

AEROSPACE INFORMATION REPORT

AIR6904™

Issued

2020-04

Rationale, Considerations, and Framework for Data Interoperability for Health Management within the Aerospace Ecosystem

RATIONALE

Current aerospace systems are generating large amounts of data; for the most part, all this data is being created by siloed entities (i.e., stakeholders like components/sub-system manufacturers, original equipment manufacturers (OEMs), and operators) and ends up living within the four walls of these individual entities. Aerospace industry can greatly benefit from turning this data into useful information to support its business goals. To achieve this goal, the industry can benefit from sharing sanitized data for developing new capabilities that benefit the industry as a whole. Hence, there is a need for a more effective and transparent way to share this data while strictly controlling the proprietary nature of the data adhering to all contractual terms and conditions. The purpose of this document is to describe the current digital data landscape and approach that can support health management.

TABLE OF CONTENTS

1.	SCOPE.....	3
1.1.	Purpose	3
2.	REFERENCES.....	3
2.1	Applicable Documents	3
2.1.1	SAE Publications.....	3
2.1.2	FAA Publications.....	3
2.1.3	Network Working Group Publications	3
2.1.4	IEEE Publications.....	3
2.1.5	Other Publications.....	4
2.2	Abbreviations and Definitions	4
3.	INTRODUCTION.....	5
4.	TECHNOLOGY CREATING BIG DATA IN THE AEROSPACE ECOSYSTEM	6
5.	BUSINESS OUTCOMES FOR DATA INTEROPERABILITY	7
6.	“HEALTH-READY COMPONENTS” DRIVEN BY IVHM DATA INTEROPERABILITY	8
6.1	Cautionary Tale.....	9
7.	BUSINESS VALUE, TRUST, AND RISK.....	10
7.1	Intra-Enterprise “Live on an Island”.....	12
7.2	Traditional Bilateral	12
7.3	Cloud Disruptor	13
7.4	Industry Collaboration	13
7.5	Data Interoperability Platform for Defense Operator	14

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 revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2020 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

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
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE AIR6904

For more information on this standard, visit
<https://www.sae.org/standards/content/AIR6904>

Documents

Document Sharing Hub

8.	WORKED EXAMPLE	14
8.1	Health Indicator Exceedances	14
8.2	Data Retrieval	15
8.3	Onboard Instruments	15
8.4	Ground Systems	15
8.5	Light Paths	16
8.6	Collaborative Analysis	16
8.7	Digital Twin and Digital Thread	17
8.8	Resolution	17
8.9	Regulatory Issues	17
9.	TECHNOLOGY LANDSCAPE	18
9.1	Cloud and Data Technologies	18
9.2	Advanced Technologies	19
9.3	Security	19
9.4	Architecture/Infrastructure	20
10.	NEXT STEPS	21
11.	NOTES	21
11.1	Revision Indicator	21
APPENDIX A	AEROSPACE ECOSYSTEM VALUE PAIRS	22
Figure 1	Data exchanges in the aerospace ecosystem	6
Figure 2	Business outcomes of IVHM	7
Figure 3	Overview of IVHM deployment process with JA6268	8
Figure 4	IVHM stakeholders	11
Figure 5	Sample data sharing business value between a pair of ecosystem participants	11
Figure 6	Data availability and growth to deliver operational, business, and maintenance decisions	13

1. SCOPE

This SAE Aerospace Information Report (AIR) offers an overview of the aspects of intellectual property (IP) protection, legislative compliance, business model, and technologies which need to be considered and addressed to implement a data interoperability, secure business model and technology platform to enable prognostics and health management (PHM) in the digital age. While this information report is restricted to the aerospace domain and also to commercial aviation, the concepts are applicable to any other domain that employs data for supporting health management functionality.

1.1. Purpose

The purpose of this document is to provide business guidance, an overview of the current technology landscape, and an approach to consider when implementing data interoperability for Health Management in either a commercial or defense environment.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP6803	IVHM Concepts, Technology and Implementation Overview
AS5395	Health and Usage Monitoring System Data Interchange Specification
JA6268	Design and Run-Time Information Exchange for Health-Ready Components

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC120-78A	Electronic Signatures, Electronic Record Keeping and Electronic Manuals.
-----------	--

2.1.3 Network Working Group Publications

RFC1958	Architectural Principles of the Internet
---------	--

2.1.4 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 802.1	is a working group of the IEEE 802 project of the IEEE Standards Association.
IEEE 802.3	is a working group and a collection of Institute of Electrical and Electronics Engineers (IEEE) standards produced by the working group defining the physical layer and data link layer's media access control (MAC) of wired ethernet.

IEEE 802.11 is a set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) computer communication in the 900 MHz and 2.4 GHz, 3.6 GHz, 5 GHz, and 60 GHz frequency bands.

2.1.5 Other Publications

Melanie Swan, Blockchain Blueprint for a new economy, O'Reilly Media, 2015.

Global Lambda Integrated Facility, "Role of Open Exchanges in the evolution of global research and education networking," May 2011. Retrieved from: https://www.glif.is/publications/papers/20110519BStA_Open_Exchanges.pdf.

2.2 Abbreviations and Definitions

A&D	Aerospace and Defense
AIR	Aerospace Information Report
ARINC	Aeronautical Radio, Incorporated
ARP	Aerospace Recommended Practice
bps	Bits per Second
CERN	European Organization for Nuclear Research (from the French)
CRC	Cyclic Redundancy Check
DAQ	Data Acquisition
DFDR	Digital Flight Data Recorder
EASA	European Aviation Safety Agency
ECS	Environmental Control System
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FTP	File Transfer Protocol
GB	Gigabyte
GLIF	Global Lambda Integrated Facility
HI	Health Indicators
HRC	Health-Ready Component
IFE	In-Flight Entertainment
IFEC	In-Flight Entertainment and Communications
IoT	Internet of Things
IP	Intellectual Property
IPSec	Internet Protocol Security

IVHM	Integrated Vehicle Health Management
L2TP	Layer 2 Tunneling Protocol
OEM	Original Equipment Manufacturer
MAC	Media Access Control
MRO	Maintenance Repair and Overhaul
MSP	Maintenance Service Provider (A superset of all entities that provide service in the aftermarket sector. This could include MRO providers, as well as others.)
NGI	Next Generation Internet
QAR	Quick Access Recorder
PHM	Prognostics and Health Management
PHY	Physical Layer
RFP	Request for Proposal
SatCom	Satellite Communication
SOA	Service Oriented Architecture
SSL	Software Sockets Layer
TB	Terabyte
TDS	Ticket Delivery Systems
WLAN	Wireless Local Area Network

3. INTRODUCTION

In the last century, the aerospace/aviation industry has leveraged advances in technology to grow and regularly re-invent itself to increase business value, improve efficiencies, and reduce risks. Over the 100+ year lifetime of the industry, the rate of change in technology, and in business models that took advantage of these new technologies, appears to be increasing continuously. Today the challenge of rapidly changing technology juxtaposed against long product lifecycles for the assets creates a challenge for the industry to realize a return on investment.

The exponential growth in the data generated from aircraft, sub-systems, and components both on and off aircraft, as well as the data generated by maintenance, operational, and logistics is creating new challenges for the ownership, management, and control of this data, within an organization, across an operational fleet, and throughout the aerospace ecosystem. Figure 1 simplifies the complex nature of data flows within the aerospace ecosystem. Each blue arrow represents a different volume of data, in different standards, flowing between the ecosystem participants, in different formats, at varying frequency, with variety of security and privacy requirements.

There are many barriers to the successful implementation of IVHM technology in the aerospace sector. For example, operational data ownership, IP rights, data security, traceability, governance, and many more. This document will discuss what we believe are the most critical barriers. As the proliferation of new technologies related to data becomes a competitive differentiator in the aerospace field, it is important to develop standards and other guidance material that can help the user navigate these new fields. SAE has taken steps in the past to provide this guidance, including, for example, AS5395 for rotorcraft systems. However, we are entering a new era of digital transformation and more information and guidance is needed. This report is a start to fill that gap.

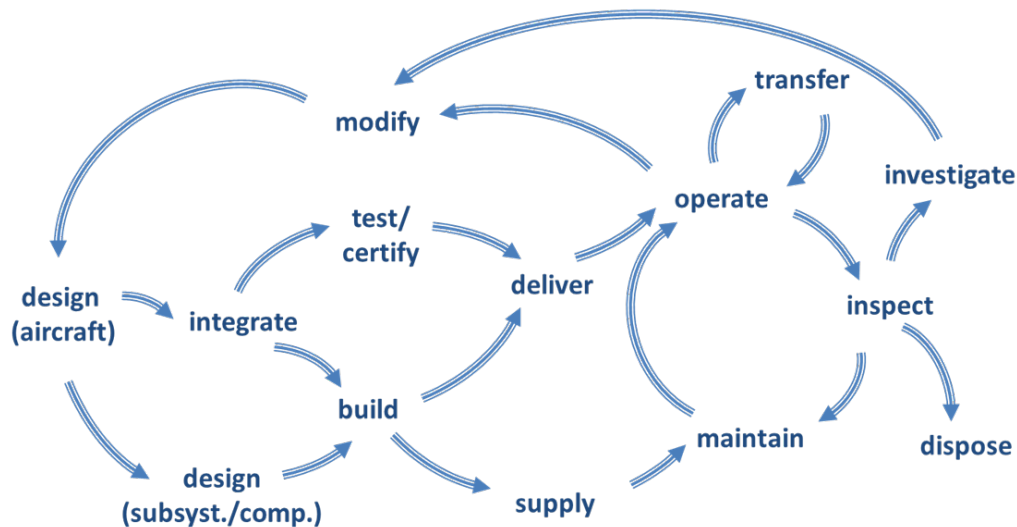


Figure 1 - Data exchanges in the aerospace ecosystem

All participants in the aerospace ecosystem want to leverage data to deliver insight and new services to their customers while protecting their own IP. The exchange of data between stakeholders in the ecosystem is complicated, non-linear, and growing exponentially. Figure 1 demonstrates the number of stakeholders involved in the aerospace ecosystem and the data sharing required between both data producers and consumers. This diagram shows a clear need for data interoperability to support efficient maintenance, logistics, operations, and design improvements for both commercial and military ecosystems. The need for data interoperability has to be balanced against the owner's data-security requirements. This document will outline different options for all aerospace ecosystem participants to collaborate and share data while ensuring their rights and obligations are properly allocated and managed. Currently, there is a barrier to innovation within the ecosystems; for example, the benefits of health-ready components will only be realized with the adoption of improved data interoperability.

4. TECHNOLOGY CREATING BIG DATA IN THE AEROSPACE ECOSYSTEM

Today there are four areas of technological development that are requiring products, companies, and the Aerospace and Defense (A&D) industry to transform themselves in order to take advantage of these technologies. These technological developments are:

1. **DIGITIZATION** of ever more and ever smaller components.
2. Almost ubiquitous **CONNECTIVITY** of these components within a vehicle and between the vehicle and the ground operations.
3. **ANALYTICS** tools to quickly and in real-time derive insight from each component, system, vehicle, process, and organization.
4. Means to **SECURE** these complex distributed systems ensures access only to those authorized to see and use that data.

Convergence of these multiple technologies is providing immense value to the aerospace industry by creating avenues for new products and services, and improved efficiencies while reducing risks and costs. This convergence presents the opportunity to address the challenges of aerospace Big Data, namely the volume of data, variety of data, veracity of data, speed of transferring the data in real time or near real time, security of data through encryption and decryption mechanisms, the insight that can be derived from the data, the value that can be generated from the data, and most importantly, who owns the data and what this ownership means in a legal sense.

The systems and components on a modern fleet of aircraft generate terabytes of data every operational hour. In the future, a single aircraft could generate data equivalent to a fleet of aircraft of today. Insights from aerospace Big Data that originate, for example, from integrated vehicle health management (IVHM) systems, may reduce costs of operations, transform operational decision making around disruptions, and improve the efficiency of maintenance operations. For example, IVHM can enable condition-based maintenance that allows reduction of scheduled maintenance through maintenance credits.

Security is critical to ensure protection of data throughout its lifecycle, from creation to disposal and while it is stored by the owner or shared with other ecosystem members. Although critical, data security is a large and very complex topic; therefore, it will be addressed in a separate document. However, in Section 9 we will outline security technologies, which today could represent components of a robust data security solution.

5. BUSINESS OUTCOMES FOR DATA INTEROPERABILITY

Business transformation happening today reflects the early stages of the new data economy. Google, Amazon, Uber, and Air BnB are leading the way data is being used to develop new products, services, and business models. However, the IP rules and Anti-Trust legislation which are in force now were developed and updated in a bygone era to regulate the then-new commodities and technologies, such as gold, oil, and telephone. These rules and laws were put in place to control the first-mover monopolies, like Standard Oil, AT&T, et al., that drove the economy of the 20th century and created public opposition, forcing governments to establish Anti-Trust regulation.

This document discusses the data implications based on the current legislation, or lack thereof, and outlines the business value and the technology to share data within an ecosystem, while protecting the intellectual property of the operator, designer, manufacturer, or service provider. As a cautionary tale, we will recount an example from the airline industry where over-controlled data, in a closed environment, led to a sub-optimal business situation, in order to reinforce the challenge and opportunity that the new data economy provides.

The advent of technology to support the aftermarket has accentuated the need for a new business model that encourages better coordination and communication between the OEM and its suppliers to reduce operational and maintenance costs while improving overall safety, as shown in Figure 2.

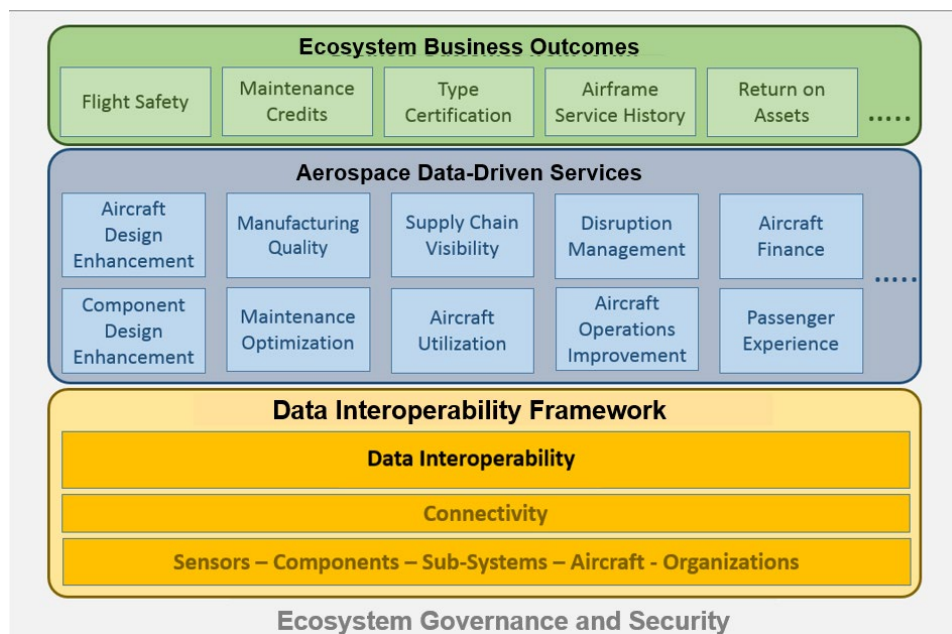


Figure 2 - Business outcomes of IVHM

With the number of stakeholders involved and the amount of data sharing required to successfully implement this new model, there is a clear need for “data interoperability” to support aerospace vehicles throughout their lifecycle and across the design, operation, maintenance, logistics, and leasing ecosystem.

Figure 2 outlines various levels of capabilities necessary to deliver new and improved business outcomes which the availability of data and today's advanced technologies are delivering, taking IVHM as an example. Similar diagrams could be drawn for other capabilities within the aerospace ecosystem. This diagram presents various layers required to realize the business value. More importantly, the diagram illustrates the need to access data across many owners and multiple sources to achieve transformative business outcomes. This document presents the functionalities required and the subsequent SAE document will address how such functionalities can create alternative solutions.

6. "HEALTH-READY COMPONENTS" DRIVEN BY IVHM DATA INTEROPERABILITY

The HM-1 committee has published a joint recommended practice document called JA6268. The JA6268 practice recommends and assists the process and procedure to be followed at design time to ensure that data and information can be shared between components or systems. However, at the operational level, more collaboration is needed to realize the benefits of Big Data for an aircraft, fleet, or program. JA6268 provides a common approach to assist suppliers in the development of components, sub-systems, and systems and to simplify the process by which integrators use these capabilities to deploy IVHM applications. In this context, the term "health ready" refers to a component or system that implements the required set of IVHM run-time interfaces and provides the associated semantic data in an appropriate format.

Figure 3 provides an overview of the overall concept behind the JA6268 recommended practice. As shown in Figure 3, JA6268 addresses (1) the design and data integration process, and (2) the integration of IVHM related run-time messages. Design-time integration uses data developed by suppliers and provided to the system integrator (upper area highlighted in light beige) to implement and integrate IVHM functionalities. Run-time messages are collected by the health management system and used by higher level reasoning functions to provide the best possible component health state advisories and support services to the various user communities (lower area highlighted in light red).

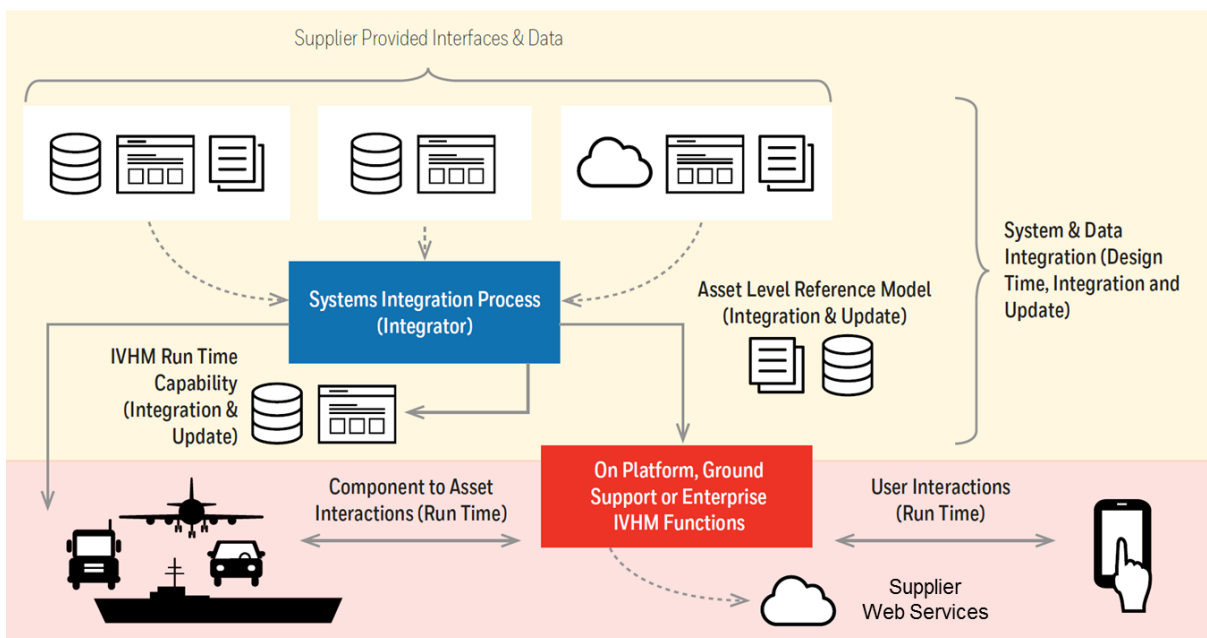


Figure 3 - Overview of IVHM deployment process with JA6268

It is important to note that suppliers may provide any combination of components, controllers, software, and services. In the paradigm of health-ready components, these are accompanied by descriptive data that allows these functions to be integrated to provide a coherent picture of the overall health status of the asset and an estimate of the cost/benefit of each candidate diagnostic/maintenance action.