Appendix

Acronyms and Definitions

Timothy J. Wilmering  The Boeing Company

AAIB
Air Accident Investigation Branch
ACARS
Aircraft Communications Addressing and Reporting System
ACID
Atomicity, Consistency, Isolation, and Durability
ACMS
Aircraft Condition Monitoring System
ADMS
Aircraft Diagnostic and Maintenance System
AI
Artificial Intelligence
AL
Autonomic Logistics
Ambiguity group
a set of diagnoses that cannot be distinguished with the given set of test outcomes
AMOC
Alternative Means Of Compliance
Anomaly
irregularity or abnormality in a system
ASIAS
Aviation Safety Information Analysis and Sharing
BIT
Built-In Test
BITE
Built-In Test Equipment
CAA
Civil Aviation Authority
Capta
a subset of data, which is selected by machine rules or by a person, where the data has relevance to a particular context of interest
CARUD
Create, be Aware, Read, Update, and Delete
CBM
Condition-Based Maintenance
CBM+
Condition Based Maintenance Plus is the application and integration of appropriate processes, technologies, and knowledge-based capabilities to improve the reliability and maintenance effectiveness of DoD systems and components. At its core, CBM+ is maintenance performed based on evidence of need provided by Reliability-Centered Maintenance (RCM) analysis and other enabling processes and technologies. CBM+ uses a systems engineering approach to collect data, enable analysis, and support the decision-making processes for system acquisition, sustainment, and operations.
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<th>Term</th>
<th>Definition</th>
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<tr>
<td>CI</td>
<td>Condition Indicator</td>
</tr>
<tr>
<td>CND</td>
<td>Can Not Duplicate</td>
</tr>
<tr>
<td>Condition-based maintenance</td>
<td>maintenance performed as governed by condition monitoring programmes²</td>
</tr>
<tr>
<td>Condition monitoring</td>
<td>acquisition of information and data that indicates the state of a machine over time²</td>
</tr>
<tr>
<td>CONOPS</td>
<td>CONcept of OPerationS</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial-Off-The-Shelf</td>
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<tr>
<td>CRIS</td>
<td>Common Relational Information Schema</td>
</tr>
<tr>
<td>CVFDR</td>
<td>Cockpit Voice and Flight Data Recorder</td>
</tr>
<tr>
<td>CVR</td>
<td>Cockpit Voice Recorder</td>
</tr>
<tr>
<td>DAPU</td>
<td>Data Acquisition and Processing Unit</td>
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<tr>
<td>DBA</td>
<td>Data-Base Administrator</td>
</tr>
<tr>
<td>DCS</td>
<td>Detection Confidence Score</td>
</tr>
<tr>
<td>Dependability</td>
<td>the ability of some system to perform its required functions when needed, as specified, and without catastrophic failure⁶</td>
</tr>
<tr>
<td>DFP</td>
<td>Detection False Positive</td>
</tr>
<tr>
<td>DI</td>
<td>Detailed Inspection</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>the conclusion(s) inferred from tests, observations, or other information; conclusion or group of conclusions drawn about a system or unit under test⁵.²</td>
</tr>
<tr>
<td>Diagnostic maturation</td>
<td>the process of monitoring diagnostic system predicted vs. actual performance to identify and implement corrective action. The goal is to enhance diagnostic effectiveness throughout the product life cycle. Diagnostic elements that may benefit from the maturation process include (but are not limited to) diagnostic models, system performance models, test programs, and even product design improvements.⁶</td>
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<tr>
<td>Diagnostic reasoner</td>
<td>a system that uses a knowledge base to infer conclusions¹</td>
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<tr>
<td>Diagnostic strategy</td>
<td>1) An approach taken to combine factors including constraints, goals and other considerations to be applied to the localization of faults in a system. 2) The approach taken to evaluate a system in order to obtain a diagnostic result.¹</td>
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<tr>
<td>DMC</td>
<td>Direct Maintenance Cost</td>
</tr>
<tr>
<td>DSS</td>
<td>Decision Support System</td>
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<tr>
<td>EAM</td>
<td>Enterprise Asset Management</td>
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</table>
EASA European Air Safety Agency
EGT Exhaust Gas Temperature
EHM Engine Health Management
EMOO Evolutionary Multi-Objective Optimization
ERP Enterprise Resource Planning
FA False Alarm
FAA Federal Aviation Administration
FADEC Full Authority Digital Engine Controller
Failure the loss of ability of a system to perform some intended function
Failure mode observable manifestation of a system fault
Failure rate number of failures within a population divided by the number of life units used by that population
False alarm an indicated fault where no fault exists
False negative an indication from a test or monitor which indicates that its outcome is “good” when the condition being monitored is actually “bad” (Type II error).
False positive An indication from a test or monitor which indicates that its outcome is “bad” when the condition being monitored is actually “good” (see false alarm or Type I error).
Fault a physical cause of anomalous behavior within a system; condition of a machine that occurs when one of its components or assemblies degrades or exhibits abnormal behaviour, which may lead to the failure of the machine
Fault isolation the process of reducing the set of diagnoses in ambiguity to a degree sufficient to undertake an appropriate corrective action
Fault progression characterization of the change in the observability of a fault over time
FBD Function Block Diagram
FC Fault Condition
FDA Flight Data Acquisition
FDAU Flight Data Acquisition Unit
FDM Flight Data Management
FDR Flight Data Recorder
FFT Fast Fourier Transform
FMEA Failure Modes Effects Analysis
<table>
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<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>FMECA</td>
<td>Failure Mode Effects Criticality Analysis</td>
</tr>
<tr>
<td>FOQA</td>
<td>Flight Operation Quality Assurance</td>
</tr>
<tr>
<td>FTA</td>
<td>Fault Tree Analysis</td>
</tr>
<tr>
<td>GAG</td>
<td>Ground-Air-Ground</td>
</tr>
<tr>
<td>GCCS</td>
<td>Global Command Control System</td>
</tr>
<tr>
<td>GCSS</td>
<td>Global Combat Support System</td>
</tr>
<tr>
<td>GSS</td>
<td>Ground Support Station</td>
</tr>
<tr>
<td>GVI</td>
<td>General Visual Inspection</td>
</tr>
<tr>
<td>HHMAG</td>
<td>Helicopter Health Management Advisory Group</td>
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<tr>
<td>HM</td>
<td>Health Management</td>
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<tr>
<td>HUMS</td>
<td>Health and Usage Monitoring System</td>
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<tr>
<td>ICAO</td>
<td>International Civil Aviation Organisation</td>
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<td>IFHM</td>
<td>Integrated Fleet Health Management</td>
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<tr>
<td>IFSD</td>
<td>In-Flight Shut Down</td>
</tr>
<tr>
<td>IFESD</td>
<td>In-Flight Engine Shut Down</td>
</tr>
<tr>
<td>IHUMS</td>
<td>Integrated Health and Usage Monitoring System</td>
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<tr>
<td>INCOSE</td>
<td>INternational Council on Systems Engineering</td>
</tr>
<tr>
<td>IN/FC</td>
<td>INspection/Functional Check</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual Property</td>
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<tr>
<td>IP</td>
<td>Internet Protocol</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IVHM</td>
<td>Integrated Vehicle Health Management</td>
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<tr>
<td>JSF</td>
<td>Joint Strike Fighter</td>
</tr>
<tr>
<td>Knowledge base</td>
<td>a set of data, data semantics and relationships, and functions used by diagnostic reasoners</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>LCC</td>
<td>Life Cycle Costing</td>
</tr>
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Integrated Vehicle Health Management

the unified capability of a system of systems to assess the current or future state of the member system health and integrate that picture of system health within a framework of available resources and operational demand.
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<td>Level of indenture</td>
<td>a hierarchical partition in a physical or functional system decomposition⁶</td>
</tr>
<tr>
<td>Level of maintenance</td>
<td>a level at which test, diagnosis, and repair operates (e.g., maintenance depot, factory, in the field)⁵</td>
</tr>
<tr>
<td>LRU</td>
<td>Line Replaceable Unit</td>
</tr>
<tr>
<td>MPIG</td>
<td>Maintenance Planning Industry Group</td>
</tr>
<tr>
<td>MRBR</td>
<td>Maintenance Review Board Report</td>
</tr>
<tr>
<td>MRO</td>
<td>Maintenance, Repair, and Overhaul</td>
</tr>
<tr>
<td>MSG</td>
<td>Maintenance Steering Group</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mean Time Between Failure</td>
</tr>
<tr>
<td>MTTR</td>
<td>Mean Time To Repair</td>
</tr>
<tr>
<td>NDI</td>
<td>Non-Destructive Inspection</td>
</tr>
<tr>
<td>NDT</td>
<td>Non-Destructive Test</td>
</tr>
<tr>
<td>NFF</td>
<td>No Fault Found</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>OSA-CBM</td>
<td>Open Systems Architecture-Condition-Based Maintenance</td>
</tr>
<tr>
<td>PCMCIA</td>
<td>Personal Computer Memory Card International Association</td>
</tr>
<tr>
<td>PDF</td>
<td>Probability Density Function</td>
</tr>
<tr>
<td>PEHM</td>
<td>Predictive Equipment Health Monitoring</td>
</tr>
<tr>
<td>P-F</td>
<td>Potential to Functional failure (interval)</td>
</tr>
<tr>
<td>PHM</td>
<td>Prognostics Health Management</td>
</tr>
<tr>
<td>P&amp;ID</td>
<td>Process and Instrumentation Diagram</td>
</tr>
<tr>
<td>POD</td>
<td>Probability Of Detection</td>
</tr>
<tr>
<td>Prognosis</td>
<td>Estimation of time to failure and risk for one or more incipient failure modes²</td>
</tr>
<tr>
<td>Prognostics</td>
<td>analysis of the symptoms of faults to predict future condition and residual life within design parameters²</td>
</tr>
<tr>
<td>PSS</td>
<td>Product Service System</td>
</tr>
<tr>
<td>QAR</td>
<td>Quick Access Recorder</td>
</tr>
<tr>
<td>R&amp;O</td>
<td>Repair &amp; Overhaul</td>
</tr>
<tr>
<td>RCM</td>
<td>Reliability-Centered Maintenance</td>
</tr>
<tr>
<td>Reliability</td>
<td>probability that a machine will perform its required functions without failure for a specified time period when used under specified conditions²</td>
</tr>
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</table>
Integrated Vehicle Health Management

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>RFID</td>
<td>Radio Frequency IDentification</td>
</tr>
<tr>
<td>RTB</td>
<td>Rotor Track and Balance</td>
</tr>
<tr>
<td>RUL</td>
<td>Remaining Useful Life</td>
</tr>
<tr>
<td>S-SHM</td>
<td>Scheduled-Structural Health Monitoring</td>
</tr>
<tr>
<td>SDI</td>
<td>Special Detailed Inspection</td>
</tr>
<tr>
<td>SE</td>
<td>Systems Engineering</td>
</tr>
<tr>
<td>SHEL</td>
<td>Safety Health Environment and Legislation</td>
</tr>
<tr>
<td>SHM1</td>
<td>System Health Management</td>
</tr>
<tr>
<td>SHM</td>
<td>Structural Health Management, Structural Health Monitoring</td>
</tr>
<tr>
<td>SME</td>
<td>Small and Medium Enterprise</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal to Noise Ratio</td>
</tr>
<tr>
<td>System</td>
<td>a collection of entities to be processed by applying a top-down, hierarchical approach; a collection of elements forming a collective, functioning entity; a collection of hardware or software components necessary for performing a function; a set of interconnected elements that achieve a given objective through the performance of a specified function.</td>
</tr>
<tr>
<td>Systems engineering</td>
<td>an interdisciplinary approach and means to enable the realization of successful systems</td>
</tr>
<tr>
<td>Test</td>
<td>a set of stimuli, either applied or known, combined with a set of observed responses and criteria for comparing these responses to a known standard</td>
</tr>
<tr>
<td>TRL</td>
<td>Technology Readiness Level</td>
</tr>
<tr>
<td>TSA</td>
<td>Time Synchronous Averaging</td>
</tr>
<tr>
<td>Type I error</td>
<td>a false positive indication – a test or monitor which indicates that its outcome is “bad” when the condition being monitored is actually “good” (see false alarm).</td>
</tr>
<tr>
<td>Type II error</td>
<td>a false negative indication – a test or monitor which indicates that its outcome is “good” when the condition being monitored is actually “bad.”</td>
</tr>
<tr>
<td>UA</td>
<td>Unexplained Anomaly</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
</tr>
<tr>
<td>Unexplained anomaly</td>
<td>a functional failure that cannot be attributed to any known system failure mode</td>
</tr>
</tbody>
</table>
Appendix Acronyms and Definitions

Validation the process of ensuring the correct system to meet customer needs has been constructed

Verification the process of ensuring that the system has met all of the developed requirements

VHM Vibration Health Monitoring

VLRS Vehicle-Level Reasoning System

V&V Verification and Validation

References

1IEEE 1232-2011, Artificial Intelligence Exchange and Service Tie to All Test Environments.

2ISO/DIS 13372, Condition Monitoring and Diagnostics of Machines—Vocabulary (Draft Update to 13372:2004).


5IEEE 1232-2002 Artificial Intelligence Exchange and Service Tie to All Test Environments.


7SAE HM-1 Committee.

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Charlie began his engineering career in the Royal Navy, joining the submarine service and moving into operating and maintaining nuclear propulsion and electrical power and distribution systems. The broad range of equipment and the independence on patrols combined to form a solid foundation of operations and maintenance practice. On finishing a full service career, Charlie joined Rolls-Royce Marine with accountability for improving reliability and maintenance; he undertook Reliability-Centered Maintenance (RCM) training and was part of a team that successfully reduced (Trident) submarine maintenance by 20% for no loss of safety or reliability. When OSyS (then known as DS&S) was formed, Charlie moved over. OSyS delivers the predictive maintenance services in all of Rolls-Royce’s market sectors in support of the company’s product-based services. He has been part of and has influenced the fundamental changes involved as EHM matured and was part of the team that conceptualized the early development of the operations room. Charlie’s current roles are as Rolls-Royce global capability owner for Equipment Health Management (EHM), program managing Rolls-Royce IVHM research, and as Chief Engineer for EHM in OSyS, heavily involved with its fitness for purpose and development.

Charlie is active in development of Predictive Maintenance standards and processes, is a member of API 691 defining risk-based maintenance for rotating machinery in the oil and gas sector, and is a member of the SAE International HM1 committee. He has combined his engineering knowledge with a formal education with a BSc (Hons) in Computer Science and an MSc in Information systems.

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Dr. Mylaraswamy joined Honeywell in 1997 after completing his Ph.D. from Purdue University. His Ph.D. thesis on blackboard-based architectures was adopted by the Abnormal Situation Management Consortium as the basis of an operator tool for addressing the $16B loss suffered by the petrochemical industry from abnormal situations and equipment malfunctions. Dr. Mylaraswamy spent his first six years in Honeywell developing and deploying an Early Abnormal Event Detection application at six refinery sites in North America.

On the Aerospace side, he was the technical lead for Honeywell’s Predictive Trend Monitoring program, a web-based application for monitoring aircraft engines. He continues to serve as the technical lead on various health management programs — within Honeywell as well the U.S. Army, NASA, UK-MOD, and Navair — to support the Aerospace Services business within Honeywell.

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He has 30+ years of experience within the automotive sector specializing in the design and manufacture of “body in white” tooling, assembly, and production systems, with 15 years being at the executive level.

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He has developed several diagnostic and prognostic capabilities utilizing technologies such as dynamic signature analysis, artificial intelligence, aero-thermal performance monitoring, finite element modeling, probabilistic remaining life analysis, and risk assessment methods. He is the co-founder and Vice President of the PHM Society, Chairman of the SAE HM-1 Integrated Vehicle Health Management Committee, board member and past Chairman of the Machinery Failure Prevention Technology (MFPT) Society, Prognostic Lead for the SAE E-32 Engine Condition Monitoring Committee, Member of the IGTI Marine Committee and ASME Controls and Diagnostics Committee, and Adjunct Professor of Mechanical Engineering at the Rochester Institute of Technology. He is the co-author of a recent book, Intelligent Fault Diagnosis and Prognosis for Engineering Systems, and has written or co-authored more than 100 technical papers related to integrated systems health management.

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Steve subsequently fulfilled senior technical management roles within Meggitt Avionics, including Chief Engineer and, from 2003, Engineering Director with overall responsibility for all engineering activity within Meggitt Avionics, and responsibility to the UK CAA and UK MoD Defence Logistics Organisation for the approval of Meggitt Avionics as a design organisation. In this latter role, Steve held responsibility for the Meggitt Avionics Integrated Health and Usage Monitoring System (IHUMS), acquired from BAE Systems in 2002.

In 2009 Steve moved from Meggitt Avionics to Meggitt PLC, supporting the Engineering aspects of a major organisational restructure of Meggitt. In January 2011, Steve took the role of Director of Engineering for Meggitt PLC, supporting Meggitt’s Executive Vice President of Technology and Engineering, Dr. Richard Greaves, in coordination of applied research, technology, design, and development across the Meggitt group.

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