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Recommendations for development of MSG-4

May 8th, 2023

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Introduction

Action from 2022 IMRBPB to form an MSG-4 Working Group.

Working Group has a total membership of 30.

A smaller task force of 9 selected to define the scope and whether a move to MSG-4, or another iteration of MSG-3 would be warranted.

To avoid pre-determining the answer, the group was renamed MSG-X Task Force.

- Phase One – completion – White Paper providing Recommendations for the development of MSG-4.

- Phase Two – to follow

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Vision Statement to evaluate MSG-3 for revision.

An ATA Task Force to review MSG-3 and identify various areas that are likely candidates for improvement. Some of these areas are the emergence **of new technology**, impact of aircraft systems and maintenance activities **on the environment, and reliability of the aircraft operations across all mission types for the evaluated fleet**. Additionally

A. **New generation aircraft** (rotorcraft, drones, eVTOL, etc..) and **emerging technologies** provide a focus, as well as motivation, for an evolutionary advancement in the development of the MSG concept.

B. Considering the extended use of **condition based maintenance** and the impact on the development of scheduled maintenance**, including the availability of digital solutions and ground-based capabilities**.

C. In order to fully utilize the benefits of this MSG concept we **encourage the incorporation of MSG methodology during the aircraft design requirements phase in order to influence the design solutions**.

D. Maintenance programs require careful analysis to ensure that only those tasks were selected which provided genuine retention of the inherent designed level of safety and reliability or provided economic benefit**; taking into account all parameters influencing aircraft integrity.**

E. **Harmonize** the development of new **MSG documentation and standards with existing and emerging guidance and policy's** .

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There are significant references to MSG-3 across the aviation industry that would need to be amended.

- Proposal is that the term MSG-3 be replaced by MSG methodology to ensure applicability to both the current and future standards.
- A separate review to document all use of the term MSG-3 in regulatory documentation and guidance material.

Recognition of this new MSG standard would be subject to each certifying authority.

Note: MSG-X Task Force has chosen to use the term Integrated Aircraft Health Monitoring (IAHM)

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Design Phase and Requirements

CBM and IAHM requires a certain level of monitoring level capability and sensing technology within the aircraft and engine.

These need to be specified at the early design requirements phase

Ideally IAHM and predictive maintenance capability would be incorporated in the OEM Design Manual and subsequently the PPH.

- This would be encouraged, ether in the General section of MSG-4 or in a separate MPIG Adopted Position (MAP).
- Develop MSG-4 processes and work-flows considering the requirements of health monitoring system(s) designed for the whole aircraft life cycle.

Further benefit could be gained by incorporating guidance within IMPS.

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Fixed Wing and Rotorcraft

In an effort to keep the philosophy consistent between fixed wing and rotorcraft along with the growth of the VTOL and eVTOL aircraft,

An initial review has indicated that a single volume may be achievable, with notation or appendices for applicability included as needed based on the content.

- A single MSG document would reduce the workload to maintain the document, and would cover all variations of vehicle types that would use the MSG-4 process.

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Propulsion

Sustainability and the global energy transition.

- SAF
- Electric power
- Hydrogen

Monitoring:

Integration will be required of all systems, many of which may benefit from an IAHM approach,

- Requires the use of safety as well as non-safety FEC tasks to be covered using IAHM.

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Hydrogen

Hydrogen has the potential to reduce noise pollution, increase efficiency and reduce emissions

Challenges of using Hydrogen:

- Modifications to the engine changes to burners, fuel ducts, heat exchangers, cooling system and turbine blades.
- Storage. Hydrogen has a much higher gravimetric energy density than kerosene, and much lower volumetric energy density
  - Liquid hydrogen (LH_2) requires four times more volume on the aircraft than jet fuel
  - jet fuel can be stored in wing tanks, hydrogen cylinders would be too large

- Cryogenic cylinders can store hydrogen at approximately -420°F (-250°C).
  - specialized materials
  - thicker walls, and sufficient isolation between stacks of cylinders

In all studies a co-dependency of structures and systems is necessary to enable successful hydrogen propulsion concepts.

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Monitoring Systems

IP180 introduced the ability to take credit for monitoring technology to alleviate on-wing scheduled maintenance burden.

While this was a philosophy shift towards CBM, the introduction of emerging and future propulsion technology requires a far greater level of integration for monitoring systems.

- It is recommended that the mapping of integrated health monitoring systems be a feature of MSG-4.

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Materials

While previously straight forward to separate materials into metallic and non-metallic when carrying out structural assessment (SSI), the introduction of composites and laminate materials has added complexity

- New workflow(s) for materials not clearly categorized as metallic or non-metallic.

Consideration should also be given as to how to treat novel materials in the future.

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Integrated Electronics and Condition Based Maintenance

On-wing Scheduled Maintenance processes across industry have incorporated approaches to CBM.

While IP180 introduced AHM as a move towards CBM, further work is required to fully integrate CBM.

Recommendation that:

- CBM be defined for MSG-4 and include the concept of soft scheduling.
- Incorporate monitoring capabilities that preclude the need for a classic task selection by considering CBM as a task type.
- Incorporate structural health monitoring (SHM) availability
  Note: possible Zonal and L/HIRF applications.

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On-Ground processing and Autonomous flight

Off-aircraft data processing is not fully reflected in MSG-3 which focuses on the on-aircraft systems. This can include:

- Analyzing health trends from systems components
- Processing data on ground
- Remote pilot
- Autonomous flight

Off-wing data processing and the security of data links for all systems should be taken into account as part of MSG-4 methodology.

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Analysis of Highly integrated Electronic Devices

MSG-3 MSI analyses of highly integrated electric/electronic devices using current MSG-3 methodology is deemed inefficient.

- A simplified approach, with new workflows would provide opportunity to enhance the efficiency of the selected maintenance requirements for these devices.

Additional guidance should be created:

- Depth of analysis needed for redundant integrated systems. e.g. MSI selection could be reviewed for potential opportunity to eliminate unnecessary analysis.
- To ensure that a simplified analysis does not jeopardize the goals of the scheduled maintenance identification process.

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Aircraft Design

Aircraft design may include many different mission types for a given fleet type, the parameters for which need to be evaluated when developing the maintenance requirements. This is more prevalent on some aircraft types than others – with some operators flying very different stage lengths, operations and certification levels such as ETOPS operations.

When these different mission types and operations give rise to different maintenance actions recommended by the OEM, there needs to be a method to provide those differences to operators.

- When new mission types are added to the design capability's, new analysis of the maintenance requirements for that type should be created.

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Human Factors

Current MSG-3 methodology forces the selection of the most appropriate task for that failure cause

- In reality multiple tasks could be applicable
- MSG-4 the logic be developed to allow for identification of multiple tasks from which operators could select the most applicable and effective for there operation, taking their HF policies into consideration.

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Artificial Intelligence

AI has a lot of possibilities for OEM and TC holders:

- maintenance program optimization
- answering technical queries with supervision
- ultimately generating task content.

Guidance developed by EASA provides the first usable guidance for Level 1 machine learning (ML). EASA define the levels of AI as follows

a). Level 1 – Assistance to Humans

b). Level 2 – Human / Machine Teaming

c). Level 3 – Autonomous Machine

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- AI is relatively young.
- Current data quality is variable with outcomes containing a high degree of uncertainty.

The task force recommends:

- Analysis be carried out during creation of MSG-4 work-flows, considering the impact and concerns relating to AI.
- Formation of an advisory SME group to develop this aspect.

High level of cooperation between NAAs to harmonize definitions and approach to AI regulations

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Further Considerations

Other topics and items reviewed by the task force were considered worthy of further analysis but are not considered imperative to MSG-4:

- Option to develop a set of MSG analyses for common equipment that can be utilized across multiple fleets and
- Evaluation of opportunities to introduce optimization methods for interval selection

Both items are potential efficiency improvements on existing MSG-3 policy but would require considerable work to determine effectiveness.

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Conclusion

Fundamental changes need to be made to MSG logic and methodologies to meet the challenges envisioned from emerging and future technologies.

Due to the number of changes proposed, introduction of MSG-4 is recommended.

- MSG-4 will introduce a philosophy shift towards Integrated Aircraft Health Monitoring (IAHM) and introduces changes for emerging and future technologies.
- MSG-3 continues to adequately meet the need for existing technologies and products in service today.

While the introduction of MSG-4 is a necessary step for future aircraft technology, the MSG-X Taskforce do not envision this being retroactively applied to existing products.

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Questions?