2021 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

CAREER: Theoretical Foundations of the UAS in the NAS Problem (Unmanned Aerial Systems in the National Air Space)

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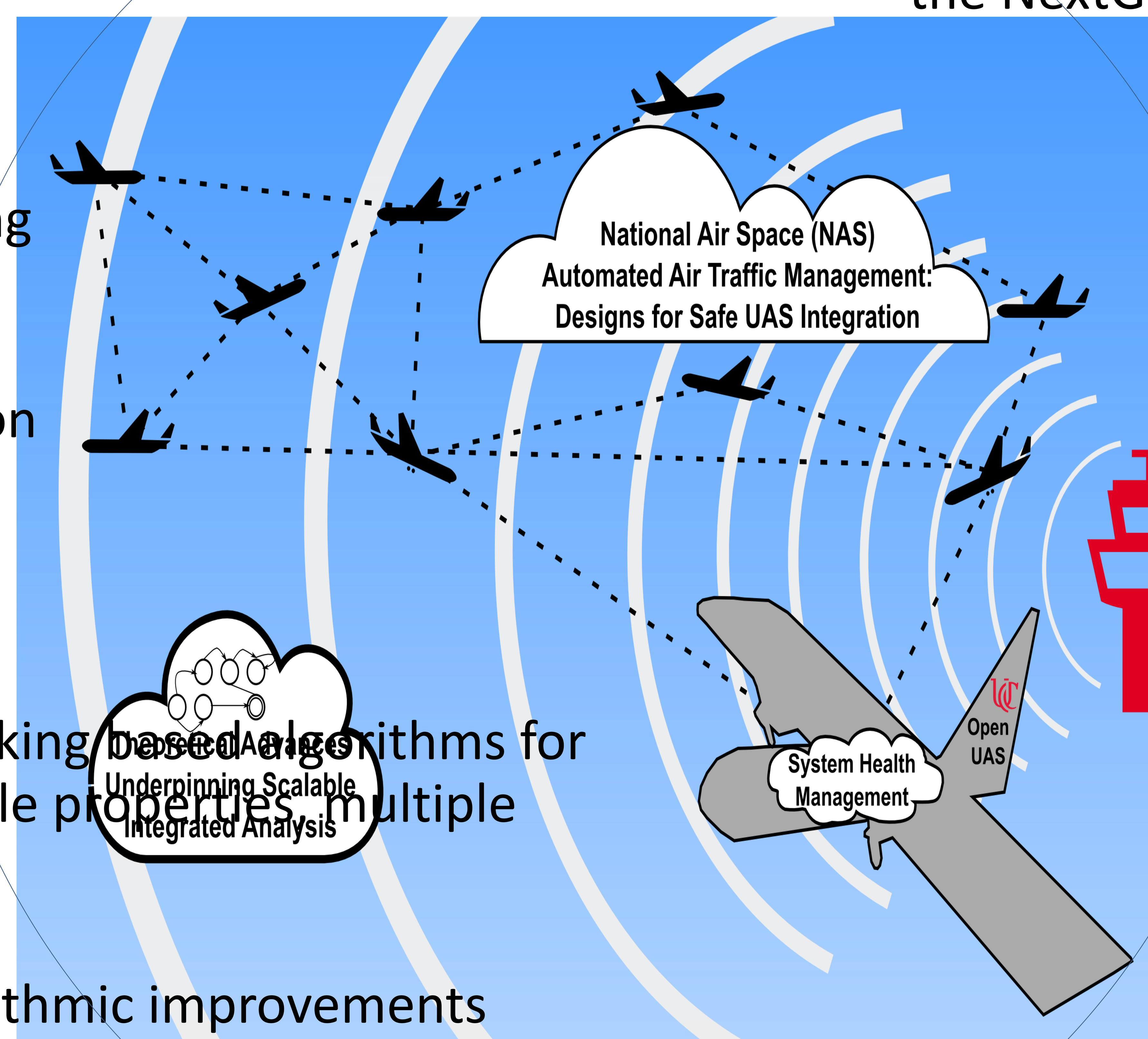
Challenge:

- **airspace-wide reasoning (NAS):** enabling design-time analysis of fleet-wide properties, scalable open-environment verification strategies
- **on-board the UAS:** real-time, on-board system health management for intelligent monitoring, mitigation triggering
- **theoretical foundations:** algorithmic advances for scalability, optimizations for real-world verification problems

Solution:

- **1) in the environment (NAS):** new symbolic model checking based algorithms for *design spaces* (multiple properties, multiple models)
- **2) underlying theory enabling their formal analysis:** algorithmic improvements for IC3-based symbolic model checking techniques
- **3) on-board the UAS:** specification elicitation and on-board, embedded-system runtime verification tailored to limit



Scientific Impact:

* Analyzed a design space of over 20,000 designs for the NextGen air traffic control system [GCMTR16]

* FuseIC3, an algorithm for checking large design spaces, is on average up to 5.48 (median 1.75) faster than checking each model individually, and up to 3.67 (median 1.72) faster than the state-of-the-art incremental IC3 algorithm.[DR17]

* Satisfiability checking algorithms for Mission-Time LTL [LVR19], LTL_f [LZPRV19]; limited resource RV for MLTL [KZJZR20]

Broader Impact:

* Algorithms and methods used by practitioners/system designers for other systems (UTM, sounding rocket)

- Algorithms extended by others, e.g., D^3 algorithm to probabilistic verification, reactive synthesis domair
- OpenUAS undergraduate research team completed test flights, publication

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