SRI International

SRI Unmanned Aircraft Systems

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Polar Technology Conference, 2016

Benefits of Small Unmanned Aircraft Systems

- UAVs are rapidly being adopted in a very diverse set of fields for the following reasons:
  - Low-cost
  - Transportable
  - Fully customizable/ programmable
  - Flexible payload/mission
  - Multi-aircraft missions
  - Becoming easier to fly

- Polar applications may include:
  - Sea ice monitoring
  - Navigational aid for sea vessels
  - Search and rescue support
  - Wildlife surveying
  - Wildlife habitat assessments
  - Mapping / photography (mulispectral)
  - Inspecting the roofs of buildings

UAVs at SRI

- UAV technology complements SRI’s expertise in sensors and remote sensing.
- Projects focus on new commercial & government applications.
- UAVs in the commercial space are poised to take off:
  - Recent advances in small, low-power electronics and autonomy have reduced the pilot skill barrier
  - Better batteries improve practicality of sUAV systems
  - Low-power, low-cost communications electronics allow real-time feedback from a/c
  - Small, low-cost sensors enable new and unique opportunities in remote observation and measurement
  - Regulatory environment catching up and somewhat guided by commercial needs

SRI's COTS UAVs

Multirotors:

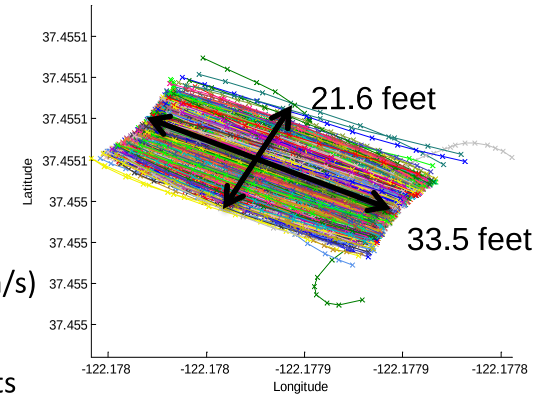
- 3DR IRIS Quadcopter
  - Open source hardware & software
  - Maximum payload 400 g, 10-15mins flight time
  - Programmable, extensive data logging
- Infinity-9 Octocopter
  - Maximum payload 5.4 – 8.1 kg, ~12 mins flight time
  - Programmable, some data logging

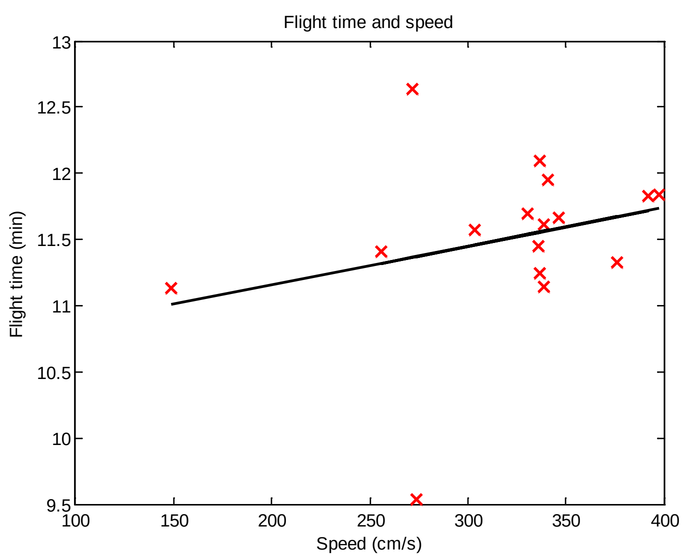
Fixed-wing

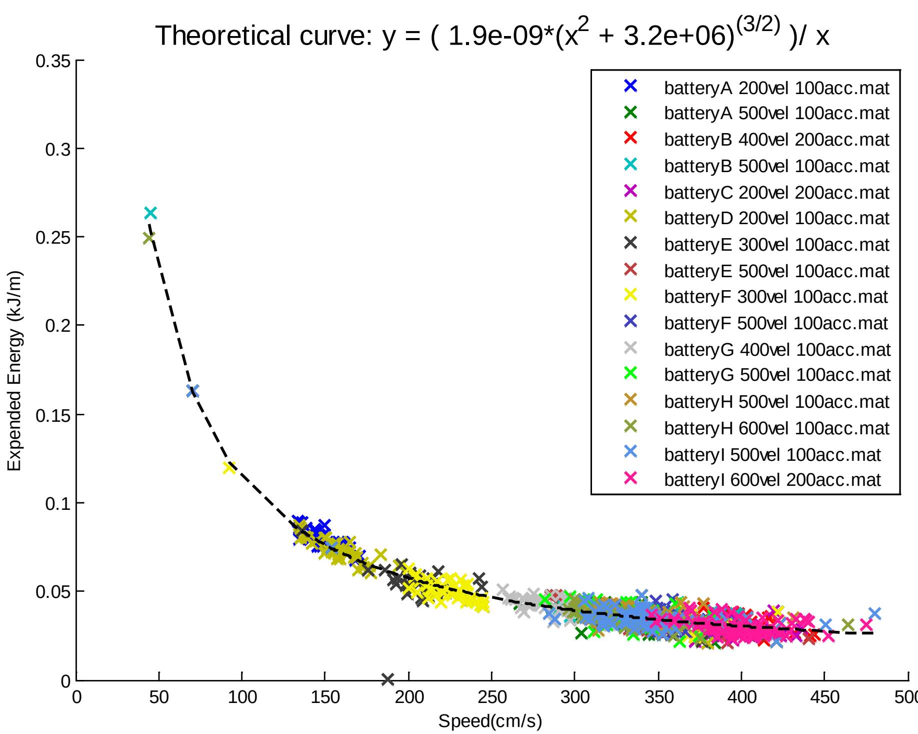
- Pandora (E)
  - Maximum payload 500 g, 6-8mins flight time
  - Used as trainer
- 3DR Aero (E)
  - Open source hardware & software
  - Maximum payload 2 kg, 40mins flight time
  - Programmable, extensive data logging
- Mugin (G)
  - Maximum payload 8 kg, 2-3 hrs flight time (est.)

Modeling Energy Consumption v. Speed

- Flights took place on two separate days
  - IRIS was programmed to fly between waypoints located 26.2 m = 85.96 ft apart
  - Varied the programmed velocity to be between 200 m/s and 600 m/s
  - IRIS was not achieving high velocity at default acceleration (100 m/s^2), so we changed the acceleration to 200 m/s^2 and flew at three different speeds (200 m/s, 400 m/s, and 600 m/s)
- Chose flight segments from paths which were primarily forward flight
  - Filtered out points close to waypoints (within 8 m), and took segments of consecutive points
- Expended energy per meter decreases at higher speeds
  - Maximum speed of quadcopter = 2000 cm/s = 44.7 mph
  - Minimum for theoretical curve = 1275 cm/s
- Slightly longer flight durations for faster speeds
  - Flights generally between about 11 and 12 minutes

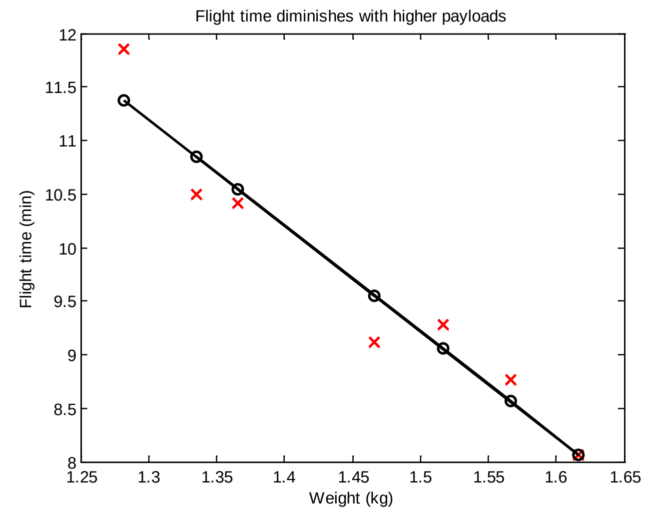


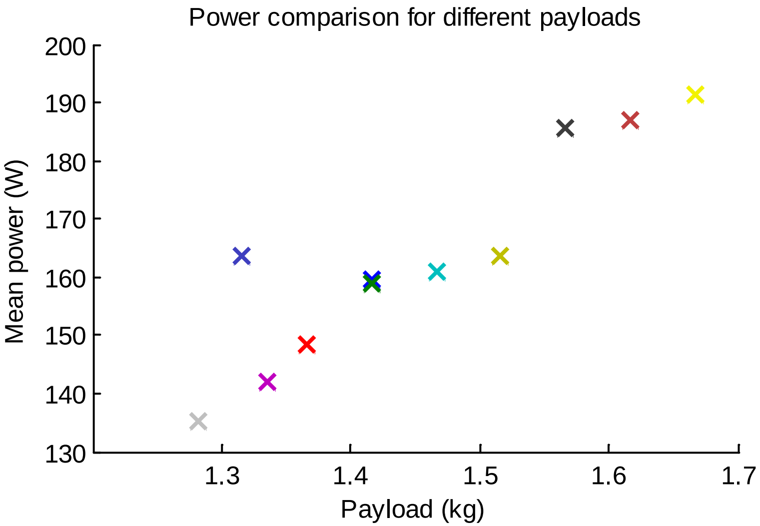


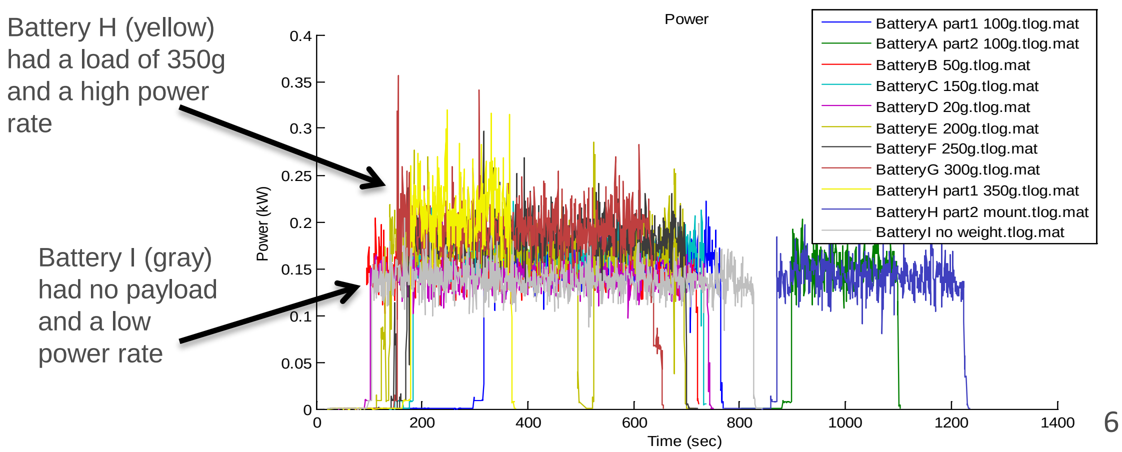


Modeling Energy Consumption v. Payload

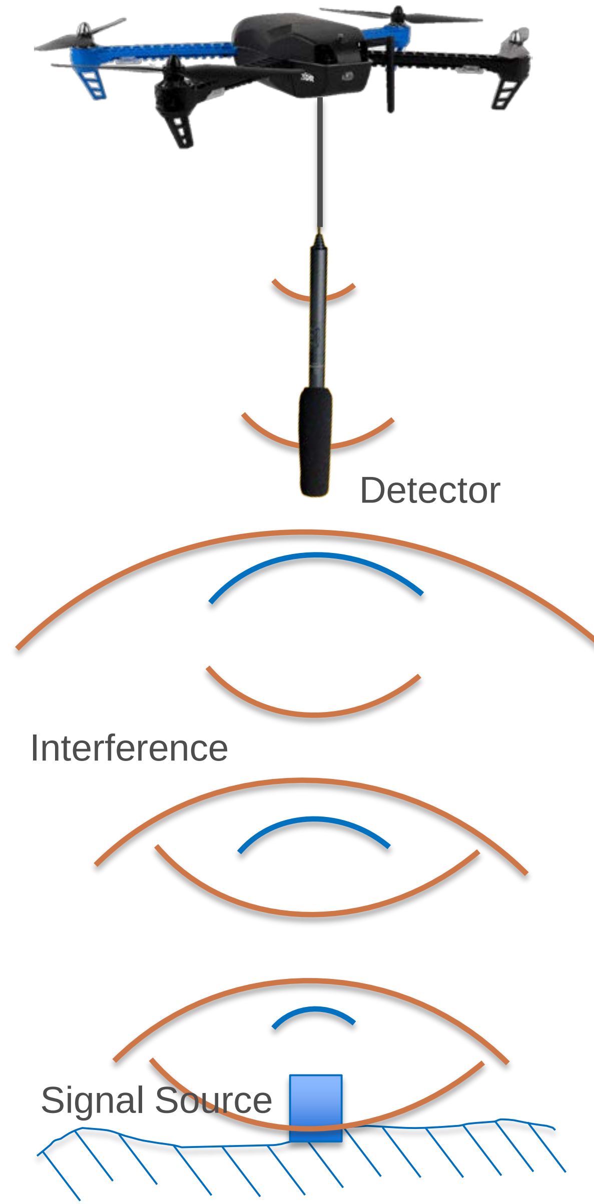
- Flight tests:
  - Varying payloads: 0g to 384g
  - Maximum payload is 400 g
  - Quadcopter had some difficulty balancing payload in the high winds
  - Wind speeds and direction recorded
- Power/Energy consumption increased for higher payloads
- Relationship between flight duration and payload
  - Flight times are shorter with heavier payloads
  - Flight durations between 8 and 12 minutes





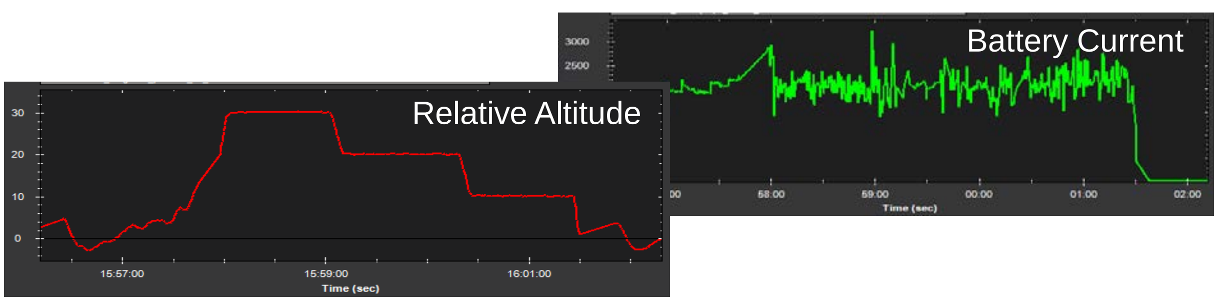


Acoustic Signal Detection Experiments



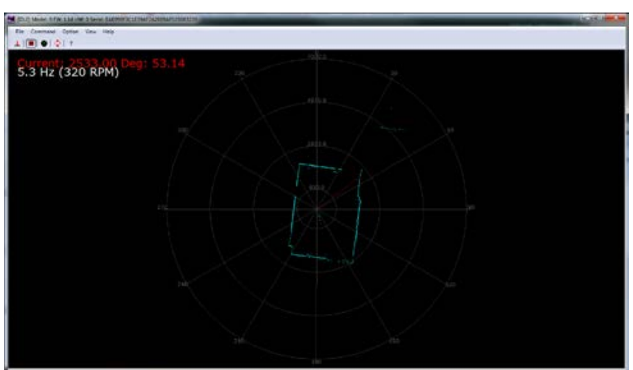
Detecting acoustic signals through motor noise at selected altitudes

- Platform: 3D Robotics IRIS Quadcopter
- Audio collection system
  - 3D Printed mounting hardware
  - Audio Technica ATR6550 Condenser Shotgun Mic ($65)
  - Tascam DR-05 Portable Digital Recorder v. 2 ($100)
- Backend processing algorithms have proposed alternative mount designs for the microphone.
- These audio tests have been proposed using a fixed wing's glide to minimize engine noise during collect.

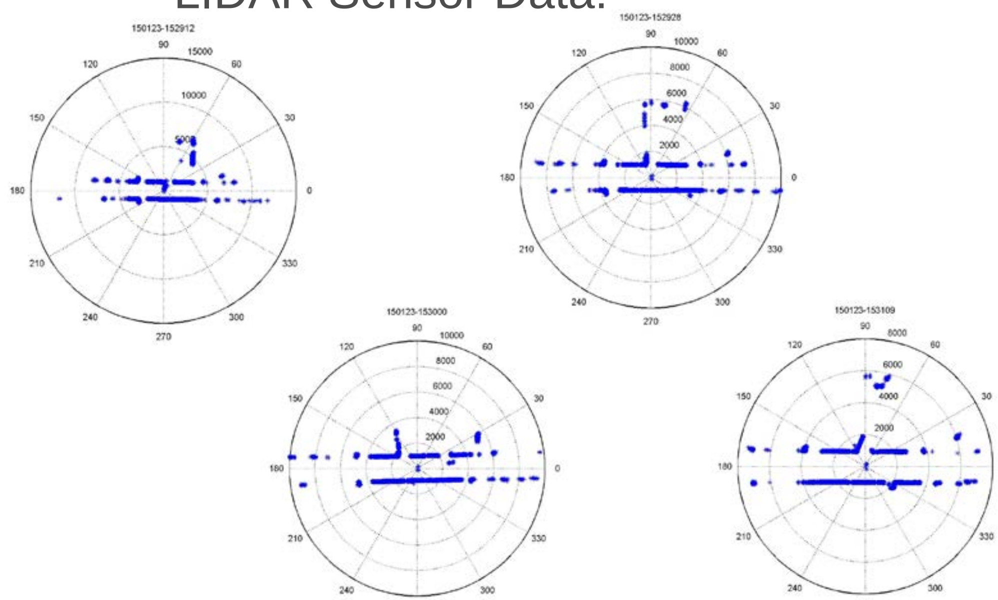


LIDAR Simultaneous Localization And Mapping (SLAM)

- Platform: 3DR IRIS Quadcopter
- COTS LIDAR Unit: Slamtec RPLIDAR ($200)
  - 2kS/s
  - Omnidirectional
  - Angular resolution: 1˚
  - Range: 6m
- Controller/Data Storage: Raspberry Pi/Arduino ($30)
- Custom 3D Printed Electronics mount
- Wireless copter telemetry (915MHz)
- Flight control (2.4GHz)
- VPN/Wi-Fi sensor control (2.4GHz)
- Post Process w/ MATLAB

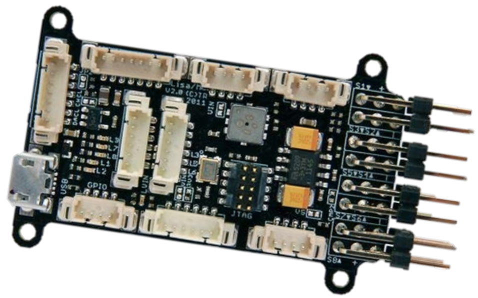


LIDAR Sensor Data:



Open Source Hardware & Software

- Open Autopilots
  - Paparazzi UAV
  - ArduPilot
  - 3DR Pixhawk
  - OpenPilot
  - Many others
- Benefits of Open Hardware
  - Minimal development cost
  - Customization
  - Feature rich
  - Large community following
- Open Software
  - Paparazzi GCS
  - QGroundControl
  - MissionPlanner
  - Tau Labs Ground Control
  - OpenPilot GCS
  - Many Others



The Super Simple UAV Design (Quadrotor Example)

Payload
kilograms

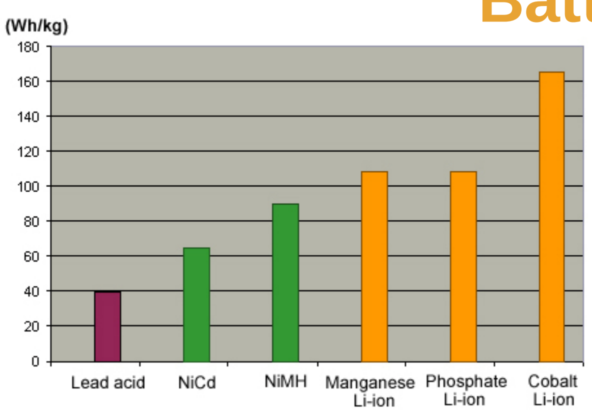
Generally want 2:1 thrust-to-weight ratio (at 100% throttle combined propeller thrust is capable of lifting 2x the weight of the craft).

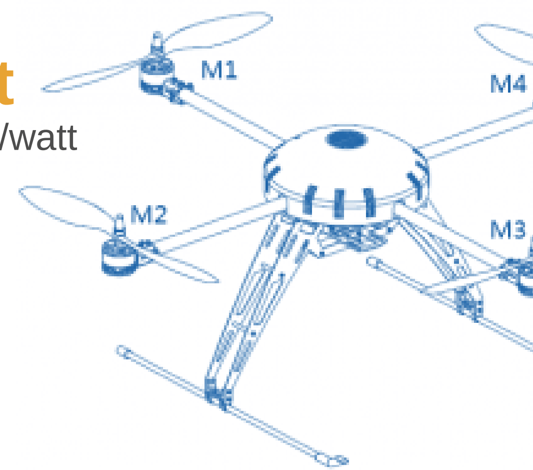
Increasing battery capacity has negative impact of thrust/lift which reduces available payload capacity

Flight Time

Battery
amp hours

Thrust/Lift
grams/watt

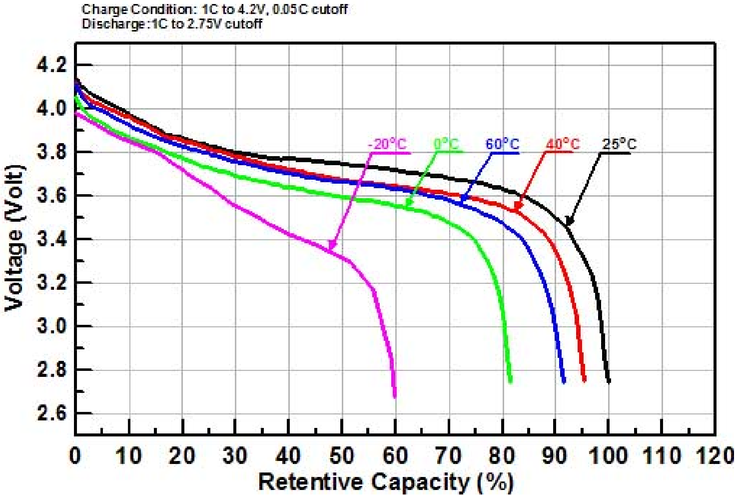




Determine the amount of power the motors need to generate that thrust and the demand on the battery

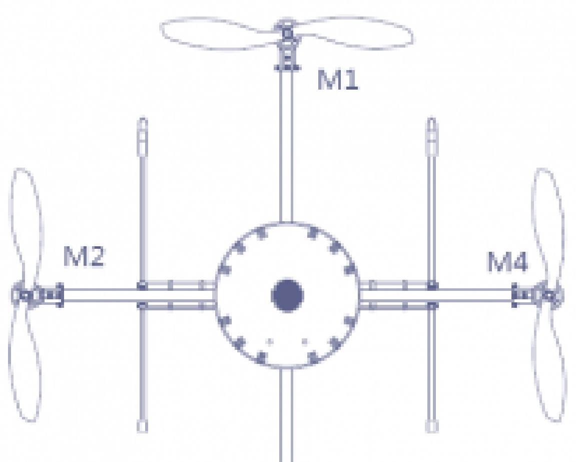
Challenges & Limitations

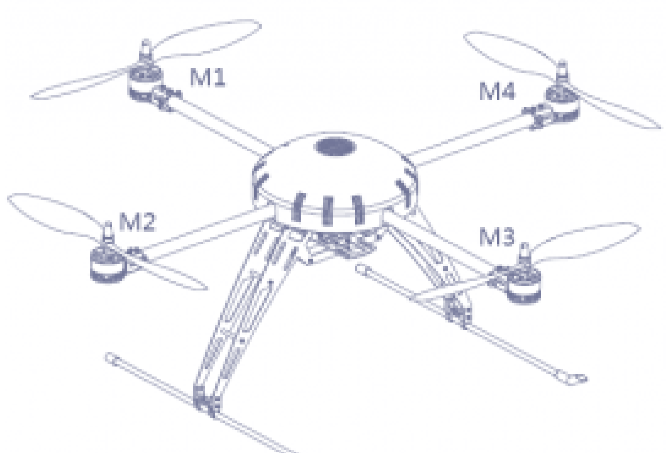
- Navigation in Arctic is not trivial
  - Rough Weather
  - Drifting sea ice
  - Poor maps/charts
  - Ionospheric effects on satellite signals -> Degraded GNSS Performances
  - Geostationary satellites are visible at very low elevation angles -> Poor SBAS signal reception, WAAS not practical
  - Lower accuracy of magnetic compasses unreliable above N70°
  - Lower accuracy of gyro compasses unreliable above N85°
- Electronics in Cold/Wet Environments
  - Some ICs not rated to -40C -> Stick to Military/Industrial temperature ratings
  - Lithium-Polymer battery degrades with temperature



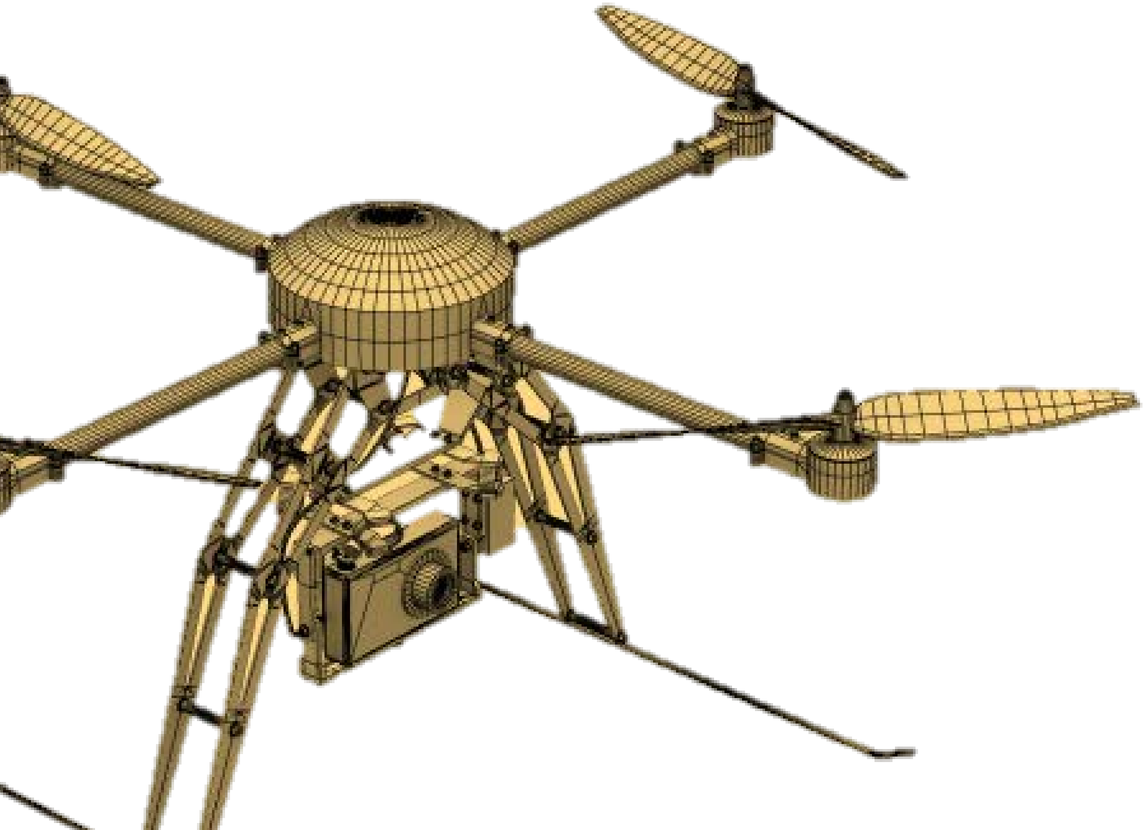
Other Interesting UAV Studies at SRI

- Plan to modify larger fixed wing aircraft and octocopter for existing SRI developed payloads
- Testing and developing sensors
  - CubeSat testing possibilities
  - LIDAR sensor ready for additional tests
  - River speed measurements based on surface current
  - Miniaturized SAR systems for FOLPEN and GMTI detection
  - White paper/proposal work





Thank You!
Questions?



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