UAS-RX
Enabling UAS Fire Ignitions in Complex Firefighting Contexts
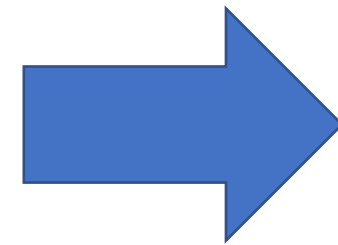
Presenter: Justin Bradley

PIs: Carrick Detweiler, Justin Bradley, Brittany Duncan, Sebastian Elbaum, Dirac Twidwell, Craig Allen, Lisa Zillig

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Problem Domain

Objectives:
- Reduce the risk of human exposure to fire
- Increase firefighters' effectiveness and efficiency in fire management

Broader impact

Technical Nugget #1: integrative functions that map the environmental knowledge and domain expertise of an operator into vehicles to support different levels of autonomy
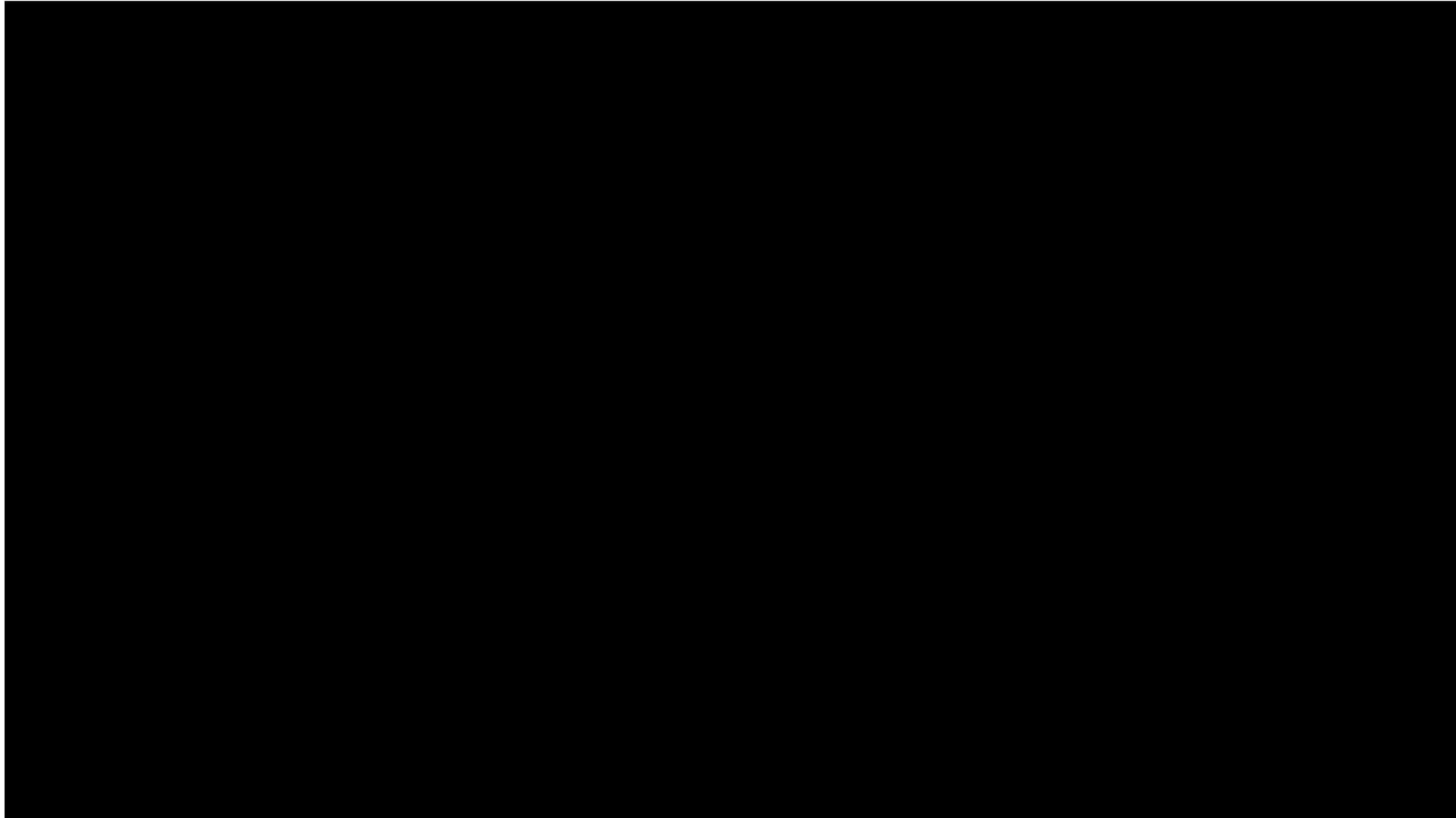

**IROS 2018: Awarded Best Paper on Safety, Security, and Rescue Robotics in memory of Motohiro Kisoi

Technical Nugget #2: motion-based languages that communicate UAS intention and knowledge to operators and bystanders
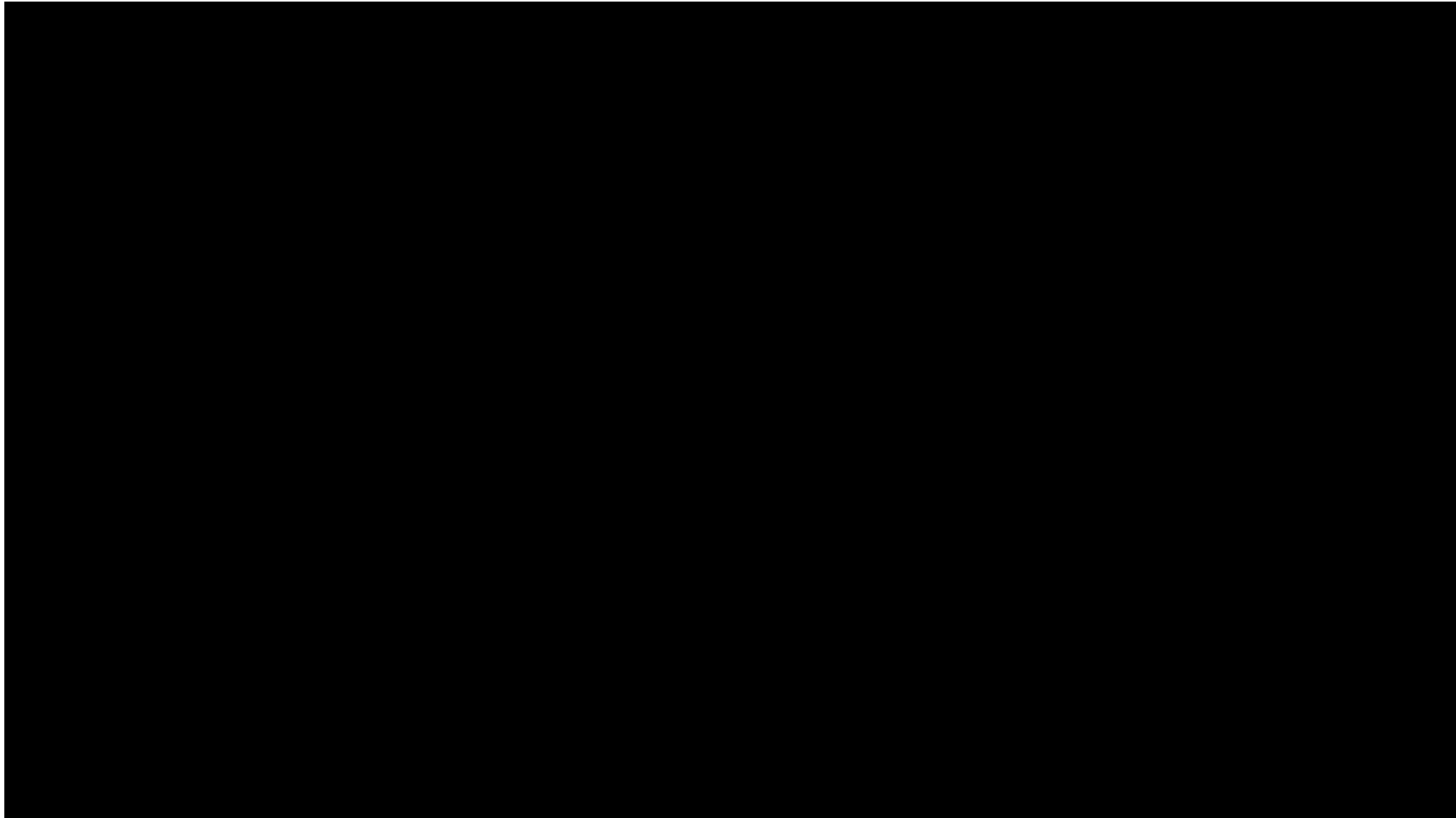
Technical Nugget #3: co-regulation methodologies that account for computational and physical resources to optimize UAS and human interactions

Technical Nugget #4: co-debugging to help diagnose and overcome failures

Technical Nugget #5: Conduct studies to identify barriers and opportunities that may affect acceptance of this technology
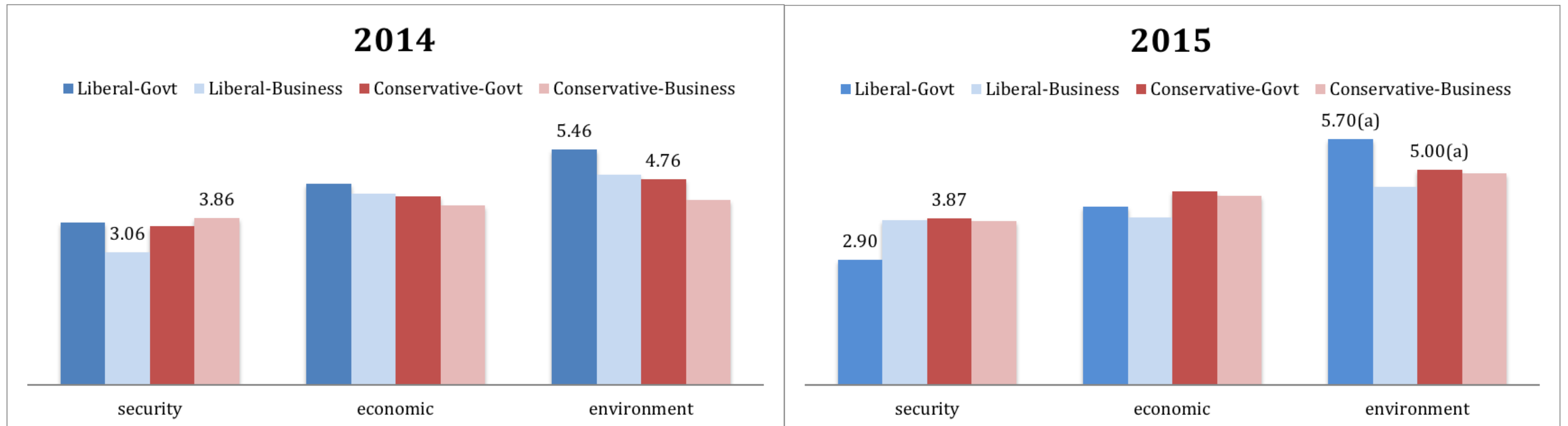
Predicted UAV support by year, UAV purpose, UAV end-user, and ideology (computed at -1 and +1 standard deviation from the sample mean ideology).

Bars representing the conditions under which there occurred significant relationships between ideology and support are labeled.
(a) Ideology-support correlation but not the ideology regression coefficient was significant in 2015.

Further Broader Impact

- **NSF REU Site: Unmanned Systems Foundations and Applications**
  - Summer 2018, 2019, 2020
  - 10-15 undergraduate researchers
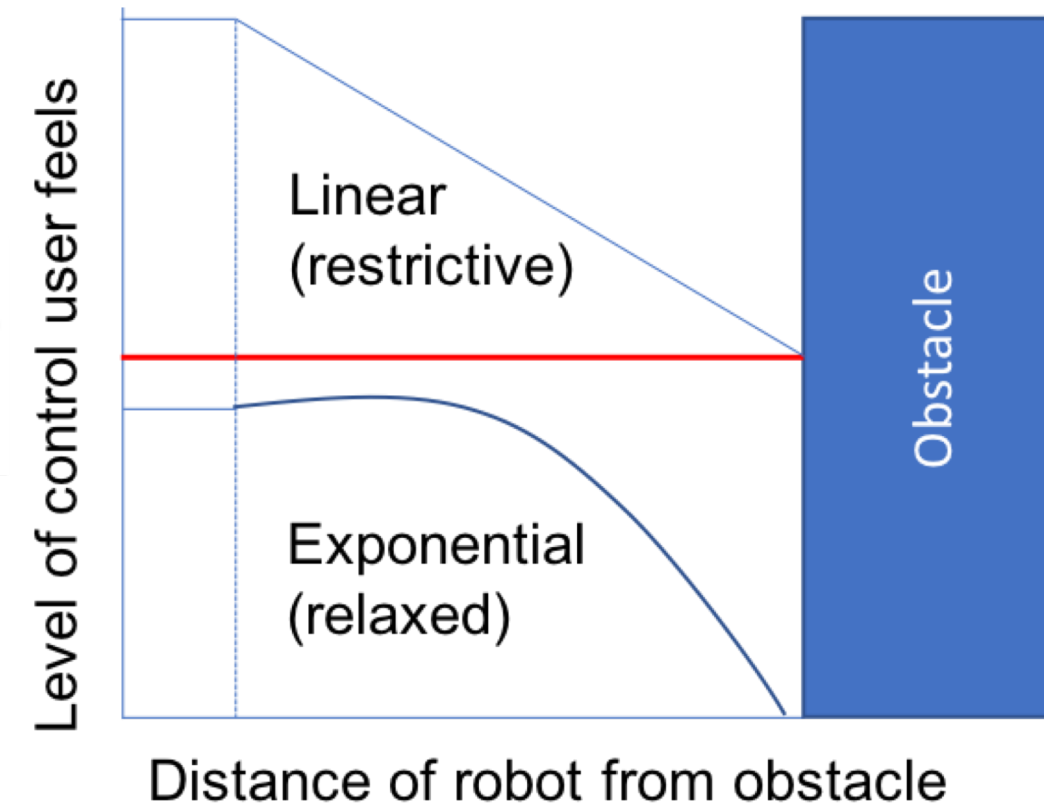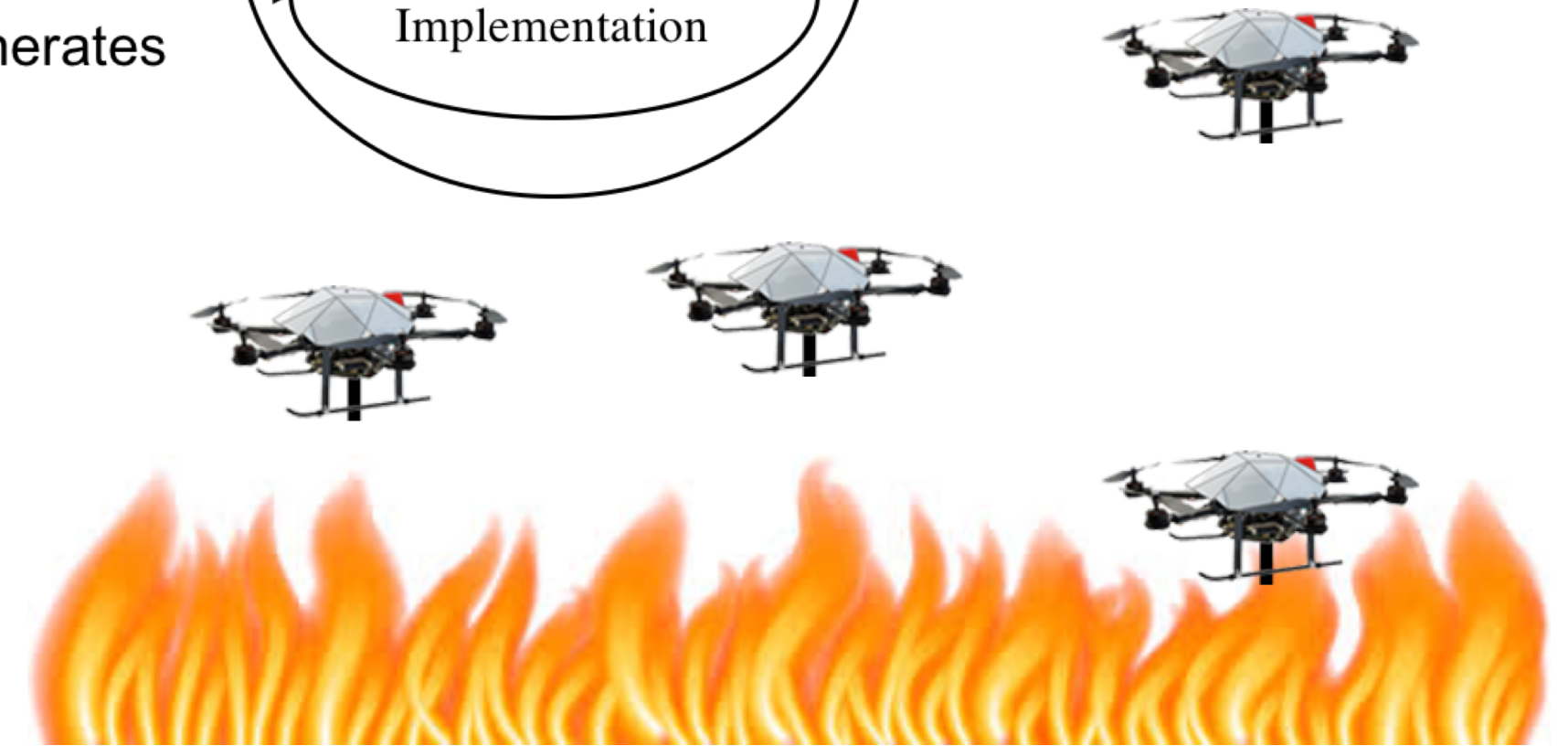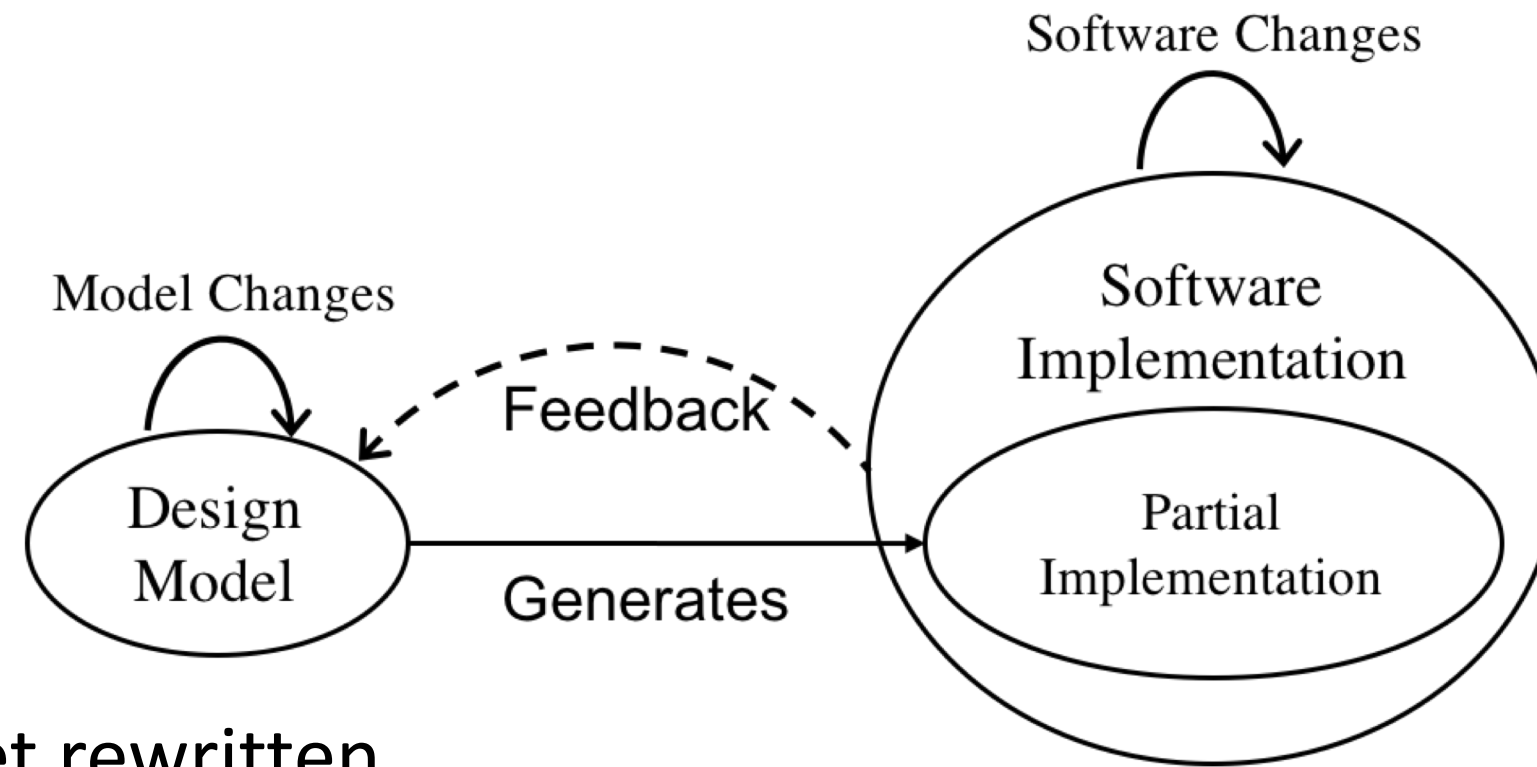 - NSF sponsored with competitive stipend
  - https://www.unl.edu/summerprogram/unmanned

Patent and Commercialization
- www.droneamplified.com

FIRE IGNITION MANAGEMENT WITH DRONES

IGNIS

BY DRONE AMPLIFIED

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Next

Software Changes

Model Changes

Design Model — Generates → Software Implementation / Partial Implementation

Feedback

- Controller evolution
  - Carefully develop and certify controller
  - Implement in software where it may get rewritten
  - Do the performance guarantees still hold?

- Multi-vehicle
  - Coordinate multiple vehicles to…
  - drop ignition spheres
  - sense temperatures, drafts, winds
  - work together with firefighters

- Inferred user preferences?
  - Can we infer intrinsic user qualities in real-time?
  - If so, we could adapt the autonomy to match

Level of control user feels

Linear (restrictive)

Exponential (relaxed)

Obstacle

Distance of robot from obstacle

Selected Publications

- C. Fernando, C. Detweiler, and J. Bradley, "Co-Regulating Communication for Asynchronous Information Consensus," in *57th IEEE Conference on Decision and Control*, 2018.

- L. Hall, U. Acharya, J. Bradley, and B. Duncan, "Inference of User Qualities in Shared Control of CPHS: A Contrast in Users," in *IFAC Cyber-Physical Human Systems*, 2018.

- E. Beachly, C. Detweiler, S. Elbaum, B. Duncan, C. Hilderbrandt, D. Twidwell, and C. Allen, Fire-Aware Planning of Aerial Trajectories and Ignitions. In *Proceedings of IEEE/RSJ International Conference on Intelligent Robotics and Systems (IROS)*, Madrid, Spain, 2018. **Awarded Best Paper on Safety, Security, and Rescue Robotics in memory of Motohiro Kisoi**

- U. Acharya, S. Kunde, L. Hall, B. Duncan, and J. Bradley, "Inference of User Qualities in Shared Control," in *IEEE International Conference on Robotics and Automation*, Brisbane, Australia, 2018, pp. 588–595.

- L. PytlikZillig, B. Duncan, S. Elbaum, and C. Detweiler, "A Drone by Any Other Name: Purposes, End-User Trustworthiness, and Framing, but Not Terminology, Affect Public Support for Drones", IEEE Technology and Society Magazine. 37 (1) 80 to 91, 2018.

- X. Zhang and J. Bradley, "Co-regulation of Computational and Physical Effectors in a Quadrotor Unmanned Aircraft System", in Proceedings of the ACM/IEEE International Conference on Cyber-Physical Systems, 2018.

- E. Beachly, C. Detweiler, S. Elbaum, and B. Duncan, "Uas-rx interface for mission planning, fire tracking, fire ignition, and real-time updating," in IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR)., 2017.

- J.-P. Ore, C. Detweiler, and S. Elbaum, "Dimensional Inconsistencies in Code and ROS Messages: a Study of 5.9M Lines of Code", In*Proceedings of IEEE/RSJ International Conference on Intelligent Robotics and Systems (IROS)*, Vancouver, Canada, 2017.

- A. Shankar, S. Doebbeling, and J. Bradley, "Toward a Cyber-Physical Quadrotor: Characterizing Trajectory Following Performance," in International Conference on Unmanned Aircraft Systems, Miami, FL, June 2017.

- N. Sharma, S. Elbaum, and C. Detweiler. Rate Impact Analysis in Robotic Systems. In *Proceedings of IEEE International Conference on Robotics and Automation (ICRA)*, Singapore, 2017.

- J.-P. Ore, C. Detweiler, and S. Elbaum. Lightweight Detection of Physical Unit Inconsistencies without Program Annotations. In *Proceedings of the 2017 International Symposium on Software Testing and Analysis (ISSTA)*, Santa Barbara, CA, 2017.

- U. Acharya, A. Bevins, and B. Duncan, "Investigation of human-robot comfort with a small unmanned aerial vehicle compared to a ground robot", in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2017.

- D. Twidwell, C. Allen, C. Detweiler, J. Higgins, C. Laney, and S. Elbaum. Smokey Comes of Age: Unmanned Aerial Systems for Fire Management. *Frontiers in Ecology and the Environment*. 14(6): 333-339, 2016.

- E. Beachly, J. Higgins, C. Laney, S. Elbaum, C. Detweiler, C. Allen, and D. Twidwell. A micro-UAS to Start Prescribed Fires. In *Proceedings of International Symposium on Experimental Robotics (ISER),* Tokyo, Japan, 2016.

- A. Taylor, S. Elbaum, and C. Detweiler. Co-Diagnosing Configuration Failures in Co-Robotic Systems. In *Proceedings of IEEE/RSJ International Conference on Intelligent Robotics and Systems (IROS)*, Daejeon, Korea, 2016.

Available Opportunities

- **REU: Unmanned Systems Foundations and Applications**
  - Summer 2019
  - Have room for 10-13 undergraduate researchers
  - NSF sponsored with competitive stipend
  - https://www.unl.edu/summerprogram/unmanned
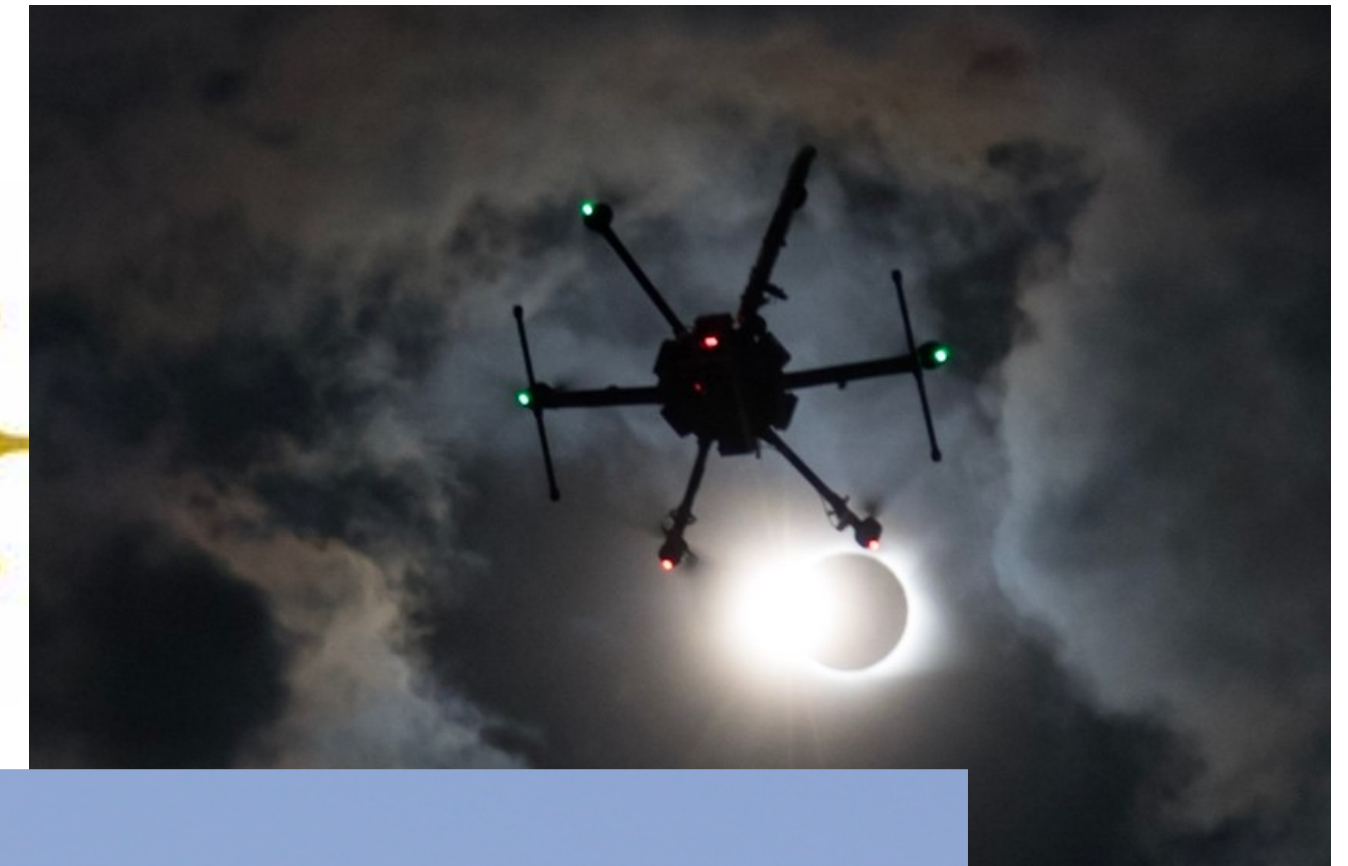
- **Postdocs: 2 openings**
  - Postdoc with **mechanical engineering** skills including SolidWorks, field testing, multicopter construction
  - Postdoc interested in the intersection of **control** and **real-time computing** in multi-agent UAS applications

- For more information, or to apply:
  nimbus-directors@cse.unl.edu