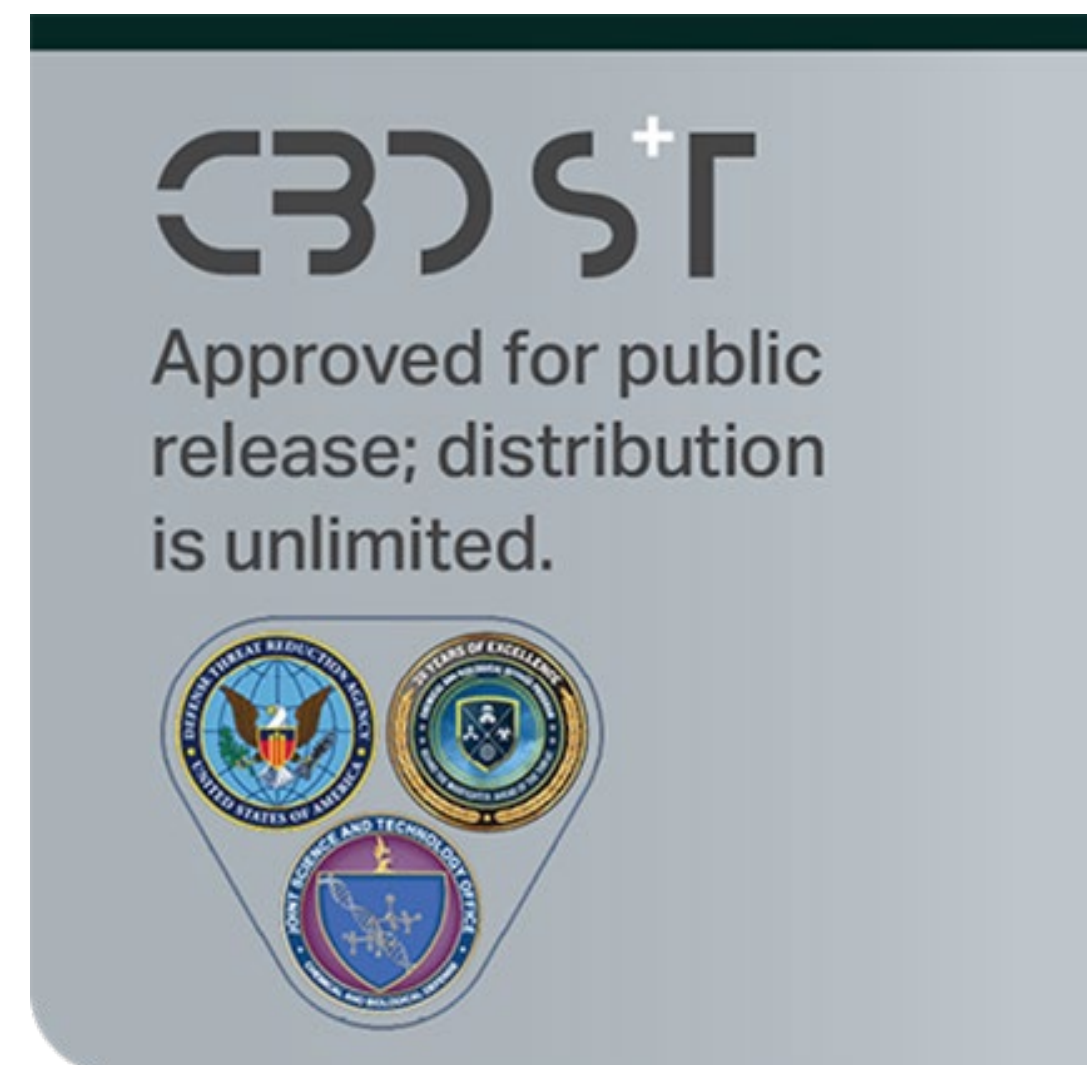




ABACUS: Autonomous BioAerosol Collection for Universal Sampling

Angela M. Zeigler, Ph.D¹, Christian Zimmerman², Daniel Wise¹, Gary Kilper, Ph.D³, Aime P. Goad¹, Roseanna Zia, Ph.D^{2,4}
¹U.S. Army Combat Capabilities Development Command Chemical Biological Center, Aberdeen Proving Ground, MD ²Science and Technology Corporation (STC), Hampton, VA ³Precise Systems, Lexington Park, MD ⁴University of Missouri, Columbia, MO

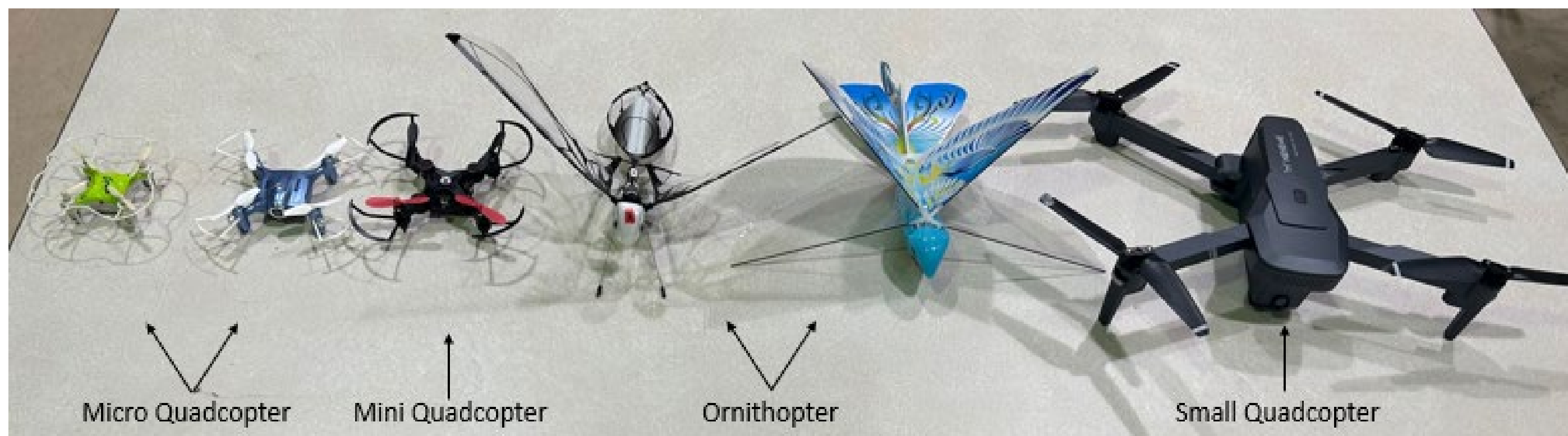


Abstract/Introduction

Small and mobile capabilities for detecting CBRNE hazards in real-time are necessary to counter our modern CBRNE threats. Recently, miniaturized autonomous vehicles have significantly advanced in their range and capabilities. Our research utilized these emerging autonomous vehicles to sample CBRNE threats for detection and analysis, and we determined how to coordinate vehicles' movements to optimize sample collection and hazard mapping.

To assess the aerosol collection capabilities of miniature autonomous vehicles, several commercial off the shelf (COTS) models, encompassing both quadcopter and ornithopter varieties, were operated within an artificial plume and sampled at various locations to determine where particles most congregate. Experimental and computational methodologies were then applied to enhance aerosol collection efficiencies on their surfaces.

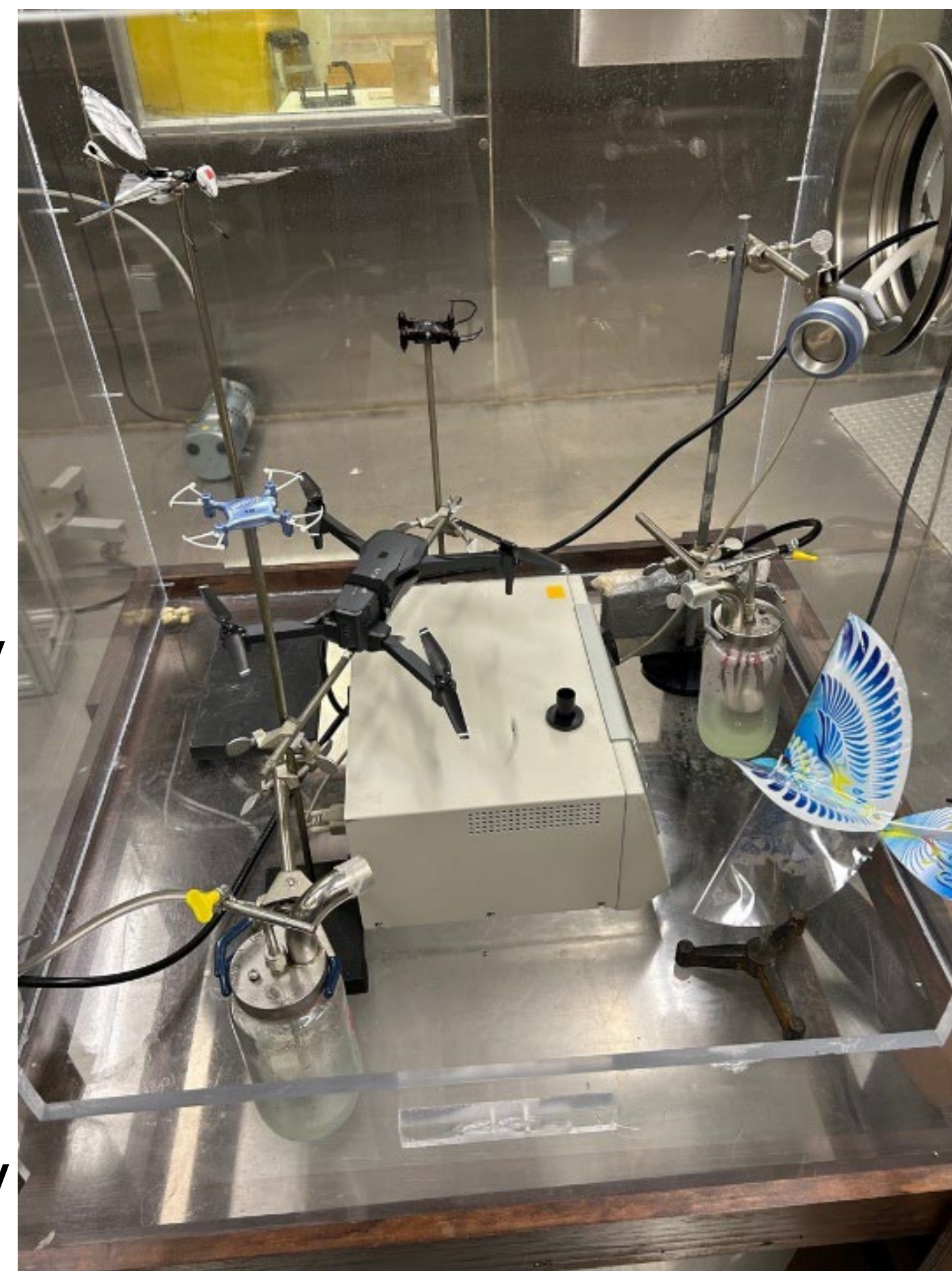
Examples of COTS Mini-Drones



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Methodology

1. Preliminary experiments used Visolite, a pink fluorescent powder, to enable visualization of the 'hot-spot' locations of aerosol collection during drone operation. The sites with the highest concentrations were sampled and analyzed.
2. For physical simulants, we used aerosolized Polystyrene Latex Spheres (PSLs) of various sizes. These particles are representative of non-sticky hard-particle-to-surface contact interactions. We also used fluorescein-tagged yeast, which represent sticky non-spherical particle-to-surface contact interactions. Together, these two scenarios covered the extreme boundary interactions to characterize and measure collection efficiencies.
3. For a realistic bioaerosol simulant, we used *Bacillus atrophaeus* (*Bg*), which has characteristics that fall somewhere between the extreme boundary interactions.
4. Testing in small aerosol chambers provided laboratory-controlled conditions for to collect samples and analyze the collection rate systematically.
5. Follow-on testing in our Wind Tunnel and Ambient Breeze Tunnel had less control but a more realistic environment. The results were compared to laboratory-controlled collection efficiencies to test for differences.

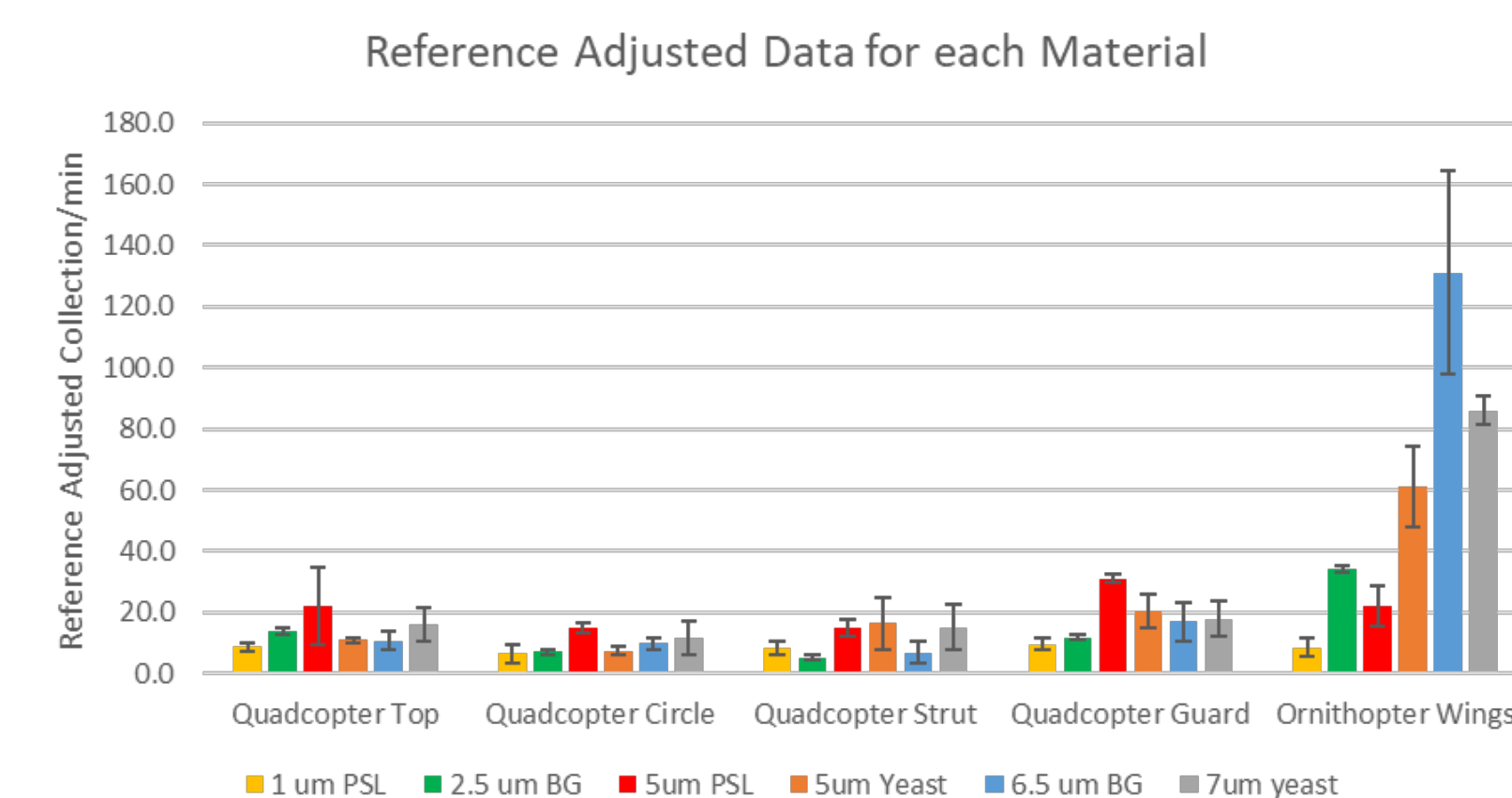


Results



Sampling site examples for quadcopters and ornithopters (left).

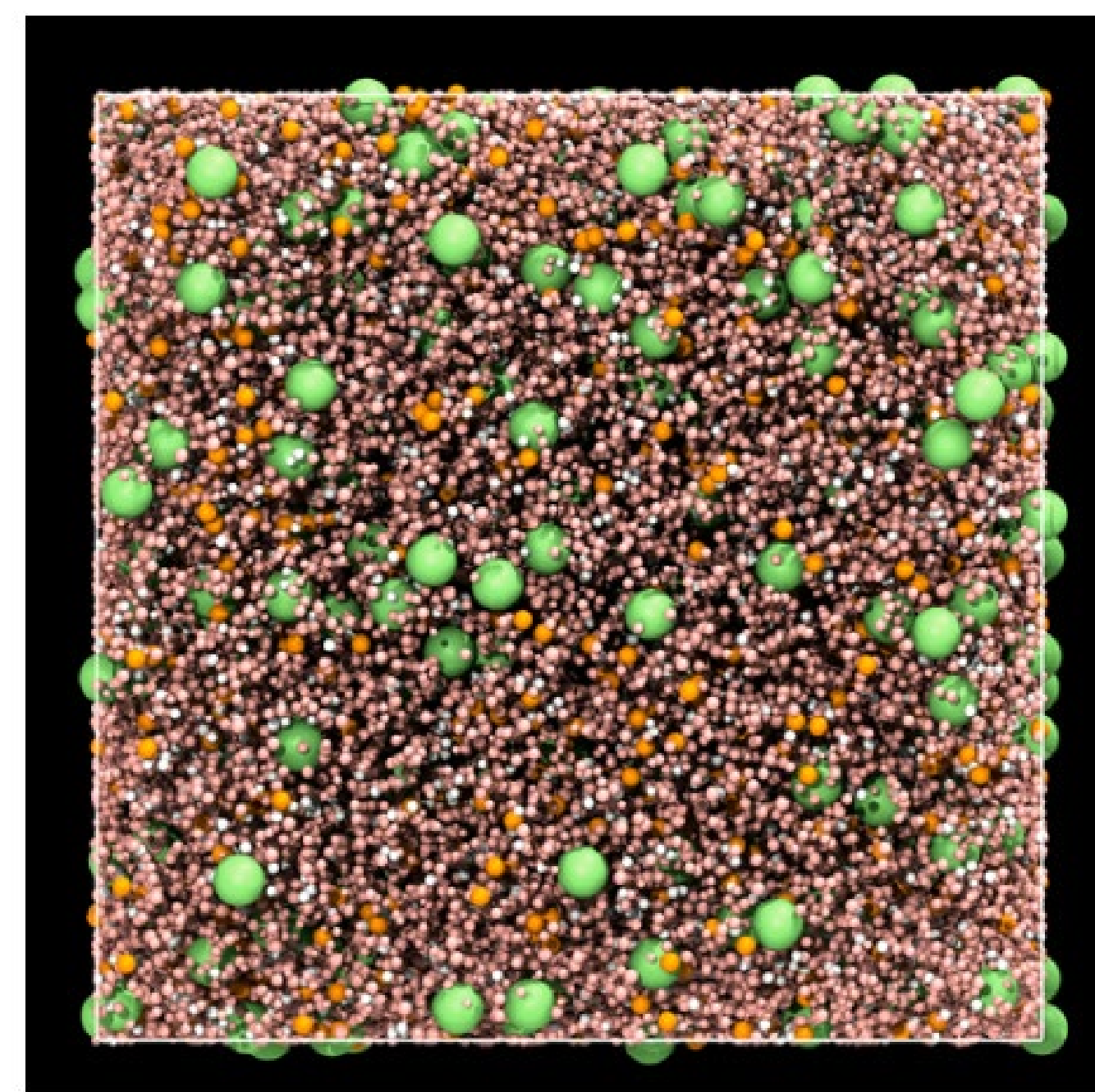
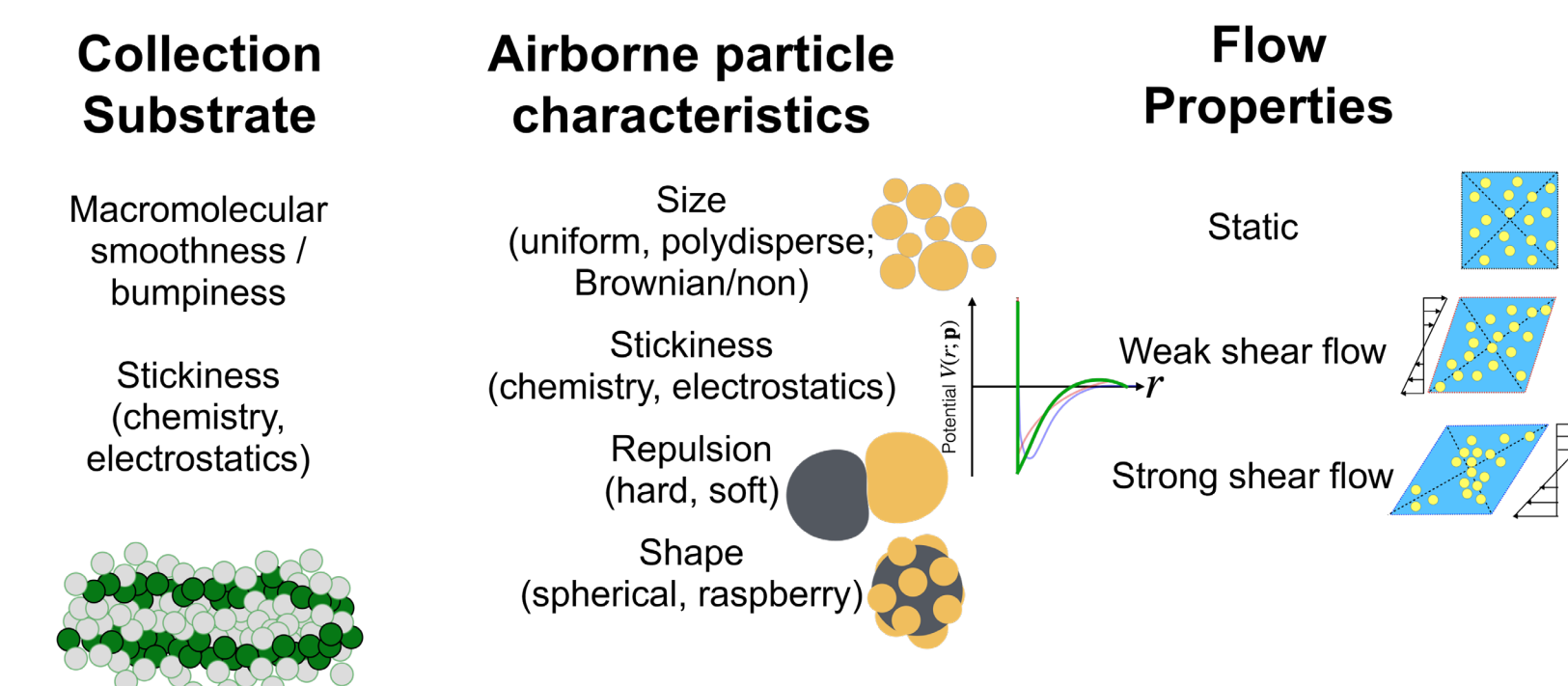
Results graphed for various sizes of the PSLs and fluorescein tagged yeast of sampling sites (right).



Computational Modelling

Computational models from Dr. Zia were combined with experimental data to guide modifications to drone appendages to increase the per-area collection sampling efficiency. Models mimicked laboratory conditions and resulted in recommendations for alternative materials or surfaces to catch-and-release target molecules.

Computational Modeling will optimize 3 aspects of aerosol collection



Key Takeaways

The key scientific advancements from this study include:

1. Development of new methodologies for testing and sampling the surfaces of small drones.
2. Improved understanding of particle-to-surface interactions and how to engineer an optimal adhesion substrate through the combination of experimental and computational methodologies.
3. Creation of a database to calculate the aerosol sampling collection capabilities for any size drone, commercially available or custom builds, for optimal utilization and sampling based on the CBRNE threat or scenario of interest.

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