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RESEARCH REPORT

Unsettled Issues Concerning Integrated Vehicle Health Management Systems and Maintenance Credits

Ravi Rajamani

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About the Editor

Dr. Ravi Rajamani is an independent consultant in the aerospace and energy sectors. He has many years of experience in the application of systems engineering principles and data analytics and model-based methods to controls, diagnostics, and prognostics, especially for propulsion systems. He has authored or coauthored five books, including *Electric Flight Technology: The Unfolding of a New Future*. In addition, Dr. Rajamani is the author of many book chapters, journal articles, conference papers, and patents. Prior to his current job, Ravi worked at Meggitt, United Technologies Corporation, and the General Electric Company. He has a PhD from the University of Minnesota and an MBA from the University of Connecticut. His earlier degrees were BTech from the Indian Institute of Technology, Delhi, and an MSc from the Indian Institute of Science, Bangalore. He is active within various SAE technical committees dealing with prognostics and health management (PHM) and electric propulsion. He is also active in the PHM Society, serving on its board of directors. He has been elected as Fellow of SAE International and of the Institution of Mechanical Engineers. He currently serves as the Editor-in-Chief of the SAE International Journal of Aerospace. In addition, he has a research appointment at the University of Connecticut and is a visiting Professor at Cranfield University.

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Abstract

The "holy grail" for prognostics and health management (PHM) professionals in the aviation sector is to have integrated vehicle health management (IVHM) systems incorporated into standard aircraft maintenance policies. Such a change from current aerospace industry practices would lend credibility to this field by validating its claims of reducing repair and maintenance costs and, hence, the overall cost of ownership of the asset. Ultimately, more widespread use of advanced PHM techniques will have a positive impact on safety and, for some cases, might even allow aircraft designers to reduce the weight of components because the uncertainty associated with estimating their predicted useful life can be reduced. The journey to that end will not be easy, but we believe that it will be successful. The entire idea of diagnostics and prognostics is to look at sensed data along with the knowledge about system operations from accurate models, and develop an estimate of whether the system is behaving in an acceptable manner. Even when operations are within a range of acceptable behavior, IVHM systems can predict future behavior of the systems from estimated deviations and trends. For example, vibration levels in an engine might be acceptable within engineering limits of operation but might start trending consistently in the "wrong" direction. Using this information to predict the condition of the engine in the future would constitute a prognostic estimate that can be used to schedule appropriate upcoming maintenance actions. In general, maintenance practices in the aviation world depend on regular inspections to ensure that systems are functioning correctly. These maintenance practices are enhanced by condition indicators that can trigger alarm conditions that require immediate or imminent action. Until quite recently, the use of IVHM systems to either increase inspection intervals or eliminate them in favor of fully condition-based maintenance (CBM) has not been deemed acceptable by regulatory authorities. In this report we will outline a few developments in recent times that point to a more favorable future for IVHM systems in affecting established maintenance

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