

SAE INTERNATIONAL

# BEST PRACTICES IN DEVELOPING PHM STANDARDS

SAE INTERNATIONAL

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SAE Aerospace Standards



# Agenda

- SAE INTERNATIONAL OVERVIEW
- CASE STUDIES
- HARMONIZED GLOBAL STANDARDS

# ABOUT SAE

- Not for profit, non-lobbying technical society
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  - Aerospace Standards – Washington DC
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# SAE INTERNATIONAL AEROSPACE STANDARDS ENABLE SAFER AND MORE EFFICIENT AIR TRAVEL

Approximately 1800 SAE International standards are used in the development of a typical airliner.

The first aerospace standard was written in 1916.

Today there are over 8500 active aerospace standards and over 17500 historical standards in circulation.



# CASE STUDIES

# Standard Adapting to Technology Advancements

- **E-32 - AIR1839, A Guide to Aircraft Turbine Engine Vibration Monitoring Systems**
- 1973 – FAR Part 25.1305 (d) (3) required engine unbalance display
- **1986 – AIR1839 Published**
  - Move from analog to digital tracking filter systems
- **1992 – Revision A**
  - Economics of vibration monitoring
  - Information for maintenance personnel
- **2001 – Revision B**
  - Tracking filter center frequency slaved to engine rotor speed
  - Spectral analysis of vibration signal
  - Comprehensive details on rotor trim balancing (in-flight data collection, balance coefficients & calculations)

SAE AIR1839 92 7943725 050496 849

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**AEROSPACE INFORMATION REPORT**

SAE AIR1839 REV. A  
Issued 1986-10  
Revised 1992-03-10

Submitted for recognition as an American National Standard

**A GUIDE TO AIRCRAFT TURBINE ENGINE VIBRATION MONITORING SYSTEMS**

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# Standard Adapting to Technology Advancements

## 2008 – Revision C

- New engines with EMU (engine monitoring unit) permit tailoring to engine OEM's EHM program and may be integrated with AHM
- Vibration analysis techniques now include Fast Fourier Transform and Pattern Matching
- Improved predictive capability

## 2015 - Upgraded to ARP1839

- Incorporates content from AS8054, Airborne Engine Vibration Monitoring System, Guidelines for Performance Standard For
- Integration of EVM into IVHM system transmits vibration data files for ground-based data analysis
- Human factors interface
- Measurement uncertainty

## 2018 – Publish ARP5987 Maintenance Credits Using EHM

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<b>SAE INTERNATIONAL</b>	<b>AEROSPACE RECOMMENDED PRACTICE</b>	<b>ARP1839</b>
		Issued
		Proposed Draft 2015-07-20

A Guide to Aircraft Turbine Engine Vibration Monitoring Systems

RATIONALE

This edition updates content, includes appropriate content from AS8054 and issues ARP1839 to an ARP in accordance with E-32 committee decision.

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# Evolution of Cost Benefits Documents



**AEROSPACE  
INFORMATION REPORT**

AIR4176	REV. A
Issued 1995-10	Reaffirmed 2005-10
Cancelled 2015-03	Superseded by ARP4176

**Cost Versus Benefits of Engine Monitoring Systems**

**RATIONALE**  
 The AIR has been superseded by a completely new document, ARP4176, which not only takes a different approach to cost and benefits of Engine Health Management, but also provides much more up-to-date information. The original AIR is, thus, out of date and of no value to readers. So, the document should be cancelled and not re-issued.

**CANCELLATION NOTICE**  
 This document has been declared "CANCELLED" as of March 2015 and has been superseded by ARP4176. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index noting that it is superseded by ARP4176. Cancelled specifications are available from SAE.


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AIR4176, Cost Versus Benefits of Engine Monitoring Systems (E-32, 1995)



**AEROSPACE  
RECOMMENDED  
PRACTICE**

SAE ARP4176
Issued 2013-02
Superseding AIR4176

**Determination of Costs and Benefits from Implementing an Engine Health Management System**

**RATIONALE**  
 This Aerospace Recommended Practice (ARP) provides insight into how to create a cost benefit analysis to determine the justification for implementing a propulsion/engine health management system. The considerable advancement of health management (HM) tools and capabilities in the past 10 years, coupled with some successful applications to legacy and new engines drove the need to re-write the original AIR and provide more specific guidance, thus creating the need for an ARP. Moreover, future fleet installability requests in recent years by potential engineers, both commercial and military, to better understand how to make a convincing business case within their organizations, thus, for many, has become the stumbling block that prevents implementation of an Engine Health Management System.

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ARP4176, Determination of Costs and Benefits from Implementing an Engine Health Management System (E-32, 2013)



**AEROSPACE  
RECOMMENDED PRACTICE**

ARP6275
Issued 2014-07

**Determination of Cost Benefits from Implementing an Integrated Vehicle Health Management System**

**RATIONALE**  
 This SAE Aerospace Recommended Practice (ARP) provides insight into the factors to be considered for not only generating a cost benefit analysis but also the justification for implementing an integrated health management system to an aircraft. With the considerable advancement of prognostics and health management (PHM) tools and capabilities in the past 10 years, more and more operators and fleet managers are asking for ways in which the overall value proposition of installing such a system, be it on in-service equipment or still-in-design systems, can be determined.

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ARP6275, Determination of Cost Benefits from Implementing an Integrated Vehicle Health Management System (HM-1, 2014)

# SAE Automotive Health Management Standards

## Passenger Car & Light-Duty Trucks On-Board Diagnostics

Standard	Title	Initial Release	No. of Revisions	Most Recent Revision
J1962	Diagnostic Connector	1992	7	2015
J1850	Class B Data Communications Network Interface	1988	8	2006
J1978	OBD II Scan Tool	1992	3	2002
J1979	E/E Diagnostic Test Modes	1991	8	2014
J2012	Diagnostic Trouble Code Definitions	1992	7	2013

# Summary

- Mechanisms exist to update SAE standards based upon technology advancements
- Over 30 year period, engine vibration monitoring evolution from AIR1839 to ARP5987  
Analog → digital tracking → trim balancing → IVHM
- Various paths utilized to adapt standards independent of technology
  - Committee collaboration
  - Outside organizations
  - Consolidation efforts
- SAE Health Management standards are **flexible** enough to incorporate new technology  
**AND YET**  
**stable** enough to support product development and regulatory requirements

## **ARD6888 Functional Specification of Miniature Connectors for Health Monitoring Purposes**

- Specifies functional needs for family of miniature connectors dedicated to health monitoring
- Suitable for severe environments (including engines)
- Prepared as background for AE-8C1, Connectors Committee to develop a new AS

## **New Work Item with AE-7B, Power Management, Distribution & Storage**

- Preparing a Lithium-ion battery health management document

## **ARP6268 Design & Online Communication Standards for Health Ready Components**

- Platform agnostic – ground vehicles or airborne vehicles

# STANDARDS APPLICABLE TO BOTH AEROSPACE AND AUTOMOTIVE

- **Some SAE Standards and Recommended Practices (JA documents) are utilized in both Aerospace and Automotive sectors**
- **Joint Aero/Auto documents are strongly encouraged and supported by SAE International in order to:**
  - Leverage our knowledge and applicable best practices across sectors
  - Broaden appeal and acceptance of SAE Standards to the benefit of industry
  - Support industry trends of cross utilization of technology and supply base across sectors
- **JA6268 Joint Recommended Practice: *Design & Run-Time Information Exchange for Health-Ready Components.***
  - Approved March 28, 2018
  - Generated within the HM-1 aero committee incorporating both Aerospace and Automotive inputs
  - Created to help reduce barriers to implementing Integrated Vehicle Health Management (IVHM) technology in aerospace and automotive sectors.
  - Registry of Health-Ready Components will be developed
  - Pilot planned by year-end 2018

## CASE STUDY 2 – Digital Transformation

***At present the rate of development of data management and sensing technology is very high. Emergent technologies such as Big Data, the Industrial Internet of Things (IIOT) and forth generation manufacturing means data interoperability will be in a continuous state of flux for some time.***

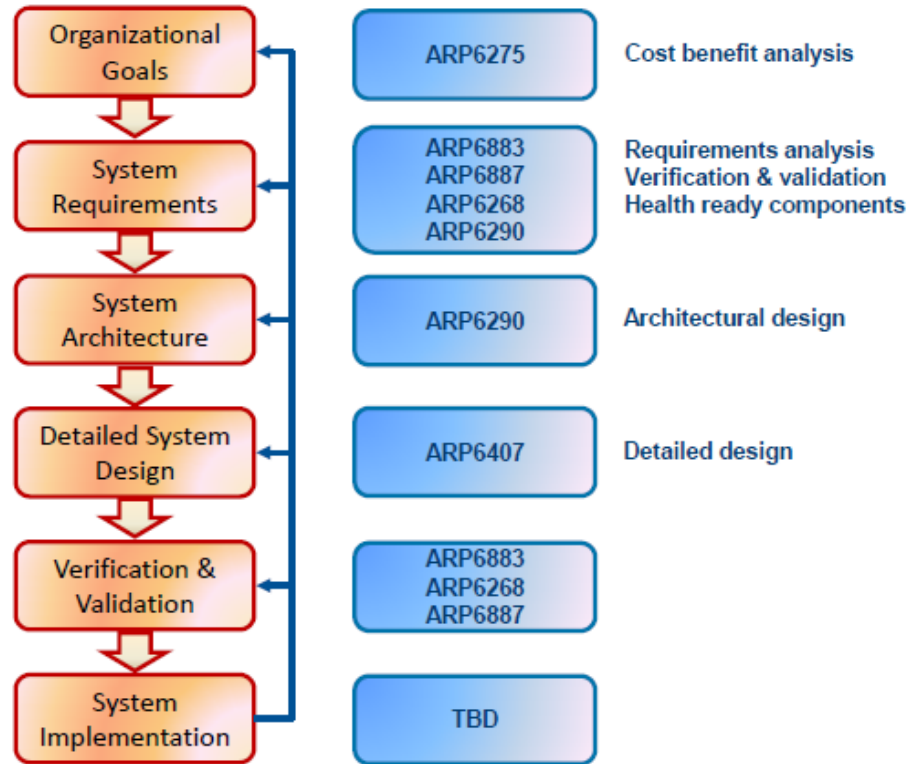
***ARP6904 - The purpose of this WIP is to outline the recommended approach to adopt, manage and develop data interoperability. With the number of stakeholders involved and the amount of data sharing required, there is a clear need for data interoperability to support the maintenance, logistics, operation and engineering analysis. This document may require frequent updating to ensure the latest knowledge is incorporated.***

# CASE STUDY 1 – SAE G-23 MANUFACTURING MANAGEMENT

- Manufacturing issues have been identified as ‘root cause’ of past problems
- Appropriate manufacturing requirements have not been specified in contracts
- Air Force identified need to develop a standard that could be called out in procurement
- SAE G-23 Manufacturing Management Committee created to address these issues through standard development
- AS6500 provides additional focus and details on critical manufacturing processes
- AS6500 aims to ensure tasks are accomplished consistently



# SAE IVHM Standards Landscape





- **HARMONIZED GLOBAL STANDARDS**

# PROFESSIONAL DEVELOPMENT SEMINARS AND ACADEMIES

- Active Safety
- Threaded Fasteners and the Bolted Joint
- Metal Fatigue
- Sensors and Actuators
- Additive / Advanced Manufacturing
- Counterfeit Parts Control
- Quality Management System Standards
- Accident Reconstruction
- Corrosion / Degradation
- Alternative Fuels and Energy Sources
- Composite Development & Design
- Cybersecurity - Vulnerability
- Connected Aircraft



## Comparison of *ASME/ISO* 1-day

Sector: [Automotive](#)

Topic: [Standardization](#), [CAD, CAM, and CAE](#), [Design processes](#)

Providing you have a basic understanding of Y14.5 Dimensioning and Tolerancing practices, this course explains the major differences between the ASME and ISO standards in a concise, easily understood manner.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on how the standards compare when dealing with symbols, feature control frames, tolerances, form controls, datums, and more. Newly acquired learning is reinforced throughout the class with numerous practice problems.

**Document: CMB7-4A**

## **Title: Glossary of Terms, Acronyms, and Definitions**

### **References**

The following standards and handbooks were used to create this glossary.

- ASME Y14.24 -1999 (R2004), Types and Applications of Engineering Drawings
- ASME Y14.34 - 2008, Associated Lists

The information in these listings was extracted from standards and documents prepared by the Systems Engineering (G47), Configuration Management (G33), Life Cycle Logistics Supportability and Enterprise Information Management Interoperability Committees along with other pertinent international, industry and government standards. It is intended that this bulletin be used as a resource to help with harmonization of terms and definitions across standards.

# QUESTIONS?

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