RESEARCH SEMINAR

Advances in Assured Aerial Autonomy: Cyber Physical Vulnerability Analysis, Correct-by-construction Autopilot Design, and Counter-UAS Systems

TUESDAY, MAY 7TH, 10:00 AM – 11:20 AM
ARMS B071

JAMES GOPPERT

Research Associate Professor Candidate

ABSTRACT

Unmanned aerial systems (UASs), also known colloquially as drones, are proliferating due to their efficiency and the minimal risk to human life when they conduct tasks such as surveillance, inspection, and search and rescue. NASA has envisioned an Advanced Air Mobility (AAM) system leveraging UASs that will be in place by 2030 where the movement of people and goods will be brought off of the ground and into the sky. To reach this vision, we must increase the safety and security of UAS operations. Increasing trust in aerial autonomy requires careful analysis of the coupling of physical components with digital control programs. Hybrid model checking techniques have been developed to consider this coupling, but the nonlinearities of the system dynamics and complexity of the control programs makes this difficult to realize for non-trivial systems. In addition, an intelligent attacker may leverage information about a UAS to construct attacks which expose system vulnerabilities not seen during normal operation. This talk will discuss approaches to address the fundamental trust gap for the AAM vision of 2030. First, we will discuss methods for Cyber-Physical Vulnerability Analysis (CPVA) including a mixed-reality sensor emulation framework. Next, correct-by-construction autopilot design will be discussed, which mitigates the complexities of performing software verification and validation (V&V) by constructing the code to have provable safety properties. We leverage Lie group theory to construct control and estimation algorithms with more efficient and less conservative reachable sets for proving safety under bounded disturbances. Finally, we will discuss counter-UAS system development for tracking nefarious actors with a low-cost self-calibrating camera network and a trajectory planning algorithm to detect weaknesses in the system.

BIOGRAPHY

James Goppert is the managing director of the Purdue UAS Research and Test Facility (PURT), the largest indoor motion capture facility in the world. He received his Ph.D. in 2018 from the School of Aeronautics and Astronautics at Purdue. His research focuses on cyber-physical vulnerability analysis, formal verification, and counter-UAS systems. He has made significant contributions to the ArduPilot, PX4, and CogniPilot open-source autopilots and has worked closely with industry, including companies such as NXP, Intel, and NVidia. James received the Outstanding Research Staff Excellence Award in 2023 and the Seed for Success Acorn Award in 2021. In addition, James is a lecturer for the School of Aeronautics and Astronautics and received the 2022 W.A. Gustafson Award for Outstanding Teaching.

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