Aerial Robotics for Inspection & Maintenance: Hybrid Platforms

European Robotics Forum 2016

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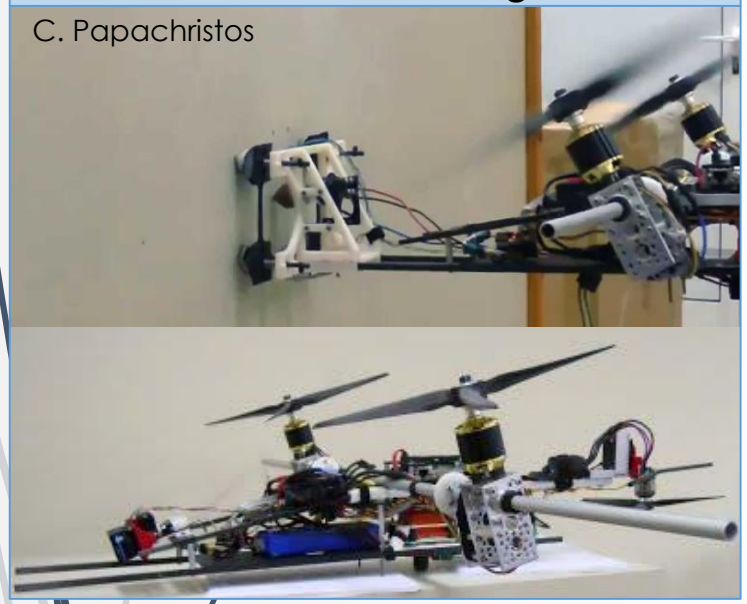
Indicative Platform Configurations

Conventional Tilt-Rotor Design (previous work)



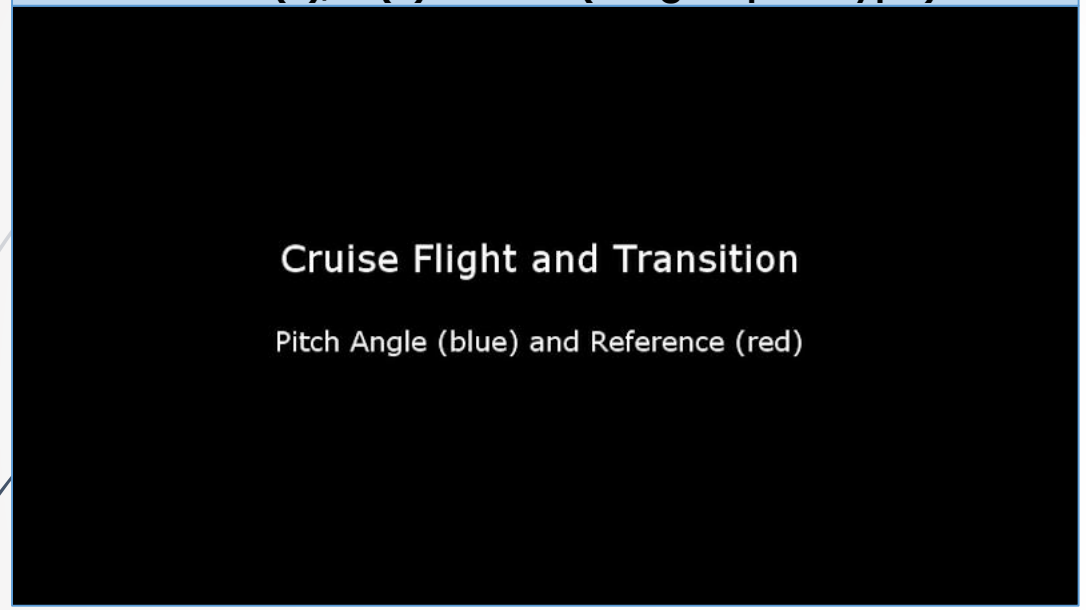
Quad-Rotor Design (UNR ongoing work)

Convertible Wing-only design (wingtra.com, ETH project)

- S. Verling, B. Weibel, M. Boosfeld, K. Alexis, M. Burri, R. Siegwart, ***"Full Attitude Control of a VTOL Tailsitter UAV"***, IEEE International Conference on Robotics and Automation 2016 (ICRA 2016), Stockholm, Sweden (Accepted - to be presented)
- C. Papachristos, K. Alexis, A. Tzes, ***"Dual-Authority Control of an Unmanned Tri-TiltRotor employing Model Predictive Control"***, Journal of Intelligent and Robotic Systems, Springer (DOI: 10.1007/s10846-015-0231-1)
- C. Papachristos, K. Alexis, A. Tzes ***"Model Predictive Hovering-Translation Control of an Unmanned Tri-TiltRotor"***, IEEE International Conference on Robotics and Automation (ICRA), May, 2013 (ICRA 2013), p. 5425-5432, Karlsruhe, Germany
- C. Papachristos, K. Alexis, A. Tzes, ***"Efficient Force Exertion for Physical Manipulation with UAVs: Exploiting the Direct Thrust-Vectoring Capabilities of a Tri-TiltRotor"***, IEEE International Conference on Robotics and Automation, ICRA 2014, Hong Kong, China, May 31-June 7, 2014, p. 4500-4505
- C. Papachristos, K. Alexis, A. Tzes, ***"Technical Activities Execution with a TiltRotor UAS employing Explicit Model Predictive Control"***, 19th World Congress The International Federation of Automatic Control, August 24-29, 2014, Cape Town, South Africa, p. 11036-11042

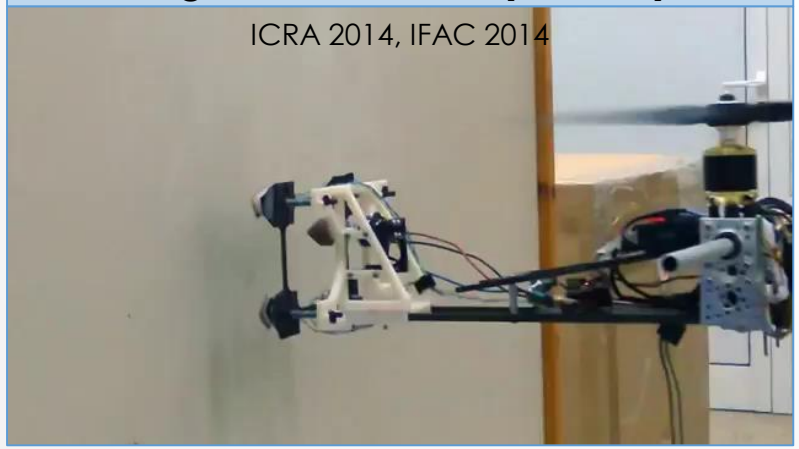
Application Potential

Full SO(3)/SE(3) Control (WingTra prototype)



Versatile Take-Off and Rapid Coverage (WingTra)

High Force Exertion (TiltRotor)



Rotorcraft & Fixed-Wing type mapping

Autonomous Exploration & Inspection

- 3D models of the structure to be inspected are typically not available.
- Real infrastructure is typically very complex in terms of geometry.
- Most of the times we care for some sort of local exploration and not coverage of everything in our environment.
- **What does it take for a robot to be able to conduct such a mission, without any prior mission, autonomously?**

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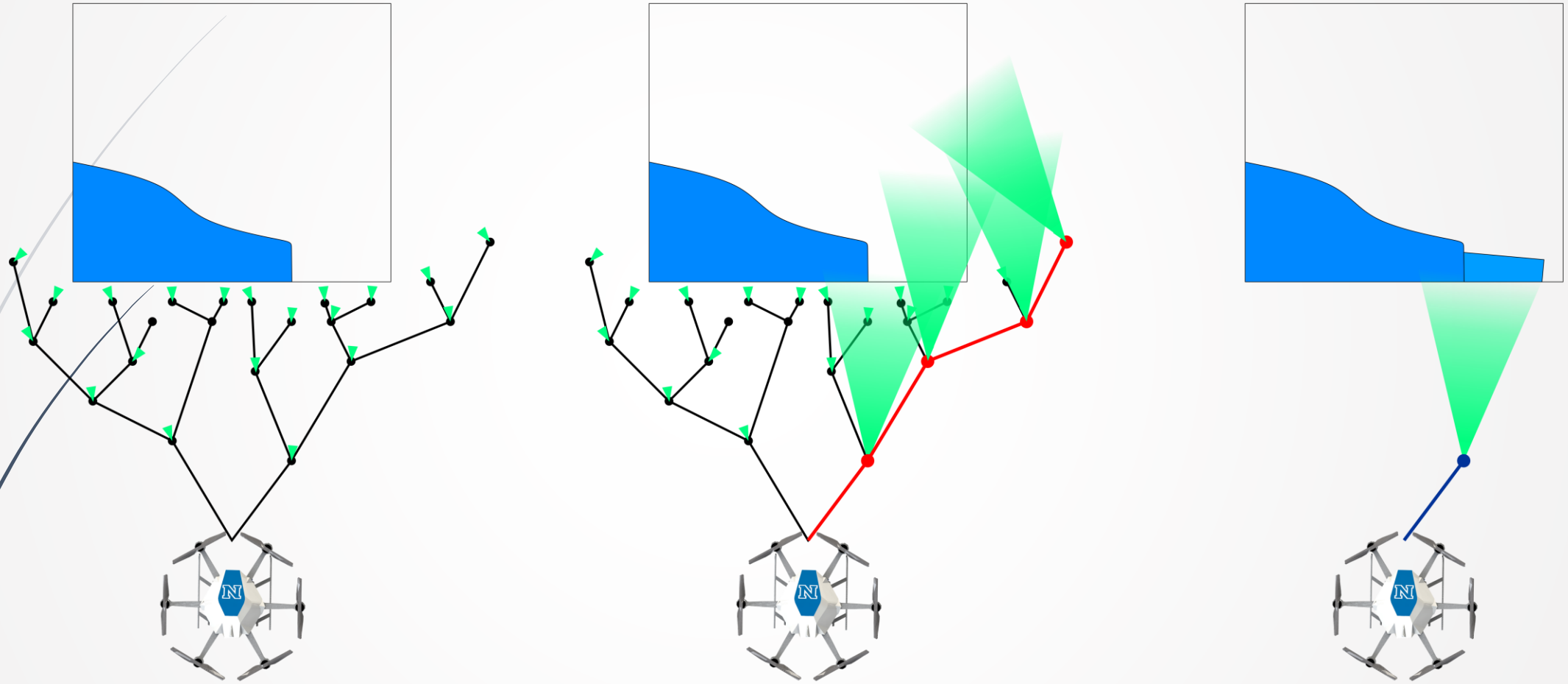
Receding Horizon Next-Best-View Planning



$$\mathbf{Gain}(n_k) = \mathbf{Gain}(n_{k-1}) + \mathbf{Visible}(\mathcal{M}, \xi_k) e^{-\lambda c(\sigma_{k-1}^k)}$$

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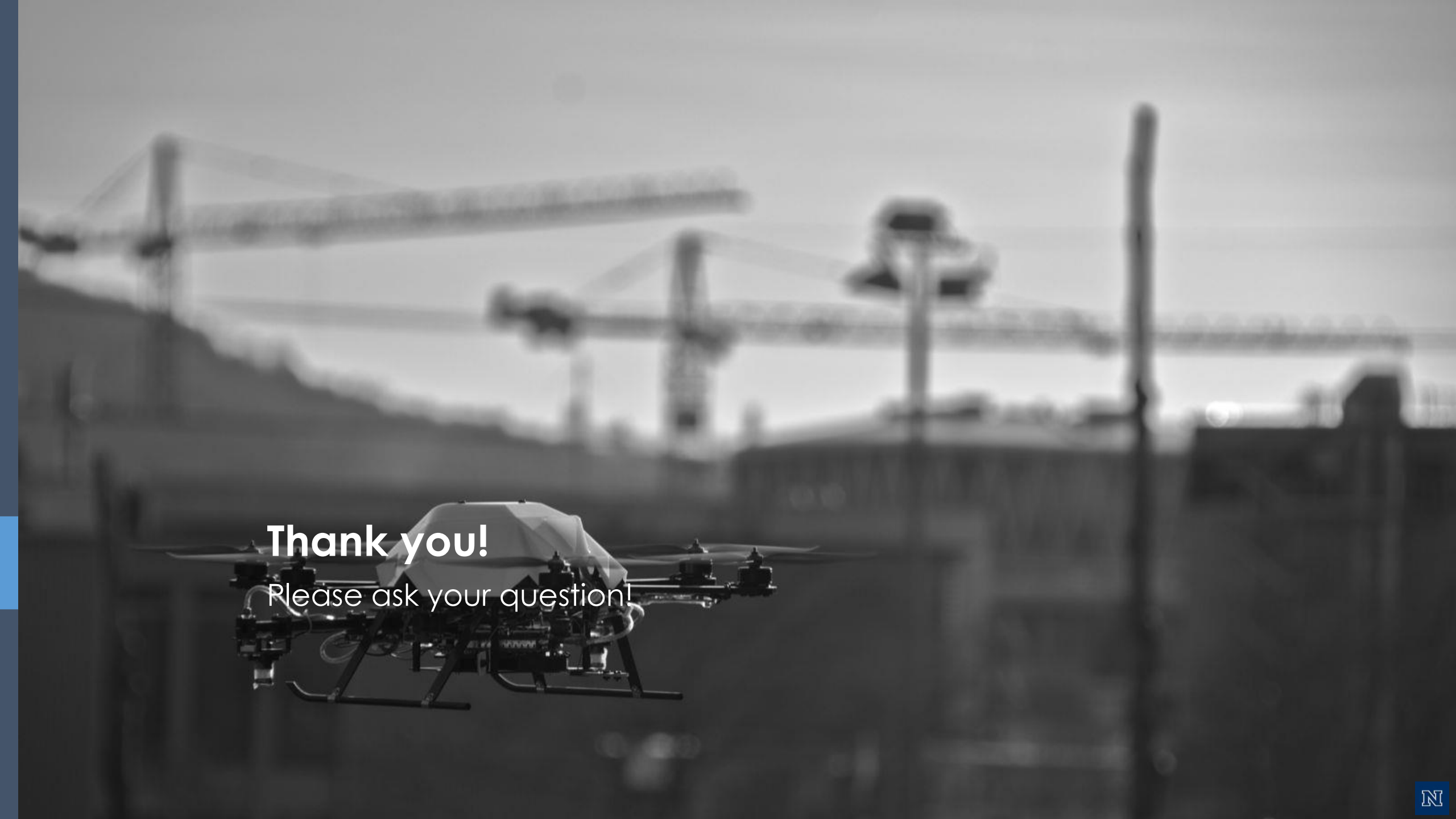
Open Source Code

- **Open Source Code:**
  - Structural Inspection Planner:
    - https://github.com/ethz-asl/StructuralInspectionPlanner
  - Next-Best-View Planner:
    - https://github.com/ethz-asl/nbvplanner

- **Associated Datasets:**
  - Structural Inspection Planner:
    - https://github.com/ethz-asl/StructuralInspectionPlanner/wiki/Example-Results
  - Next-Best-View Planner:
    - https://github.com/ethz-asl/nbvplanner/wiki/Example-Results
  - Solar-powered UAV Sensing & Mapping:
    - http://projects.asl.ethz.ch/datasets/doku.php?id=fsr2015



Thank you!

Please ask your question!