SAE INTERNATIONAL

BEST PRACTICES IN DEVELOPING PHM STANDARDS

SAE INTERNATIONAL

Logen Johnson

SAE Aerospace Standards

Agenda

- SAE INTERNATIONAL OVERVIEW
- CASE STUDIES
- HARMONIZED GLOBAL STANDARDS

ABOUT SAE

- Not for profit, non-lobbying technical society
- Global, industry-managed, industry-led programmes
- Standards Development Organisation (SDO)
- Wealth of engineering knowledge in books, standards, papers, online content
- Technical conference provider
- Engineering training provider
- Offices in North America, Asia, Europe:
  - World Headquarters – Warrendale PA, USA
  - ARINC HQ – Bowie, MD, USA
  - Aerospace Standards – Washington DC
  - Asia – Shanghai, PRC
  - Aerospace Standards Europe – London, Brussels

THE SAE PORTFOLIO

A Global Association of More Than 140,000 Engineers and Related Technical Experts

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.

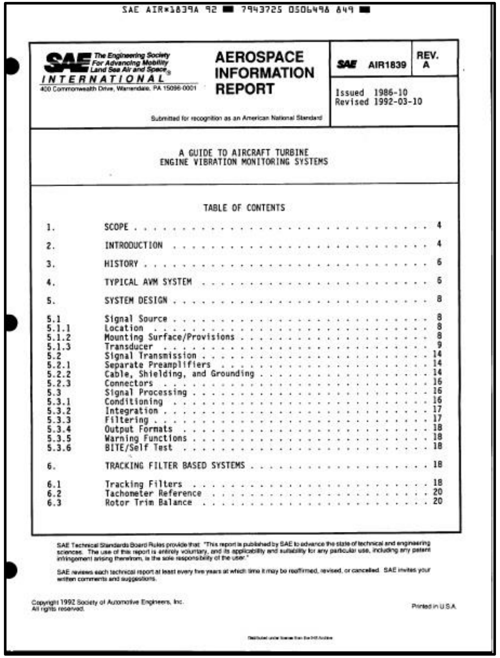
The first aerospace standard was written in 1916.

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 AIR*1839A 92 ■ 7943725 0506498 849 ■

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

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

TABLE OF CONTENTS

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Printed in U.S.A.

Standard Adapting to Technology Advancements

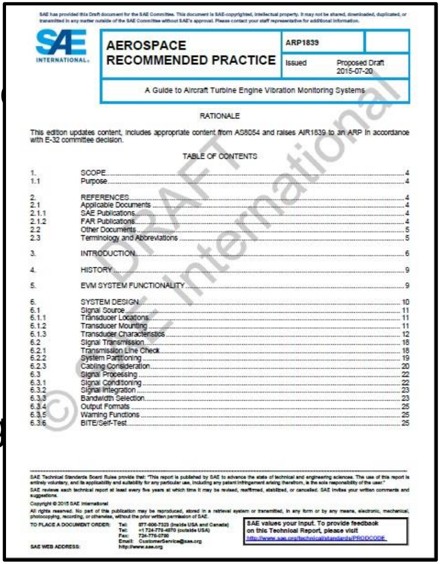
2008 – Revision C

- New engines with EMU (engine monitoring unit) permit tailoring to engin 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



SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE	ARP1839	
	Issued	Proposed Draft 2015-07-20

A Guide to Aircraft Turbine Engine Vibration Monitoring Systems

RATIONALE

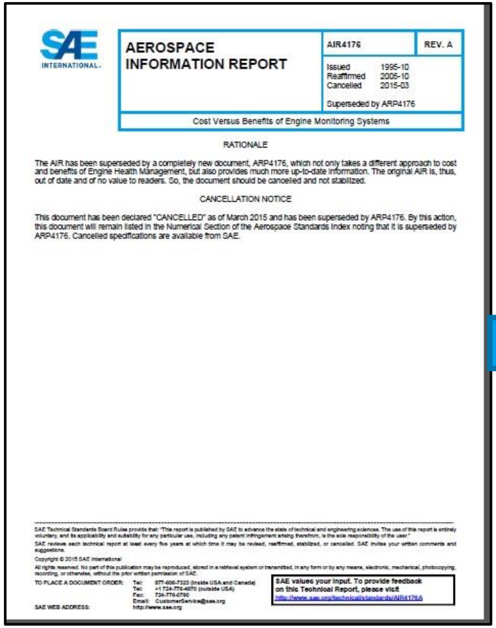
This edition updates content, includes appropriate content from AS8054 and raises AIR1839 to an ARP in accordance with E-32 committee decision.

TABLE OF CONTENTS

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit http://www.sae.org/technical/standards/PRODCODE

Evolution of Cost Benefits Documents



SAE INTERNATIONAL

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

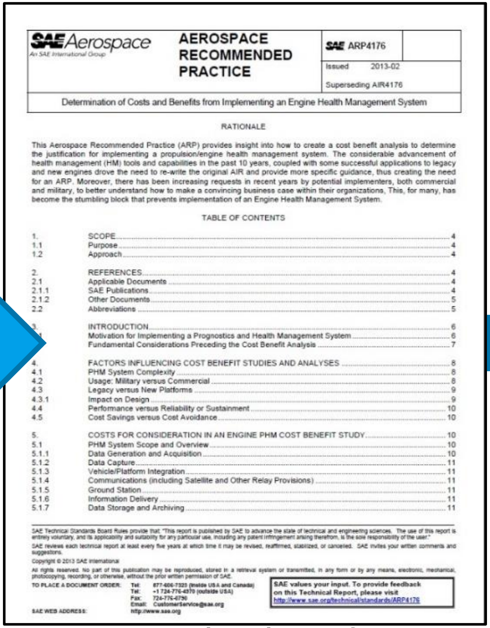
RATIONALE

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 stabilized.

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.

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



SAE Aerospace

AEROSPACE RECOMMENDED PRACTICE

ARP4176

Issued 2013-02

Superseding AIR4176

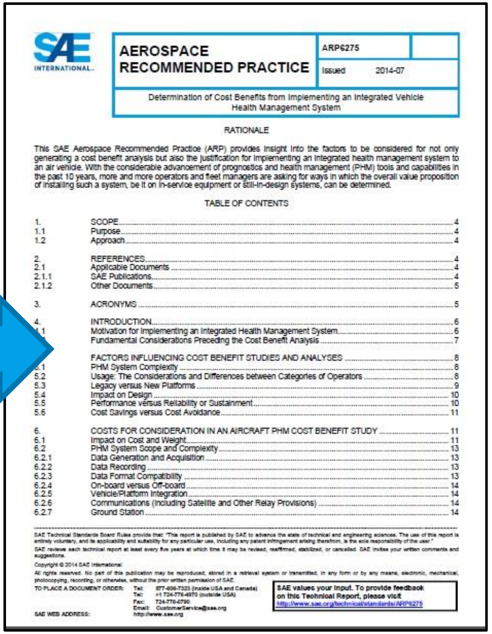
Determination of Costs and Benefits from Implementing an Engine Health Management System

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, there has been increasing requests in recent years by potential implementers, both commercial and military, to better understand how to make a convincing business case within their organizations. This, for many, has become the stumbling block that prevents implementation of an Engine Health Management System.

TABLE OF CONTENTS

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



SAE INTERNATIONAL

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 air vehicle. 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.

TABLE OF CONTENTS

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

HM-1 Documents Involving Other SAE Technical Committees

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

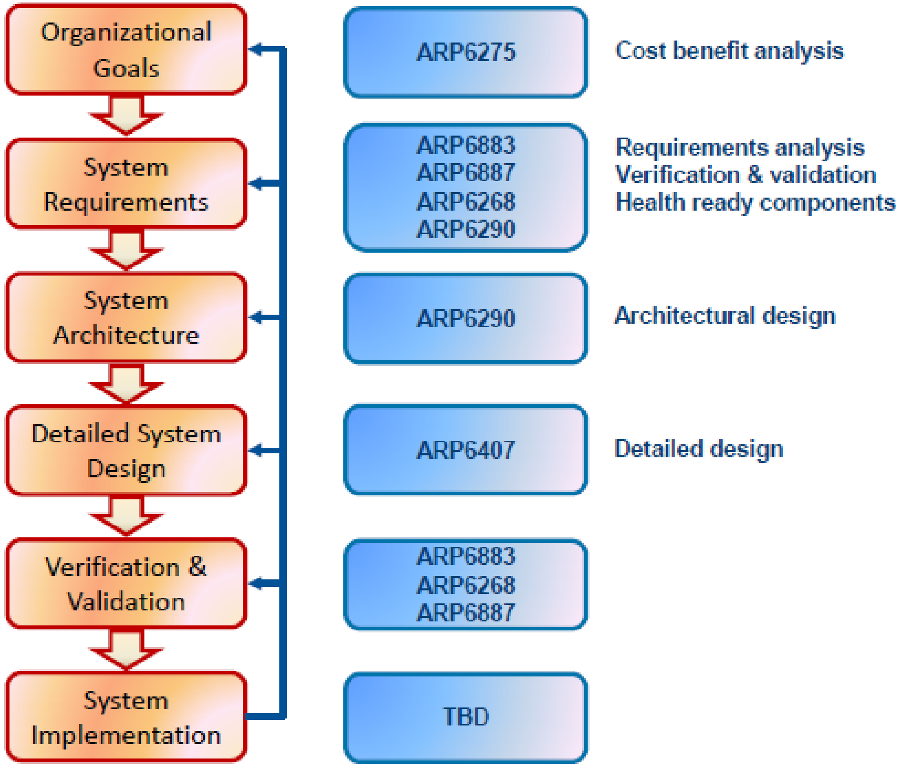
At present the rate of development of data management and sensing technology is very high. Emergent technologies such as Big Data, the Industrial Internet of Things (IIOT) and forth generation manufacturing means data interoperability will be in a continuous state of flux for some time.

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

SDO COLLABORATION

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.

SDO COLLABORATION

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?

Logen Johnson
Aerospace Standards Engineer
SAE International
m +1 724.272.0495
Logen.johnson@sae.org