IEEE Aerospace and Electronic Systems Society

Stage 2 – Delphi Survey for IEEE AESS TechOps Experts

Dear Colleagues,

First, I would like to express my deepest gratitude for your invaluable contributions during Stage 1 of the Delphi Survey. Your thoughtful and comprehensive responses have laid the groundwork for identifying the key challenges, opportunities, and priorities critical to achieving digital transformation and sustainable development goals in the aerospace and aviation sectors. From your insights, we have been able to distill a wealth of knowledge that now serves as the foundation for this next phase of the Delphi process.

As we move into Stage 2, our goal is to build upon the data and themes gathered in Stage 1. This stage focuses on refining and prioritizing the identified challenges, opportunities, technologies, trends, and strategies to guide actionable recommendations for AESS TechOps. By leveraging your expertise and fostering collaboration across academia, industry, and government, we aim to generate a strategic vision that aligns with the evolving needs of the aerospace and aviation ecosystem. The ultimate objective of this process is to derive scientifically robust, consensus-driven outcomes that will advance the role of the IEEE AESS community in driving technological innovation and sustainability.

Thank you once again for your continued participation and dedication to this important initiative. We look forward to your insights in Stage 2 and to collaboratively shaping the future of aerospace and aviation systems with lasting impact.

Kind regards,

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Objectives

The second stage of this Delphi survey aims to deepen, refine, and prioritize the data gathered during the first round. By engaging experts across IEEE AESS Technical Operations Panels, this stage seeks to achieve a prioritized ranking of challenges, opportunities, technologies, trends, and strategies critical to progress Digital Transformation (DT) and Sustainable Development (SD) goals in the aerospace and aviation sectors. This process will help formulate actionable and scientifically sound strategies that can guide AESS TechOps toward fostering technological innovation and adaptive pathways for the industry. This stage emphasizes collaboration among industry, government, and academic experts to derive consensus on the challenges and opportunities laid out in Stage 1 and refine the outputs to guide future strategies and initiatives for the IEEE AESS community.

Survey Section 1: Prioritization of Challenges and Opportunities

1.1 Challenges

Instruction:
Rate the significance of the following challenges currently impacting the aerospace and aviation sectors. Use a scale of 1 (Not significant) to 7 (Extremely significant). If needed, include any further notes or suggestions in the "Open Comments."

Challenges List:

- Integration of legacy systems with modern digital technologies.
- Regulatory and certification bottlenecks delaying the adoption of emerging technologies.
- Lack of trustworthy Artificial Intelligence (AI).
- Cybersecurity threats due to increased connectivity of IoT sensors and systems.
- Lack of economic incentives for sustainable aviation development.
- High costs of new technologies and associated operational transformations.
- Lack of appropriate Intellectual Property (IP) frameworks for joint research and innovation initiatives.
- Insufficient long-term funding for high-risk research and low TRL innovations.
- Workforce skill gaps in emerging technologies, data science, and sustainability.

OPEN COMMENTS_____

1.2 Opportunities

Instruction:
Rate the potential impact of the opportunities in aligning Digital Transformation (DT) and Sustainable Development (SD) objectives in the aerospace and aviation sectors. Use a scale of 1 (Low impact) to 7 (High impact). If needed, include any further notes or suggestions in the "Open Comments."

Opportunities List:

- Adoption of digital twins for lifecycle analysis, performance optimization, and reduced environmental impact.
- Expansion of Urban Air Mobility (UAM) as a sustainable alternative for short-haul transport.
- Increasing the use of AI/ML for predictive maintenance and fuel optimization.
- Developing and scaling hydrogen/electric-powered propulsion systems for significant emissions reduction.
- Leveraging autonomous systems for safer, lower-cost, and more efficient logistics and operations.
- Using LEO satellites for global connectivity, space traffic management, and precision navigation.
- Innovating sustainability-driven business models, such as "Sustainable-as-a-Service."

OPEN COMMENTS_____

Survey Section 2: Ranking of Emerging Technologies

2.1 Technological Impact

Instruction:
Rank the following emerging technologies in order of their potential transformative impact on aerospace and aviation over the next 5–10 years (1 = Most impactful, 7 = Least impactful). If needed, include any further notes or suggestions in the "Open Comments."

Emerging Technologies List:

- Artificial Intelligence/Machine Learning (AI/ML).
- Autonomous systems for cargo/passenger and other air operations.
- Hydrogen and hybrid-electric propulsion systems.

- Natural, advanced, and recyclable materials.
- Low-Earth Orbit (LEO) satellites and space-based CNS systems.
- Quantum computing for optimization, encryption, and operational insights.
- Digital twin and digital thread concepts for cohesive lifecycle management.

OPEN COMMENTS_____

2.2 Integration Effectiveness

Instruction:
Rate the challenges and ease of integrating the following technologies into existing aerospace systems on a scale of 1 (Extremely difficult) to 7 (Relatively easy). If needed, include any further notes or suggestions in the "Open Comments."

Topics for Evaluation:

- Integration of AI/ML for safety-critical and autonomous operations.
- Operationalization of autonomous systems in crowded/unsegregated airspaces.
- Adoption of hybrid-electric and hydrogen propulsion technologies in existing fleets.
- Retrofitting aircraft with advanced, sustainable materials.
- Implementation of satellite-based Communication, Navigation, and Surveillance (CNS) frameworks.
- Adoption of autonomous systems for disaster relief operations.
- Airport/spaceport multimodal integration.

OPEN COMMENTS_____

Survey Section 3: Key Trends Shaping the Future

3.1 Trend Significance

Instruction:
Rate the significance of the following trends in shaping the future of aerospace and aviation. Use a scale of 1 (Low significance) to 7 (High significance). If needed, include any further notes or suggestions in the "Open Comments."

Trends List:

- Urban Air Mobility (UAM) and Advanced Air Mobility (AAM).

- Expansion of commercialization in space (e.g., reusable spacecraft, space tourism, point-to-point space transportation).
- Advances in Low-Earth Orbit (LEO) space-traffic management.
- Development of "multi-domain operational frameworks" integrating manned and autonomous systems.
- Emerging use of small, interconnected, and modular capabilities in aerospace and aviation systems.
- Increasing applications of aerospace technologies for active climate intervention.

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3.2 Industry Adaptation Recommendations

Instruction:
Select and rank the top three strategies to guide the aerospace sector's adaptation to these trends (1 = Most Recommended, 3 = Least Recommended). If needed, include any further notes or suggestions in the "Open Comments."

Adaptation Strategies List:

- Develop an effective approach linking strategy with technology roadmaps.
- Build partnerships with technology start-ups for rapid innovation cycles.
- Develop industry-focused training and continuing education programs.
- Invest in urban CNS infrastructure to scale Urban Air Mobility (UAM).
- Prioritize modular and software-first designs for scalable aviation systems.
- Enhance regulations for AI-enabled and autonomous systems to align with industry trends.
- Implement open standards for seamless collaboration and data interoperability.

OPEN COMMENTS_____

Survey Section 4: Strategies for Collaboration and Integration

4.1 Effectiveness of Collaboration Strategies

Instruction:
Rate the effectiveness of each collaboration strategy in fostering innovation and alignment

between academia, industry, and governments. Use a scale of 1 (Not effective) to 7 (Highly effective). If needed, include any further notes or suggestions in the "Open Comments."

Collaboration Strategies List:

- Establish translational research centers and innovation testbeds.
- Enable shared funding mechanisms and public-private partnerships.
- Advance global standards for modular technology integration (e.g., SOSA, MOSA).
- Launch practical academic exchange programs targeting emerging technology domains.
- Address the industrial workforce upskilling and reskilling requirements associated to DT and SD.
- Facilitate high-risk research through joint consortia for transformational innovation.

OPEN COMMENTS_____

4.2 Integration of Supply Chain Strategies

Instruction:
Rank the following strategies for effectively integrating digital transformation and sustainability across the aerospace supply chain (1 = Most effective, 5 = Least effective). If needed, include any further notes or suggestions in the "Open Comments."

Integration Strategies List:

- Develop trust-based data sharing frameworks for predictive solutions across organizations.
- Create end-to-end digital thread ecosystems for improved traceability and efficiency.
- Incorporate diverse partnerships, including start-ups and SMEs, across the supply chain.
- Strengthen standardized communication interfaces aligning with open-source platforms.
- Develop an integrated aerospace (DDT&E) and aviation (operations) supply chain for emerging flight technologies and applications.
- Promote a resilient and secure energy supply chain, including both conventional and more sustainable aviation fuels.
- Build frameworks and agreements for collaborative Intellectual Property (IP) development.

OPEN COMMENTS_____

Survey Section 5: Workforce Development and Reskilling

5.1 Critical Skills for Future Workforce:

Instruction:
Rate the importance of these skills for the future aerospace workforce. Use a scale of 1 (Not critical) to 7 (Extremely critical). If needed, include any further notes or suggestions in the "Open Comments."

Critical Skills List:

- Application and development of AI/ML technologies.
- Sustainability in aviation and aerospace systems.
- Guidance, navigation, and control of advanced aerospace platforms.
- Cyber-Physical Systems (CPS) and Internet-of-Things (IoT).
- Proficiency in digital signal processing for aerospace systems.
- Cybersecurity expertise applied to connected digital and autonomous systems.
- Advanced avionics engineering and system integration design.
- Systems-level knowledge of multi-domain (space, military, commercial) operations.
- Test and evaluation of intelligent and autonomous systems

OPEN COMMENTS_____

5.2 Workforce Development Initiatives:

Instruction:
Rank the most effective workforce development initiatives for reskilling aerospace professionals to align with emerging trends and technologies (1 = Most effective, 6 = Least effective). If needed, include any further notes or suggestions in the "Open Comments."

Workforce Development Initiatives List:

- Revise academic curricula with a focus on practical and interdisciplinary skills.
- Develop robust internship and mentorship programs with industry collaboration.
- Launch industrial training and continuing education programs on DT and SD.
- Enhance industry-funded certifications and continuing professional development.
- Support high-risk academic research targeting innovation at TRLs 3–5.
- Invest in immersive learning environments, including VR/AR-based simulation labs.
- Develop hybrid bootcamps addressing a blend of technical and soft skills.

OPEN COMMENTS

Key Instructions for Participants

1. **Participation:** Provide responses based on your expert knowledge and assessments of practical, technical, and strategic challenges within the industry.
2. **Clarity:** Use open comments to provide clarification, suggest new areas of focus, or highlight potential gaps.
3. **Rating Scale:** For all 'rate' questions, use the full range of the scale to reflect your opinion or prioritize items as requested.
4. **Confidentiality:** All individual responses are treated anonymously. Aggregated results will inform strategies moving into Stage 3.

Next Phase (Stage 3 – Consensus Round)

After completion of Stage 2, aggregated and anonymized survey results will be shared. A third and final round will refine any unresolved issues and finalize recommendations or frameworks for DT and SD goals in aerospace.

Thank you for contributing your expertise to this important initiative! Together, we look forward to advancing the goals of IEEE AESS.