SASWATA PAUL

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RESEARCH INTERESTS

Logic, formal methods, semantics, autonomous systems, and their applications in the verification of aerospace systems, assurance of AI/ML, assurance case generation, model-based design, and system certification.

EXPERIENCE

Research Engineer — May 2022 - Present
General Electric Global Research — *Niskayuna, NY*

- Principal Investigator for the FAA Certification of AI/ML program.
- Led the development of Overarching Properties-based assurance arguments for AI/ML systems under the FAA Certification of AI/ML program.
- Led the development of design review tools for DO-178C and ARP-4754 from the RACK curated database under the DARPA ARCOS Program.
- Led the development of the RITE IDE for the RACK curated database under the DARPA ARCOS Program.
- Designed an automated approach for the generation of assurance cases from the RACK curated database under the DARPA ARCOS Program.
- Conducted research on using semantic technologies, formal tools, and softare systems for the certification and assurance of safety-critical systems and authored several research papers, technical reports, and patents.
- Contributed to proposals funded by DARPA, AFRL, and ARL.
- Actively involved in the following projects: DARPA ARCOS, FAA Certification of AI/ML, ACE MBSE (funded by GE Aerospace), NASA V&V, DARPA PEARLS,

Graduate Research Assistant — May 2017 - May 2022
Rensselaer Polytechnic Institute — *Troy, NY*

- Developed the first machine-checked proof of eventual progress for the Synod consensus protocol.
- Developed a failure-aware actor model for formal reasoning about distributed communication in airborne networks.
- Developed a formal library in Athena tailored towards reasoning about distributed coordination protocols.
- Developed a formally verified protocol for ensuring situational awareness in autonomous aircraft.
- Designed a data-driven approach for the runtime verification of distributed systems using formal proofs.
- Designed a provably-correct decentralized and autonomous air traffic management technique for Urban Air Mobility.
- Developed a formally verified strategic conflict-aware flight planning algorithm.
- Developed a data-driven approach for generating high-fidelity emergency trajectories for fixed-wing aircraft.

Research Intern — Jun. 2020 - Aug. 2020, May 2021 - Jul. 2021
General Electric Global Research — *Niskayuna, NY*

- Worked on DARPA and NASA-funded programs with the High-Assurance Systems team.
- Developed a formal data model for constructing Operational Risk Assessment artifacts (NASA V&V).
- Developed an approach for auto-generating assurance case fragments from the VERDICT toolchain (DARPA CASE).
- Proposed an approach to generate certification reports from the curated RACK database (DARPA ARCOS).
- Developed an SMT-based approach for strategic detection and elimination of aircraft conflicts for Urban Air Mobility.

Graduate Teaching Assistant — Aug. 2016 - May 2017, Aug. 2020 - Dec. 2020
Rensselaer Polytechnic Institute — *Troy, NY*

- Conducted practical labs, held office hours, proctored exams, and graded assignments and exams for courses such as Computer Science I, Principles of Software, and Programming Languages.

Summer Intern — May 2014 - Jul. 2014
Society for Natural Language Technology & Research — *Kolkata, India*

· Developed an Android application for generating the shortest/cheapest bus route between two given destinations.

EDUCATION

Ph.D. in Computer Science *May 2022*
Rensselaer Polytechnic Institute, Troy, NY, USA

M.S. in Computer Science *Dec. 2018*
Rensselaer Polytechnic Institute, Troy, NY, USA

B.Tech. in Computer Science & Engineering *May 2015*
National Institute of Technology, Agartala, Tripura, India

HONORS AND DISTINCTIONS

· *Best Paper Award*, Certification and DO-178C session, at the 42nd AIAA/IEEE DASC, Barcelona, Spain, Oct. 2023.
· *Robert McNaughton Prize* for outstanding achievements, Rensselaer Polytechnic Institute, May, 2022.
· *Best Paper Award*, Software Development track, at the 40th AIAA/IEEE DASC, San Antonio, TX, Oct. 2021.
· Received the *GE Impact Award* as a summer intern at GE Research, Niskayuna, NY, Aug. 2020 & Jul. 2021.
· Finalist for *Best Student Paper Award* at the 38th AIAA/IEEE DASC, San Diego, CA, Sep. 2019.
· Topper of the CS, Rensslear Polytechnic Institute, May, 2022. department at NIT Agartala in the 8th semester of B.Tech., May 2015.
· Secured 1st position in inter-college coding competition at NIT Agartala, 2013.
· Secured 2nd position at Holy Cross School Agartala in Indian School Certificate examination, 2011.
· Secured 4th position at Holy Cross School Agartala in Indian Certificate of Secondary Education examination, 2009.

PUBLICATIONS

Journal and Conference Publications:

1. R. Lorch, B. Meng, K. Siu, A. Moitra, M. Durling, **S. Paul**, S. C. Varanasi, and C. McMillan. "Formal Methods in Requirements Engineering: Survey and Future Directions", In *Proc. of the International Conference on Formal Methods in Software Engineering*, To appear in Apr. 2024.

2. B. Meng, J. Debnath, S. Varanasi, E. Manoloios, M. Durling, **S. Paul**, D. Prince, S. Alsabaggah, R. Haadsma, C. McMillan, C. Zhang, and T. Oates. "Towards a Correct-by-Construction Design of Integrated Modular Avionics", In *Proc. of the 23rd Conf. on Formal Meth. in Comp. Aided Design*, Oct. 2023.

3. **S. Paul**, D. Prince, N. Iyer, M. Durling, N. Visnevski, B. Meng, S. Varanasi, K. Siu, C. McMillan, and M. Meiners. "Towards the Certification of Neural Networks using Overarching Properties: An Avionics Case Study", In *Proc. of the 42nd AIAA/IEEE Digit. Avionics Syst. Conf.*, Oct. 2023.

4. **S. Paul**, C. Alexander, M. Durling, K. Siu, D. Prince, B. Meng, S. Varanasi, and D. Stuart. "Automated DO-178C Compliance Summary Through Evidence Curation", In *Proc. of the 42nd AIAA/IEEE Digit. Avionics Syst. Conf.*, Oct. 2023.

5. **S. Paul**, E. Cruz, A. Dutta, A. Bhaumik, E. Blasch, G. A. Agha, S. Patterson, F. Kopsaftopoulos, C. Varela. "Formal Verification of Safety-Critical Aerospace Systems", *IEEE Aerospace and Electronic Systems Magazine*, Apr. 2023.

6. P. Zhou, **S. Paul**, A. Dutta, C. Varela, F. Kopsaftopoulos. "On Formal Verification of Data-Driven Flight Awareness: Leveraging the Cramér-Rao Lower Bound of Stochastic Functional Time Series Models", In *Proc. of InfoSymbiotics/DDDAS2022*, Oct. 2022.

7. **S. Paul**, G. A. Agha, S. Patterson, and C. A. Varela. "Eventual Consensus in Synod: Verification using a Failure-Aware Actor Model", *Innovations in Systems & Software Engineering: A NASA Journal*, Jul. 2022.

8. **S. Paul**, S. Patterson, and C. A. Varela. "Formal Guarantees of Timely Progress for Distributed Knowledge Propagation", *Proc. of the 3rd Workshop on Formal Methods for Auton. Syst.*, Oct. 2021.

9. V. T. Valapil, H. Herenzia-Zapana, M. Durling, K. Armstrong, **S. Paul**, S. Borgyos, A. Moitra, and W. Premerlani. "Towards Formalization of a Data Model for Operational Risk Assessment", *Proc. of the 40th AIAA/IEEE Digit. Avionics Syst. Conf.*, Oct. 2021.

10. B. Meng, **S. Paul**, A. Moitra, K. Siu, and M. Durling. "Automating the Assembly of Security Assurance Case Fragments", *Proc. of the 40th Int. Conf. on Comp. Safety, Reliability, and Security*, Sep. 2021.

11. **S. Paul**, G. A. Agha, S. Patterson, and C. A. Varela. "Verification of Eventual Consensus in Synod Using a Failure-Aware Actor Model", *Proc. of the 13th NASA Formal Methods Symp.*, May 2021.

12. B. Meng, D. Larraz, K. Siu, A. Moitra, J. Interrante, W. Smith, **S. Paul**, D. Prince, H. Herencia-Zapana, M. F. Arif, M. Yahyazadeh, V. T. Valapil, M. Durling, C. Tinelli, and O. Chowdhury. "VERDICT: A Language and Framework for Engineering Cyber-Resilient and Safe System", *Systems*, Mar. 2021.

13. **<u>S. Paul</u>**, S. Patterson, F. Kopsaftopoulos, and C. A. Varela. "Towards Formal Correctness Envelopes for Dynamic Data-Driven Aerospace Systems", *Handbook Dyn. Data-Driven App. Syst.*, Accepted Nov. 2022. *(To appear)*

14. **<u>S. Paul</u>**, S. Patterson, and C. A. Varela. "Collaborative Situational Awareness for Conflict-Aware Flight Planning", In *Proc. of the 39th AIAA/IEEE Digit. Avionics Syst. Conf.*, Oct. 2020.

15. B. Meng, A. Moitra, A. W. Crapo, **<u>S. Paul</u>**, K. Siu, M. Durling, D. Prince, H. Herencia-Zapana. "Towards Developing Formalized Assurance Cases", In *Proc. of the 39th AIAA/IEEE Digit. Avionics Syst. Conf.*, Oct. 2020.

16. **<u>S. Paul</u>**, F. Kopsaftopoulos, S. Patterson, and C. A. Varela. "Dynamic Data-Driven Formal Progress Envelopes for Distributed Algorithms", In *Proc. of InfoSymbiotics/DDDAS2020*, Oct. 2020.

17. E. Cruz-Camacho, **<u>S. Paul</u>**, F. Kopsaftopoulos, and C. A. Varela. "Towards Provably Correct Probabilistic Flight Systems", In *Proc. of InfoSymbiotics/DDDAS2020*, Oct. 2020.

18. **<u>S. Paul</u>**, S. Patterson, and C. A. Varela. "Conflict-Aware Flight Planning for Avoiding Near Mid-Air Collisions", In *Proc. of the 38th AIAA/IEEE Digit. Avionics Syst. Conf.*, San Diego, CA, USA, Sep. 2019.

19. **<u>S. Paul</u>**, F. Hole, A. Zytek, and C. A. Varela. "Wind-Aware Trajectory planning for Fixed-Wing Aircraft in Loss of Thrust Emergencies", In *Proc. of the 37th AIAA/IEEE Digit. Avionics Syst. Conf.*, London, England, Sep. 2018.

Other Publications:

1. **<u>S. Paul</u>**, D. Prince, N. Iyer, M. Durling, N. Visnevski, B. Meng. "Assurance of Machine Learning-Based Aerospace Systems: Towards an Overarching Properties-Driven Approach", Tech. Report, *United States Department of Transportation*, Sep. 2023.

2. **<u>S. Paul</u>**, "Formal Verification of Decentralized Coordination in Autonomous Multi-Agent Aerospace Systems", PhD Dissertation, *Rensselaer Polytechnic Institute*, Troy, NY, May 2022.

3. **<u>S. Paul</u>**, "Emergency Trajectory Planning for Fixed-Wing Aircraft", Master's Thesis, *Rensselaer Polytechnic Institute*, Troy, NY, Dec. 2018.

4. **<u>S. Paul</u>**, F. Hole, A. Zytek, and C. A. Varela. "Flight Trajectory Planning for Fixed-Wing Aircraft in Loss of Thrust Emergencies", Tech. Report, *Rensselaer Polytechnic Institute*, Troy, NY, Dec. 2017.

PROFESSIONAL ACTIVITIES

· Mentored undergraduate and graduate researchers working at the Worldwide Computing Laboratory, Rensselaer Polytechnic Institute.

· Reviewer for UCC 2017, IEEE BigData 2017, AAMAS 2019, IEEE Cluster 2019, FMCAD 2023, and ISSRE 2023.

· Conducted workshops for high school students for "STEM Day" at the Worldwide Computing Laboratory, Rensselaer Polytechnic Institute, in 2018 and 2019.