THE 15TH WORLD CONGRESS ON ENGINEERING ASSET MANAGEMENT

AUG 15-18, 2021
Bonito, Brazil - Virtual Event

PROGRAM & ABSTRACT BOOKS

Organizers and partners:
15th WORLD CONGRESS ON ENGINEERING ASSET MANAGEMENT

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PRESENTATION

Dear Attendees,

The 15th WCEAM will provide a pleasant forum for high-quality deliberations on technical, economic issues centered around sustainable management of engineered assets in the era of the fourth industrial revolution technologies and globalization 4.0 business models. Paper presentations and panel discussions will cover industry sectors such as aeronautics & aerospace, agriculture & agro-processing, construction & built environment, conventional & renewable energy electricity and water utilities, maritime, public infrastructure especially education & health care delivery and transportation, manufacturing, mining & minerals processing especially oil & gas, and telecommunications.

This is the detailed program and the abstracts of the papers that will be presented in the 15th WCEAM. If you have any questions, we are more than happy to assist you through email: wceam2021@ufms.br.

Thank you,

Prof. João O. P. Pinto

15TH WCEAM 2021 Chair
Federal Univ. of Mato Grosso do Sul, Brazil
KEYNOTE SPEECH

KEYNOTES

Name: LUIZ HENRIQUE MANDETTA  
Title: CHALLENGES WITH INFRASTRUCTURE TO SUPPORT COVID-19 VACCINATION ROLL-OUT  
Date/Hour: 16 August (Monday) | 09:00 – 10:30

Name: KOFI SMITH  
Title: MANAGING AIRPORT INFRASTRUCTURE DURING COVID-19  
Date/Hour: 17 August (Tuesday) | 09:00 – 10:30

Name: MARIO CESAR MASSA DE CAMPOS  
Title: ASSET CONTROL, MONITORING AND DIAGNOSTIC IN INDUSTRY 4.0 - EXAMPLES IN THE OIL&GAS INDUSTRY  
Date/Hour: 18 August (Wednesday) | 09:00 – 10:30

WORKSHOPS

Workshop Session MW1
Name: HUAI WANG  
Title: Decision-Making Tools for PV Inverter Maintenance in Solar Power Plants  
Date/Hour: 16 August (Monday) | 12:00 – 13:30

Workshop Session MW2
Name: DAN NOWER P.E.  
Title: Motion Amplification and Machine Condition Monitoring  
Date/Hour: 16 August (Monday) | 12:00 – 13:30

Workshop Session TW2
Name: DAVID HOOD (Chair)  
Title: On Climate Change Sustainability and Infrastructure Asset Management  
Date/Hour: 17 August (Monday) | 12:00 – 13:30

Workshop Session TW2
Name: RON MOORE  
Title: Reliability Excellence, including performance metrics and case studies  
Date/Hour: 17 August (Monday) | 12:00 – 13:30
### SUMMARY SCHEDULE

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<td>Keynote 1 Challenges with infrastructure to support Covid-19 vaccination rollout</td>
<td>Keynote 2 Managing Airport Infrastructure during Covid-19</td>
<td>Keynote 3 Asset Control, Monitoring and Diagnostic in Industry 4.0 - Examples in the Oil &amp; Gas Industry</td>
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<td>Workshop Session MW1 Decision-Making Tools for PV Inverter Maintenance in Solar Power Plants Prof. Kuan Meng, Aalborg University, Denmark</td>
<td>Workshop Session TW2 On Climate Change Sustainability and Infrastructure Asset Management</td>
<td>Workshop Session WC1 Reliability Excellence, including performance metrics and case studies | Ron Narra, Managing Partner, The RM Group, Inc</td>
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SCHEDULES

16 August (Monday)

07:00 – 07:30 OPENING CEREMONY & WELCOME

Moderator: João Pinto

07:00 – 07:10 Brazilian welcome
João Onofre Pereira Pinto

07:10 – 07:30 ISEAM welcome
Joe Amadi-Echendu

PAPER SESSIONS

07:30 – 09:00 Paper session MA1 (Industry Presentations - Category C)

Chairs: Lutfiye Manli
Dimitris Kyritsis

07:30 – 07:50 PAPER ID04- STRATEGIC ASSET MANAGEMENT UNDER ENERGY TRANSFORMATION
Lutfiye Manli

07:50 – 08:10 PAPER ID05- DIGITAL ASSET MANAGEMENT UNDER ENERGY TRANSFORMATION
Lutfiye Manli, Nathaniel Dunnett

08:10 – 08:30 PAPER ID13- ONTOLOGIES AND DIGITALIZATION FOR ACHIEVING PREDICTIVE MAINTENANCE: +GF+’S MACHINE TOOL OPTIMUM PRODUCTION FACTORY 4.0
Marlène Hildebrand, Dimitris Kyritsis, Jérome Clavel, Roberto Perez

08:30 – 08:50 PAPER ID33- ASSET MANAGEMENT PENETRATES SUCCESS CULTURE IN SAUDI ARAMCO
Mohammed Altawili
PAPER SESSIONS

07:30 – 09:00 Paper session MA2 (Category A)
Chairs: Antonio Guillen
Adolfo Crespo

07:30 – 07:50 PAPER ID76- CAN INDUSTRY 4.0 KEEP ITS PROMISES? A LITERATURE-BASED COMPARISON OF EXPECTATIONS AND EXPERIENCES
Lasse Metso, Nils Thenent

07:50 – 08:10 PAPER ID10- A MAINTENANCE MANAGEMENT IMPROVEMENT FRAMEWORK FOR ASSET MANAGEMENT
Renan F. da Silva, Gilberto F. M. Souza

08:10 – 08:30 PAPER ID40- AN INTANGIBLE ASSET MANAGEMENT PROPOSAL BASED ON ISO 55001 AND ISO 30401 FOR KNOWLEDGE MANAGEMENT
Vicente González-Prida, Antonio Guillén, Carlos Parra, Eduardo Candón Fernández, Pablo Martínez-Galán Fernández

08:30 – 08:50 PAPER ID70- THE TRANSITION OF MANAGEMENT AND ACCESS TO INFORMATION IN A MANUFACTURING COMPANY OF MEDIUM SIZE THROUGH ISO 55001 REQUIREMENTS AND INDUSTRY 4.0 MACHINES ACQUISITION
Ana Carolina Gandini Panegossi, Ethel Cristina Chiari da Silva

PAPER SESSIONS

07:30 – 09:00 Paper session MA3 (Category A)
Chairs: Robin Platfoot
Turuna Seecharan

07:30 – 07:50 PAPER ID09- THE JOURNEY TOWARDS SUCCESSFUL APPLICATION OF MAINTENANCE 4.0 AND SERVICE MANAGEMENT 4.0
Mirka Kans

07:50 – 08:10 PAPER ID57- INFLUENCE OF THE EAMS MASTER DATA ON IMPLEMENTING MAINTENANCE STRATEGY
Robin Platfoot

08:10 – 08:30 PAPER ID22- FAULT DIAGNOSIS AND ISOLATION FOR DIESEL ENGINE COMBUSTION CHAMBERS BASED ON AUTOENCODER AND BP NEURAL NETWORK
Yonghua Yu, Jia Hu, Jianguo Yang
08:30 – 08:50  PAPER ID19- System for Early Detection of Insulation Failures of Electric Machinery  
Bruno Reno Gama, Wilson Cesar Sant’Ana, Luiz Silva, Erik Bonaldi, Germano Lambert-Torres, Camila Paes Salomon, Isaac Antonio dos Santos Areias, Daniel Almeida Arantes, Fernanda Vilas Boas, Fabio Monteiro Steiner, Rafael Bartholomeu Bernardo Carvalho

KEYNOTE  
Moderator: Joe Mathew

09:00 – 10:30  KEYNOTE 1: CHALLENGES WITH INFRASTRUCTURE TO SUPPORT COVID-19 VACCINATION ROLL-OUT  
LUIZ HENRIQUE MANDETTA (former Brazilian Health Minister)

PANEL SESSIONS
10:30 – 12:00  Coordinators: Joao Pinto & Joe Amadi-Echendu

10:30 – 11:15  Panel Session 1: RESEARCH TRENDS IN ASSET MANAGEMENT  
UFMS Brazil  
Prof Ruben Barros Godoy, Federal Univ. of Mato Grosso do Sul, Brazil  
Prof Luigi Galotto Junior, Federal Univ. of Mato Grosso do Sul, Brazil  
Prof Moacyr A. Gomes de Brito, Federal Univ. of Mato Grosso do Sul, Brazil

WORKSHOP SESSIONS
12:00 – 13:30  Coordinators: Belle Upadhyaya  
Ype Wijnia

12:00 – 13:30  Workshop Session MW1: DECISION-MAKING TOOLS FOR PV INVERTER MAINTENANCE IN SOLAR POWER PLANTS  
Prof Huai Wang, Aalborg University, Denmark

12:00 – 13:30  Workshop Session MW2: MOTION AMPLIFICATION AND MACHINE CONDITION MONITORING  
Dan Nower P.E. RDI Technologies, Inc

MEETING SESSION
13:30 – 14:00  ISEAM Meeting
17 August (Tuesday)

07:00 – 07:30  ISEAM Awards

Moderator: Joe Amadi-Echendu & Joe Mathew

07:00 – 07:15  ISEAM Lifetime Achievement

Joe Mathew

07:15 – 07:30  ISEAM Achievement

Joe Amadi-Echendu

PAPER SESSIONS

07:30 – 09:00  Paper session TA1 (Category A)

Chairs: Lin Ma
Michael Cholette

07:30 – 07:50  PAPER ID61- CONDITION-BASED INSPECTION GROUPING POLICY FOR BOILER HEAT EXCHANGER TUBES

Huy Truong-Ba, Michael Cholette, Lin Ma, Geoff Kent

07:50 – 08:10  PAPER ID66- RAILWAY TRACK GEOMETRY DEGRADATION MODELLING AND PREDICTION FOR MAINTENANCE DECISION SUPPORT

Sinda Rebello, Michael Cholette, Huy Truong-Ba, Venkat Reddy, Alan Rosser, Tina Watkin

08:10 – 08:30  PAPER ID36- PROPOSITION OF A GENERIC DECISION FRAMEWORK FOR PRESCRIPTIVE MAINTENANCE DECISION-MAKING: AN APPLICATION TO THE AUTOMOTIVE SECTOR

Pedro Dias Longhitano, Khaoula Tidriri, Christophe Berenguer, Benjamin Echard

08:30 – 08:50  PAPER ID15- REVISITING AGRICULTURAL TECHNOLOGIES IN THE 4IR ERA

Anthea Amadi-Echendu, Nonceba Tyatyantsi
PAPER SESSIONS
07:30 – 09:00  Paper session TA2 (Category A)
   Chairs: Jouko Laitinen
            Ype Wijnia

07:30 – 07:50  PAPER ID65- DEVELOPING A LUBRICATION OIL AGE PREDICTION MODEL
   Najat Mohammad Nazari, Masdi Muhammad

07:50 – 08:10  PAPER ID58- THE EFFECT OF KNOWLEDGE BASED FEATURE EXTRACTION ON FAILURE DETECTION OF CONTROL SURFACE FAILURES OF FIGHTER AIRCRAFT
   Tauno Toikka, Jouko Laitinen, Kari Koskinen

08:10 – 08:30  PAPER ID20- MODEL PROPOSAL FOR FAILURE DETECTION AND CLASSIFICATION OF INTERNAL COMBUSTION ENGINE OPERATING CONDITION

08:30 – 08:50  PAPER ID50- A STRATEGIC ASSET MANAGEMENT FRAMEWORK FOR IMPROVING TRANSPORT INFRASTRUCTURE: ANALYSIS FOR BELGIAN LAND TRANSPORT MODES
   Laura Molinari, Elvira Haezendonck, Manuel Hensmans

PAPER SESSIONS
07:30 – 09:00  Paper session TA3 (Category A)
   Chairs: Nuno Almeida
            Adolfo Crespo

07:30 – 07:50  PAPER ID41- OVERVIEW FOR LEASING OR BUYING DECISIONS IN INDUSTRIAL ASSET MANAGEMENT
   Vicente González-Prida, Carlos Parra, Fredy Kristjanpoller, Pablo Viveros, Antonio Guillén, Adolfo Crespo

07:50 – 08:10  PAPER ID82- MACHINE LEARNING BASED PREDICTION OF FATIGUE EVENTS IN RAILWAY RAILS
   Vincent Laurent, Olivier Vo Van, Mathilde Mougeot

08:10 – 08:30  PAPER ID94- SIMULATION-BASED AUTOMATION FOR CONSISTENT ASSET MANAGEMENT DECISIONS: PILOT-TEST APPLICATION FOR ASSESSING URBAN RESILIENCE
Seyed Rezvan, Nuno Almeida, Maria João Falcão Silva, Marta Duarte

08:30 – 08:50  PAPER ID97- EXPLORING THE USE OF POWER BI DASHBOARDS TO SUPPORT ASSET MANAGEMENT PLANNING DECISIONS
Pedro Costa, Jaime Silva, Lígia Ramos, Nuno Almeida, Ana Camanho

KEYNOTE
Moderator: Joe Amadi-Echendu

09:00 - 10:30: KEYNOTE 2: MANAGING AIRPORT INFRASTRUCTURE DURING COVID-19
DR. KOFI SMITH (CEO Keystone Management & former CEO Atlanta Airlines Terminal Company)

PAPER SESSIONS
10:30 – 12:00  Paper session TB1 (Category A)
Chairs: Mirka Kans
Ype Wijnia

10:30 – 10:50  PAPER ID07- EXPLORING THE RELATIONSHIP BETWEEN MAINTENANCE AND SUSTAINABILITY - A LITERATURE REVIEW
Ramsey Jardim, Mirka Kans

10:50 – 11:10  PAPER ID87- BENCHMARKING ASSET INFORMATION QUALITY OF A UTILITY COMPANY IN BRAZIL
Bruno Pinto Vieira, Marco Antônio Calijorne Soares, Fernando Parreiras, José Ricardo Gonçalves, Bárbara Guimarães Penna

11:10 – 11:30  PAPER ID08- ASSESSING THE ECONOMIC AND ENVIRONMENTAL EFFECTS OF GRAVEL RECYCLING DURING GRAVEL ROAD MAINTENANCE
Nea Svensson, Mirka Kans

11:30 – 11:50  PAPER ID88- ASSET INFORMATION MANAGEMENT SYSTEMS: CRITICAL SUCCESS FACTORS IN THE BRAZILIAN ELECTRICITY SECTOR
Alexsandro Teixeira Gomes, Fernando Parreiras
PAPER SESSIONS
10:30 – 12:00  Paper session TB2 (Category A)
   Chairs: Joao Pinto
   Raymundo Cordero Garcia

10:30 – 10:50  PAPER ID02- ALIGNING ASSET MANAGEMENT WITH THE UN SUSTAINABLE
   DEVELOPMENT GOALS FOR THE GOVERNMENT OF BANGLADESH AND
   HELPING TO BUILD RESILIENCE IN BANGLADESH
   Caroline Elms, Peter Scuderi, Kaitlin Shilling, Nahila Rahman

10:50 – 11:10  PAPER ID31- FACILITATING CHANGE TOWARDS PREDICTIVE MAINTENANCE
   Martine Van den Boomen, Marc Botermans, Thijs De Weerd, Andreas Burzel

11:10 – 11:30  PAPER ID79- APPLICATION OF FREQUENCY DIVISION MULTIPLEXING AND
   NEURAL NETWORKS IN THE OPERATION AND DIAGNOSIS OF THE STATOR
   CURRENT AND SHAFT POSITION SENSORS USED IN ELECTRIC/HYBRID
   VEHICLES
   Raymundo Cordero, Thyago Estrabis, Polynne Modesto, Joao Pinto

11:30 – 11:50  PAPER ID80- MODELLING THE EFFECT OF MAINTENANCE-INDUCED FAILURES
   FROM PERIODIC TESTING OF SAFETY-CRITICAL EQUIPMENT IN THE OIL AND
   GAS INDUSTRY
   Jon Selvik, Hans Petter Lohne

PAPER SESSIONS
10:30 – 12:00  Paper session TB3 (Industry Presentations - Category C)
   Chair: Turuna Seecharan

10:30 – 10:50  PAPER ID35- SUSTAINABLE ENERGY SYSTEM ASSET MANAGEMENT:
   MODELLING TO SUPPORT DECISION MAKING
   Andrew Kilmartin

10:50 – 11:10  PAPER ID46- REPAIR AND PROTECTION FOR BEARINGS AND GEARS BY USING
   SILICON-BASED ADDITIVE TECHNOLOGY
   Stefan Bill, E. Michael Konig

11:10 – 11:30  PAPER ID60- MOBILE TECHNOLOGY FOR MAINTENANCE AND IMPROVEMENT
   OF ASSET MANAGEMENT IN BOLIVIA-BRAZIL GAS PIPELINE
   Rogério Orlandeli Sanches

11:30 – 11:50  PAPER ID86- USING DIGITAL TWIN FOR ASSET INTEGRITY MANAGEMENT - A
   SUBSEA EQUIPMENT USE CASE
   Otavio Correa, Jorge Luiz Seleme Mariano
WORKSHOP SESSIONS
12:00 – 13:30  Coordinators: Belle Upadhyaya
Joao Pinto

12:00 - 13:30 WORKSHOP SESSION TW1: On Climate Change Sustainability and Infrastructure Asset Management
DAVID HOOD (Chair, Long Future Foundation)

12:00 - 13:30 WORKSHOP SESSION TW2: Reliability Excellence, including performance metrics and case studies
RON MOORE (Managing Partner, The RM Group, Inc)

MEETING SESSION
14:00 - 15:00: Organizing Committee Meeting

18 August (Wednesday)

07:00 – 07:30 BEST PAPER AWARDS & 16TH WCEAM ANNOUNCEMENT
Moderators: Belle Upadhaya & Adolfo Crespo
07:00 - 07:15 Best paper awards
Belle Upadhaya
07:15 - 07:30 16th WCEAM announcement
Adolfo Crespo

PAPER SESSIONS
07:30 – 09:00  Paper session WA1 (Category A)
Chairs: Kerry Brown
Raymundo Cordero Garcia

07:30 – 07:50 PAPER ID72- THE VALUE OF BUSINESS PROCESS MANAGEMENT TO UNDERSTAND COMPLEX ASSET MANAGEMENT PROCESSES
Kanika Goel, Michael Cholette, Moe T Wynn, Lutfiye Manli, Lara Meyers

07:50 – 08:10 PAPER ID06- TOWARDS EVIDENCE-BASED DECISION MAKING IN ASSET MANAGEMENT
19

08:10 – 08:30  PAPER ID17- HOW TO BUILD AN OPTIMAL LONG-TERM ASSET RENEWALS AND MODERNIZATION PLAN DRIVEN BY QUANTIFIED COST/RISK/PERFORMANCE VALUE
John Woodhouse, Saulo Trento, Peter Jay

08:30 – 08:50  PAPER ID96- SPEED OF INNOVATION DIFFUSION IN GREEN HYDROGEN TECHNOLOGIES
Lourenço Correia, Oliver Schwabe, Nuno Almeida

PAPER SESSIONS
07:30 – 09:00  Paper session WA2 (Category A)
Chairs: Helena Kortelainen
        Joao Pinto

07:30 – 07:50  PAPER ID92- A SENSOR-LESS DAYLIGHT HARVESTING APPROACH USING CALIBRATION TO REDUCE ENERGY CONSUMPTION IN BUILDINGS
Brenden Harris, Juan Montes

07:50 – 08:10  PAPER ID52- TURNAROUND MAINTENANCE IN PROCESS INDUSTRY: CHALLENGES AND POTENTIAL SOLUTIONS
Antti Rantala, Helena Kortelainen, Toni Ahonen

08:10 – 08:30  PAPER ID42- RESILIENCE RATING SYSTEM FOR BUILDINGS AGAINST NATURAL HAZARDS
Marta Duarte, Nuno Almeida, Maria João Falcão Silva, Seyed MHS Rezvani

08:30 – 08:50  PAPER ID78- DEVELOPING ASSET OPERATIONS AND MAINTENANCE STRATEGY TO DEAL WITH IMPACT OF COVID-19
Ibifuro Ihemegbulem, David Baglee

PAPER SESSIONS
07:30 – 09:00  Paper session WA3 (Category A)
Chairs: Jeremy Novak
        Marcio L. M. Kimpara

07:30 – 07:50  PAPER ID68- CREATING VALUE AND BUSINESS BENEFITS FROM JOINT OFFERINGS OF ASSET PERFORMANCE MANAGEMENT TOOLS IN THE CAPITAL-INTENSIVE INDUSTRIES
Minna Rääkkönen, Leila Saari, Katri Valkokari, Antti Rantala, Helena Kortelainen
07:50 – 08:10  PAPER ID93- FRAMEWORK FOR THE USE OF BLOCKCHAIN TO SUPPORT THE DEVELOPMENT OF ASSET INFORMATION MODELS
Mohammad Darabseh, João Poças Martins

08:10 – 08:30  PAPER ID95- DIGITAL TWINS IN ASSET MANAGEMENT: POTENTIAL APPLICATION USE CASES IN RAIL AND ROAD INFRASTRUCTURES
João Vieira, João Clara, Hugo Patricio, Nuno Almeida, João Poças Martins

08:30 – 08:50  PAPER ID98- THE POTENTIAL FOR DIGITAL TWIN APPLICATIONS IN RAILWAY INFRASTRUCTURE MANAGEMENT
Christiaan Doubell, Karel Kruger, Anton Basson, Pieter Conradie

KEYNOTE
Moderator: João Pinto

09:00 - 10:30:  KEYNOTE 3: ASSET CONTROL, MONITORING AND DIAGNOSTIC IN INDUSTRY 4.0 - EXAMPLES IN THE OIL&GAS INDUSTRY
MARIO CAMPOS (CEO SmartAutomation)

PAPER SESSIONS
10:30 – 12:00  Paper session WB1 (Category A)
Chairs: Damjan Maletic
         Ype Wijnia

10:30 – 10:50  PAPER ID11- CASE STUDY CRITIQUE OF ISO 5500X-BASED AUDITING AND CERTIFICATION
Joe Amadi-Echendu, Kolomane Khoarai, Mapule Lebata

10:50 – 11:10  PAPER ID14- CONTINUOUS QUALITY IMPROVEMENT AND BUSINESS PERFORMANCE: THE MEDIATING ROLE OF PHYSICAL ASSET MANAGEMENT
Damjan Maletič, Basim Al-Najjar, Matjaž Maletič, Boštjan Gomišček

11:10 – 11:30  PAPER ID12- CONDITION ASSESSMENT OF ENGINEERED ASSETS IN ERA OF SOCIETY 5.0
Joe Amadi-Echendu, George Botholo, Keaton Raman

11:30 – 11:50  PAPER ID16- PRAGMATIC PERFORMANCE MANAGEMENT
Ype Wijnia
PAPER SESSIONS
10:30 – 12:00 Paper session WB2 (Category A)
  Chairs: Joao Pinto
          Jouko Laitinen

10:30 – 10:50 PAPER ID59- FAILURE DETECTION AND ISOLATION BY LSTM AUTOENCODER
  Tauno Toikka, Jouko Laitinen, Kari Koskinen

10:50 – 11:10 PAPER ID75- EFFICIENT IMPLEMENTATION OF ARTIFICIAL NEURAL NETWORKS FOR SENSOR DATA ANALYSIS BASED ON A GENETIC ALGORITHM
  Andre Estefani, Raymundo Cordero, Joao Pinto

11:10 – 11:30 PAPER ID91- MACHINE LEARNING APPROACH FOR ASSET INFORMATION INTEGRATION
  José Ricardo Gonçalves, Bruno Pinto Vieira, Marco Antônio Calijorne Soares, Fernando Parreiras

11:30 – 11:50 PAPER ID84- ONLINE TEMPERATURE ESTIMATION OF PERMANENT MAGNET SYNCHRONOUS MACHINES (PMSM) USING NON-LINEAR AUTOREGRESSIVE NEURAL NETWORKS WITH EXOGENOUS INPUT (NARX)
  Thainara de Araújo, Renan Aryel Fernandes da Silva, Marcio L M Kimpara, Joao Pinto

PAPER SESSIONS
12:00 – 13:30 Paper session WC1 (Category A)
  Chairs: Turuna Seecharan
          Georges Abdul-Nour

12:00 – 12:20 PAPER ID26- ASSET MANAGEMENT AND ENERGY EFFICIENCY IMPROVEMENTS IN A CRITICAL ENVIRONMENT - THE CASE OF A UNIVERSITY BIOTERIUM
  Pedro Barandier, Antônio João Marques Cardoso

12:20 – 12:40 PAPER ID44- A FRAMEWORK FOR GAMIFICATION TO ENCOURAGE ENVIRONMENTALLY FRIENDLY DRIVING HABITS
  Turuna Seecharan

12:40 – 13:00 PAPER ID03- METHODOLOGY FOR OPTIMIZING PREVENTIVE MAINTENANCE PROGRAMS FOR EQUIPMENT ON AN ELECTRICAL DISTRIBUTION NETWORK
  Gabrielle Biard, Georges Abdul-Nour, Raynald Vaillancourt, Karim Brunet-Benkhoucha
PAPER ID34- COMPARISON OF STATIC AND DYNAMIC TRAFFIC ASSIGNMENT MODELS IN EVALUATION OF DISRUPTIVE PRECIPITATION IMPACTS ON SURFACE TRANSPORTATION
Raif Camara Bezerra Bucar, Yeganeh Mashayekh Hayeri

PAPER SESSIONS
12:00 – 13:30 Paper session WC2 (Category A)
Chairs: Raymundo Cordero Garcia
Dragan Kolmjenovic

12:00 – 12:20 PAPER ID48- WATER HAMMER INTERACTION BETWEEN HYDRAULIC POWER GENERATOR AND HYDRAULIC PASSAGES
Sorin-ioan Lupa, Georges Abdul-Nour, Martin Gagnon

12:20 – 12:40 PAPER ID54- PROBABILISTIC TECHNICO-ECONOMIC ANALYSIS OF HYDROELECTRIC POWER UNIT OPERATION AND MAINTENANCE INCLUDING PROGNOSTIC
Michel Blain

12:40 – 13:00 PAPER ID55- PARTICULATE MATTER MONITORING IN JOINVILLE, SANTA CATARINA, BRAZIL
Marianna Gonçalves, Emílio Mercuri

13:00 – 13:20 PAPER ID45- DETERMINATION OF WATER CONTENT IN HEAVY FUEL OIL USING A RELATIVE PERMITTIVITY METER
Daniel Arantes, Mateus Campos, Luiz Silva, Wilson Sant’Ana, Carlos Teixeira,
Germano Lambert-Torres, Erik Bonaldi, Levy Oliveira, Germando Costa

13:30 – 14:00 CLOSING CEREMONY
Moderator: Belle Upadhya

13:30 – 13:45: ISEAM goodbye
Joe Amadi-Echendu

13:45 – 14:00 Brazilian goodbye
João Pinto
KEYNOTES

LUIZ HENRIQUE MANDETTA

Biography: Dr. Mandetta received Bachelor’s degree in medicine from Gama Filho University, Rio de Janeiro, Brazil, in 1989 and specialist’s degree in Pediatric Orthopedics, Federal University of Mato Grosso do Sul, Mato Grosso do Sul, Brazil, and Fellow at Emory University, Atlanta - Georgia, the United States in 1995. In the military service, he served as a doctor, becoming the first lieutenant in the army. As a politician, Mandetta was municipal secretary of health in 2004, acting against the outbreak of Dengue in Campo Grande, federal deputy, between 2010 and 2018. As Minister of Health (2019-2020), he had as his biggest challenge, fight the spread of COVID 19. Mandetta was removed from office for transparently fighting COVID 19.

Institution: Former Brazilian Health Minister
KOFI SMITH

Biography: Kofi received his Bachelor’s degree in Industrial Engineering from the Georgia Institute of Technology in 1999, an Executive MBA in Global Business at Georgia Tech’s Scheller College of Business in 2009, and an Executive Doctorate in Business Administration from the J. Mack Robinson School of Business at Georgia State University in 2018. Dr. Kofi Smith serves as the President & CEO of the Atlanta Airlines Terminal Company (AATC). With several significant titles and awards acquired over the course of his life, Dr. Smith has sat on a research panel in Washington, under the Airport Cooperative Research Program of the Transportation Research Board (TRB) and National Academies.

Institution: CEO Keystone Management & former CEO Atlanta Airlines Terminal Company
MARIO CESAR MELLO MASSA DE CAMPOS

Biography: Dr Campos received his Bachelor’s in Electrical Engineering from the Military Institute of Engineering (1984), Master in Chemical Engineering from the Federal University of Rio de Janeiro (1990), and Ph.D. at the Chemical Engineering Laboratory - Ecole Centrale Paris (1997). He is currently a founding partner of SmartAutomation and acts as a consultant in Intelligent Automation, Control and Process Optimization, developing and implementing new technological solutions for the Industry. Dr. Campos Worked from 1985 to February 2021 as a senior technical consultant at the Leopoldo Américo Miguéz de Mello Research and Development Center (CENPES) at PETROBRAS in the area of Instrumentation, Control, Optimization and Process Automation.

Institution: CEO Smart Automation
HUAI WANG

Biography: Dr. Wang received Bachelor’s degree in electrical engineering from Huazhong University of Science and Technology, Wuhan, China, in 2007 and Ph.D. degree in power electronics, from the City University of Hong Kong, Hong Kong, in 2012. Dr. Wang is currently Professor with the Center of Reliable Power Electronics (CORPE), Department of Energy Technology at Aalborg University, 9220 Aalborg, Denmark. He leads a project on Light-AI for Cognitive Power Electronics. Dr. Wang is currently the Chair of the IEEE PELS/IAS/IES Chapter in Denmark. He serves as an associate editor of IEEE Journal of Emerging and Selected Topics in Power Electronics and IEEE Transactions on Power Electronics.

Institution: Aalborg University, Denmark
DAN NOWER P.E.

Biography: Mr. Nower received Bachelor’s degree in Mechanical Engineering from the University of Missouri-Rolla, Rolla, USA. With 35+ years of field service, product development, machine design and sales experience in the area of Asset Monitoring Technologies, Mr. Nower is a Level III Vibration Analyst, a US Professional Engineer registered in the state of Tennessee, a member of the American Society of Mechanical Engineers, and currently holds 13 US Patents.

Institution: RDI Technologies, Inc
David A. Hood

Biography: Professor David Hood AM is a civil and environmental engineer with vast experience across major civil and military projects, professional development in emerging economies, senior management in both the public and private sectors and in education. He is a passionate advocate for action to address global heating resulting from the burning of fossil fuels. With several significant titles and awards acquired over the course of his life, Professor Hood joined the Board of Beyond Zero Emissions (BZE), and was appointed Deputy Chairman. He is a Queensland Councilor of the Australian Conservation Foundation (ACF) and has served on the ACF Board.

Institution: Long Future Foundation Australia
Biography: Ron Moore is the Managing Partner of The RM Group, Inc., which provides operational excellence seminars, consulting, change management, and benchmarking services. Ron is the author of Making Common Sense Common Practice, 5th ed.; of What Tool? When? A Management Guide, 2nd ed.; of Where Do We Start Our Improvement Program?; of Business Fables & Foibles; of A Common Sense Approach to Defect Elimination; and of Our Transplant Journey: A Caregiver’s Story, as well as some 70 journal articles. He holds a BSME, MSME, MBA, PE and CMRP.

Institution: Managing Partner, The RM Group, Inc
PANEL SESSION

LUIGI GALOTTO JUNIOR

Biography: Dr. Galotto received B.S. and M.Sc. Degrees in Electrical Engineering from Federal University of Mato Grosso do Sul – UFMS, Campo Grande, Brazil, in 2003 and 2006, respectively, and Ph.D. in 2011 in Power Electronics and Automation from Universidade Estadual Paulista (UNESP). Dr. Galotto is currently an adjunct professor and researcher at the Federal University of Mato Grosso do Sul (UFMS). The main areas of expertise are: Power Electronics, Control Systems and Applied Statistics and Artificial Intelligence Techniques. Among the main projects carried out are: Monitoring and diagnosis of sensors, Sulfur analyzers in natural gas, Fault tolerance methodology in sensors and Converters for Generation with Photovoltaic Energy.

Institution: Federal University of Mato Grosso do Sul
Biography: Dr. Brito received the B.S., M.Sc., and D.Sc. Degrees in Electrical Engineering from São Paulo State University - UNESP, Campus of Ilha Solteira, Brazil, in 2005, 2008, and 2013, respectively. He received the Best Thesis award in 2013, working with algorithms for grid-connection converters. He was a Course Coordinator at UTFPR and a member of the Undergraduate and Professional Education Council of UTFPR. Dr. Brito is currently a professor of the Electrical Engineering Course at the Federal University of Mato Grosso do Sul (UFMS). He is a Permanent Professor of the Postgraduate Program in Electrical Engineering. He acts as a Reviewer of several International Journals, and His interest includes grid-connected inverters for photovoltaic applications and all the algorithms involving this application.

Institution: Institution: Federal University of Mato Grosso do Sul
RUBEN BARROS GODOY

Biography: Ruben Barros Godoy was born in Campo Grande, Brazil. He received the B.Sc. and M.Sc. degrees from the Federal University of Mato Grosso do Sul (UFMS), Campo Grande, Brazil, in 2004 and 2006, respectively, and the Ph.D. degree from Paulista State University, Ilha Solteira, Brazil, in 2010. He carried out his post-doctoral internship with Ecole de Technologie Supérieure, Montreal, Canada. Since May 2010, he has been a Faculty Member with the UFMS. His main publications are related to applications in power electronics and wireless power transfer. His current research interests include grid-tied photovoltaic power systems, wireless power transfer for electrical vehicles and implantable devices, and modern power meters and algorithms for charging stations.

Institution: Federal University of Mato Grosso do Sul
ABSTRACTS

Paper Session MA1 (Industry Presentations - Category C)
Chairs: Lutfiye Manli & Dimitris Kyritis

PAPER ID04- STRATEGIC ASSET MANAGEMENT UNDER ENERGY TRANSFORMATION
Lutfiye Manli

Abstract: The energy supply industry is undergoing transformative change. It is more important than ever to understand and develop a sustainable transmission network for the future. The industry generally focuses on network and mainly connection and planning issues however understanding asset management challenges are also equally critical and vital for the future of transmission companies. Electricity utilities are currently facing with many asset related issues such as dynamically changing patterns of asset utilisation, stranded assets, faster deterioration, obsolescence due to technology advancements, difficulty of life extension, new asset types and so on. The ecological climate has changed in the last ten years and the change is forecast to accelerate in the future. These changes in climatic conditions that have previously been stable are driving changes in the network capacity due to the thermal limits of network elements. This changes the risk vs capacity balance for the network, so as time marches on safety risk and regulatory compliance risk increases, transmission networks can then either accept the additional risk, reduce the network capacity or look for alternative solutions. Innovative solutions that are outside the ‘business as usual’ approach are needed to minimise risk and avoid unnecessary asset replacement. As the cost of new technology decreases, opportunities to deploy previously expensive solutions, such as asset monitoring devices, utility scale storage and demand management, are now cost effective.

PAPER ID05- DIGITAL ASSET MANAGEMENT UNDER ENERGY TRANSFORMATION
Lutfiye Manli, Nathaniel Dunnett

Abstract: Digital assets go beyond traditional asset management methodologies such as ISO 55000 that focus primarily on physical assets. Digital assets, with varied asset classes and technologies, are far more integrated, complex and subject to a wider concept of value beyond ‘utilisation’. This complexity becomes more challenging under the energy transformation many electricity utilities are facing. This paper will explore and detail the challenges of strategic
digital asset management within a utility with some examples and propose an innovative thinking approach how strategic asset management can be achieved under dynamically changing energy environment.

PAPER ID13- ONTOLOGIES AND DIGITALIZATION FOR ACHIEVING PREDICTIVE MAINTENANCE:
+GF+’S MACHINE TOOL OPTIMUM PRODUCTION FACTORY 4.0
Marlène Hildebrand, Dimitris Kyritsis, Jérome Clavel, Roberto Perez

Abstract: Europe currently has a strong position in the manufacturing market for goods and services, as it is the source of 15% of its GDP. In order to retain this competitiveness with other continents, it is essential that the European industry leverages the opportunities offered by Big Data. Thanks to digitalization and the Industry 4.0 paradigm, factories could shorten their time to market, predict and prevent their downtime, efficiently plan their resources, optimize machine behavior, and eliminate defects. More specifically, advanced analytics and predictive maintenance could reduce equipment downtime by 50% and increase production by 20%. (Digital Transformation of European Industry and Enterprises report, European Commission, 2015). However, only 3% of useful manufacturing data is tagged and even less is analyzed, because most of it is stored in isolated silos, following different data schemas, and is spread across the product and factory lifecycles. This issue underlines the need for data transformation and aggregation platforms and tools, but also for data standardization. In the context of the European Horizon 2020 BOOST4.0 project, we developed a pilot for the manufacturing of Georg Fischer’s spindles. This pilot includes an Extract-Transform-Load pipeline to collect data from heterogenous sources, transform it by adding semantics, and store it as linked data, using the latest software development technologies. It also uses an ontology for the semantical model, in order to standardize data and ensure that data is expressed using one common model all across the factory. The data can then be queried, visualized and also analyzed, because it is machine-readable thanks to the semantics, and an algorithm of machine learning runs on it to deliver information for predictive maintenance. Through this pilot, we demonstrate the possibilities that the combination of ontologies and modern software architecture can offer in terms of asset digitalization, data standardization and data analysis, indicating a path forward for Factories 4.0.
Abstract: Nowadays, many big organizations are falling out from the asset management excellence platform as they are focusing more on fancy and expensive tools of Predictive Maintenance, IoT and Maintenance 4.0 and failing to get the basics in place. These organizations are still in their comfort zone and manage their physical assets by relying more on a reactive environment, which leads to unnecessary costs and low-performance impact. Since 2018, Saudi Aramco’s Western Region Distribution Department (WRDD) established a unique initiative, ‘Excellence Path-forward’, which follows a well-defined top-down approach to reliability and asset management. The philosophy of this initiative is to get the basics rights and prepare for a valuable future, realizing the impact of the maintenance and reliability technology. WRDD first invested on building a culture of reliability by treating reliability like safety and involving operations, maintenance and engineering. It started to comply with Saudi Aramco Total Plant Reliability Management (TPRM); for instance, asset repair history, FRACAS, bad actor, switchover to revisit those procedures and revive them instead of them getting shelved and going unnoticed by stakeholders. Furthermore, WRDD has implemented several violation radar systems to fix the culture and remove the silo effects among the functional team members including but not limited to lack of planning and scheduling, outdated assets hierarchy and BOM, which lead to improper quality and a high reactive culture that impacts the maintenance expenditure (OPEX) of the department. Recently, the presentation will incorporate ISO 55001 journey in 2020 where WRDD has managed to acquire ISO 55001 certification in asset management that strengthened and the overall operational excellence journey. This standard aims to specify the requirements for an integrated, effective management system for assets. successful demonstration of the effective implementation of Asset Management System by completing all three formal phases with non-conformity after developing a rigid framework, Strategic Asset Management Plan to integrate the requirements of this ISO with functional areas including maintenance, engineering, operation, planning and accounting to deliver a common value to the organization. Finally, WRDD won the silver title in the prestigious 2020 Maintenance and Reliability President Awards for these initiatives among 36 operating departments. Moreover, it has sustained and carried on its excellence journey and adopted Maintenance 4.0 and Predictive Maintenance, exhibiting its commitment to its vision to being a world-class distributor of high-quality petroleum products in a safe and reliable manner to its customers.
PAPER ID76- CAN INDUSTRY 4.0 KEEP ITS PROMISES? A LITERATURE-BASED COMPARISON OF EXPECTATIONS AND EXPERIENCES

Lasse Metso, Nils Thenent

Abstract: The purpose of this article is to show the main topics of Industry 4.0 and how expectations relate to experiences outlined in academic articles between 2012 and 2020. A quantitative keyword analysis is accompanied by a qualitative review of the top 10 keywords as well as expected benefits and experiences. Based on the top 10 keywords that accompany “Industry 4.0” a conceptual model is presented to show how these keywords relate to each other. Findings show that expected benefits of Industry 4.0 are efficiency gains, quicker ways to market, flexibility and significant cost savings in production processes. In contrast, the implementation in particular in small and medium enterprises is hampered by lacking expertise of new technologies and the required invest. While technology is available, companies lack strategy for its implementation. Companies that have successfully implemented Industry 4.0 benefit from efficiency, flexibility, quality and deliverability gains. It is also found that a focus on technology leaves aside other aspects such as implications on organizational culture and working conditions. This research is limited to journal and conference publications listed in the Scopus database. The use of specific search words and combinations of their synonyms and year further limits potential references. As such, some of the most cited articles about Industry 4.0 might be excluded. This article contributes to the discussion on Industry 4.0 through a condensed overview of the most prominent topics and by showing what promises of Industry 4.0 have materialized or not. As such, the value of this work is an orientation towards realistic expectations of Industry 4.0 in research and practice.

PAPER ID10- A MAINTENANCE MANAGEMENT IMPROVEMENT FRAMEWORK FOR ASSET MANAGEMENT

Renan F. da Silva, Gilberto F. M. Souza

Abstract: Asset management has become an active field of research with the consolidation of the international ISO 55000 series. It coordinates activities to realize value from assets in organizations. Maintenance is one of the main stages to deliver business outcomes from
physical assets over its life cycle. In the fourth industrial revolution scenario, it could not be different. Establishing activities to address unwanted incidents, nonconformities, and opportunities for improvement is an important and required element in the maintenance management of an asset management system. The standards, however, are not specific and only determine what needs to be done, not how to do it. Accordingly, this paper proposes a framework for maintenance management improvement (MMI) based on the international standard ISO 55000 series for asset management. To this end, a four-step methodology was applied. First, an ISO 55000 series review focused on a broad understanding of the concepts and requirements for the improvements in an asset management system is presented. Then, a framework was developed for MMI and demonstrated through a maintenance case study application in a Brazilian hydroelectric plant. Finally, the framework processes were correlated and discussed with the improvement requirements of ISO 55001. As the main result, an MMI framework for addressing improvements has been demonstrated to maintenance management for asset management. It encompasses activities for elaborating control and corrective actions, dealing with consequences, addressing opportunities for improvement, critically assessing events, and analysing root causes. It was evidenced the framework is able to address nonconformities, incidents, and opportunities systematically. Therefore, these findings are expected to contribute to the researchers and practitioners in the field of asset management as the proposed framework based on the ISO 55000 series is an approach to the achievement of continuous improvement in maintenance management and, consequently, in asset management.

PAPER ID40- AN INTANGIBLE ASSET MANAGEMENT PROPOSAL BASED ON ISO 55001 AND ISO 30401 FOR KNOWLEDGE MANAGEMENT

Vicente González-Prida, Antonio Guillén, Carlos Parra, Eduardo Candón Fernández, Pablo Martínez-Galán Fernández

Abstract: This contribution is intended to provide a view on the standards ISO 55001 (requirements for an asset management system) and the ISO 30401 (requirements for a knowledge management system), in order to consider knowledge and human asset management, as a relevant dimension for all engineering and industrial sectors. An intangible asset management framework is proposed in this paper, considering the principles and requirements of the above-mentioned standards, together with methodologies already developed for physical asset management, in order to coordinate and realize value (in this
case) from the industrial knowledge. This proposal is intended to be a helpful decision support tool in order to align the different knowledge areas to the industry strategy and, in particular, to the business drivers of the company. Such a proposal will require first the identification of the key company knowledge areas, which are needed to sustain and grow the business, supporting strategic decision-making. After that prioritization, a gap analysis shall be performed in order to reckon if the core knowledge and the key industrial capabilities match with the current company resources and where they lie (people expertise, document repositories, etc.). This analysis will help not only to detect core capabilities to be developed and/or acquired by the organization, but also to reassign efficiently the current company resources to more critical activities with more added value. Finally, connections to risk and uncertainty references, the digitalization industry process, as well as to possible future research lines are commented as a conclusion.

PAPER ID70- THE TRANSITION OF MANAGEMENT AND ACCESS TO INFORMATION IN A MANUFACTURING COMPANY OF MEDIUM SIZE THROUGH ISO 55001 REQUIREMENTS AND INDUSTRY 4.0 MACHINES ACQUISITION

Ana Carolina Gandini Panegossi, Ethel Cristina Chiari da Silva

Abstract: Asset management studies have shown that access to quality information is one of the main critical success factors for asset management standards implementation and effective decision-making. However, studies also show that quality asset data have been a barrier to accessing quality information because several departments process data collection and register, and rarely are integration and connection in them. The introduction of artificial intelligence machines is the latest trend in the manufacturing industry. Its primary motivation is to ensure reliable, complete data and real-time information linking all parts or elements of the value chain. In this context, this research aims to present a medium-sized manufacturing company with difficulty managing its assets due to a lack of reliable information, and that started implementing the ISO 55001:2014 requirements. Concomitantly, the company started to replace its CNC (Computer Numeric Control) lathes for Industry 4.0 CNC lathes. So, this study aims at conducting a bibliographic review of the changes that the fourth industrial revolution will bring to asset management; and show how asset information management is today with the changes that the ISO 55001 information requirements implementation have brought to the studied company. As a result, this study suggests that it is possible to compile quality data with proper training. By distributing to each asset responsible operator the data
collecting and register, and then integrating all data into the ERP (Enterprise Resource Planning), it is possible to obtain quality information. This research also suggests how possible access to information will be with introducing intelligent equipment. And, probably, how will be in the company with intelligent CNC lathes acquisition. Despite currently being able to count on real-time information, the company of this study is not prepared for such disruption. Just as the successful implementation of the ISO 55001:2014 requirements is directly related to corporate culture, the new technologies acquisition and the use of their data also depend on organizational factors. Therefore, before engaging its efforts and invests its capital in acquiring more 4.0 CNC lathes, the company needs to continue investing in its best assets: the people who will know how to use the Industry 4.0 benefits.

Paper session MA3 (Category A)
Chairs: Robin Platfoot & Turuna Seecharan

PAPER ID09- THE JOURNEY TOWARDS SUCCESSFUL APPLICATION OF MAINTENANCE 4.0 AND SERVICE MANAGEMENT 4.0
Mirka Kans

Abstract: The paper discusses the role of maintenance in the digital era and propose directions for supporting the technology and business transformation towards Maintenance 4.0 and Service Management 4.0. For achieving this, the paper summaries previous research in the area and conceptualizes the transformation of maintenance towards Maintenance 4.0 and Service Management 4.0. The concept applies a systems approach on digitalization and recognizes the need for combining several working areas (production and maintenance management, information systems management, improvement processes and business management) for successful digital transformation within maintenance. Service Management 4.0 describes how maintenance becomes a business opportunity and modular maintenance offerings a way to approach the new opportunities. The concepts proposed in the paper provide support for industries in the digital transformation process towards Maintenance 4.0 and Service management 4.0.
Abstract: Large organisations are reliant on the successful configuration and implementation of their Enterprise Asset Management Systems (EAMS) to enable effective maintenance of their extensive asset portfolios. To manage the range of required functionality and to deliver a meaningful service to multiple teams with varying roles and responsibilities, these systems are increasingly complex which poses a significant risk to the delivery of asset management services. The complexity of large EAMS requires skills ranging from advanced information systems and database knowledge to detailed understanding of the specifics of the EAMS to general maintenance expertise. Rarely do these skills combine in an efficient and integrated project that sets up the organisation for long-term success in utilising the system which reflects leading practice maintenance strategies. This paper explores the combined requirements of database logic, information systems and design of maintenance strategies to understand the kinds of risks organisations need to address to achieve the successful establishment of the maintenance performance they are targeting. The work has delved deeply into the specification of critical fields in modern EAMS which have significant impact on the performance of maintenance governed by the system based on its master data. The end goal of this research is to deliver tools to maintenance practitioners that accommodates the complexity of database design and systems logic but does not require such expert knowledge for the user to track and report their own maintenance strategy as it is implemented in their EAMS. Without this breakthrough in reporting and insight to the maintenance teams they will continue to follow inefficient procedures which are costly and do not necessarily address the risk in their operations. The potential savings across a significant maintenance portfolio will range between 10 and 30% of their annual outlay. The paper presents case studies drawn from the mining industry but covers both fixed and mobile plant. It charts the maintenance requirements for complex assets as specified by contemporary techniques such as FMEA to what data needs to be managed in the EAMS and how it must be loaded. It then compares these requirements to examples drawn from major sites and the risk posed by deficiencies in cycle time, quality of procedural specification and coverage of the asset portfolio. It documents key principles which users of such systems should consider in assessing their systems as well as establishing new sites and equipment.
PAPER ID22- FAULT DIAGNOSIS AND ISOLATION FOR DIESEL ENGINE COMBUSTION CHAMBERS BASED ON AUTOENCODER AND BP NEURAL NETWORK
Yonghua Yu, Jia Hu, Jianguo Yang

Abstract: In order to improve the efficiency and accuracy of diesel engine combustion chamber fault isolation, a method of combining the feature dimension reduction of AutoEncoder network and the fault isolation of BP neural network was proposed based on acoustic emission signals. Taking a Z6170 diesel engine of China ZICHAI company as an example, some fault simulation tests of exhaust valve and piston rings under experimental environments were carried out, and the acoustic emission signals of the cylinder head were collected, then the time-domain, frequency-domain and other characteristic parameters of different signal sections in the whole cycle were extracted. The dimension of characteristic parameters was reduced by using AutoEncoder network, then the fault diagnosis and fault isolation was carried out by using BP neural network, so that a fault diagnosis and fault isolation model of combustion chamber components was established. After training and verification of the model, it shows that the proposed diagnosis and isolation method is effective with capability of identifying the faults of exhaust valve and piston ring for the combustion chamber parts of diesel engines, therefore, it is promising to detect and isolate the condition of combustion components automatically.

PAPER ID19- SYSTEM FOR EARLY DETECTION OF INSULATION FAILURES OF ELECTRIC MACHINERY
Bruno Reno Gama, Wilson Cesar Sant’Ana, Luiz Silva, Erik Bonaldi, Germano Lambert-Torres, Camila Paes Salomon, Isac Antonio dos Santos Areias, Daniel Almeida Arantes, Fernanda Vilas Boas, Fabio Monteiro Steiner, Rafael Bartholomeu Bernardo Carvalho

Abstract: This work presents the development of a system for detection of early damage to insulation of electrical machines. This system is composed by a hardware implemented in a FPGA board in conjunction with a software written in C#. The frequency response analysis (FRA) technique is used to infer about the machine insulation condition. The application of FRA consists of obtaining, periodically, the impedance spectra of the device under test (DUT). The obtained spectra are compared with a base spectrum, called baseline. Differences between the baseline and the acquired spectra can indicates a damage or the forming of a failure mechanism in machine insulation. The software implements a sweep frequency algorithm to
control the hardware and obtain the machine impedance spectra. This algorithm communicates with the hardware, sending commands for generation and acquisition of signals in a predefined frequency range. With the acquired signals, the software is able to calculate the impedance for each signal and, in the end of the process, the impedance spectrum is obtained. Since the early damage diagnosis is based in comparison between spectra, and a visual analysis requires a well-trained and expert maintenance team, it is proposed in the literature the use of some statistical indexes to compare the data. Those indexes have the advantage of obtaining a more objective diagnosis of the DUT, since visual analysis is subject to subjective interpretations. The software also implements some of the indexes proposed in the literature for a better analysis of the machine insulation. To evaluate the developed system, experimental results are presented using a machine with taps on its windings in order to emulate insulation faults. Since insulation faults represents a considerable percentage of electrical machines failure, the proposed system has great potential in industrial applications, preventing unscheduled stops of the machinery.

Paper Session TA1 (Category A)
Chairs: Lin Ma & Michael Cholette

PAPER ID61- CONDITION-BASED INSPECTION GROUPING POLICY FOR BOILER HEAT EXCHANGER TUBES
Huy Truong-Ba, Michael Cholette, Lin Ma, Geoff Kent

Abstract: Boiler heat exchanger tubes lose thickness over time, resulting in costly ruptures and losses in capacity as thin tubes are taken out of operation. To mitigate the costs associated with thickness loss, boiler tubes are inspected and can be preventive taken out of service (i.e. “plugged”) to avoid in-service ruptures. Moreover, there is an economic dependence among thousands of tubes of heat exchangers in inspection and maintenance activities where a large setup cost may be induced when inspection is conducted for any tube. This paper extends the authors’ previous study on boiler tube inspections to include a dynamic inspection and preventive maintenance grouping policy to pursue additional savings on setup costs. The inspection policy is said to be condition-based since the time for next inspection is based on the current inspected state. A heuristic thickness loss threshold for plugging is computed for each tube by balancing the risk of an in-service rupture with the lost revenue due to capacity loss and an optimal inspection grouping strategy is developed using the Markov Decision Process paradigm. The policy is applied to a case study of a boiler operating in an Australian
sugar factory and benchmarked with policies that represent current practices and do not consider grouping. The results show that the proposed condition-based grouping inspection policy yields significant savings compared to tube individual inspection policies.

PAPER ID66- RAILWAY TRACK GEOMETRY DEGRADATION MODELLING AND PREDICTION FOR MAINTENANCE DECISION SUPPORT
Sinda Rebello, Michael Cholette, Huy Truong-Ba, Venkat Reddy, Alan Rosser, Tina Watkin

Abstract: Rail operators manage many kilometres of railway infrastructure, which represent a large and costly investment. As with any asset, the deterioration of track infrastructure is unavoidable, and maintenance and renewal (M&R) of rail infrastructure is necessary to ensure an efficient, comfortable and safe rail network. One of the key degradation modes is the distortion of track geometry from repeated loading, and the inspection and maintenance of this geometry is often the greatest component of total maintenance costs. Thus, the frequency of inspection and maintenance tasks needs to be carefully balanced: too high and too many unnecessary track closures are needed; too low and the risk of regulatory violations is too high. It is therefore of paramount importance to develop engineering methods that enable the balancing of risk and direct costs of inspection and maintenance actions across these linear assets. To accomplish this, track geometry deterioration must be modelled to account for spatial variation in degradation patterns and uncertainty in the degradation rates. This paper describes methods for predicting track geometry degradation to provide support for maintenance planning. The track geometry data recorded by the Track Recording Car (TRC) and the maintenance work orders were used for degradation modelling. The degradation indicator considered in this study was the deviation of the longitudinal level from the design value sampled at every 100m-long track segment. The 95th percentile absolute deviation was selected to summarize the condition of each segment; this indicator provided better sensitivity to local issues than the mean deviation and was also more robust to outliers than the maximum deviation. A Wiener process model was built to model the time-evolution of the geometry condition indicator. The model parameters of each segment were estimated by dividing the degradation into between-maintenance runs and employing standard maximum likelihood estimation techniques. It was found that the proposed degradation model provided good fits to the data, except in some extreme cases where the TRC data exhibits large changes in the degradation indicator between two runs. Nevertheless, even in these cases the Wiener process model “responds” to this lack of confidence about the slope in an intuitively appealing
manner: the variance on the slope is increased to reflect a lack of confidence in the degradation rate. Finally, the utility of the model in maintenance decision making is demonstrated. Using the estimated model parameters, the expected number of different maintenance interventions was estimated under different maintenance policies.

PAPER ID36- PROPOSITION OF A GENERIC DECISION FRAMEWORK FOR PRESCRIPTIVE MAINTENANCE DECISION-MAKING: AN APPLICATION TO THE AUTOMOTIVE SECTOR

Pedro Dias Longhitano, Khaoula Tidriri, Christophe Berenguer, Benjamin Echard

Abstract: The digitalization of the economy in the past decades has made data availability grow and become more important. New technologies are raising and the possibilities that will be open with the Internet of Things are countless. On the other hand, from the maintenance point of view, clients are more demanding, wanting systems that will not have breakdowns while reducing exploitation costs. This challenging scenario has pushed companies in the direction of more intelligent maintenance solutions that involve choosing the best course of action in terms of system availability. Nowadays, these solutions are usually called prescriptive maintenance. Although the term prescriptive maintenance, alongside with prescriptive analytics, has gained some popularity in recent years [1], there is no clear definition of what it really means. The boundaries between predictive and prescriptive maintenance are not well defined, and we have to be careful when employing those terms to avoid confusion and justify the use of such expressions. We argue that a rigorous definition of prescriptive maintenance is important to guide and frame future work on the area and to develop the necessary tools to design and implement solutions that really achieve reliability maximization and cost minimization in industrial application. We believe that prescriptive maintenance can be defined in relation with the concept of health management that is well established in the prognostic and health management community [2]. In this paper, we present a modelling framework that highlights the differences between predictive and prescriptive maintenance and helps to guide the development of generic decision-making algorithms for up-time maximization. The framework relies heavily on the concept of close-loop decision process, meaning that algorithms must be robust, deal with uncertainty and assess the effect of the decisions chosen on the system to adapt them as often as required. To this aim, data availability is not enough, it is also necessary to have models that capture the reality of the degradation phenomena and account for different usage conditions, environment changes, parameters configurations, etc. Those models will feed in turn failure prediction algorithms
and optimization routines that indicate how to proceed in terms of system exploitation, choosing what to do from a set of pre-established and modeled actions in order to reach a minimum cost. Comparing the expected outcome with the reality, we calibrate our decisions, closing the loop. We illustrate this modelling framework with a concrete use-case in the automotive sector, showing the necessary steps to design and implement a prescriptive maintenance algorithm for a specific component at trucks from Volvo.

PAPER ID15- REVISITING AGRICULTURAL TECHNOLOGIES IN THE 4IR ERA
Anthea Amadi-Echendu, Nonceba Tyatyantsi

Abstract: Revisiting agricultural technologies in the 4IR era. Food security is becoming a growing problem worldwide. Much focus should therefore be placed on the agricultural sector with a view of equipping the sector for increased food production capabilities. The agricultural sector is changing rapidly globally due to the fourth industrial revolution (4IR) mega technologies, resulting in smarter ways to farm. These technologies allow farmers to maximise production remotely while controlling every aspect of crop farming such as pest control, soil conditions, crop monitoring, and soil moisture. These advances will allow farmers to be more profitable, efficient and environmentally friendly. However, evidence suggests that small-scale farmers are left behind in the use of 4IR mega technologies in South Africa. The purpose of this paper is to highlight the use of various 4IR technologies in the agricultural sector by using a desktop review of current literature. The paper recommends for a government-driven entity to be established that will focus on building capacity for small-scale farmers to build more sustainable and bigger businesses to assist in increased food production through the introduction of 4IR technologies.

PAPER ID65- DEVELOPING A LUBRICATION OIL AGE PREDICTION MODEL
Najat Mohammad Nazari, Masdi Muhammad

Abstract: In this study, lubrication oil age is predicted based on selected monitoring indicators. The information that were extracted from the oil analysis report are the TBN, oxidation, kinematic viscosity (100°C), contaminants and elemental analysis. Correlation analysis was applied to the data to assess the relationship between the lubrication parameters and oil age.
Based on the analysis, oxidation was identified to have high correlation with oil age. Mahalanobis-Taguchi Gram Schmidt (MTGS) method was applied to identify the critical variable to predict oil age. Based on the MTGS analysis, TBN, oxidation, Pb and Mo have a positive SN ratio gain and were selected to be included in the lubrication oil age prediction model. The study demonstrates the lubrication oil age prediction model based on Artificial neural network (ANN) with TBN, oxidation, Pb and Mo as predictor variables with an R squared of 0.8176, MSE and MAD of 1191 and 26 respectively. Based on the available sample data and threshold value, it can also be observed that readings of the lubrication oil parameters are still within limits after the recommended duration for lubrication oil to be in service. These findings are beneficial for future works to predict the remaining useful life of lubrication oil.

PAPER ID58: THE EFFECT OF KNOWLEDGE BASED FEATURE EXTRACTION ON FAILURE DETECTION OF CONTROL SURFACE FAILURES OF FIGHTER AIRCRAFT
Tauno Toikka, Jouko Laitinen, Kari Koskinen

Abstract: While the area of maintenance is developing from scheduled maintenance toward the condition based maintenance also the failure detection that utilizes system operational data becomes more important. The failure detection from system data can be done in many manners but a process of feature extraction is present more or less almost when the system data is high dimensional. In this study we examine an effect of system knowledge based feature extraction on the further performance of an algorithmic tasks of failure detection on the operational flight data of a fighter aircraft. The failures for validating the results are several flight control surface failures from the flight data. The failure detection algorithms are comprehensive set of algorithms from the field of anomaly detection, novelty detection, one class classification and unsupervised machine learning. This study demonstrates that some specific failure detection algorithms are more robust for feature extraction and can perform well even with low level of feature extraction when detecting the flight control surface failures. This result can be further used for selecting algorithms for failure detection tasks for other subsystems of aircraft in cases when the system knowledge and expertise are lacking.
Abstract: Alternative internal combustion engines are thermal machines employed in the generation of mechanical torque for moving, transporting and electricity generation. These thermal machines can be built for small applications, such as aircraft model, but also for tasks that require large power outputs such as thermal power plants. In electricity generation, internal combustion engines have as their main advantage the immediate availability for occasional demand. This advantage places thermal power stations equipped with internal combustion engines as an UPS (Uninterruptable Power Supply) for the interconnected grid of the Brazilian national electricity system. The intermittent operation regime and the high level of availability required increase the reliability level and the need for preventative maintenance of these machines. This is accomplished through overt controls of temperature and pressure at critical machine points, as well as part replacement when parts reach their nominal life-time. This methodology produces high costs in the electricity generation application of these machines. Monitoring the temperature, pressure and chemical properties of working fluids in the operation of internal combustion engines allows one to track formal statistics, characterized by abnormal machine patterns, behaviors and events. A matrix structure was established, built from representative sub-matrices of the auxiliary systems of the engine, such as: lubrication, cooling, feed-injection and turbocharger. Given the central sub-matrix formed by the powers and efficiencies involved in electrical generation, the resulting mathematical model allows one to determine which auxiliary system is producing the greatest influence on generation. In addition, compared to a standard internal combustion engine behavior, one can detect the auxiliary system that is most likely to fail. Even with intermittent operation of the internal combustion engine, malfunctioning of the auxiliary systems can be temporarily raised or accumulated, providing a direction for predictive maintenance and, consequently, a reduction in operating costs of electricity production. The developed model was simulated for the operating data of an internal combustion engine model similar to Wärtsilä 18V46-C2. The results of this demonstration are shown in this paper, showing the compatibility of simulated results with actual failure data for the analyzed model.
A STRATEGIC ASSET MANAGEMENT FRAMEWORK FOR IMPROVING TRANSPORT INFRASTRUCTURE: ANALYSIS FOR BELGIAN LAND TRANSPORT MODES

Laura Molinari, Elvira Haezendonck, Manuel Hensmans

Abstract: In today’s society, infrastructure asset management is a priority for multiple policymakers as it is key to guarantee high-quality transport infrastructure. While the relative quality of transport infrastructure in a number of Western European countries is deteriorating, the volumes of freight and passengers, as well as the expected service levels of all modes of transport for citizens and businesses, are increasing sharply. In response, infrastructure asset managers have developed and integrated technical and management system innovations. While short-term cost and damage control is taken better care of, a long-term asset vision and strategic principles supporting a strong future transport infrastructure network are still largely missing in many EU countries. In this paper, we analyze the strategic infrastructure asset management (SIAM) for Belgian road transport, rail and inland waterways through a cross-case analysis. Our literature study identifies strategic asset management principles, potential barriers and solutions for transport infrastructure assets in general, as well as for the different transport modes in particular. Through in-depth interviews with Belgian top administrators, the principles and SIAM framework for different types of mainland infrastructure are analyzed. We find, based on the studied Belgian cases, that ‘one SIAM-model does not fit all’, and that a variety of models, adapted to transport modes and the regional context, could better suit the strategic goals of different policies.

OVERVIEW FOR LEASING OR BUYING DECISIONS IN INDUSTRIAL ASSET MANAGEMENT

Vicente González-Prida, Carlos Parra, Fredy Kristjanpoller, Pablo Viveros, Antonio Guillén, Adolfo Crespo

Abstract: One of the main interests for today’s companies is to reduce the life cycle cost of those assets included in their productive processes. With that purpose, new business models are considering the acquisition of services provided by an asset, in stead of the direct ownership of such asset. In other words, the focus is that the asset’s ownership remains in the service supplier, since the company just purchases the results obtained using the asset during
a specific period. This asset utilization is at the end of the day the value added by the asset to the productive process. With that idea, this contribution is intended to summarize an overview of factors in order to decide between “lease or buy” an industrial asset. The choice between buying or leasing an asset must take into account different aspects, all of them with advantages and disadvantages, that must provide finally a positive influence in the profit and loss statement. Together with this discussion, one of the factors to take into account is nowadays the new digital tools that come from the so-called Fourth Industrial Revolution (4ID). These new tools (i.e. the IoT) support the asset management in a servitization context, contributing with big data analytics to facilitate the decision making in terms of criticality and reliability assessments as well as other decisions involved in the industrial asset management. In fact, the Digital Transformation may simplify the connection among system, process, asset and service, dealing with massive information interconnected among different assets, as well as different organizations like the asset user and the service supplier.

PAPER ID82- MACHINE LEARNING BASED PREDICTION OF FATIGUE EVENTS IN RAILWAY RAILS

Vincent Laurent, Olivier Vo Van, Mathilde Mougeot, Jean-Michel Ghidaglia

Abstract: Rolling Contact Fatigue (RCF) cracks can appear at the surface or subsurface of rails due to the repeated passage of wheels. These defects, such as squats and head-checks, can propagate and lead to rail fracture. The occurrence of rail fractures could have economic (delayed trains, maintenance costs) and passenger safety (derailment) implications. To avoid rail fractures, the French National Railway Company (SNCF) applies a strict method with both corrective and scheduled maintenance strategies which have a high cost for the company. Many mechanical studies have been carried out on of RCF for initiation and propagation of cracks at a local scale. These models are computationally costly, which makes their direct use for maintenance difficult, meaning that less refined degradation models have been developed. Moreover, models based on mechanical simulations cannot consider exogenous phenomena. The aim of this paper is to train data driven models to better predict crack initiation and to highlight the observed phenomena that are not yet explained by mechanical models. For this study, some supervised machine learning algorithm are tested such as Random Forest and Survival Trees which are considered suited to the problem, mainly for their ability to explain results. The rail is separated into continuous and homogeneous sections regarding available features. These features are numerous and continuously enriched. The first ones considered are those which do not vary with time. These are called “infrastructure features” and contain
data such as rail material and profile, nominal velocity of the trains, UIC group (which corresponds with traffic density classification), curvature and slope of the track… Other time varying features such as real traffic and rail grinding are to be implemented in future work. A work on the feature set is also shown in this paper, which is called feature engineering. Each choice in this section is evaluated regarding model performance. For crack initiation, the date of the event “crack initiation is observed” is used to compute the age of the rail when the event occurs. For Survival Trees, this event is considered as the death of the rail. Its survival law using Kaplan-Meier estimator can thus be computed. For random forest, we compute probability of appearance of the event between sections of the rail using time shifting windows. For each of these possibilities, the performance is evaluated and compared.

**PAPER ID94- SIMULATION-BASED AUTOMATION FOR CONSISTENT ASSET MANAGEMENT DECISIONS: PILOT-TEST APPLICATION FOR ASSESSING URBAN RESILIENCE**

Seyed Rezvan, Nuno Almeida, Maria João Falcão Silva, Marta Duarte

**Abstract:** Decision-makers in public and private asset-intensive organizations strive to consistently deliver and maximize benefits in the face of competing investment alternatives. The intended aim of these decisions is to satisfy organizational objectives and stakeholders’ needs and expectations. This paper proposes a decision-making support tool based on a novel multi-criteria decision analysis (MCDA) approach using Analytic Hierarchy Process (AHP). This support tool enables Automated Rational and Consistent Decision Making (ARCDM) by simulating scenarios and behaviors of a virtual Panel of Experts (PoE) with different perspectives. These scenarios are organized into a pairwise multi-layer decision-making matrix that supersedes the need for a PoE. The proposed decision-making support tool is test-ed in an Urban Resilience Evaluation System (URES) with a breakdown structure of 16 indicators and 75 parameters grouped into five interrelated dimensions: environmental, economic, organizational, social, and technical to be weighted. A building portfolio with seven different types of use (hospitals, schools, industrial facilities, shopping centers, hotels, research facilities, and residential) is used as a testbed for applying the support tool. The successful application of the proposed ARCDM support tool on the URES breakdown structure shows that similar applications can be made in other asset management decision making contexts, such as feasibility studies, design, construction, operation and maintenance, rehabilitation, and disposal of constructed assets that comprise the built environment for cities and societies.
PAPER ID97- EXPLORING THE USE OF POWER BI DASHBOARDS TO SUPPORT ASSET MANAGEMENT PLANNING DECISIONS

Pedro Costa, Jaime Silva, Lígia Ramos, Nuno Almeida, Ana Camanho

Abstract: Asset-intensive organizations have to deal with significant amounts of data. These data must be properly processed to generate information, which must be handled appropriately to support sound decision-making in a way that creates value for the organization's stakeholders. Robust and timely decision-making depends on the successful transformation of data into structured information that is intuitive and supportive. This paper deals with this topic and aims at contributing with an exploratory study to deploy dashboards using Power BI. It presents a practical use case of an indicator-based investment planning process of a water utility. The empirical case study includes developing a relational model for the data and information needed for an indicator-based approach to planning the investment needs of the asset portfolio of a water supply system.

PAPER ID07- EXPLORING THE RELATIONSHIP BETWEEN MAINTENANCE AND SUSTAINABILITY - A LITERATURE REVIEW

Ramsey Jardim, Mirka Kans

Abstract: The business environment is rapidly changing for industrial companies, giving raise to both threats and opportunities. Two main challenges that affect all parts of the company business are sustainability and digitalization. Understanding the sustainability aspects is necessary for organizations in order to establish a sustainable and green production, while digitalization acts as an enabler for reaching this goal. Maintenance is a major contributor toward sustainable production, and the development of maintenance towards sustainability should therefore be carried out in all process stages of the product's life cycle. However, the relationships between maintenance and sustainability are still unclear, which affects the possibilities for establishing an efficient sustainable maintenance strategy. Besides, the role of digitalization in achieving sustainability has to be established, so companies can take full advantage of the technical developments within this area. The purpose of this paper is to explore the relationship between maintenance and sustainability and to establish a framework for approaching sustainable maintenance. With the establishment of a common framework of
definition and understanding, the development of sustainable maintenance principles is supported. This is done by reviewing literature in the topics of sustainability and sustainable production, maintenance and sustainability, asset management, and smart maintenance. The findings are described in a framework for approaching sustainable maintenance in industrial companies based on three main pillars viz., eco-efficiency indicator, asset management, and digitalization in order to reduce production costs, hazardous waste, and environmental and humans' negative impact. The main conclusion is the need for more investigations to fulfil the gaps in integrating the sustainability aspects in the production processes, maintenance strategy and asset management.

PAPER ID87- BENCHMARKING ASSET INFORMATION QUALITY OF A UTILITY COMPANY IN BRAZIL
Bruno Pinto Vieira, Marco Antônio Calijorne Soares, Fernando Parreiras, José Ricardo Gonçalves, Bárbara Guimarães Penna

Abstract: Context: Asset information combines data about physical assets for asset management decision-making. It has an important impact on the efficiency and performance of asset intensive businesses. While asset information management and asset information monitoring play an important role in asset management, low levels of asset information quality can have consequences, such as missed business opportunities, inadequate decisions and flawed risk analysis. Objective: To conduct a gap analysis on the perception of employees of a Utility Company in Brazil about the asset information quality in their respective areas, roles, segments and hierarchical levels. Method: We applied a questionnaire based on the AIMQ model [20], using five-point Likert items. We collected 70 questionnaires answered. The AIMQ model assesses asset information quality on the following dimensions: Accessibility, Appropriate, Amount, Believability, Completeness, Concise, Representation, Consistent, Representation, Ease of Operation, Free-of-error, Interpretability, Objectivity, Relevancy, Reputation, Security, Timeliness, and Understandability. Results: With the application of questionnaires based on the AIMQ model, the access to Company’s data presents a very small satisfaction rate, considering hierarchical levels and professional experience. Only the “Relevance” dimension reached an average higher than 3, which shows the low perception of respondents about the quality of information. The analysis of the results (using quality standards, metrics for verification, and the rules created) shows only two samples reached a percentage above 60% correctness, reaching an overall average of only 25.95%. Regarding
completeness, the global average was slightly higher, reaching 35.23%. Some correlations resulting from this study are: Free-of-error x Objectivity; Accessibility x Ease of Operation; Understandability x Interpretability; Believability x Free-of-error. Conclusions: Benchmarks developed from the AIMQ model help comparing asset information quality across organizations and provide a baseline for assessing IQ improvements. The study presents important correlations for choosing further automatic techniques for evaluating data quality on asset management databases.

PAPER ID08- ASSESSING THE ECONOMIC AND ENVIRONMENTAL EFFECTS OF GRAVEL RECYCLING DURING GRAVEL ROAD MAINTENANCE
Nea Svensson, Mirka Kans

Abstract: Approximately 300,000 kilometers of the Swedish road network consists of gravel roads. These roads contribute to accessibility and accessibility throughout Sweden, which is especially important in rural areas. An annual operation and maintenance grant are paid to these roads to be maintained and kept open to public transport, but the grant covers only part of the total maintenance costs. Some of the most costly maintenance activities are planning and graveling. When graveling, natural resources in the form of rock and gravel are used, which is an energy-intensive process that has a negative impact on the environment. A couple of methods exist for recycling of gravel from the roads, but the utilization is rather limited. In order to promote and motivate recycling of gravel, it is important to highlight the environmental benefits of using recycled gravel, but also to be able to assess the economic impact as additional costs may arise. The overall purpose of the paper is to gain deeper understanding of the environmental and economic effects of recycling of gravel during gravel road maintenance. To achieve this, a calculation model is developed to estimate the environmental impact and economic effects of gravel road maintenance. The purpose of the calculation model is to be able to compare alternative methods for graveling. The calculation model is evaluated through a test scenario with three alternative methods for graveling; two where gravel recycling is performed by the means of two different methods and one in which new gravel is used. The test scenario shows that it is economically and environmentally beneficial, in a life cycle perspective, to use recycled gravel for road graveling.
PAPER ID88- ASSET INFORMATION MANAGEMENT SYSTEMS: CRITICAL SUCCESS FACTORS IN THE BRAZILIAN ELECTRICITY SECTOR
Alexandro Teixeira Gomes, Fernando Parreiras

Abstract: As the Electricity Sector has a strategic role in the socioeconomic development of a country, shortages have a damaging effect for all consumers and for the company itself. Therefore, companies in the Electricity Sector is considered asset-intensive, as their performance depends on the performance of their assets. This work has as objective to evaluate the critical success factors, promoting good performance on the Asset Information Management Systems in the Brazilian Electricity Sector. To achieve this objective, we defined a model that analyzes the impact of implementing Asset Information Management Systems into organizational performance indicators of companies in the Electric Sector. To validate this model we simulate connections that were performed through structural equation modeling, based on data obtained directly from professionals from different sectors of Generation, Transmission and Distribution companies in Brazil, in a previously defined form for this research. The relevance of the research is the analysis of the relation between impact and correlation in the Asset Information Management Systems, so that companies in the Electric Sector can prioritize efforts in factors of greater impact. The research is limited to evaluating only the Information within the Management Systems of Assets, with suggestions for future research to evaluate the other elements.

Paper Session TB2 (Category A)
Chairs: Joao Pinto & Raymundo Cordero Garcia

PAPER ID02- ALIGNING ASSET MANAGEMENT WITH THE UN SUSTAINABLE DEVELOPMENT GOALS FOR THE GOVERNMENT OF BANGLADESH AND HELPING TO BUILD RESILIENCE IN BANGLADESH
Caroline Elms, Peter Scuderi, Kaitlin Shilling, Nahila Rahman

Abstract: Bangladesh is at an important point in its development trajectory. A country labelled as one of the Least Developed Countries (LDC) after its liberation in 1971 now experiences significant economic growth with billion-dollar industries. This has put Bangladesh on track to graduate from the LDC tier as defined by the United Nations (UN) by 2024. The National Resilience Programme (NRP) was launched in 2018 to support the Government of Bangladesh to achieve this goal. Through the NRP, the Ministry of Local Government, Rural Development
and Cooperatives, Local Government Engineering Department (LGED), with strategic support from the UN Office for Project Services (UNOPS), has committed to designing, planning and implementing sustainable resilient rural infrastructure. Outcomes of this commitment need to be driven by inclusive, gender-responsive initiatives and improved holistic asset management practices. LGED is therefore a key player in Bangladesh’s development, with the responsibility of providing resilient and accessible infrastructure that supports the delivery of essential services that serves all members of the community. For new or existing rural road infrastructure to deliver services and support resilience for the community, it needs to be driven by a holistic strategy that prioritises resilience outcomes. An Asset Management framework for infrastructure resilience provides exactly that – an opportunity for LGED to transform the way it delivers resilience through its assets. Arup, a global firm with demonstrated leadership in outcome-led asset management, collaborated with UNOPS and LGED to bring this framework to life. The outcome of this joint effort was organisational transformation at LGED through a process of collaboration, co-creation and capacity building. A tailored, appropriate and practical asset management framework was developed for LGED, connecting to organisational, national and international priorities. This enables LGED to harness rural infrastructure to achieve resilient outcomes, building towards an inclusive, safe and sustainable road network. LGED’s journey towards good practice asset management of rural road infrastructure for resilient outcomes in Bangladesh is captured in this Case Study.

PAPER ID31- **FACILITATING CHANGE TOWARDS PREDICTIVE MAINTENANCE**

Martine Van den Boomen, Marc Botermans, Thijs De Weerd, Andreas Burzel

**Abstract:** Predictive maintenance is the promise of the future in infrastructure asset management. Predictive maintenance more and more uses sensor data. Sensors are relatively cheap, and their data mostly comes in huge quantities. Trends or flags may be observed in the data, sometimes with traditional statistical analyses and more often with advanced analyses such as machine learning techniques. These trends and flags may indicate a developing problem, allowing maintenance professionals to act before a failure occurs. However, as of today predictive maintenance is far from being common practice in infrastructure asset management. Failure mechanisms are often extremely complex. Besides knowing how to search for flags and trends, one should first know what to search for. Also, on the organisational side barriers are found. Often, big data is available in infra-structure organisations but underutilised for various reasons such as inaccessibility of data, client
unfriendly user interfaces and a lack of tools to analyse data effectively by maintenance engineers. The current research investigates the potential for more predictive maintenance in current professional practices, not by adding new sensors but through exploitation of existing data (data mining) and removal of barriers which professionals experience in using such data.

**PAPER ID79- APPLICATION OF FREQUENCY DIVISION MULTIPLEXING AND NEURAL NETWORKS IN THE OPERATION AND DIAGNOSIS OF THE STATOR CURRENT AND SHAFT POSITION SENSORS USED IN ELECTRIC/HYBRID VEHICLES**
Raymundo Cordero, Thyago Estrabis, Polynne Modesto, Joao Pinto

**Abstract:** Fast, precise and robust sensing of currents and motor shaft angle is essential for the excellent performance of electric and hybrid vehicles (EV/HEV). Multiplexing techniques are commonly applied in data acquisition systems (DAQs) to digitize the signals sensed in EV/HEV drives. Frequency-division multiplexing (FDM) applied to get the signals from current sensors and re-solver angular position sensor has advantages over conventional multiplexing approaches. However, problems such as aging and mechanical imperfections distort the outputs of those sensors, producing measurement errors of the angular position and currents. Conventional techniques designed to compensate for those errors cannot be applied in signals multiplexed in frequency. This paper proposes online techniques to detect and compensate for the distortions in the resolver sensor and current sensors. The demultiplexing process was adjusted to allow distortion detection and compensation. An auto-associative neural network (ANN) compensates for the current measurement error, while an energy-based technique is applied to compensate for the distortions in the resolver outputs. The obtained results show that the distortions were compensated, allowing a more accurate estimation of stator currents and angular position when FDM is applied in EV/HEV DAQs.

**PAPER ID80- MODELLING THE EFFECT OF MAINTENANCE-INDUCED FAILURES FROM PERIODIC TESTING OF SAFETY-CRITICAL EQUIPMENT IN THE OIL AND GAS INDUSTRY**
Jon Selvik, Hans Petter Lohne

**Abstract:** Determining appropriate maintenance programmes for technical inventory is recognized as important for quality reliability and safety management in the oil and gas industry. The programme could be achieved through reliability-centred maintenance (RCM) analysis, where safety-critical equipment with potential for hidden failures is given particular
attention. Output of the analysis is seen in combination with relevant requirements to perform functional testing of the equipment. The testing involves collecting and analysing data for verification of acceptable reliability and safety levels during the operational phase. This testing is often required in periodic intervals, where shorter intervals might be required initially or after failures for more control. Despite the intention of such activity, it could however influence equipment conditions in a negative way and over time contribute to a reduced reliability performance, i.e., lead to maintenance-induced failures. In this paper, focus is on periodic testing of the component ‘downhole safety valve’ (DHSV), and mechanisms leading to its failure. We consider the use of an age-adjusting imperfect repair model for analysing the effect of maintenance-induced DHSV failures and discuss the influence of recommended industry guidance. We particularly discuss the benefits of a test strategy having initially one to three months intervals, compared with an alternative strategy with constant six-month or one-year intervals. Based on the analysis, the 12-month interval gives the highest overall probability of failure on demand despite reducing the probability for maintenance-induced failures. There is a marginal difference between the other two alternatives, where then the selected distributions and uncertainties play a larger role. Barrier data collected by the Petroleum Safety Authority Norway (RNNP project data) is used for the analysis.

**Paper Session TB3 (Industry Presentations - Category C)**
**Chairs: Turuna Seecharan**

**PAPER ID35- SUSTAINABLE ENERGY SYSTEM ASSET MANAGEMENT: MODELLING TO SUPPORT DECISION MAKING**

Andrew Kilmartin

**Abstract:** The aim of this paper, presentation and poster is to introduce the European Union’s Horizon 2020 ENSYSTRA Innovation and training network project (Energy Systems in Transition) ensystra.eu and more specifically address energy system market design: modelling and investment decisions to support energy transitions in the European North Sea Region. The paper/presentation focuses on how we applied the Decision Quality (DQ) framework to the EUs Energy Union policy and how to specify and implement the derived market design reform policies. In addition through technical and economic analysis we consider how the market design asset and infrastructure investment opportunities can be selected, prioritized and financed through the European Green Deal. The presentation and paper will describe how decision analysis and policy processes can be further enhanced through the decision dialogue
support sustainable energy transitions. The energy system market design framing, modelling and assessment requirements are based on the vision of the future Low Carbon energy system with Renewable and Sustainable Energy Source integration. To do this we will assess how energy system transition policy and implementation challenges can be framed, how energy system modelling has developed and how the techno-economic analysis undertaken to support the decision and policy process. Finally we will describe how investment opportunities through infrastructure build or sanction of projects of common interest can be managed to realise the low carbon transformation. Furthermore we wish to show how the decision quality and dialogue process can help accommodate uncertainty and manage the risk associated with investment decisions and opportunities. This is especially challenging considering the timing, urgency and challenges when planning and delivering the transformation of a low carbon and zero emissions energy system. All the above must be balanced against the plans to expand, upgrade and interconnect new services and the focus to integrate renewable energy sources, energy storage and flexibility into the system in order to bring clean, sustainable and affordable energy to all in a sustainable and affordable manner to meet the sustainable development goals and to ensure a resilient and robust energy system fit for the future.

PAPER ID46- REPAIR AND PROTECTION FOR BEARINGS AND GEARS BY USING SILICON-BASED ADDITIVE TECHNOLOGY
Stefan Bill, E. Michael Konig

Abstract: REWITEC® is a part of the CRODA group and develops an innovative silicon-based surface treatment technology for gears and bearings of wind turbines. The active particles use lubricants as a carrier and build through their adsorption a protective and repairing silicon-based coating on the surface. When applying the products treated systems can run better with reduced friction, wear, surface roughness and temperature. These effects lead to higher efficiency, great reliability and longer lifetime. For the further improvement and development of the technology, REWITEC® works since many years closely with several research institutes, universities and OEMs, which are able to perform tribological tests with high accuracy and reliability in the lab and in the field. Beside numerous scientific tests there are more than two thousand successful treated wind turbines, where REWITEC® was applied in the gearbox or main bearing. For a meaningful evaluation of the applications, REWITEC analyses and compares the steel surfaces topography in the systems before and after the treatment. The REWITEC® Replica Set makes it possible to perform surface analysis of gears or bearings by
taking imprints of the representative areas of the surface with high precision and reliability. The subsequent analysis of the imprints with light microscopy provides a valuable information about the surface condition from the tribological point of view. REWITEC® performs such analysis for especially representative applications or according to customer requirements. In this presentation we would like to show the advantages of REWITEC® technology, highlights of the scientific studies about gear and bearing tribology and some examples of technology application in wind turbines. Generally, REWITEC® achieves in running systems like gears or bearings a friction reduction between 20 and 60 %. At the same time the surface roughness and wear are also significantly reduced. Due to the system modification the surface temperature decreases too. All in all, these effects provide a longer lifetime and higher efficiency of the tribological systems.

PAPER ID60- MOBILE TECHNOLOGY FOR MAINTENANCE AND IMPROVEMENT OF ASSET MANAGEMENT IN BOLIVIA-BRAZIL GAS PIPELINE
Rogério Orlandeli Sanches

Abstract: Mobile technology offers benefits to efficiently populate maintenance database. TBG S/A implemented an innovative solution, using wireless mobile devices, that carries work orders, detailed job plans and asset maintenance histories. This solution helps technicians on their inspection and maintenance jobs at the 2,600 kilometers long pipeline with a more dynamic system that improves accuracy of the recorded field data as well as optimizes maintenance costs and provides higher availability of maintenance crews. The project uses smartphones as the mobile component of the application. The devices carry maintenance work orders and equipment data necessary for field calibration. It allows to send/receive data to the database at SAP-ERP system when operation online. The most important advantages of TBG system are: • increased efficiency in the execution and maintenance records provided by the easy handling system; • increased availability of the teams due to data import and export versatility, since mobile devices are connected full time to the company network via 3G/4G and Wi-Fi access; • automatic replication to all devices of any change to business rules, processing parameters, formulas used in calculations and other tasks that needed microcomputer support, regardless of their geographical position; • centralization of maintenance data in SAP-ERP system and automatic updating of mobile devices on each data synchronization process; • simultaneous software update on mobile devices every available version, regardless of their geographical position; • equipment failure data recorded
accordingly to ISO 14224 (2001) fault log catalog, using specific and parameterized fields to display the list of components, mechanisms and causes of failure, enabling the statistical monitoring of such data; • faster and more accurate instrument calibration process, (business rules and formulas embedded in the device). Then, the use of mobile technology as maintenance support tool provides an increase on reliability, better performance in TBG maintenance management, reduced costs, dynamism to the maintenance team and efficiency in carrying out the field work, standardization of data recorded in SAP-ERP system, providing agility in data searches and simplification of planning processes to maintain the Bolivia-Brazil pipeline.

PAPER ID86- USING DIGITAL TWIN FOR ASSET INTEGRITY MANAGEMENT - A SUBSEA EQUIPMENT USE CASE
Otavio Correa, Jorge Luiz Seleme Mariano

Abstract: The focus of this paper is on gathering the main parameters for a maintenance management tool, by developing a field data collection process that feeds a Digital Twin of a subsea equipment. The Digital Twin and Artificial Intelligence technologies can contribute to guarantee the asset’s integrity, especially if combined with predictive maintenance and other digital solutions. The product derived from the study is a software, developed by Vidya. The software uses the Digital Twin technology, which establishes a constant flow of data between the digital model and the real asset. By combining this technology with Artificial Intelligence (Predictive Algorithms), Machine Learning, 3D models and IoT (Internet of Things) communication with sensors wireless, the industrial manager can have a complete visualization and centralize the whole operation of the industrial plant. Through the Digital Twin, you can collect and combine all the documents generated in the firsts phases of the PLM (Project Lifecycle Management) and provide them for the operational team. In a case that will be cited along the article, we show how much time operational teams that worked with BOP (Blowout Preventer) have saved just with the centralization of documents and data from other sources in a single platform. Also, with Predictive Algorithms, the software will outline an inspection and maintenance plan. It can predict workforce, logistics and other variables to be considered for mobilization. It is also possible to visualize the parts contained in the plans, both by the manager and by the team that will carry out the work. Therefore, reducing the maintenance budget and saving time and effort of the team responsible for the asset integrity management. Finally, after carrying out all the necessary calculations for the activities
mentioned above, the software delivers in a single platform, a significant time saving to monitoring, planning and maintaining the piece of equipment in question.

Paper Session WA1 (Category A)
Chairs: Kerry Brown & Raymundo Cordero Garcia

PAPER ID72- THE VALUE OF BUSINESS PROCESS MANAGEMENT TO UNDERSTAND COMPLEX ASSET MANAGEMENT PROCESSES
Kanika Goel, Michael Cholette, Moe T Wynn, Lutfiye Manli, Lara Meyers

Abstract: Asset Management (AM) processes play a significant role in organisations' profitability. Clearly documented and managed AM processes improve the delivery potential of assets and minimise the costs and risks involved. Business Process Management (BPM) is a discipline that uses various methods, tools, and techniques to discover, model, analyse, measure, improve, optimise, and automate business processes. Despite the prevalence and proven effectiveness of BPM in a wide variety of domains, there has been little research investigating its potential for describing AM processes. This paper presents a case study that explores the application of BPM to power transmission assets. BPM principles were applied for decision modelling and to capture the lifecycle of power transmission assets. The case study demonstrates how BPM application to AM processes can result in greater clarity of processes, increased collaboration, a better understanding of data, external rules, and regulations, and serve as an internal point of audit.

PAPER ID06- TOWARDS EVIDENCE-BASED DECISION MAKING IN ASSET MANAGEMENT
Helena Kortelainen, Antti Rantala, Toni Ahonen, Jesse Tervo

Abstract: Evidence-based asset management aims at making right decisions and optimizing asset management processes with best available information. Asset information systems are widely applied in industrial companies to collect and store asset related data. However, competence and experience of people, -i.e. tacit knowledge -has a crucial role in the decision-making. In this paper, we discuss information transfer, usability of current IT-systems and data utilization in daily tasks of different user groups. In addition, we outline a solution that supports the way towards evidence-based approach in process industry.
PAPER ID17- HOW TO BUILD AN OPTIMAL LONG-TERM ASSET RENEWALS AND MODERNIZATION PLAN DRIVEN BY QUANTIFIED COST/RISK/PERFORMANCE VALUE

John Woodhouse, Saulo Trento, Peter Jay

Abstract: As assets deteriorate and/or new technology becomes available, asset-intensive industries across the world struggle with the challenge of building plans and justifying the necessary reinvestment to renew and modernize their equipment. This paper presents a methodology for rapidly creating an optimized long-term asset renewal plan that targets the maximization of value to the organization. It ensures alignment with top-level strategic objectives, while at the same time is built from the bottom up, based on the real assets condition, system functions and criticalities. It also involves broad participation and buy-in from technical staff, so there is widespread consensus on the emerging priorities.

The methodology is based upon the 6-step SALVO Process for Strategic Asset Lifecycle Value Optimization, the product of a 5-year multi-sector R&D collaboration programme. Benefits of the method include the ability to calculate and demonstrate the monetized value, risks and other business impacts generated by each proposed intervention at different potential timings, and the optimization of combined effects within any overriding constraints (such as budgets, resources or timing commitments). This involves quantifying and modelling the trade-offs between Capex, Opex, risks, performance and sustainability, with mixed quality data and tacit knowledge sources, using state-of-the-art decision support tools. It also achieves, usually for the first time, true alignment between technical and financial departments, providing a transparent and auditable basis for the interventions and funding requirements. A case study is demonstrated and discussed, with lessons learnt, from the successful creation of a 10-year renewal and modernization plan at a large electricity transmission company (ISA CTEEP) in Brasil. This work formed part of a wider 3-year asset management innovation project under the R&D programme supported by the Brazilian electrical sector regulator, ANEEL.

PAPER ID96- SPEED OF INNOVATION DIFFUSION IN GREEN HYDROGEN TECHNOLOGIES

Lourenço Correia, Oliver Schwabe, Nuno Almeida

Abstract: In face of increasing pressure regarding climate change and greenhouse gases emissions, various countries and economic regions are setting ambitious action plans for a systematic transition towards a carbon-neutral economy. For example, the European Union
PAPER ID92- A SENSOR-LESS DAYLIGHT HARVESTING APPROACH USING CALIBRATION TO REDUCE ENERGY CONSUMPTION IN BUILDINGS

Brenden Harris, Juan Montes

Abstract: Using daylight to offset renewable power generation and energy consumption in buildings has attracted significant attention in recent years. More specifically, daylight harvesting (DH) systems have attributes that reduce energy consumption, but there has been limited uptake because compliant DH designs are rarely explored during design phases. A contributing factor is that the cost of equipment, and the installation of such, rarely achieves satisfactory investment returns. To demonstrate an economic benefit, this paper presents a predictive energy saving simulation that can be applied to artificial lighting designs. The results show that when using a sensor-less daylight harvesting (SDH) algorithm to predict energy savings, satisfactory financial returns can be achieved by modifying existing lighting control systems (LCS). To support this finding, a simulation using a prototype LCS, and real-world case study on a high-rise building was carried-out to demonstrate the financial assessment methodology that is used to predict energy savings.
**PAPER ID52 - TURNAROUND MAINTENANCE IN PROCESS INDUSTRY: CHALLENGES AND POTENTIAL SOLUTIONS**  
Antti Rantala, Helena Kortelainen, Toni Ahonen

**Abstract:** Turnaround maintenances (TAMs) are huge projects in terms of manpower and expenditure and therefore they have a direct effect to company’s profitability. TAMs include several challenges, such as prioritizing the maintenance tasks, scheduling the project, sharing information among all stakeholders on site and keeping focal company’s maintenance data in the IT systems updated. Due to the significance of TAM in economic and safety perspective, solutions for the challenges are needed, and advanced technologies could play a major role in solving these challenges. For example, sensor technology and software could help in evaluating asset condition and prioritizing maintenance tasks. In addition, mobile technology and apps could enable smoother information sharing on site. Moreover, external expertise could be brought into the TAM project by utilizing virtual- and augmented reality.

**PAPER ID42 - RESILIENCE RATING SYSTEM FOR BUILDINGS AGAINST NATURAL HAZARDS**  
Marta Duarte, Nuno Almeida, Maria João Falcão Silva, Seyed MHS Rezvani

**Abstract:** In recent decades, there has been an increase in the frequency and intensity of natural disasters. The worldwide growth of population, and consequently of infrastructure, increases the exposure to risks of this type. The expectation that the frequency of such disasters will increase amplifies the need to act today, to minimize the associated economic risks and costs in the future. The ability of buildings to maintain or restore their functionality after disruptive events, within a certain period, has increasingly attracted the attention of academics and professionals. This work intends to study and develop a method to measure the resilience of built assets. Therefore, a resilience classification system is proposed, which assesses resilience according to 5 dimensions (environmental, economic, organizational, social, and technical), which are subdivided into 16 indicators and 75 parameters. This proposal is based on various existent systems such as REDi or Building Scorecard, and its applicability is tested with 11 buildings with varied uses. The results are analysed via SPSS using a Pearson correlation coefficient matrix and clustering techniques. These empirical cases allowed improvements in the system initially proposed. The proposed resilience classification system allows classifying and comparing the performance of buildings, identifying their vulnerabilities, essential information to establish investment priorities. Multiple stakeholders are involved in
the life cycle of buildings that may benefit from the developed proposal. The work carried out is in its early stages of development and includes the identification of improvements to be developed in future work.

PAPER ID78- DEVELOPING ASSET OPERATIONS AND MAINTENANCE STRATEGY TO DEAL WITH IMPACT OF COVID-19
Ibifuro Ihemegbulem, David Baglee

Abstract: The COVID-19 pandemic has resulted in huge change for businesses some of which have transformed their operations and structure e.g. market needs, moving entire workplaces to remote working, adjusting production lines and pausing or shutting down production. Due to changes in asset operation, manufacturing optimization and fluctuating compositions, many business are processing strategy for plants and equipment that have been taken out of operational service or shutdown. Challenging times can be a facilitator for future innovation and development; this paper explores the impacts of COVID-19 pandemic, on Asset operations and maintenance. Some businesses are realigning operations (textile manufacturer producing face masks) to support the combat against COVID-19, thou seem outstanding but the short and long-term impact on assets needs to be considered. Most Assets are operating nonstop due to demand in supply that is unfamiliar to these assets with businesses delaying maintenance. Increase in production as per high demand has led to challenges in maintenance as most Assets are running to failure; reduction or adjustment in production still needs routine maintenance. The hurdles to maintenance are also suppliers stopping or reducing delivery of spare parts to the plant; non-availability of raw materials, fewer maintenance technicians on each shift. It’s factual that maintenance ensures the plant is running but social distancing will be considered because of staff’s breakdown. Businesses will require maintenance practices adjusted, retooling and reconfigured as assets are now been used for a different purpose other than what they were built for; While the urge to preserve finance and reduce cost, the risks associated with changes to assets should be considered and understood; the benefits and increase risk to the assets must be clearly outlined. Maintaining assets effectively extends its service life and provides information about the condition and servicing requirements of the assets. Inadequate maintenance leads to underperforming assets that cause increased risks, service disruptions and untimely asset failure. Consequences of delayed proactive maintenance can affect asset condition; increase corrective maintenance, service interruptions and failures, significant financial costs. The consequences of late maintenance are mostly
underrated, or not considered in the asset management for lack of framework and strategy to accurately measure these consequences. Continuous improvement of operation and maintenance activities is a major component of asset management principle as it has significant impact in asset lifecycle costs, management of risk, and service delivery performance. Well-planned executed operations and Asset Management Principles restore investor confidence and trust. This paper contributes to the evolving economy by determining the importance of Operations and Maintenance activities in the lifecycle of the asset and the process of asset management; encourage proactive maintenance to improve service delivery and reduce lifecycle costs. This paper will serve as a guide for the Asset managers to improve their organization’s Operations and Maintenance practices and align them with the asset management principles.

**Paper Session WA3 (Category A)**

**Chair**: Jeremy Novak & Marcio L. M. Kimpara

**PAPER ID68**: CREATING VALUE AND BUSINESS BENEFITS FROM JOINT OFFERINGS OF ASSET PERFORMANCE MANAGEMENT TOOLS IN THE CAPITAL-INTENSIVE INDUSTRIES

Minna Räikkönen, Leila Saari, Katri Valkokari, Antti Rantala, Helena Kortelainen

**Abstract**: In capital intensive industries, the purchasing of IoT, predictive maintenance or other digital solutions is very complex as there already exists several separate legacy systems. Also for a single solution provider, the customer needs and expectations can be huge, and they might not have all resources or competences needed for the delivery. In our research, we examined various aspects related to joint offering development and value creation. We define the joint offering as a concept or solution that is co-created in collaboration with two or more actors that usually have complementary technological skills or value creation logics. Based on our study, there is still relatively little joint offerings deployed supporting asset performance management and execution of asset management operations. To discover the interaction between the actors willing to provide a joint-solution, we further sketched value network models from the anonymised industrial challenges. Finally, the developed conceptual framework clarifies the scene of both the business opportunities and value assessment. The first part of the framework, business opportunities, considers the business models, value networks and analysis of business opportunities and risks. The later part, business value assessment, is built on capital and operating expenditure and revenues summarizing the business value.
FRAMEWORK FOR THE USE OF BLOCKCHAIN TO SUPPORT THE DEVELOPMENT OF ASSET INFORMATION MODELS
Mohammad Darabseh, João Poças Martins

Abstract: Asset Information Models (AIM) represent a record of all the information related to a built asset collected during delivery and operational phases. During the operational phase, several updates are implemented on the model to ensure that it matches reality. In order to improve models' data reliability and increase digital data security, this article proposes the use of blockchain technology to support information management and security for Asset Information Models. Blockchain is an emerging data protection technology that helps improve data management and tracking changes. The paper aims to showcase blockchain technology and its ability to create a trustless data exchange environment that helps automate data updating and reduce manual work. Blockchain-powered AIMs is a secured and auditable version of the traditional ones, which create more utility for such asset by reducing chances of foul play in the digitalised construction environment.

DIGITAL TWINS IN ASSET MANAGEMENT: POTENTIAL APPLICATION USE CASES IN RAIL AND ROAD INFRASTRUCTURES
João Vieira, João Clara, Hugo Patricio, Nuno Almeida, João Poças Martins

Abstract: Asset management is data-intensive and new tools and processes are often necessary to collect, manage, analyse and use asset data. The use of these tools can improve organisational knowledge and decision-making. Industry 4.0 tools are prompting the digital transformation of organisations and emerging innovation opportunities. Among these tools are those supporting the concept of Digital Twin (DT). The concept started being mentioned a few decades ago, but the discussion around its definition and potential applications still continues. This paper explores some of the interpretations of the concept of DT and its interrelation with some Industry 4.0 tools. Besides presenting some of the known benefits and opportunities related to DT applications in specific industries such as aerospace and manufacturing, namely in the early stage of asset lifecycle, the paper seeks to emphasise the vast exploratory potential of DT use in infrastructure asset management, especially in the operation and maintenance phases. This presentation includes the description of an
exploratory project for DT implementation in rail and road networks by the largest infrastructure management body in Portugal.

PAPER ID98- THE POTENTIAL FOR DIGITAL TWIN APPLICATIONS IN RAILWAY INFRASTRUCTURE MANAGEMENT

Christiaan Doubell, Karel Kruger, Anton Basson, Pieter Conradie

Abstract: The potential of digital twin technology has become apparent in recent literature, occurring evermore frequently in literature as the world moves on to the fourth industrial revolution. The use of digital twins in industries such as manufacturing, aerospace and aviation, and healthcare, has illustrated its value in lifecycle data management, control, monitoring, and more. This paper presents a review of digital twin applications in railway infrastructure. Considering digital twin adoption for public infrastructure, the rail industry is still at an early stage with few recorded implementations. However, digital twins present the possibility of addressing the emerging needs of infrastructure management in the rail sector. Identified needs include the integration of data from various sources, validation of management tactics, and the processing of large volumes of data.

Paper Session WB1 (Category A)
Chairs: Damjan Maletic & Ype Wijnia

PAPER ID11- CASE STUDY CRITIQUE OF ISO 5500X-BASED AUDITING AND CERTIFICATION

Joe Amadi-Echendu, Kolomane Khoarai, Mapule Lebata

Abstract: The main proposition of the ISO 5500x series of standards is that any organization that intensively deploys engineered assets should implement a ‘management system for asset management’. As the anthropocene age transcends the era of Society 5.0 powered by fourth industrial revolution technologies, curiously, the composite ISO 5500x series of standards are tantalizingly applied for auditing and certification in engineering asset management. What does it really mean to audit and certify on the basis of the ISO 5500x series of standards? The discourse in this paper uses empirical evidence from two case studies to examine the conundrum of auditing and certification according to the ISO 5500x series of asset management standards.
PAPER ID14- CONTINUOUS QUALITY IMPROVEMENT AND BUSINESS PERFORMANCE: THE MEDIATING ROLE OF PHYSICAL ASSET MANAGEMENT

Damjan Maletič, Basim Al-Najjar, Matjaž Maletič, Boštjan Gomišček

Abstract: This study examines the mediating effects of physical/engineering asset management on the relationship between continuous quality improvement and business performance. Using empirical data based on survey data from six European countries (i.e. Greece, Poland, Slovakia, Slovenia, Sweden, and Turkey), this study used mediation analysis to address the research problem. A macro for SPSS was used to estimate the size of an indirect effect of continuous quality improvement on business performance by a proposed mediator. The results of this study show that physical asset management mediates the effect of continuous quality improvement on business performance. This study provides valuable insights into mechanisms that have the potential to improve business performance. The results contribute to a better understanding of how companies could achieve higher performance outcomes through the introduction of continuous quality improvement and through physical asset management practices.

PAPER ID12- CONDITION ASSESSMENT OF ENGINEERED ASSETS IN ERA OF SOCIETY 5.0

Joe Amadi-Echendu, George Botlholo, Keaton Raman

Abstract: In the era of Society 5.0 powered by fourth industrial revolution technologies, the pervading cliché of “information about everything” is aggressively transforming how we monitor and assess the reliability, resilience, and vulnerability of engineered assets such as personal gadgets, equipment, machinery, inter-connected and interdependent facilities and infrastructure that constitute modern-day cyber-physical systems. Two case studies of conventional approaches to condition assessments are briefly discussed in the paper. Given that the era of Society 5.0 proffers huge technology-driven paradigm shifts, the contention is that the sustainability imperative demands a wider and more holistic approach to condition and performance assessments of engineered discrete assets and asset systems.
Abstract: To manage the realization of value, the core concept of asset management, it is vital to have a good understanding of what that value is, how it is produced and how it can be measured. In this paper, we first make a connection between the concept of value, its production in a value chain and the asset lifecycle and conclude that these concepts are not necessarily aligned. Next, we address issues in performance management. Common practice is to use Key Performance Indicators (KPIs) to keep track of results, with multiple KPI’s often compiled into a business dashboard or balanced scorecard. To be effective, KPIs need to be valid, functional and legitimate. Unfortunately, a focus on pursuing targets can provoke strategic behavior resulting in destruction of value. Furthermore, targets may be aimed at the wrong lifecycle, be part of an optimization or be blind for optimization across portfolios. To address these challenges, we propose a pragmatic approach based on the cost to benefit ratio of interventions, embedded in a social setting. This model has been applied for an organization with 3 separate but comparable portfolios. The concept still has to be tested in a more diverse setting.

Abstract: Failure diagnosis on some system is often preferred even the data of the system is not designed for the condition monitoring and does not contain any or contains little example cases of failures. For this kind of system, it is unrealistic to directly observe condition from single feature or neither to build a machine learning system that has been trained to detect known failures. Still if any data describing the system exists, it is possible to provide some level of diagnosis on the system. Here we present an LSTM autoencoder approach for detecting and isolating system failures with insufficient data conditions. Here we also illustrate how the failure isolation capability is effected by the choice of input feature space. The approach is tested with the flight data of F-18 aircraft and the applicability is validated against several leading edge flap (LEF) control surface seizure failures. The method shows a potential for not only detecting a potential failure in advance but also to isolate the failure by allocating the
anomaly on the data to the features that are related to the operation of LEFs. The approach presented here provides diagnostic value from the data than is not designed for condition monitoring neither contain any example case failures.

PAPER ID75- EFFICIENT IMPLEMENTATION OF ARTIFICIAL NEURAL NETWORKS FOR SENSOR DATA ANALYSIS BASED ON A GENETIC ALGORITHM

Andre Estefani, Raymundo Cordero, Joao Pinto

Abstract: The reliability of many industrial processes depends on the sensor system. However, these sensors can be affected by noise, perturbations and failures. Hence, sensor monitoring and diagnosis are fundamental to guarantee the quality of an industrial process. Nowadays, artificial neural networks (ANN) are widely used in sensor signal processing and diagnosis. However, those ANNs usually require many artificial neurons, being difficult to implement in software and hardware due to their high computational costs. This paper presents an optimized implementation of artificial neurons in ANNs for sensor data analysis using a Genetic Algorithm (GA). The objective of GA is to find an adequate segmentation to reduce the activation function approximation error. One of the advantages of the proposed approach is that the cost function used in GA considers the effect of factors such as the ANN architecture or the number of bits used in arithmetic operations. The proposed ANN implementation technique aims to get the best possible approximation for a specific ANN architecture, making easier its implementation in software and hardware. Simulation and experimental results using FPGA (Field Programmable Gate Array) prove the advantages of the proposed approach for implementing sensor data analysis systems based on ANNs.

PAPER ID91- MACHINE LEARNING APPROACH FOR ASSET INFORMATION INTEGRATION

José Ricardo Gonçalves, Bruno Pinto Vieira, Marco Antônio Calijorne Soares, Fernando Parreiras

Abstract: Asset information is about physical assets data for asset management. It plays an important impact on business efficiency and performance on their asset usage and maintenance. Multiple sources of this information can bring impacts on organizations data driven strategies or even on its life cycle. These multiple sources could came from in house systems development or thought companies mergers or acquisitions. In both cases, asset management information will be dispersed around the organization, undermining its
confidence, unless data integration methods were applied to solve it. In this paper we implemented and evaluated, machine learning approach aiming to solve data integration issue. Our endeavor starts reviewing the literature about machine learning approaches used for data integration and them, we implemented, trained and evaluated models using asset management data structures. As a result, we were able to train a model that achieves 99.8% of accuracy. With this model, we evaluate it against three asset management public data set, achieving a overall accuracy of 78.3% which lead us to conclude that machine learning techniques can be used to solve data integration issue. More studies can be focused in other deep learning approaches and in creating an annotated data set in asset management domain to improve models performance.

PAPER ID84- ONLINE TEMPERATURE ESTIMATION OF PERMANENT MAGNET SYNCHRONOUS MACHINES (PMSM) USING NON-LINEAR AUTOREGRESSIVE NEURAL NETWORKS WITH EXOGENOUS INPUT (NARX)

Thainara de Araújo, Renan Aryel Fernandes da Silva, Marcio L M Kimpara, Joao Pinto

Abstract: PMSMs are widely used in high-performance industry applications. This popularity is due to their high torque-to-inertia ratio, high efficiency, low maintenance, fast dynamic response, among others features. However, the construction of such machines includes some components that are highly sensitive to the temperature, hence, requiring control strategies that mitigate failures and loss management, taking the machine temperatures into account. Sensor-based temperature measurements of such parts are difficult to be implemented, and are not always well-accurate. Therefore, this paper proposes an approach based on artificial neural network model to estimate the temperature at the most critical points of a PMSM, namely, the permanent magnet, stator teeth, windings, and stator yoke. In this study, the variables, ambient and coolant temperatures, motor speed, and the stator voltages and currents in the direct and quadrature axes are taken as inputs to a Non-linear Autoregressive Neural Networks with Exogenous Input (NARX). To develop and test the proposed temperature estimator, a 140-hour multivariate database from a torque-controlled 52 kW PMSM was used. The obtained results have shown that the proposed method successfully estimates the temperature at the selected points.
PAPER ID26- ASSET MANAGEMENT AND ENERGY EFFICIENCY IMPROVEMENTS IN A CRITICAL ENVIRONMENT - THE CASE OF A UNIVERSITY BIOTERIUM

Pedro Barandier, António João Marques Cardoso

Abstract: A bioterium is an area for raising and maintenance of laboratory animals used for research and/or teaching activities. Its main goal is to ensure the required environmental, nutritional and health controlled conditions. In the analyzed case – the Bioterium of the Faculty of Health Sciences (FCS) of the University of Beira Interior (UBI), Portugal – the occupied area of 630 m2 requires that the environmental conditions be uninterruptedly maintained at a temperature of 21 ºC and an air-humidity of 50%. These requirements demand a constant utilization of the HVAC system, in particular, the use of chillers and propane boilers, for cooling and heating purposes, respectively. Indeed, the location presents a significative weather variation over the year, with a maximum mean temperature of 34 ºC and a minimum mean temperature of -4 ºC. Therefore, in case of a system failure breakdown, the bioterium main goal may not be fulfilled, with drastic consequences for the living beings, and also, for the on-going research activities. Asset management is thus a key concern. Additionally, due to the aforementioned incessant use of this critical environment, the energy consumption may rise up and consequently, the energy costs as well. At the same time, this energy consumption may present significant opportunities for reduction and improvement, mainly in the area of energy efficiency. For that, the energy costs must be dealt with in the very same way as the other outlays, such as labor and materials, for example, that are considered as variable costs. Furthermore, such opportunities for improvements may likewise enable a more profitable asset management of the bioterium facilities, mainly with the advent and evolution of new technologies, which besides being more efficient, provide more useful information as well. Based on the analyzed data, related to the energy consumption of the facilities, through the use of relevant quality tools, opportunities for improvements were identified and also analyzed, such as the proposal for the replacement of both chillers and boilers by heat pumps for climatization, the use of smart-meters for a better and more precise data acquisition through an adequate interface with the environment, and also the proposals for the implementation of automation and control technologies for lighting and temperature control, among others. In conclusion, better energy systems efficiency, automation and
control, and the possibility of adopting on-condition maintenance strategies were some of the accomplished results.

**PAPER ID44 - A FRAMEWORK FOR GAMIFICATION TO ENCOURAGE ENVIRONMENTALLY FRIENDLY DRIVING HABITS**

**Turuna Seecharan**

**Abstract:** The performance of transportation systems is of crucial importance for individual mobility, commerce and for the economic growth of all nations. In recent years, modern society has been facing more traffic jams, higher fuel prices and an increase in Carbon Dioxide emissions. According to NASA Global Climate Change, the current warming trend is extremely likely (greater than 95 percent probability) to be the result of human activity since the mid-20th century. Although general awareness in sustainability issues has improved in recent years through mass media coverage, this knowledge is not always translated into actual sustainable practice. The transportation sector consumes more petroleum than any other sector, and that share has increased over time from about 50% in 1950 to about 70% in 2018. In 2016, light-duty vehicles accounted for 58.5% of transportation energy use while medium/heavy-duty trucks and buses accounted for 23.9%. Vehicle miles travelled was seven times higher in 2017 than in 1950. The number of vehicles in operation was more than six times higher in that same period, while the resident population doubled. Data collected in Duluth, Minnesota found that although multi-modal commuting infrastructure exists, young drivers’ primary mode of transportation is their personal vehicle. It is hypothesized that encouraging environmentally friendly commuting in young drivers will more likely lead to long-term environmentally habits. However, how can these habits be encouraged in mid-sized cities? At what point does using a personal vehicle becomes “inconvenient”? This paper surveys existing tools and techniques in reducing fuel consumption and CO2 levels in the transportation sector and its potential applicability in small to medium-sized cities. As companies move toward sustainable thinking, the triple bottom line theory expands traditional accounting to include, in addition to the economic impact, the social and environment impacts of products and decisions. Optimal trajectory towards sustainable transport is not likely to be resolved by any single solution but, rather, requires carefully crafted interventions that work in an integrated way to achieve change consistently throughout the transport system. This work hypothesizes that these interventions should address the people, planet and profit dimensions of the triple bottom line and, thus, sustainable operations. In the transportation sector, the Fourth Industrial
Revolution emphasizes advances in communication and connectivity with breakthroughs in emerging technologies in fields such as fully autonomous vehicles sector. In mid-sized cities, the transition to intelligent transportation systems is slower than in larger cities where population growth is rapid. However, reducing CO2 emissions from transportation should also consider the needs of mid-sized cities and to apply the appropriate methodology. Multi-criteria decision-making models and tools exist to apply the appropriate maintenance strategy based on the type of failure. This paper presents a review of existing and emerging technologies in the transportation sector with the goal of reducing CO2 emissions. It also sets the framework for the application of a multi-criteria decision-making and the triple bottom line for the design and operation of sustainable passenger transport systems for mid-sized cities.

PAPER ID03- METHODOLOGY FOR OPTIMIZING PREVENTIVE MAINTENANCE PROGRAMS FOR EQUIPMENT ON AN ELECTRICAL DISTRIBUTION NETWORK

Gabrielle Biard, Georges Abdul-Nour, Raynald Vaillancourt, Karim Brunet-Benkhoucha

Abstract: This article outlines the methodology developed by Hydro-Québec Distribution (HQD) for optimizing the maintenance policy related to equipment on an electrical distribution network based on the estimated useful life, reliability and replacement costs. This methodology relies on the failure modes analysis as well as on the statistical analysis of operational data and safety risk. Its application will be demonstrated using MV three-phase gang operated overhead switches, but the methodology is applicable to assets on a distribution network with a preventive maintenance program, including equipment refurbishment. The application of the optimal preventive maintenance policy obtained with the proposed methodology on approximately 5000 equipment generated labour gains of more than 2,000 hours per year, a useful life considerably higher than the design life and economic gains of more than $400k per year. The proposed application case contributes to the literature relating MV three-phase overhead switches, which is currently absent, and to the optimization of its maintenance strategy.
PAPER ID34- COMPARISON OF STATIC AND DYNAMIC TRAFFIC ASSIGNMENT MODELS IN EVALUATION OF DISRUPTIVE PRECIPITATION IMPACTS ON SURFACE TRANSPORTATION

Raif Camara Bezerra Bucar, Yeganeh Mashayekh Hayeri

Abstract: This study presents and validates a framework to assess the vulnerability of surface transportation systems to disruptive precipitation by triangulating results from traditional traffic assignment models under flood scenarios of different magnitudes. We assessed the vulnerability of the surface transportation network of Hoboken, NJ to pluvial flood events by integrating flood disruption and traffic simulation models in a single model. The behavioral assumptions necessary to the adaptation of drivers’ route choices within a disruption framework are discussed and generalized in this paper. Application of traffic assignment models within a microscopic simulation environment predicted a higher impact to the surface transportation system when compared to its macroscopic counterparts. The uncertainty related to drivers’ imperfect perception of the network was evaluated by comparing different traffic modeling assumptions within the same simulation environment. Distinctive patterns in mobility disruption due to flooding were seen across different traffic assignment models, providing validity to the results of our framework. Disruption of crucial shortest distance paths between origin-destination pairs such as city exits were seen to greatly contribute to mobility disruption, indicating that city authorities can enhance transportation resilience by protecting the affected regions from flooding or designing detours around the access points.

Paper Session WC2 (Category A)
Chairs: Raymundo Cordero Garcia & Dragan Kolmjenovic

PAPER ID48- WATER HAMMER INTERACTION BETWEEN HYDRAULIC POWER GENERATOR AND HYDRAULIC PASSAGES

Sorin-Ioan Lupa, Georges Abdul-Nour, Martin Gagnon

Abstract: At the beginning of the century more simplistic theories were used to design the hydraulic passages [1, 2]. Later, classic numerical models and simulations were employed [3]. Nowadays, water hammer dynamic models are based on the concept of similarity of the Hydraulic Power Generator (HPG) with a variable orifice where the runner can act as a dynamic orifice [4]. The present work has the purpose to identify factors that contribute to the water hammer phenomenon and establish their influence [5]. Experimental recordings of HPG behavior during load rejections were studied. The main parameter controlled during these
experiments was the closing rate of the wicket gates. The study was made on 30 HPG configurations, for different types of turbine (Francis, Kaplan, propeller, saxo) and different types of hydraulic passages (long / short, underground / external, low / high head, etc.) within Hydro-Québec HPG fleet. For each configuration, several points at different fast closing rates were recorded. The recorded parameters were: the wicket gates position, the pressure in spiral case and penstock, the speed of the unit, the pressure in the draft tube, the upstream and downstream levels, and the position of the runner blades. Furthermore, the influences of a second wicket gates closing rate, the position of the runner blades and the cam curve have been also observed on some HPG. Other parameters like the intumescence of the upstream and downstream levels were not systematically recorded on all HPGs. We observe that the overpressures measured in the transient zone are relatively high. For load rejection at maximum wicket gate opening, this tendency increase for some of the low head HPG and decrease for high head HPG. These observed behaviors will improve the calculation models [6] and help find the main factors to account for during the design of hydraulic passages, as well as the parameters to adjust during commissioning.

PAPER IDS4- PROBABILISTIC TECHNICO-ECONOMIC ANALYSIS OF HYDROELECTRIC POWER UNIT OPERATION AND MAINTENANCE INCLUDING PROGNOSTIC

Michel Blain

Asbtract: Large utilities need to optimize the investment made to maintain their assets. For a utility like Hydro-Québec (37 GW) an important part of those investments are made to maintain their hydroelectric facilities. Fatigue and cavitation are the two main degradation mechanisms of hydroelectric turbine runner blades. However, of the two, fatigue is often considered difficult to manage since the damage cannot be monitored until significant cracks appear which then are automatically considered critical. For this study, the impact of inspections, starting frequency and an anticipated wheel replacement were evaluated by comparing them to a reference scenario where the turbine runner blades would have been operated following traditional frames. The analysis demonstrated the following points: • It is possible to observe the impact of the improvements (frequency of inspection, stop/start, replacement date, etc.) separately in the techno-economic analyses; • Unexpected breakdowns can be taken into account for informed risk management; • Investment deferrals can be analyzed taking into account the risk; • Risk management proposes the updating of models (e.g. when a crack appears). In fact, the model presented allows to define the required
maintenance and operation plans according to the postponement that will be chosen in a global optimization of the production fleet. The sensitivity analysis therefore shows the importance of the operation and maintenance forecast to be carried out according to the specific design of each wheel and the deferral date chosen in the context of this global optimization. With this kind of analysis, the decision-maker could possibly (while controlling the risk): • Unexpectedly distribute the fatigue load over the different turbines runner blades by increasing the wear on some of them to protect others in order to delay their replacement; • Postpone as much as possible the replacement of those that will not be subjected to fatigue loading. The paper will be structured as follows. First, an overview of the modelling strategy will be presented. Then, the parameters of the study case and the methodology used will be detailed. A sensitivity analysis will show the impact of the different assumptions on the mean net present value and the probability of regret. Finally, we will discuss the results for several units in terms of applicability for decision making and asset management.

PAPER ID55- PARTICULATE MATTER MONITORING IN JOINVILLE, SANTA CATARINA, BRAZIL
Marianna Gonçalves, Emílio Mercuri

Abstract: Air pollution is directly related to the increased risk of acute respiratory infections, and it was estimated by the World Health Organization that 6.5 million deaths in 2012 were caused by air pollution-related illnesses. In Brazil, there are few cities that have air quality data collection, although legislation has been recently updated and quality standards have been planned with promising targets, according to CONAMA Resolution 491/2018. This research presents an alternative air quality monitoring station, focused on the use of Internet of Things (IoT) resources, low-cost equipment and real-time acquisition via the internet. The purpose of the research is to use the SDS011 sensor for particulate matter (PM10 and PM2.5) concentration monitoring in Joinville, Santa Catarina, Brazil, connected to the Raspberry Pi computer. The code for data acquisition of the sensor was developed in Python and the data cloud storage was done through the use of Dropbox API. The system aims to reduce the costs of equipment and monitoring stations along with their energy consumption, in addition to enabling real-time monitoring, with availability of data for the scientific community and the city population, also representing an easy-to-install and cheap maintenance. The results show the time series of particulate matter as well as the daily profile and the data completeness calculated for the period of monitoring. It is intended as future work to relate the measurements of PM10 and PM2.5 with other methodologies and compare data with other
equipment. Joinville is a highly industrialized city and has no official monitoring, so the continuity of this work with the expansion of monitoring stations is vital to make the data available to the population and to understand the relationship between local atmospheric stability and air quality.

**PAPER ID45- DETERMINATION OF WATER CONTENT IN HEAVY FUEL OIL USING A RELATIVE PERMITTIVITY METER**

Daniel Arantes, Mateus Campos, Luiz Silva, Wilson Sant'Ana, Carlos Teixeira, Germano Lambert-Torres, Erik Bonaldi, Levy Oliveira, Germando Costa

**Abstract:** The measurement of relative permittivity of fluids is a convenient way to identify the amount of each element in a two-component mixture. This approach applies especially to cases in which the permittivities of the two components are far apart from each other, such as determining the water content in heavy fuel oil (HFO). The latter is a high-viscosity and high-density fuel, obtained from residual portions in the distillation process of crude oil. The presence of water in HFO is generally unwanted, and can be a major concern due to equipment degrading, decrease in heat transfer capabilities and loss of burning efficiency. This work addresses the determination of water content in HFO samples, benefiting from the great difference between the relative permittivities of both fluids. A relative permittivity meter designed specifically for this purpose was employed. The meter uses capacitance as its working principle, and comprises a capacitive sensor that is in direct contact with the oil, and a capacitance meter circuit that connects to the sensor. This paper describes both components, as well as the calibration procedures involved in their usage. HFO samples with different amounts of water were prepared and probed in order to obtain a relationship between water content and relative permittivity. The collected data provides enough information to determine the amount of water present in other HFO samples, by measuring its permittivity and using adequate interpolation methods.