Turtle Road-Kill Prevention via Slung Payload Control

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Introduction

Due to ever-expanding cities, roads are built through animals' habitats. Slow-moving animals like turtles are especially at risk due to their slow speeds. One conservation biologist at New York State University found that turtles have a "10 percent annual kill rate from road kills, and that some of these regions likely have up to 20 percent mortality rates due to traffic encounters." (ABC News, 2001). This document proposes that autonomous quadrotor drones with slung-payload controls would be able to monitor certain stretches of roads and move slow-moving animals like turtles and tortoises out of harm's way.

Hypothesis: Quadrotor slung payloads can effectively and timely transport turtles off roads, ensuring their safe removal from traffic pathways.

Photo: Glenn Lowson, The Star

Research Investigation

What are traditional methods, and do they work?

Signs

Signs are the most commonly used tools to warn motorists about wildlife in road areas. However, signs are not effective in preventing turtle mortality. According to a study from the University of New York, *Testing the Effectiveness of Turtle Crossing Signs as a Conservation Measure*, "there was no evidence that there was a difference in road mortality, measured as Dead-On-Road (DOR)/km/day" (Glenn Johnson, 2009). The study collected two data points: driver speed and road mortality on ten road stretches both before and after warning signs were erected. The lack of effective prevention means that this traditional method does not work

Overpass "Ecoduct"

In the Netherlands, a national park created Ecoduct De Woeste Hoeve, an overpass filled with greenery that slopes over the road. Around the overpass, fences funnel animals to the overpass (Canadian Geographic, 2020). The Netherlands currently has 30 similar wildlife bridges, with plans to build 20 more (Wageningen University, 2024). The Ecoduct strategy is very successful, however, it requires city planning and investment, which is a major factor in why Ecoducts are not common.

Fences

According to an article by Canadian Geographic, fences are the most effective method to decrease road-kill (Canadian Geographic, 2020). Despite this, animals still find ways around, shifting the "road-kill hotspots." The image at the bottom of the page in the "Interesting items

found" section shows these hotspots (Canadian Geographic, 2020). These fences are expensive to build and maintain and are "not directly relevant to driver safety," so transportation agencies do not add them (Canadian Geographic, 2020).

Relying on Citizens

Similar to the sign strategy, relying on the alertness of the average person is not a scientific approach, nor will it significantly change the rates of turtle/tortoise mortality.

Where can autonomous quadrotor drones innovate?

Using an autonomous road-kill-prevention system via a fleet of quadrotor drones would ensure that there is always "someone" watching. Where mass-signage is a reliable, stationary way to inform human drivers of a turtle area The project would be deemed successful under two conditions: the drones may be effectively deployed autonomously without human intervention, and that the drone network could be priced less than or equal to the cost of mass signage.

- How do the costs (estimate) compare between traditional and this method

Detection of animals on the road (Out of Scope)

- Feasibility
    - Sub-hypothesis: We will need some sort of camera system (OpenCV?) that will constantly check for turtles/tortoises
        - Can existing security cameras be used (instead of paying for tons of new cameras?)
    - Counter (without research) what will happen in the nighttime?

The act of picking up: is it safe to lift a turtle/tortoise?

While not autonomous, reading through the guides of how to pick up turtles/tortoises manually can help with figuring out where to create an apparatus. Information retrieved from Mid-Atlantic Turtle & Tortoise Society.

Turtles/tortoises should be picked up with supports on each side of their shells. This implies that the apparatus used to pick up turtles/tortoises should be, at minimum, a two-prong claw.

They should not be picked up by the tail.

This is not an issue as we are not picking the turtle/tortoise up by the tail.

They should not be turned quickly.

Perhaps some sort of gimbal/stabilizer could be used to minimize the motion of the turtle/tortoise payload

They can be rotated, however they should not be put through 360-degree rotation as to not twist their intestines.

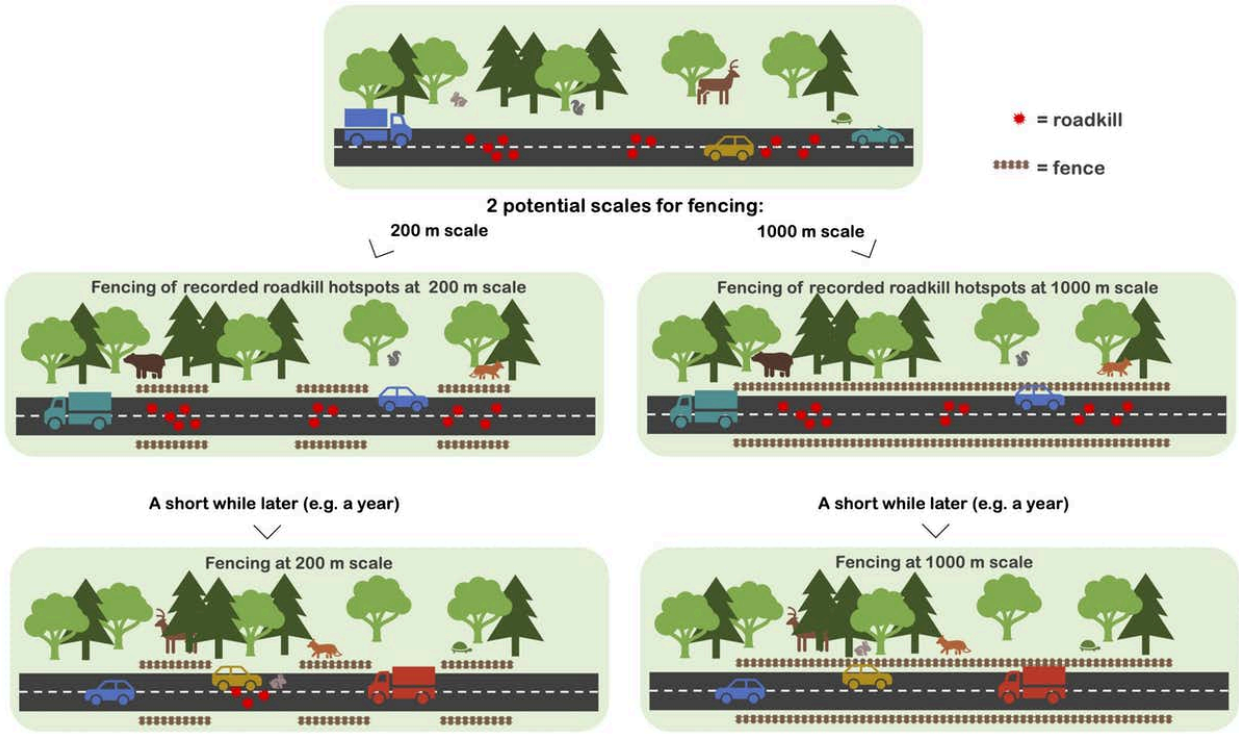
This adds further implications to the gimbal (see “how do gimbal systems work” section)

Slow, controlled movements should be used with the drone

Ensure that drone operator is certified and trained

Do not stick an apparatus between the top and bottom shell of a box turtle; the hole between expands and contracts.

Not an issue.

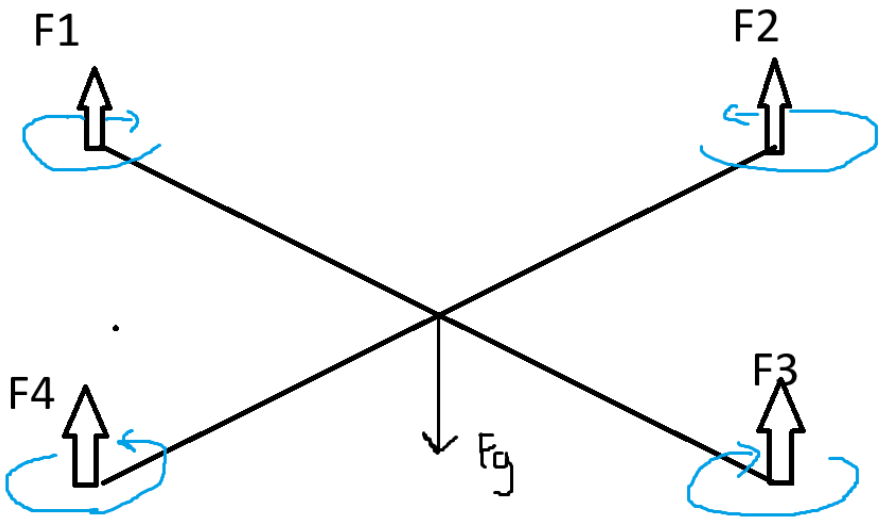


(Canadian Geographic, 2020)

Proofs

- State that whatever we're doing, works
    - This is why it will work
        - Physics
            - Free body diagram
                - force balances
                - Stress (see if it can hold)/strain (measure deformed length by original length)

        - Do some searching for the F450 drone lifting specs etc
        - Propeller 1045
    - String analogy
        - Instead of just pulling it, analyze the materials to see if it will hold



Physics

Items to collect:

- ☐ Weight of the turtle/tortoise (W) (for Fg)
- ☐ Lift force generated by the drone (L)
- ☐ Tension in the slung payload string (T)
- ☐ Drag force (D) due to air resistance

$L = W + T$

Stress and Strain Analysis

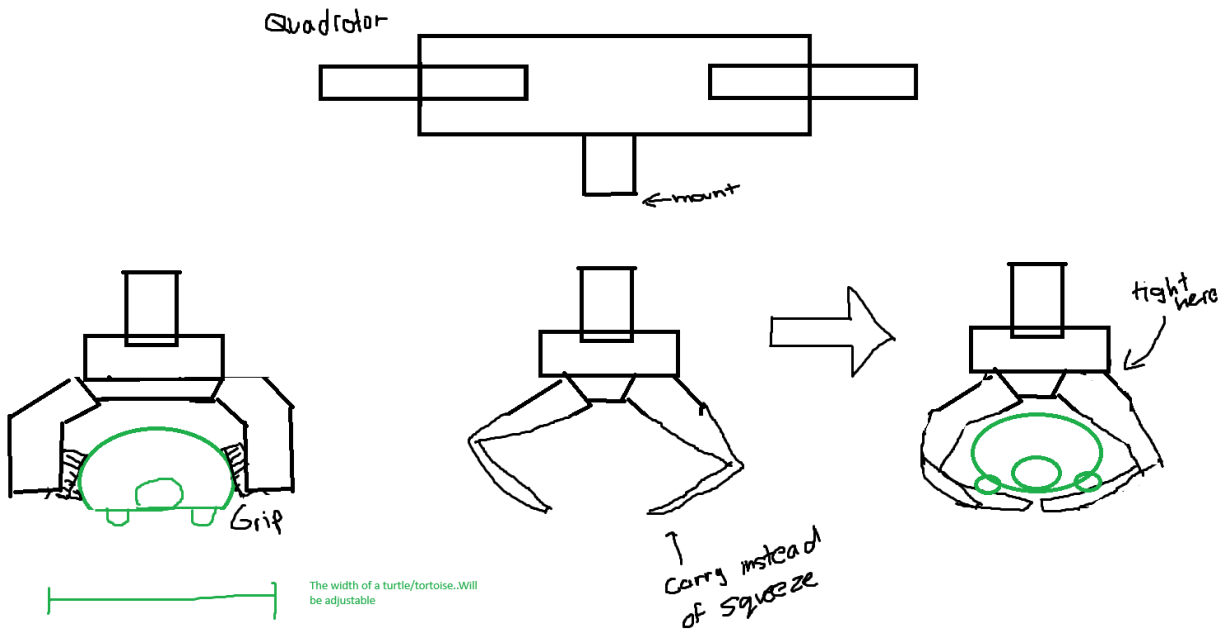
Materials:

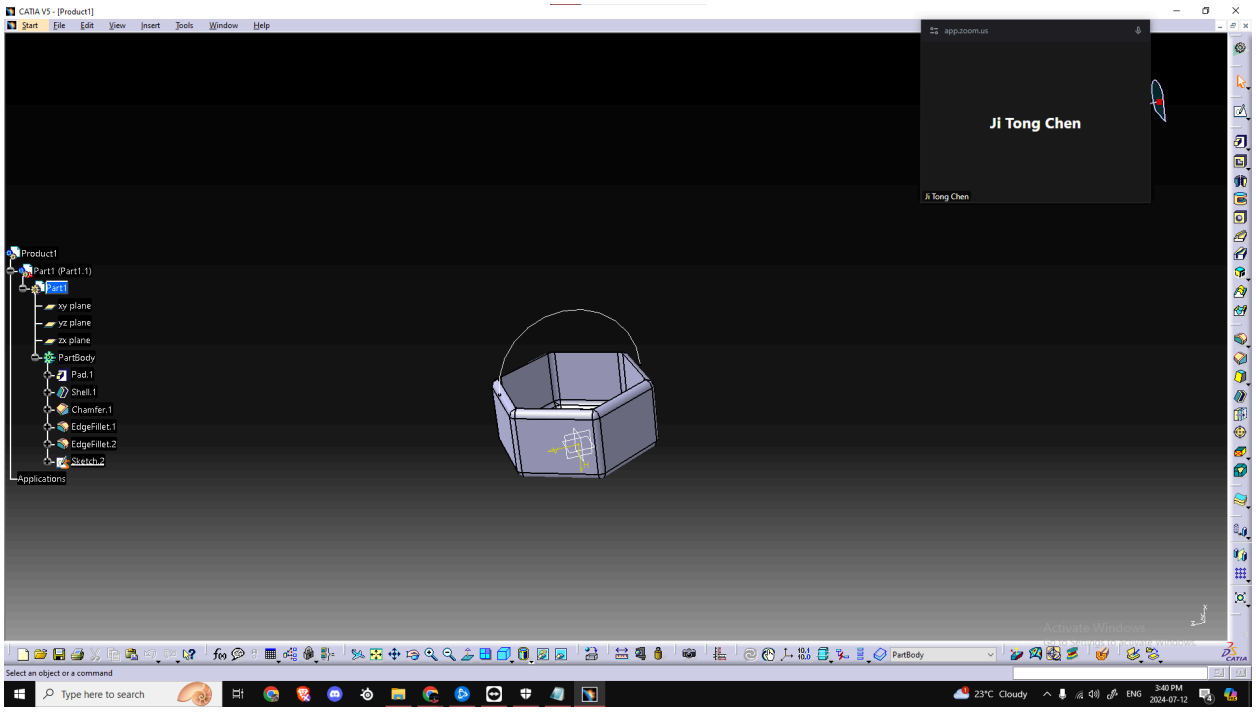
- Kevlar string or high-strength nylon ?
    - Tensile strength
    - Kevlar: ~2,600 MPa
    - Nylon: ~500 MPa
    - PLA?
    - PETG?

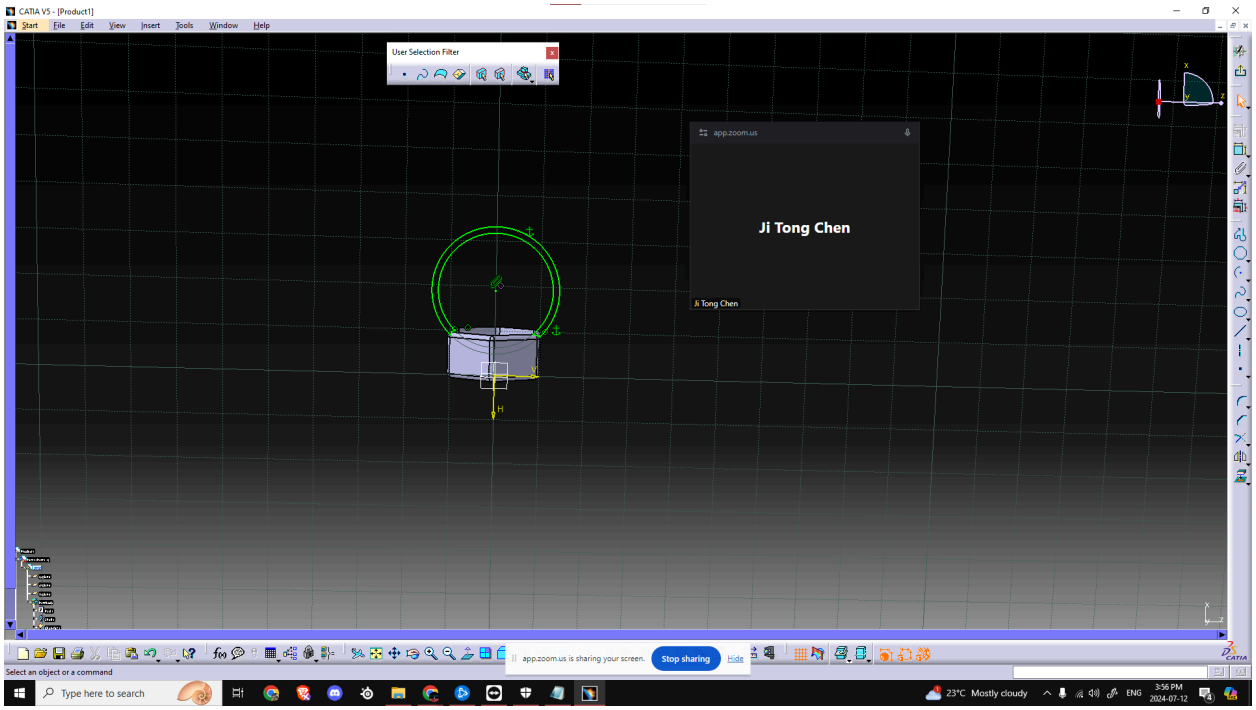
Use program to analyze materials to see if it will hold

Process Photos

Initial Thoughts for Designs







References

How to Handle a Turtle. (n.d.). Mid-Atlantic Turtle & Tortoise Society. Retrieved July 11, 2024, from https://www.matts-turtles.org/handling-turtles.html

Jaeger, J. A., Spanowicz, A., & Teixeira, F. Z. (2020, December 7). *Wildlife can be saved from becoming roadkill with a new tool that finds the best locations for fences*. Canadian Geographic. Retrieved July 4, 2024, from https://canadiangeographic.ca/articles/wildlife-can-be-saved-from-becoming-roadkill-with-a-new-tool-that-finds-the-best-locations-for-fences/

Mentzer, R. (2019, July 10). An Innovative Underpass Keeps Turtles Off The Highway. It's Saved Dozens From Becoming Roadkill. *WPR*.

https://www.wpr.org/animals/innovative-underpass-keeps-turtles-highway-its-saved-dozens-becoming-roadkill

Mitigation. (n.d.). Wildlife Collision Prevention Program. Retrieved July 11, 2024, from https://www.wildlifecollisions.ca/prevention/mitigation.htm

1 Final Report: Testing the effectiveness of turtle crossing signs as a conservation measure. To: Peter O'Shea, St. Lawrence R. (n.d.). NY Power Authority. Retrieved August 7, 2024, from https://www.nypa.gov/-/media/nypa/documents/document-library/re-licensing/stl/slrref-project-reports-proposals/testingeffectivenessturtlecrossing2009.pdf

Reducing the risk of wildlife collisions | WSDOT. (n.d.). WSDOT. Retrieved July 11, 2024, from https://wsdot.wa.gov/construction-planning/protecting-environment/reducing-risk-wildlife-collisions

Turtles Decline Due to Road Kill - ABC News. (2001, August 9). *ABC News*. https://abcnews.go.com/Technology/story?id=98351&page=1

Watch for Wildlife on the Road This Spring to Reduce Roadkill. (2023, May 1). Ontario Nature. Retrieved July 11, 2024, from https://ontarionature.org/news-release/watch-for-wildlife-on-the-road-this-spring-to-reduce-roadkill/

Wildlife bridges. (n.d.). WUR. Retrieved August 7, 2024, from https://www.wur.nl/en/research-results/dossiers/file/wildlife-bridges.htm

Kevin JiTong Chen	**Milestones:** 1. SCITech Abstract Submission (May 23rd) - Done **2. Simulation Results (July 1st)** **3. Fully Functional Retraction Mechanism (July 15th)**	**Last Week:** Tested Electronics (all parts working except one chip need replacing) Need extra sensors, ultrasonic/lidar for position drift, angle sensor to help encoder Measurment is not too accurate due to too slow data collection time for arduino when running multiple tasks Tested using ultrasound sensors for ground detection with water in bathtub, accurate to 1cm. Preliminary simulation functional and can get data (eg, swing/movment from payload, quadrotor) Design, tune PID controller for cable length **To Do:** come up with stabelization technique in simulation to lower payload movment Rework arduino code to make Make changes to the angle measurments and dedicate motor control to arduino and use faster ESP32 as microcontroller to read encoder data

07/04 - Develop ideas for project

07/11 - Began research document and proposal for “Turtle road-kill prevention project”

07/12 - BONUS DAY - Begin early work with CATIA software, Reese onboarded onto the 3D CAD software and began to make 3D models + further work on research document

07/18 - Continued work on CATIA models, planned out grabber mechanism

07/25 - Researching motors and

08/01 -

IR receiver next to arduino

Practice arduino c++ skills

Building Process

Project	Status	Who Is Bringing	Notes
Four arms		Kevin	
Body	Waiting on motor -Amazon	Kevin	
Remote control with IR (in progress)		Kevin	
Motor Controller		Kevin	
Extra item to print		Reese (file)	
Arduino		Reese	
Laptop		Reese	
Charger		Reese	

Project	Status	Who Is Bringing	Notes
Mouse		Reese	

Milestones: 1. Researched and complete literature reviews on slung payloads 2. Learned and CAD safe animal claw mechanism 3. Designed electrical components for remote control (Arduino) 4. Assembly and test 5. Demo	Last Week: - Worked on CATIA - Figured out what is the grabber mechanism To Do: - Find motor that will be sufficient for the project - Finish formal document - Physics (requires that I have all the files, to run analysis) - Answer all your own questions Define scope

Miniature version of F450

Grappling method

How to transport safely

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Demos

- Wind tunnel
- Drone piloting
- Motion capture experiments

- Learn Catia
    - Schedule a session to setup
    - Watch YouTube videos on Catia
    - Designing
        - Keep all rough work for the design process
    - Can start CADding designs out as well in 2w or so (~25th jul)
- Learn how to use the 3D printer

    - Bambu studio ← slicer
    - Creality print
- We'll build a drone right away (for learning)
- Then use the pre-built one
- Learn how to fly a DJI drone

Ideally complete by the 9th

The 16-18 would be a buffer, not in the scope per se

Proof wise:

Force balances

Stress/strain

Drone

MT2216II Motor

1045 Prop

Slicer weight → *9.81 → exact F_g

With the proof proving "this drone can fly"

—

Scope (formal)

- Creating parts

- Manual control drone + the turtle part

Learn CAD

Draw it out

CAD it out

Do the math, calculations are exact

- Underpowered motor w/ own gear box
- Underpowered motor with THEIR gear box
- Enough power motor without any gear box
- Some have attached gear boxes

Future Considerations

https://www.amazon.ca/MECCANIXITY-Reduction-500RPM-Gearbox-Aircraft/dp/B0BF9KVY3D/r[…]dc%2Barduino%2Bmotors%2Bwith%2Bgearbox%2Caps%2C71&sr=8-37&th=1

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https://www.amazon.ca/Encoder-Reduction-Gearbox-Replacement-28BYJ-48/dp/B08F34WFWR/[…]3354&sprefix=dc+arduino+motors+with+gearbox%2Caps%2C71&sr=8-28

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https://www.amazon.ca/SazkJere-ULN2003-Stepper-28BYJ-48-Compatible/dp/B0BVVM4FZ3/re[…]x%2Caps%2C71&sr=8-59-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9idGY&th=1

8:26

could add pressure sensors for varying size turtles

8:27

also could add something soft like sponge or dots of hot glue to hold the turtle in pace without too much pressure

Idea Generation (scraps)

- Can autonomous drones be used to survey roads and pick up small slow animals (payload) and move them away
    - https://www.missinganimalresponse.com/lost-pet-tips/drones-and-lost-pet-recovery-how-effective-are-they/
        - Animal searching, but does not involve payload
    - https://www.thewildest.com/pet-lifestyle/drone-animal-rescue-assert
        - Animal searching, but does not involve a payload
- Can autonomous drones deliver medication(payload) to areas in need
    - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10166545/
        - Research paper debunking these efforts
    - https://blog.petrieflom.law.harvard.edu/2021/04/15/drone-enabled-pharmaceutical-delivery/
        - Harvard research paper on drone-enabled pharmaceutical delivery

- ~~Can autonomous drones be used to survey animals in wildlife?~~
    - Not slung payload
    - https://www.researchgate.net/publication/351360616_A_Novel_Method_for_Using_Small_Unoccupied_Aerial_Vehicles_to_Survey_Wildlife_Species_and
    - _Model_Their_Density_Distribution/link/662fe42e08aa54017acd1549/downloajd