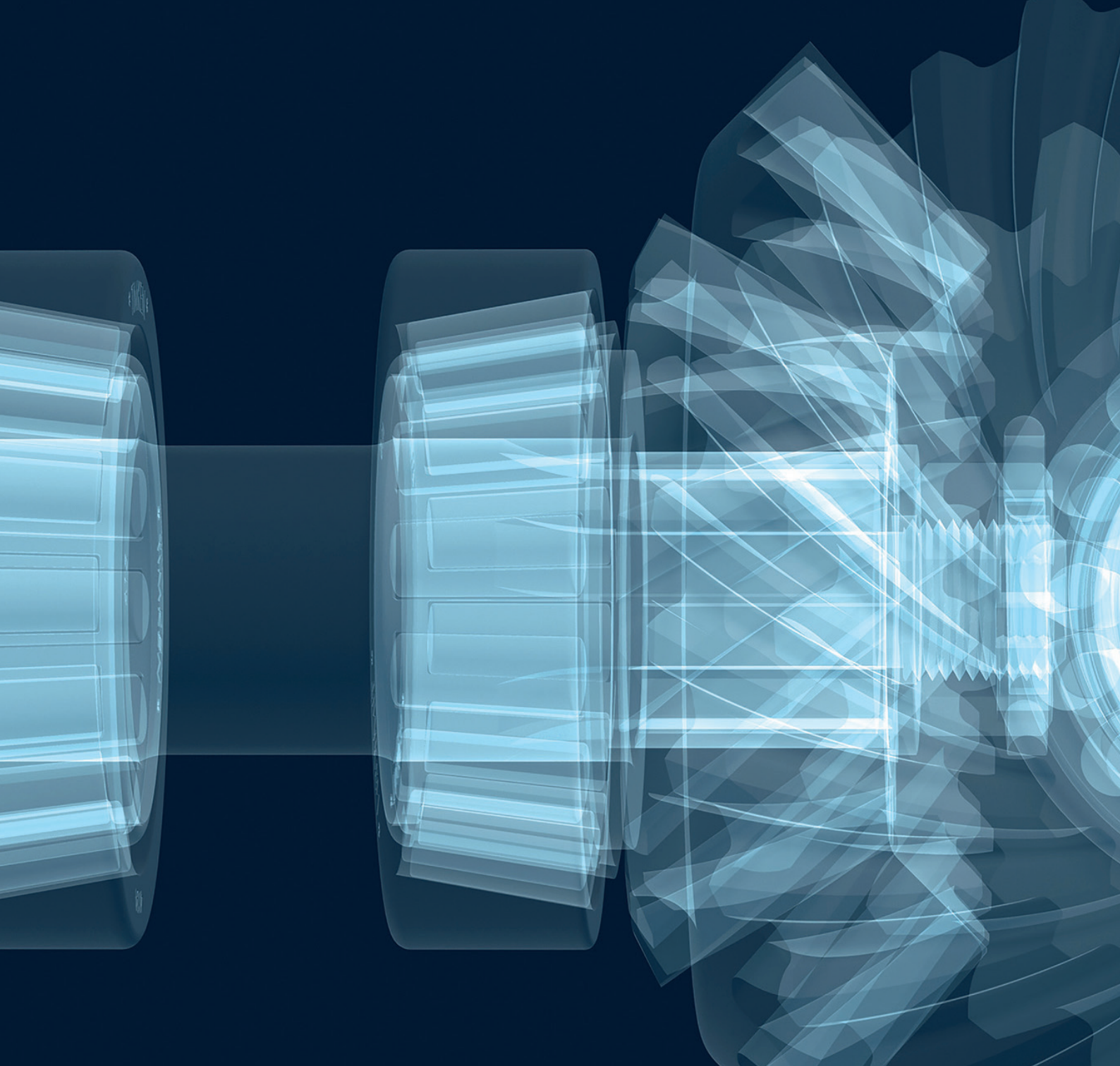
8 June 2015   Day 1 | Location: Teknova, Terje Løvås vei 1, 4879 Grimstad

08:20	Delegates bus departure from Hotel Scandic Bystranda* in Kristiansand to Teknova's workshop venue** in Grimstad. * Østre Strandgate 74, 4608 Kristiansand	**Terje Løvås vei 1, 4879 Grimstad
09:00-09:15	*Workshop registration and coffee*

Session 1   Opening session

09:15-09:30	**Opening address** Dr. Klaus Schöffel, CEO of Teknova
09:30-10:00	**Remote control is the next step for oil and gas** Anne-Grete Ellingsen, CEO of Global Center of Expertise NODE
10:00-10:45	**Keynote speech: Condition Based Maintenance – Barriers to implementation** Prof. Ian K. Jennions, Director of the Integrated Vehicle Health Management Center at Cranfield University (UK)
10:45-11:00	*Coffee break*

Session 2   Industrial condition monitoring, lessons from the aerospace industry sector

11:00-11:30	**Application of HUMS (Health and Usage Monitoring System) techniques to industrial condition monitoring. Examples of a case study from the aerospace industry: Development of HUMS for helicopters.** Dr. Eric Bechhoefer, CEO of GPMS (US) and Affiliated Chief Scientist at Teknova
11:30-12:00	**Presentation of the financial benefits of the HUMS program on the helicopter fleet CH-146 Griffon.** Terry Murphy, 1st Line Support Specialist from Bell Helicopter Textron Canada Limitée
12:00-13:00	*Lunch & coffee*

Session 3	Implementation of CM & CBM strategies in the drilling process
13:00-13:30	**Message from the machine: Presentation of the current developments and latest progresses with regards to NOV implementation of CM & CBM** Julian Zec, Engineering Manager Condition Monitoring for NOV Oddvar Birkeland, Principal Engineer CM/CBM for NOV Jon Kristen Ugland, Controls Product Strategist CBM for NOV
13:30-14:00	**CBM, Big Data and the Proactive Enterprise** Dr. Tor I. Waag, Technical Advisor for MHWirth and Affiliated Senior Scientist Physics for Teknova
14:00-14:30	**Event detection during pressure managed drilling – generic methodology and a case study** Prof. Mogens Blanke, Professor from the Technical University of Denmark and Adjunct Professor at NTNU, Norway
14:30-15:00	*Coffee break and discussions between delegates*
Session 4	Topic to be announced
15:00-16:00	TBA
16:00-16:30	**Wrap up of day 1**
16:30-17:00	Delegates bus departure from Teknova's workshop venue* to Hotel Scandic Bystranda** in Kristiansand. *Terje Løvås vei 1, 4879 Grimstad | ** Østre Strandgate 74, 4608 Kristiansand
19:00-21:30	**Dinner for the delegates** Location: Sjøhuset Restaurant, Østre Strandgate 12 A, Kristiansand

9 June 2015	**Day 2** | Location: Teknova, Terje Løvås vei 1, 4879 Grimstad

08:30	Delegates bus departure from Hotel Scandic Bystranda* in Kristiansand to workshop venue**
	* Østre Strandgate 74, 4608 Kristiansand | **To be announced

09:00-09:15	*Coffee break*

Session 5	Diagnostics and prognostics

09:15-09:45	**Recent development of acoustic emission based health monitoring and fault diagnosis techniques and methodologies.** Prof. David He, Director of Intelligent System Modelling & Development Laboratory.

09:45-10:15	**Performance based monitoring and diagnostics of electrical submersible pump systems: A case study** Dr. Dheeraj Sing, Postdoctoral fellow at the department of electrical and computer engineering, University of Alberta Canada.

10:15-10:30	*Coffee break*

10:30-11:00	**Mathematical methods for prognostics** Dr. Rune Schlanbusch, Senior Scientist Physics for Teknova

11:00-11:30	**An integrated online condition monitoring and prognostic framework for rotating equipment**

11:30-12:00	**Wrap up of session 5**

11:30-12:30	*Lunch*

12:30-14:30	**Visit to an equipment manufacturer**

14:30-15-00	Delegates bus departure from the workshop venue* to: Hotel Scandic Bystranda** and then Kristiansand airport.
	*TBA | ** Østre Strandgate 74, 4608 Kristiansand

Remote control is the next step for oil and gas

Spanning the history of the oil and gas industry, from spinningchains and hard core manual labor on-site – to more automated work processes, there is no doubt what is the next step for oil and gas: Integrated operations remotely controlled from land.

Also, to do maintenance when maintenance is needed, not at fixed intervals, will increase the all-important operation hours of a rig, a ship or any other installation.

Both measures would reduce costs in an industry where cost reduction is highly anticipated.

Anne-Grete Ellingsen

> **CEO of Global Center of Expertise NODE (Norwegian Offshore & Drilling Engineering)**

Ellingsen is the CEO of GCE NODE – a world-leading technology cluster serving the global energy and maritime industries. She holds a BSc in chemistry, a MSc. in Petroleum Technology, a BSc. in Economics and an Executive Master in Energy Management. She has participated in AFFs leadership courses for managers and senior executives.

Ellingsen has experience from several executive positions; CEO of Vestavind Offshore, Director of strategy and business development at Statkraft Agder Energi Vind, Managing Director of Agder Energi Produksjon and Director of foreign investments in Agder Energi. Her experience includes Director of the affinity/partner marked for Gjensidige Group, Managing Director of the Federation of Norwegian Commercial and Service Enterprises (HSH), several management positions in up- and downstream oil and gas operations with Statoil and Elf Aquitaine (now Total) in Norway and international, covering both on- and offshore operations. She has been Secretary General of the World Petroleum Congress and Deputy minister at the Ministry of Oil and Petroleum.

Condition Based Maintenance
– Barriers to Implementation

The concept of Condition Based Maintenance (CBM) is very appealing. Being able to use the full life of components in an asset would seem to make good economic sense. The reality of how CBM can be applied to assets then requires a more in-depth view and many different factors, that can be seen as barriers to its implementation, emerge.

That is not to say that condition, or health, management cannot be used to achieve economic benefit, a number of examples show this to be true; rather that the attainment of true CBM is at the moment beyond our grasp.

This talk will explore a number of issues surrounding implementation of CBM, illustrated mostly from the civil aerospace sector, show some CBM enabling technology, and draw some conclusions for future direction.

Professor Ian K. Jennions

> **Director of the Integrated Vehicle Health Management Centre (IVHM) at Cranfield University (UK).**

> **Director of the Prognostics and Health Management (PHM) Society.**

> **Vice-chairman of SAE's IVHM Steering Group.**

The career of Professor Jennions spans some 40 years, working mostly for a variety of gas turbine companies. He has a Mechanical Engineering degree and a Ph.D. in CFD, both from Imperial College, London. He has worked for Rolls-Royce (twice), General Electric and Alstom in a number of technical roles, gaining experience in aerodynamics, heat transfer, fluid systems, mechanical design, combustion, services and IVHM. He moved to Cranfield in July 2008 as Professor and Director of the newly formed IVHM Centre. The centre is funded by a number of industrial companies, including Boeing, BAE Systems, Rolls-Royce, Thales, Meggitt, MOD and Alstom Transport. He has led the development and growth of the centre, in research and education, since its inception.

He is also on the editorial Board for the International Journal of Condition Monitoring, a Director of the PHM Society, vice-chair of the SAE IVHM Steering Group and contributing member of the HM-1 IVHM committee, a Chartered Engineer and a Fellow of IMechE, RAeS and ASME.

Application of HUMS (Health and Usage Monitoring System) techniques to industrial condition monitoring. Examples of a case study from the aerospace industry: development of HUMS for helicopters.

The condition monitoring (CM) requirements of helicopter are for example (1) gearbox analysis and the need for actionable information to the component level, (2) Multi-plane rotor balance, (3) Structural health monitoring and (4) The effect of the helicopter regime on measurements.

These have led to the development of power analysis tools, which can be applied to Industrial CM. Such tools lead to improved component fault detection, diagnostics and prognostics. Prognostic techniques can greatly improve logistics support and help reduce overall cost of system.

Dr. Eric Bechhoefer

> **President of GPMS.**

> **Affiliated Chief Scientist at Teknova.**

Dr. Bechhoefer is the president of GPMS, Inc., a company focused on the development of low cost condition monitoring systems for aerospace and industrial applications. He is the author of more than 100 juried papers on condition monitoring and prognostics health management, and holds 23 patents in the field of CBM. He also holds six best paper nominations, and was awarded IEEE Green Mountain Section 2012 Engineer of the Year. He is on the board of Directors of the Prognostics Health Management Society.

Dr. Bechhoefer was a former Naval Flight Officer and Combat Officer on the USS Dwight D. Eisenhower, as well at the Senior Technologist at Goodrich Aerospace, and Chief Engineer at NRG Systems, prior to starting his own company.

Presentation of the financial benefits of the HUMS (Health and Usage Monitoring System) program on the helicopter fleet CH-146 Griffon.

Over the years, the cost/benefit balance of HUMS available for rotorcraft have generated much debate, especially at the procurement phase of new aircraft. Currently, there is consensus within and outside the HUMS community regarding the safety benefits of having a HUMS system installed.

The talk will show that the total savings of the HUMS program are conservatively estimated at $2.1M per year, which definitively surpasses the annual investment required to keep the program running.

Terry Murphy

> **Specialist HUMS / HUMS 1st Line Support Specialist.**

> **Provide direct support to the Royal Canadian Air Force (Bell 412) CH146 Griffon Helicopter Fleet.**

> **Provide direct support to 11 squadrons of helicopters located throughout Canada.**

Terry Murphy is the Health and Usage Monitoring Systems Program Lead (HUMS) for Bell Helicopter Textron Canada limited (BHTCL). Under contract with the Canadian Department of National Defense, Terry (BHTCL) provides technical management, support and training for a fleet of Bell 412 aircraft across Canada. He holds a Level II, Category 3 certification in vibration analysis, numerous aircraft technical training courses and 17 years' experience in the field of HUMS.

Murphy was a member of the Royal Canadian Air Force for 32 years, retiring as a Warrant Officer in 2011 when he joined Bell Helicopter Canada. During the last 17 years, he has travelled extensively training and promoting the benefits of the HUMS program. Originally from St. John's Newfoundland, Canada, he currently lives in Oromocto, New Brunswick.

Message from the machine

As a global actor in the drilling market, covering land and offshore parts of industry, National Oilwell Varco (NOV) is also part of the business chain from equipment design to complete overhaul phase. These factors place NOV centrally to have interest in developing advanced monitoring and maintenance solutions.

As a part of the program, NOV develops and deploys different but complementary analytical solutions (physical modeling) and data driven methods (machine learning).

We will present some overview and user cases in both approaches.

Julian Zec

> **Engineering Manager Condition Monitoring, National Oilwell Varco**

Julian Zec works with development of global CM and CBM solutions with focus on analytics and knowledge/communication systematization for National Oilwell Varco. He has his degree in MSc Cybernetics, Signal Processing and physics, Bsc Clinical Engineering from the University of Stavanger, and a grade in Organizational Development and Leadership from Norwegian School of Economics in Bergen (NHH), certificate in chemistry. He has 10 years of work experience in the oil and gas industry – within R&D, engineering, EPCI and operations (offshore and onshore) from NOV, Seadrill and FMC Technologies, and is currently working as an Engineering Manager Condition Monitoring at NOV.

CBM, Big Data and the Proactive Enterprise

Monitoring of industrial processes and operations create huge amounts of data. The challenge is to make sensible use of the data collected. The EU funded project ProaSense is an initiative across six countries with a total budget of 4.2 million Euro over three years.

The industrial partners are MHWirth and HELLA Saturnus in Slovenia. The research partners are SINTEF in Norway (lead), FZI in Germany, JSI in Slovenia, Uninova in Portugal, ICCS in Greece and Nissatech in Serbia. The aim is to create a scalable, distributed computer architecture based around the OODA loop: Observe, Orient, Decide and Act.

The system shall be capable of analyzing live streams of sensor and human input data from various sources, starting with data enrichment followed by complex event processing, decision support and direct action (or when not allowed: recommendation of action). The first version has been implemented and is now being tested on the industrial use cases. The second iteration will be carried out in 2016.

Dr. Tor I. Waag

> **Technical Advisor, MHWirth**
> **Affiliated Senior Scientist Physics, Teknova**

Dr. Tor I. Waag received his PhD and MSc from NTNU in Trondheim, Norway, both in laser light scattering and signal processing related to photon correlation spectroscopy. After his PhD he received a grant to spend a year with Chevron Oil Field Research Laboratory in La Habra, California to become familiar with technology relevant for the petroleum industry. He has worked with SINTEF Petroleum Research in the fields of seismic acquisition and processing, ultrasonic NDT and electromagnetic sensors, and later in the SINTEF spin-off company Sensorlink with condition monitoring of pipelines and offshore equipment, geomagnetic modelling for improvement of wellbore surveying accuracy, and Extremely Low Frequency electromagnetic communication through steel pipeline walls. Waag is affiliated with Teknova and now holds a position as Technical Advisor in MHWirth, working with CBM for offshore drilling equipment. He is an elected member of the Norwegian Academy of Technological Sciences (NTVA).

Event detection during pressure managed drilling – generic methodology and a case study.

A generic methodology is presented and its features and benefits are demonstrated via case studies.

Detection of changes in a process can be based on monitoring of signals that carry information about physical variables of the process. Conventional monitoring and alarm systems check whether values from individual sensors exceed a threshold. Prognosis of faults or diagnosis that an incident is under development requires far more elaborate techniques.

The talk will show how statistical change detection methods can detect events early in their development, often much earlier than change is noticeable to human operators, and it explains how very low false alarm probability can be combined with high sensitivity to actual changes in the process through recent progress in research.

Professor Mogens Blanke

> **Professor at Technical University of Denmark.**

> **Adjunct Professor at NTNU, Norway.**

> **Technical Editor, IEEE Transactions on Aerospace and Electronic Systems.**

> **Associate Editor, Control Engineering Practice.**

Mogens Blanke is Professor in Automation and Control at the Technical University of Denmark and Adjunct Professor at Institute of Technical Cybernetics at NTNU in Trondheim. His career included six years in industry, one within aerospace and five within marine automation. His recent research has focused on theoretic and engineering methods for fault-diagnosis and fault-prognosis, fault-tolerance in autonomous systems and systems architectures to obtain desired safety properties.

Blanke had a central role in pioneering the area of fault-tolerant control, demonstrating both ideas towards a methodology in the area and widely recognized applications of the methods including fault-tolerant attitude control for the Danish Ørsted satellite in addition to application in several industrial, robotic and marine systems. Blanke has strived to combine theory development with engineering applicability, and has obtained genuine experience with a range of physical and mechanical systems. He is Technical Editor for IEEE Transactions on Aerospace and Electronic Systems and Associate Editor for Control Engineering Practice.

Recent development of acoustic emission based health monitoring and fault diagnosis techniques and methodologies.

Vibration sensors and corresponding analysis methods have been utilized as the industry standard for machinery health monitoring and fault diagnosis over the past years. However, acoustic emission (AE) analysis based methodologies recently have captured growing acceptance.

In comparison with the most widely used vibration signals, AE signals have the following advantages: (1) insensitive to structural resonance and unaffected by typical mechanical background noises, (2) more sensitive to activities of faults, (3) provide good trending parameters and (4) localization of measurements to the machine being monitored.

These advantages make the AE based techniques potentially more competitive than the vibration based techniques for the rotational machinery health monitoring and fault diagnosis.

Professor David He

> **Director of Intelligent Systems Modeling & Development Laboratory, University of Illinois, Chicago**

> **Associate Editor, Journal of Intelligent Manufacturing.**

David He received his B.S. degree in metallurgical engineering from Shanghai University of Technology, MBA degree from The University of Northern Iowa, and Ph.D. degree in industrial engineering from The University of Iowa in 1994. He is a Professor and Director of the Intelligent Systems Modeling & Development Laboratory in the Department of Mechanical and Industrial Engineering at The University of Illinois, Chicago.

Dr. He's research areas include machinery health monitoring, diagnosis and prognosis, failure analysis of complex systems, quality and reliability engineering, and manufacturing systems design, modeling, scheduling and planning.

Performance based monitoring and diagnostics of electrical submersible pump systems: A case study

The talk will give an insight into ESP (Electrical Submersible Pump) system, its failure modes, and key sensors used for asset monitoring. A performance model (with a case study) will be presented for fault detection in ESP wells. Due to the nature of the subsea environment, the quantity of data to assess the health of an ESP is limited. Therefore a performance model based approach (using limited down-hole and surface data) is developed to estimate key performance indicators.

Statistical changes in the pattern of performance indicators is further used to detect, some common fault in ESP system (wear, shaft damage, hole in tubing) and well condition (increase in water cut, increase in reservoir pressure).

Dr. Dheeraj Singh

> **Postdoctoral fellow at the department of electrical and computer engineering, University of Alberta Canada.**

Dr. Singh finished his doctorate in Mechanical Engineering at Pennsylvania State University. His doctoral thesis is in the area of fault detection and estimation. He completed his Masters Degree in Mechanical Engineering at Indian Institute of Technology, Kharagpur, followed by a two years break from academics to gain industrial experience. After deciding to return back to academics, he joined Penn State University in 2006 as a doctoral student and then enrolled for concurrent Master Program in Electrical Engineering.

Prior to his Ph.D. he worked at the Engineering Research Center at Tata Motors Ltd. as a senior design engineer. After two years with Tata Motors, he moved to the US to pursue his Ph.D., and then joined Global Research Center, GE Bangalore, where he worked on Diagnostics and Prognostic methods for different mechanical system, specifically for electrical submersible pump. Dr. Singh is currently a postdoctoral fellow at University of Alberta. His research mainly focuses on developing novel employed for detection, diagnosis and prognostics of mechanical faults in complex systems.

Teknova is an independent non-profit institute for applied R&D. Its core competences include the fields of *Smart Instrumentation, Modelling & Simulation*, and *Energy & Environmental Technologies*. A team of talented and dedicated researchers working at the forefront of scientific innovation, bring forward solutions that create value to the customers - mainly within the process, oil & gas, and cleantech industries.

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