

## Machine Learning for Optimized E2E Advanced Materials Lifecycle - Materials Design, Development, Analytics & Testing

**Elmar Bonaccurso,**

Rene Böttcher, Matthias Geistbeck, Adrian Krüger,  
Serge Maison, Rainer Stößel  
Airbus Central Research and Technology, Materials  
Technology Department - 1XRM

[elmar.bonaccurso@airbus.com](mailto:elmar.bonaccurso@airbus.com)

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The aerospace industry is increasingly prioritizing the development of a circular and sustainable aviation ecosystem. This transition necessitates an End-to-End (E2E) optimization of the materials lifecycle—spanning from initial substance selection to in-service performance and eventual recycling. The primary drivers are the reduction of environmental and climate impacts, improved health and safety (such as identifying non-toxic alternatives), and maintaining global competitiveness by significantly reducing time-to-product and research costs.

While digital materials informatics are gaining ground, it is currently "not obvious" how to fully replace human expertise with AI within highly regulated, qualified aerospace processes. Existing AI capabilities largely serve as support functions; however, the long-term goal is to move toward autonomous functions where humans maintain final decision-making authority. Airbus utilizes a multifaceted Machine Learning Toolbox to address these challenges, roughly categorized into four strategic areas:

- **Explorative Tools:** Utilizing automated data mining and analytics to extract insights from vast datasets
- **Predictive Tools:** Implementing ML surrogate models and multimodal AI to conduct high-fidelity chemistry simulations
- **Innovative Tools:** Leveraging Inverse Design and Generative AI to treat materials as design variables rather than fixed constraints
- **Adaptive Tools:** Employing reinforcement and continuous learning to enable Closed-Loop Manufacturing, where AI monitors and optimizes process parameters in real-time

The integration of these ML tools offers the potential for a drastic reduction in discovery costs and R&D timelines. By enabling Multidisciplinary Design Optimization (MDO), materials can be optimized simultaneously with manufacturing processes and system designs. Furthermore, adaptive learning provides operational robustness, allowing for the rapid re-design and re-qualification of complex structures, such as composites, in the event of supply chain disruptions. Several examples of successful applications will be briefly introduced to the audience.

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