# FrontUQ 2024

## Workshop on Frontiers of Uncertainty Quantification in Engineering

**September 24-27, 2024**
**Braunschweig, Germany**

DLR

KIT Karlsruher Institut für Technologie

Technische Universität Braunschweig

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GAMM UQ

This is the short version of the booklet. A full version with all abstracts can be downloaded at `https://www.frontuq-2024.com/` with password *UQ4aero.2024*.

If you would like to receive the book of abstracts in print, please indicate this here and collect it later at the reception desk.


The open-source LaTeX template, AMCOS_booklet, used to generate this booklet is available at `https://github.com/maximelucas/AMCOS_booklet`

# Contents

# About

After a break during the Covid-19 pandemic, the FrontUQ workshop series will resume in 2024. The 4th edition will take place September 24-27 2024 in Braunschweig and will feature the topic "Uncertainty Quantification (UQ) for Aerospace Engineering". It is jointly organized by groups of TU Braunschweig, Karlsruhe Institute of Technology and the German Aerospace Center.

UQ has a long tradition in aerospace engineering and is gaining momentum again with the current research emphasis on Certification by Analysis. The workshop aims to bridge the gaps between the uncertainty quantification and aerospace communities. The first day puts special emphasis on UQ software, with multiple UQ software projects presenting themselves in hands-on tutorials.

Contributions featuring mathematical method development, applications in aerospace engineering and new approaches to UQ software design are welcome.

Topics of interest include but are not limited to:

- Efficient uncertainty propagation
- Estimation of model form error
- Advanced methods for the estimation of failure probabilities
- Surrogate modeling and error estimation
- Imprecise probability models
- UQ approaches suitable for multi-disciplinary problems
- Robust design and optimization
- Scalable UQ techniques that are applicable to industrial grade problems
- Data-driven approaches and UQ
- Software for UQ

**Keynote Lectures**

- Raúl Tempone, Alexander von Humboldt Professor, Mathematics for Uncertainty Quantification Chair, RWTH Aachen University and Applied Mathematics, King Abdullah University of Science and Technology
- Richard Dwight, Professor at the Faculty of Aerospace Engineering, TU Delft
- Elisabeth Ullmann, Professor of Scientific Computing and Uncertainty Quantification, TUM
- John Schaefer, Boeing Designated Expert in Uncertainty Quantification, Boeing
- Bojana Rosic, Professor and Head of the Applied Mechanics and Data Analysis Group, ET Faculty, University of Twente
- Richard Butler, Professor of Aerospace Composites, University of Bath

FrontUQ is a workshop of the GAMM Activity Group on Uncertainty Quantification `https://gamm-ag-uq.github.io/index.html`.

# Organizing committee

Philipp Bekemeyer (German Aerospace Center)
Ulrich Römer (TU Braunschweig)
Sebastian Krumscheid (KIT)
Linus Seelinger (KIT)

# Scientific committee

Andrea Barth (University of Stuttgart)
Stefan Görtz (German Aerospace Center)
Ulrich Römer (TU Braunschweig)
Linus Seelinger (KIT)
Philipp Bekemeyer (German Aerospace Center)
Sebastian Krumscheid (KIT)
Laura Scarabosio (Radboud University)
Lorenzo Tamellini (CNR-IMATI Pavia)

# Timetable

CT: Contributed Talk, SC: Software Contribution, KL: Keynote Lecture.

## Tuesday, 24 of September - Software Day

| | | | |
|---|---|---|---|
| 8:45–9:00 | **Registration** | | |
| 09:00–10:00 | SC | **L. Seelinger**<br>KIT | Introduction to UM-Bridge and Software-Tools |
| 10:00–10:30 | SC | **L. Seelinger**<br>KIT | UQ Problem used for Tutorials |
| 10:30–11:00 | **Coffee Break** | | |
| 11:00–12:00 | SC | **N. Lüthen**<br>ETH Zürich | Uncertainty Quantification with UQLab and UM-Bridge |
| 12:00–13:00 | **Lunch** | | |
| 13:00–14:00 | SC | **C. Piazzola**<br>Technical University of Munich | The Sparse Grids Matlab KIT |
| 14:00–14:30 | **Coffee Break** | | |
| 14:30–15:30 | SC | **S. Dolgov**<br>University of Bath | TT Toolbox |
| 15:30–16:00 | **Coffee Break** | | |
| 16:00-17:00 | SC | **C. Krill**<br>Johns Hopkins University | UQpy 4.2: Scientific Machine Learning |

# Wednesday, 25 of September

| | | | |
|---|---|---|---|
| 08:00–08:15 | **Registration** | | |
| 08:15–08:30 | **Opening** | | |
| 08:30-09:30 | KL | **J. Schaefer**<br>Boeing | Industry Perspective on UQ to Enable High-Fidelity Predictive Modeling for Aerospace Design and Analysis |
| 09:30–10:00 | **Coffee Break** | | |
| 10:00-10:30 | CT | **D. Di Francesco**<br>The Alan Turing Institute | Towards Risk-Optimal Certification by Analysis |
| 10:30–11:00 | CT | **L. Werthen-Brabants**<br>Ghent University | Towards Trustworthy Neural Networks for Certification by Analysis - Fuel Tank Flammability Reduction System |
| 11:00–11:30 | CT | **J. Unger**<br>BAM | Uncertainty Quantification and Model Extension for Digital Twins through Model Bias Identification |
| 11:30–12:00 | CT | **D. Valente**<br>DLR | Provenance-Driven Framework for Robust Aerospace System Performance |
| 12:00–13:00 | **Lunch** | | |
| 13:00–14:00 | KL | **R. Tempone**<br>RWTH Aachen and KAUST | Stochastic Optimization: Adaptive Variance Reduction and Bayesian Quasi-Newton Methods |
| 14:00–14:30 | CT | **T. Zhou**<br>Chinese Academy of Sciences | Information Bottleneck based Uncertainty Quantification |
| 14:30–15:00 | CT | **J. Dölz**<br>Universität Bonn | On Uncertainty Quantification of Eigenvalues and Eigenspaces with Higher Multiplicity |
| 15:00–15:30 | CT | **B. Kent**<br>CNR-IMATI | Adaptive-in-Time Stochastic Collocation Approximation for Parametric Parabolic PDEs |
| 15:30–16:00 | **Coffee Break** | | |
| 16:00–16:30 | CT | **J. Parekh**<br>DLR | Identification and Handling of Uncertainties in Computational Aerodynamics |
| 16:30–17:00 | CT | **S. Baars**<br>TU Braunschweig | Thompson Sampling and Partitioned Surrogates for Multidisciplinary Design Optimization |
| 17:00–17:30 | CT | **M. Alder**<br>DLR | Probabilistic Technology Assessment of Complex Transportation Systems |
| 18:30 | **Dinner at LaCupola** | | |

# Thursday, 26 of September

| | | | |
|---|---|---|---|
| 08:30-09:30 | KL | **R. Dwight**<br>TU Delft | Statistical Methods for Generalizable Data-Driven Turbulence Modelling |
| 09:30–10:00 | **Coffee Break** | | |
| 10:00-10:30 | CT | **F. Lößle**<br>DLR | Uncertainty Quantification in Aircraft Noise Calculation: Current Status and Challenges at DLR |
| 10:30–11:00 | CT | **H. Geisler**<br>Leibniz University Hannover | A New Paradigm for Engineering Simulations Under Uncertainties: Time-Separated Stochastic Mechanics |
| 11:00–11:30 | CT | **J. Bachner**<br>DLR | Uncertainty Propagation for Multi-Hole Pneumatic Probes in Turbomachinery Flows |
| 12:00–13:00 | **Lunch** | | |
| 13:00–14:00 | KL | **E. Ullmann**<br>Technical University of Munich | Rare Event Estimation with PDE-based Models |
| 14:00–14:30 | CT | **E. Løvbak**<br>KIT | Markov Chain Monte Carlo for Particle Solvers |
| 14:30–15:00 | CT | **P. Hristov**<br>GATE Institute | Backcalculation for Design Under General Uncertainty: An Introduction and a Tutorial |
| 15:00–15:30 | CT | **K. Tüting**<br>TU Braunschweig | A Modeling Perspective on Tracing Uncertainties in Dynamic Systems |
| 15:30–16:00 | **Coffee Break** | | |
| 16:00–16:30 | CT | **D. Pölzleitner**<br>DLR | Feature and Extrapolation Aware Uncertainty Quantification for AI-based State Estimation |
| 16:30-17:00 | CT | **N. Dridi**<br>Femto ST | Uncertainty Quantification Using Bayesian Neural Networks |
| 17:00–17:30 | CT | **D. Tyagi**<br>BAM | Damage Localisation and Quantification from Modal Data using Sparsity Promoting Priors |

# Friday, 27 of September

| | | | |
|---|---|---|---|
| 08:30-09:30 | KL | **R. Butler**<br>University of Bath | Certification for Design: Re-shaping the Testing Pyramid for Composite Aerostructures |
| 09:30-10:30 | KL | **B. Rosic**<br>University of Twente | Stochastic Modelling of Composite Material Anisotropy and Surrogate Modelling |
| 10:30–11:00 | **Coffee Break** | | |
| 11:00–11:30 | CT | **V. Narouie**<br>TU Braunschweig | Polynomial Chaos-based Statistical Finite Element Analysis with Non-Conjugate Prior |
| 11:30–12:00 | CT | **F. Zacchei**<br>Politecnico di Milano | Multi-Fidelity Delayed Acceptance for PDE Inverse Problems with Progressive Neural Network Surrogates |
| 12:00–12:30 | CT | **D. Anton**<br>TU Braunschweig | Statistical Calibration of Constitutive Models from Full-Field Data Using Physics-Informed Neural Networks |
| 12:30–13:00 | **Lunch** | | |
| 13:00–16:00 | **Visit of Aerospace Facilities** | | |

# List of Participants

| | |
|---|---|
| Tawfiq Ahmed | DLR, Germany |
| Marko Alder | DLR, Germany |
| David Anton | TU Braunschweig, Germany |
| Susanna Baars | TU Braunschweig, Germany |
| Johannes Bachner | DLR, Germany |
| Philipp Bekemeyer | DLR, Germany |
| Jan Blechschmidt | TU Chemnitz, Germany |
| Valentin Breaz | University of Bristol, UK |
| Richard Butler | University of Bath, UK |
| Lars de Jong | TU Braunschweig, Germany |
| Domenic Di Francesco | The Alan Turing Institute, UK |
| Jürgen Dölz | Universität Bonn, Germany |
| Sergey Dolgov | University of Bath, UK |
| Noura Dridi | FEMTO-ST, France |
| Richard Dwight | TU Delft, Netherlands |
| Benjamin Fröhler | DLR, Germany |
| Hendrik Geisler | LUH, Germany |
| Tushar Anil Gholap | DLR, Germany |
| Stefan Görtz | DLR, Germany |
| Ling Guo | Shanghai Normal University, China |
| Lucas Hermann | TU Braunschweig, Germany |
| Clara Hoffmann | KIT, Germany |
| Petar Hristov | Gate Institute, Bulgaria |
| Yannik Hüpel | TU Braunschweig, Germany |
| Benjamin Kent | CNR-IMATI, Italy |
| Jörn Niklas Kersken | DLR, Germany |
| Louise Kluge | KIT, Germany |
| Connor Krill | Johns Hopkins University, USA |
| Sebastian Krumscheid | KIT, Germany |
| Sihyeong Lim | DLR, Germany |
| Felix Lößle | DLR, Germany |
| Emil Løvbak | KIT, Germany |
| Nora Lüthen | ETH Zürich, Switzerland |
| Charbel Mallah | DLR, Germany |
| Vahab Narouie | TU Braunschweig, Germany |

| | |
|---|---|
| Jigar Parekh | DLR, Germany |
| Chiara Piazzola | TUM, Germany |
| Moritz Poguntke | TU Chemnitz, Germany |
| Markus Pollak | TU Braunschweig, Germany |
| Daniel Pölzleitner | DLR, Germany |
| Ulrich Römer | TU Braunschweig, Germany |
| Bojana Rosic | University of Twente, Netherlands |
| John Schaefer | Boeing, USA |
| Leonard Schnelting | TU Braunschweig, Germany |
| Julius Schultz | TU Braunschweig, Germany |
| Linus Seelinger | KIT, Germany |
| Raúl Tempone | RWTH Aachen/KAUST |
| Katja Tüting | TU Braunschweig, Germany |
| Divyansh Tyagi | BAM, Germany |
| Elisabeth Ullmann | TUM, Germany |
| Jörg F. Unger | BAM, Germany |
| Deoclecio Valente | DLR, Germany |
| Sander van den Broek | University of Bristol, UK |
| Lorin Werthen-Brabants | Ghent University, Belgium |
| Hazem Yaghi | TU Braunschweig, Germany |
| Liang Yan | Southeast University, China |
| Filippo Zacchei | Politecnico di Milano, Italy |
| Tao Zhou | Chinese Academy of Sciences, China |

# Practical Information

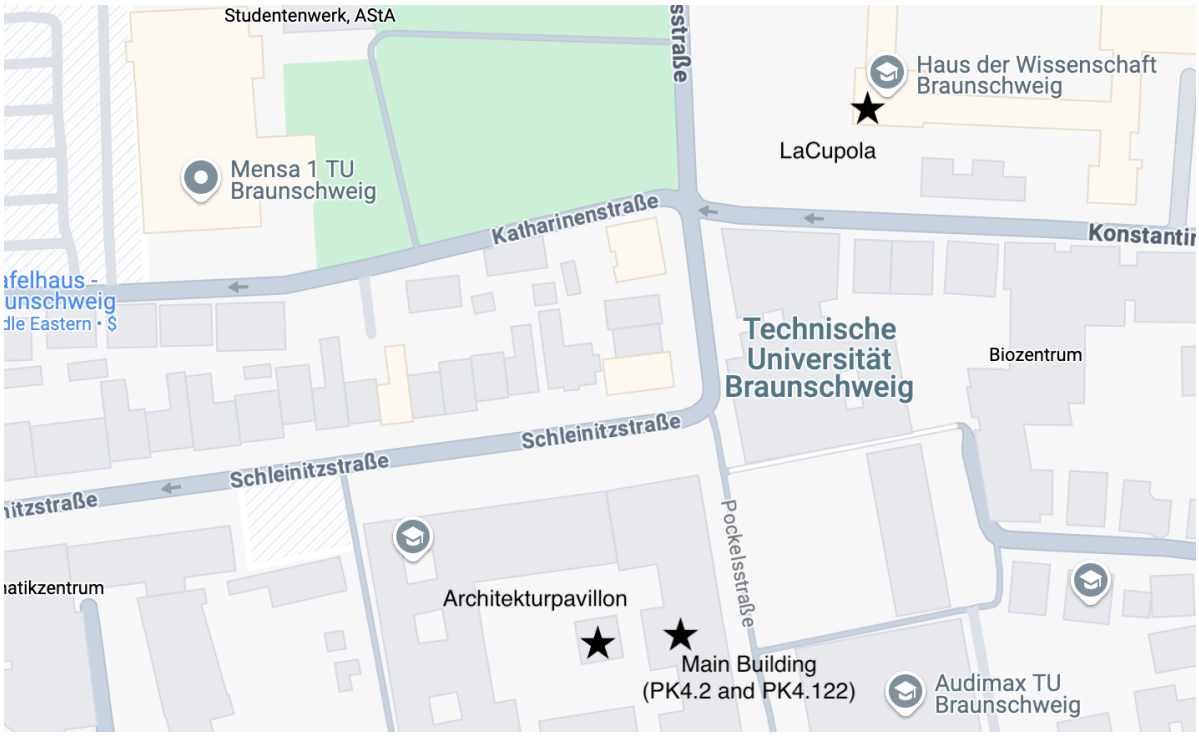
The **workshop** will primarily take place at the *Architekturpavillon* of TU Braunschweig, located within the main building. It is accessible from both the ground and first floors.

The **Software Day** will begin in the *Architekturpavillon* and continue with hands-on exercises in Rooms PK 4.122/PK 4.117 on the first floor.

**Coffee breaks and lunch** will be served in room PK4.2, also on the first floor of the main building, and the *Architekturpavillon*.

**WiFi** (eduroam) will be available throughout the conference. For attendants without eduroam access, Guest WiFi accounts will be provided at the Conference Desk.

The **conference dinner** will be hosted on Wednesday, 25th of September at 18:30, at "LaCupola", located in the Haus der Wissenschaft, Pockelsstraße 11, 38106 Braunschweig.



# Sponsors

We are grateful for the support of:

- TU Braunschweig
- KIT - Karlsruher Institut für Technologie
- German Aerospace Center (DLR)
- Center for Mechanics, Uncertainty and Simulation in Engineering (MUSEN)
- Cluster of Excellence: Sustainable and Energy Efficient Aviation ($SE^2A$)
- CRC: Synergies of Highly Integrated Transport Aircraft (SynTrac)
- GAMM UQ Activity Group