IVHM – a Key Enabler for Future Civil Aerospace

Professor Ian K Jennions

Cranfield IVHM Centre

November 26th, 2018

www.cranfield.ac.uk

Integrated Vehicle Health Management

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Vehicle Maturation/ New Product

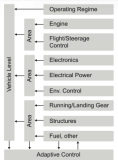
Design
Engineering
Manufacturing

- Production, certification & testing
- Total ownership costs
- System & life cycle
- Requirements
- FMECAs
- Design models
- Failure modes/models
- System test data

Sense




Acquire



Transfer



Analyse

Data Repository
& Ground Processing

Act

Health Status
- Current
- Predicted

Operational Control

- Operational Demand
- Fleet Availability
- MR & O leading

- Operational Schedule
- Operational Effectiveness

Health Status

Maintenance &
Logistics

- Maintenance Scheduling
- Spares Supply
- Asset Tracking
- Maintenance Execution




The World of Civil Aerospace *

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Testing

Certification

Operation

Manufacture

The Aircraft

Service / MRO

Design

Standards

Environment

Safety

* SAE book, due out later in 2018

Talk Outline

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- Battle for the MRO space
- Maintenance Credits
- Autonomy, technology speed
- EU 261

Lufthansa Technik - Aviatar

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InsideMRO

MAINTENANCE, REPAIR & OVERHAUL > SUPPLY CHAIN & LOGISTICS

Lufthansa Technik Chairman Seeks Other Stakeholders For Digital Platform

Lufthansa Technik, the biggest MRO in the world, openly invites competitors to join forces in its digital platform to fight potential OEM monopolies.

Lee Ann Shay | Sep 26, 2018

Delta's Atlanta MRO Engine Facility

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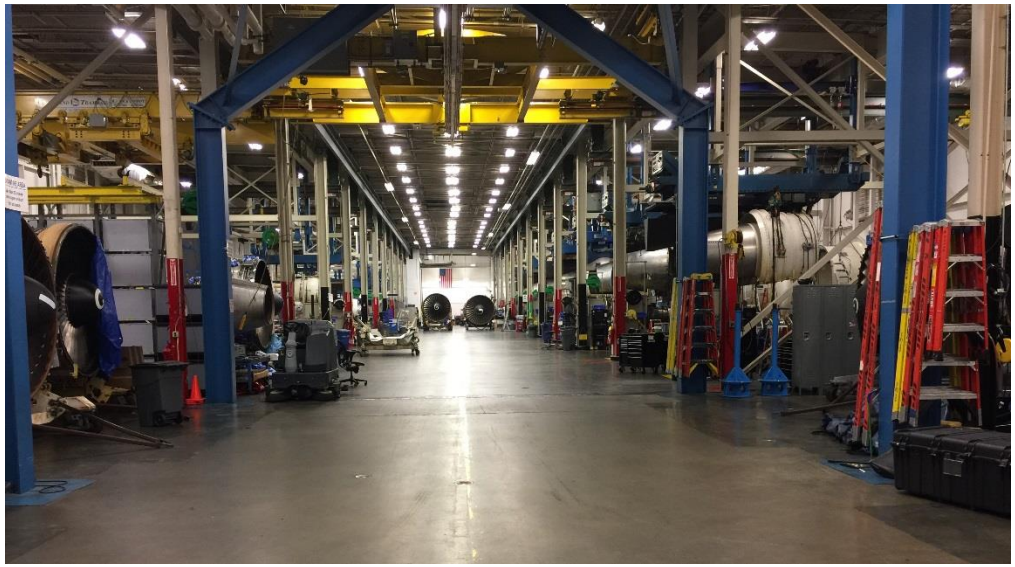

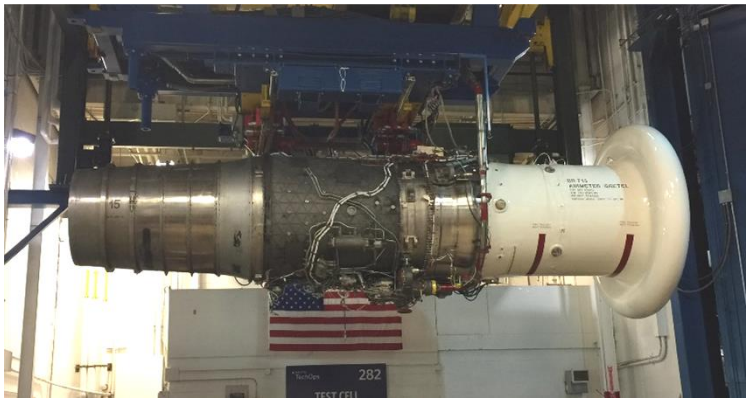

Delta's Atlanta MRO Facility

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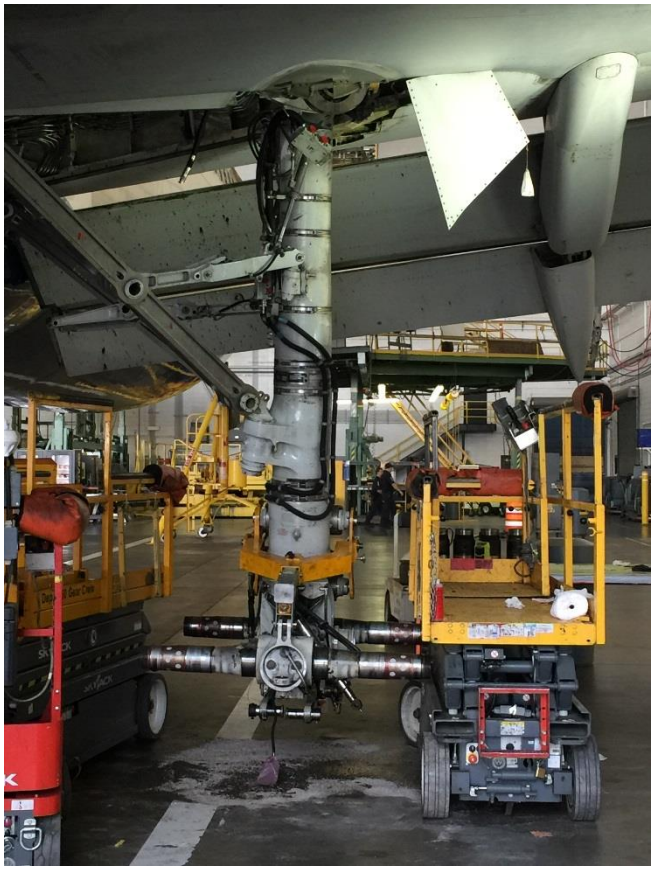

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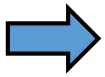

- Battle for the MRO space
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Civil Aerospace Engagement

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The Aircraft that Looks After Itself - The Civil Aircraft of the Future, RAeS, London, Nov 2011

Civil Aircraft Technology Enabled Services – an industry co-operation day, RAeS, London, Nov 2013

Civil Aircraft Technology Enabled Services – a first step towards achieving maintenance credits, Joint SAE/RAeS, London, Oct 2014

IVHM and Maintenance Credits Workshop, Joint SAE/Cranfield/RAeS Cranfield, April 2015

Workshop with Operators/MROs, Joint SAE/Cranfield/RAeS, FIA2016, July 2016

Achieving Maintenance Credits

Farnborough INTERNATIONAL AIRSHOW 11-17 JULY 2016

Tuesday 12 July 2016, 08:00 to 12:00

Aim: Obtain Operator/MRO engagement and input into on-going process to develop standards in the following areas:

a) Collaborating with Regulators
b) Recommended Practices for Maintenance Credits Processes
c) Recommended Practice for Data Interoperability

Agenda:

Welcome
Keynote Speaker (TBC)
Facilitated breakfast sessions to obtain feedback on evolving standards documents
Panel Discussion
Working meetings

SAE - Maintenance Credits

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SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE	ARP5987™	
	Issued	Updated Draft 2018-04

A Process for Utilizing Aerospace Propulsion Health Management Systems for Maintenance Credit

RATIONALE

This document has been written to provide a process to achieve Maintenance Credits using Aerospace Propulsion Health Management Systems in a consistent way. This will help Regulators carry out assessments of the merits of a Maintenance Credit application with a view to provide approval.

This document reflects the fact that regulatory approval has been provided to multiple engine and aircraft Original Equipment Manufacturers (OEMs), allowing the use of Propulsion Health Management functionality in the mitigation of Airworthiness Directives, extending inspection intervals, compliance with Maintenance Steering Group-3 (MSG-3) and more effective utilization of component lives to increase 'time on wing'.

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SAE - Regulators and Data

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SAE Aerospace
An SAE International Group

AEROSPACE

AEROSPACE INFORMATION REPORT

SAE AIR6900	REV
Issued Revised	

APPLICABLE INTEGRATED VEHICLE HEALTH MANAGEMENT (IVHM)

REGULATIONS, POLICY, AND GUIDANCE

RATIONALE

There is a gap between the technical capabilities of IVHM technology and the application of this technology at the aircraft operating certificate holder to affect the scheduling of and actions performed during aircraft maintenance operations. Several contributing factors to this gap include the required levels of IVHM airborne and ground hardware and software certification, and changes to an aircraft operator's maintenance program within the existing set of regulations, policy, and guidance.

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1. SCOPE

This AIR establishes a collection of regulations, policy, and guidance applicable to design approval applicants, aircraft operating certificate holders, and maintenance repair and overhaul (MRO) organizations enabling adoption of IVHM technology for use in aircraft maintenance. One of the AIR's objectives is to set the foundation for aircraft operating certificate holders to engage with regulators to get

SAE INTERNATIONAL

AEROSPACE INFORMATION REPORT	AIR6904™	
	Issued	Proposed Draft 2018-04-10

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

RATIONALE

Current aerospace systems are generating large amounts of data and 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), 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 the business goals. To achieve this goal, the industry can benefit from sharing their 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

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SAE - Regulators

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Bill Heliker and Marcus Labay, FAA, attended
SAE's IVHM Fall 2018 meeting
– to learn more about IVHM

SAE - Health Ready Sub-systems

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SURFACE VEHICLE/AEROSPACE RECOMMENDED PRACTICE	JA6268™	PropDft Dec2017
	Issued	Proposed Draft 2017-12-20
Design & Run-Time Information Exchange for Health-Ready Components		

RATIONALE

This Surface Vehicle & Aerospace Recommended Practice was created to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and automotive sectors by introducing health-ready components. Health-ready components are augmented either to monitor and report their own health or, alternatively, ones where the supplier provides the integrator sufficient information to accurately assess the component's health via a higher-level system on the vehicle. The principal motivation for health-ready components is to facilitate enhanced IVHM functionality in supplier-provided components that better meet the needs of end users and government regulators in a cost-effective manner. Underlying this motivation is the assumption that market forces will drive the need to achieve IVHM's benefits, which will in turn drive new requirements that suppliers must ultimately meet. This recommended practice has two primary objectives: (1) to encourage the introduction of a much greater degree of IVHM functionality in future vehicles at a much lower cost, and (2) to address legitimate intellectual property concerns by providing recommended IVHM design-time and run-time data specification and information exchange alternatives in an effort to help unlock the potential of IVHM.

Health Ready Components— Unlocking the Potential of IVHM

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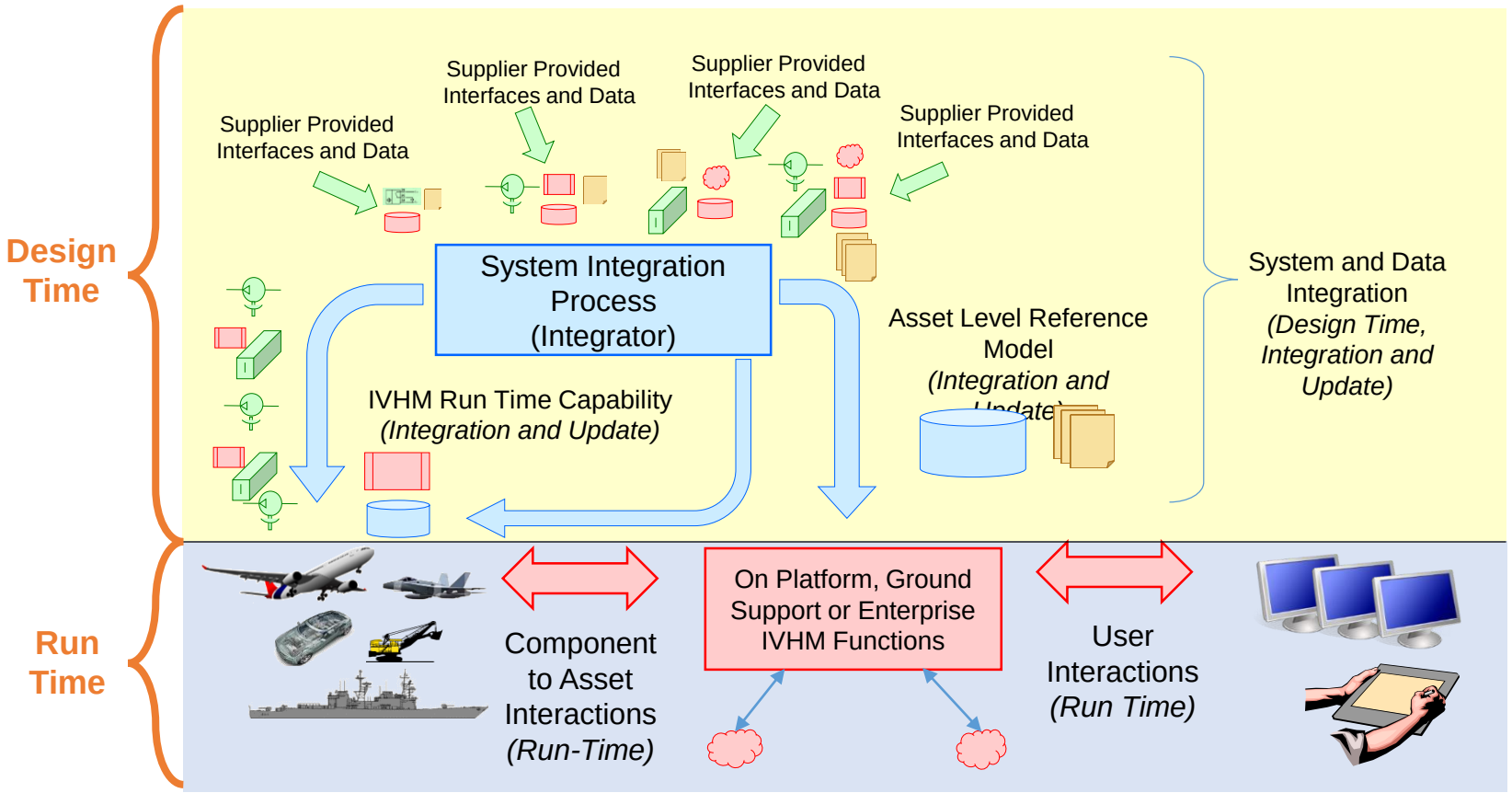

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SAE's Automated Driving Levels

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SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Waymo and Driverless Cars

Waymo and Driverless Cars

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Insurance via Trov:

https://www.prnewswire.com/news-releases/trov-and-waymo-partner-to-launch-insurance-for-ride-hailing-300573229.html

The cost being trip based, but not passed on to the rider:

https://www.theverge.com/2017/12/19/16796370/waymo-trov-self-driving-car-insurance

Washington allows autonomous cars as ‘strict regulation woul ddo more harm than good’:

https://arstechnica.com/cars/2018/10/waymo-wont-have-to-prove-its-driverless-taxis-are-safe-before-2018-launch/

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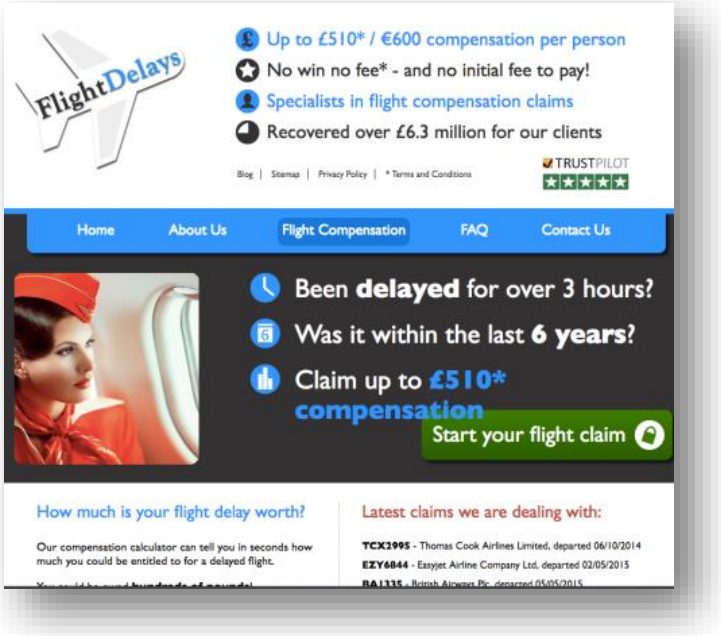
EU 261/2004

- Under EU Regulation 261/2004, passengers are entitled to up to £460 in compensation when their flight lands at their destination more than three hours
- In September 2015, the Court of Justice of the European Union judged, regarding Case C-257/14:[16]
  - Even in the event of a flight cancellation on account of unforeseen technical problems, air carriers are required to compensate passengers.
  - However, certain technical problems resulting, in particular, from hidden manufacturing defects affecting the safety of flights or acts of sabotage or terrorism may exempt air carriers from their obligation to pay compensation.



https://en.wikipedia.org/wiki/Regulation_261/2004

http://www.thisismoney.co.uk/money/holidays/article-2271213/How-claim-EU-flight-delay-compensation-EC-261-2004.html#ixzz4GuApOdGJ

Conclusion

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- IVHM is maturing and support in maintenance practises, maintenance credits, autonomy and legislation demonstrates it
- More yet to come, in: health ready components, safety, certification and design
- In all case IVHM is a key enabler of the way forward

Core Partners, Members & Collaborators

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Embraer - AHEAD