RFID JOURNAL VIRTUALLY LIVE!

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Use of Drones for Outdoor Inventory
The cases of Metal Pipes and Cattle

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Use of UAV-RFID for Oilfield Tubulars

Hundreds or thousands tubulars

Across large fields

Labor Intensive Inventory

RFID to the Rescue

Passive UHF RFID

Tag cost = $0.15

Adhered to pipe cap or to foam insulator

RFID reader on UAV

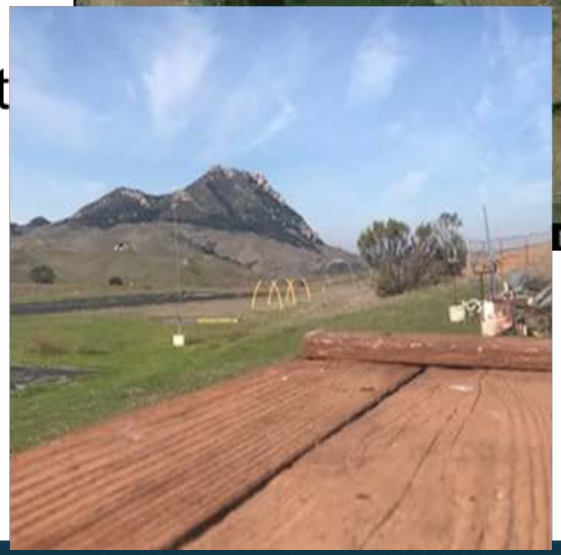
Experiment #1 – Establish Base Read Range

Experimental Flight Range

Read range testing

Zip ties for tag attachment

Promising results – 12’



Experiment #2 – Reading Reliability on Oilfield Tubulars

Santa Maria Holdings Site

Oil drilling pipes

Tags on insulation strips

Results: 3m 100% read 2 minute hover time

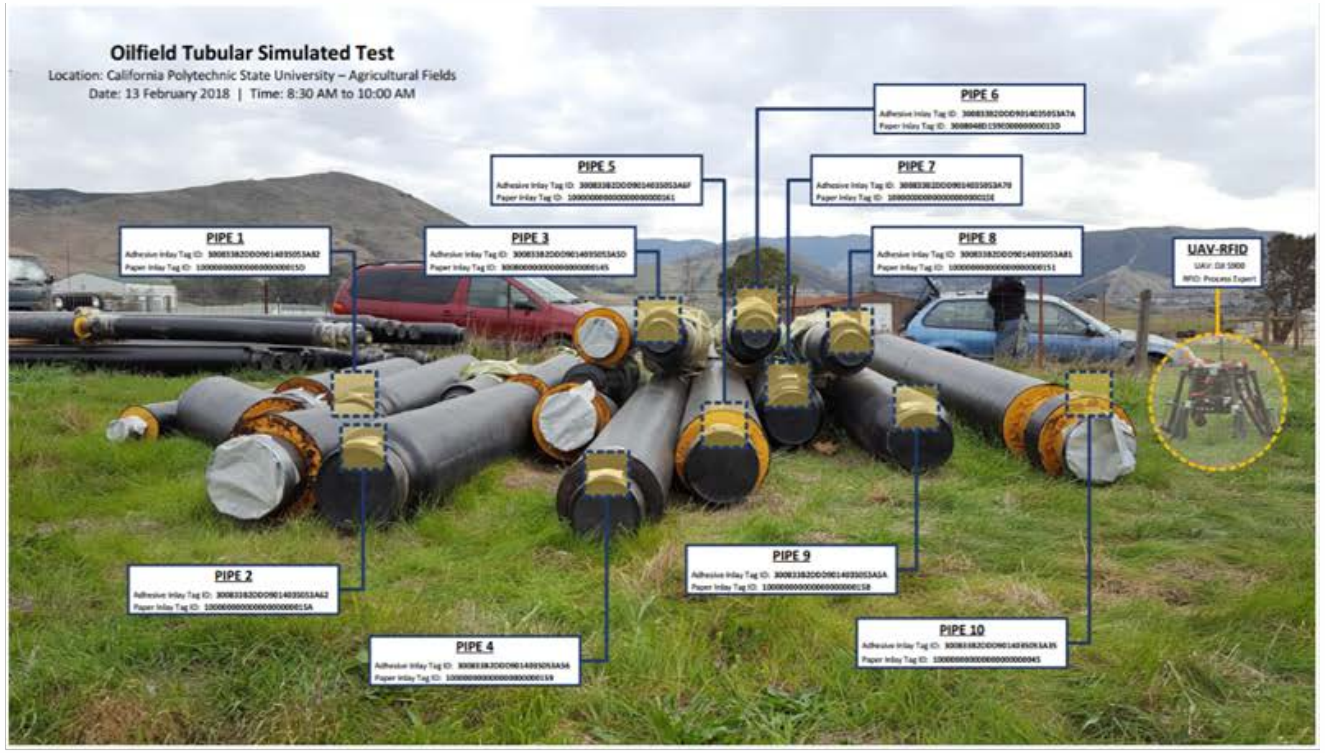
Experiment #3 – Reading 2 Tag Types

Cal Poly Experimental Site

Insulated hot water pipes

Insulated tags on metal
Labels on pipe insulation

Results: 2.5m 95% read
2 minute hover time



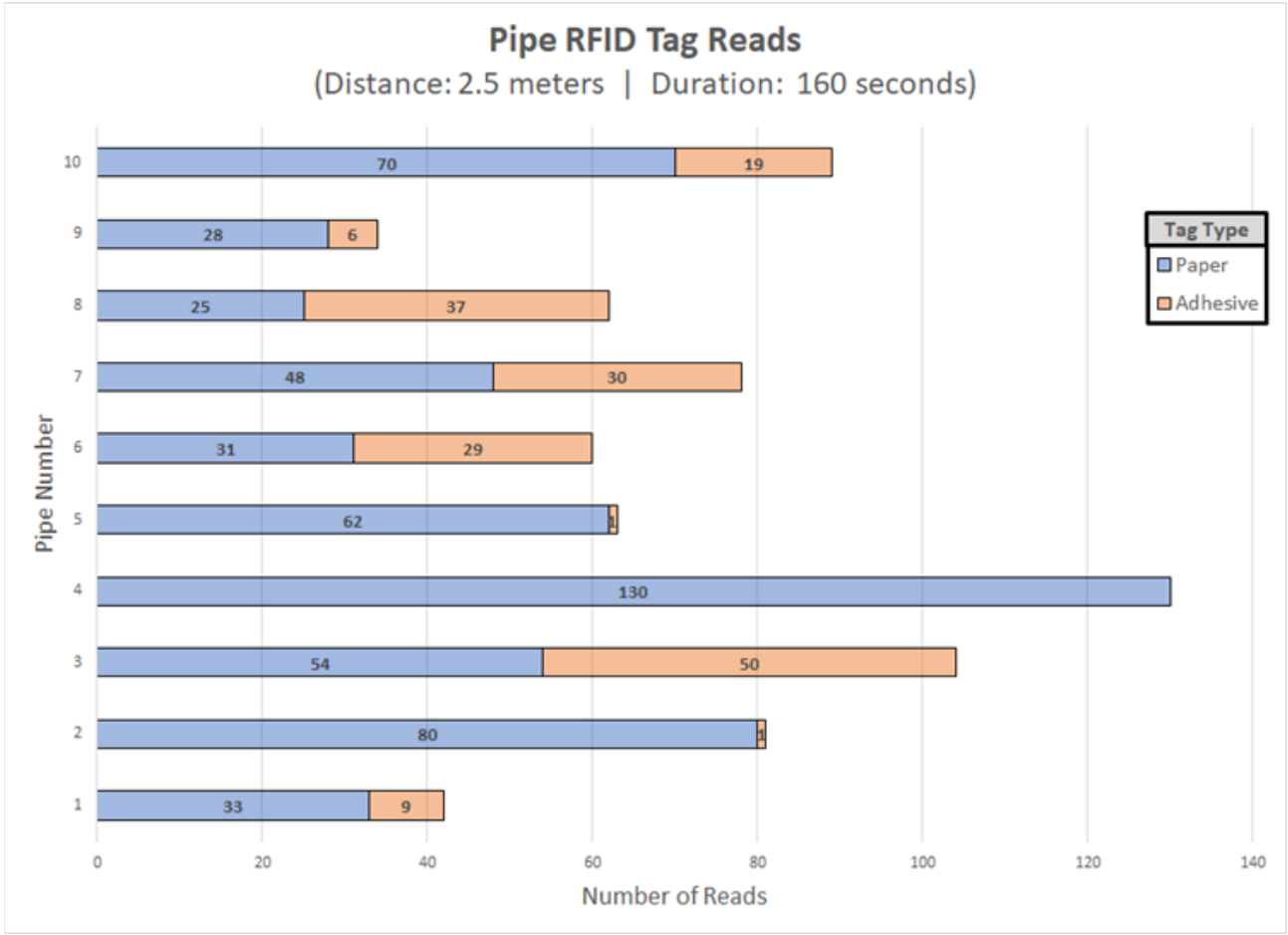
Number of Tag Reads – Reading Reliability

Variability is common

Experiment with tag types

Experiment with insulation

Results: 2.5m 95% read with adhesive,
100% read of paper tags



Conclusions and Future Research

Variability is common

Experiment with tag types

Experiment with insulation

Results: Promising, require more experimentation: layouts, materials, environmental conditions

Use of UAV-RFID for Grazing Cattle Inventory

Livestock Tracking

UAV-RFID *System Constraints*

RFID scanning radius

350 ft ≈ 106m

RFID scanning area

35753 m2

UAV Flight Speed

16 m/s

UAV Flight Time per Charge

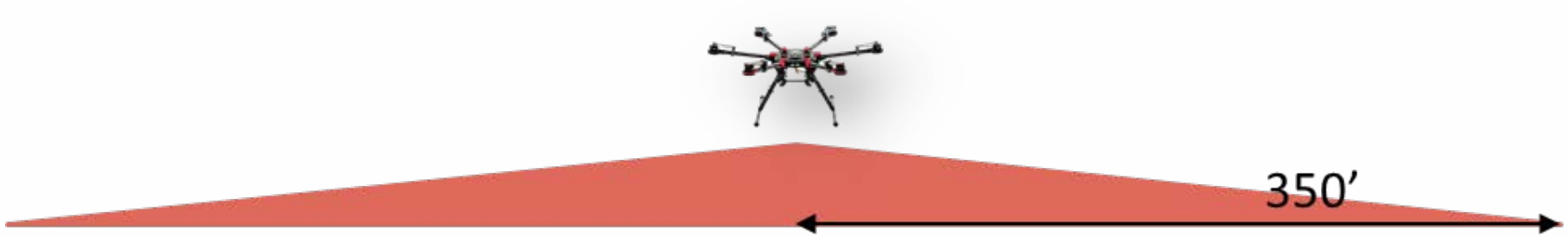
15 min

Ranch Area

2,562 acres

Intesive Grazing Pasture Area

up to 293 acres



Problem

To utilize the RFID-UAV system for cattle tracking, the following must be considered:

- *The location of each cow is unknown within the pasture.*
- *The UAV must fly within 350’ of each cow.*
- *The UAV flight time is limited to 15 minutes.*

Alternatives Considered
System Adjustments

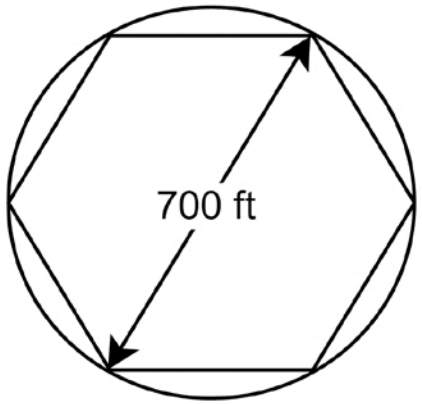
- Increase the flight time
- Enhance read range
- Additional UAV + RFID interrogator
- Reduce the flight path

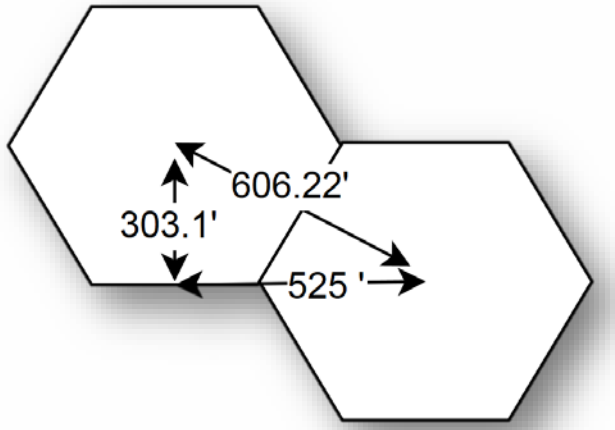
Path Optimization Method – *Traveling Salesman Problem*

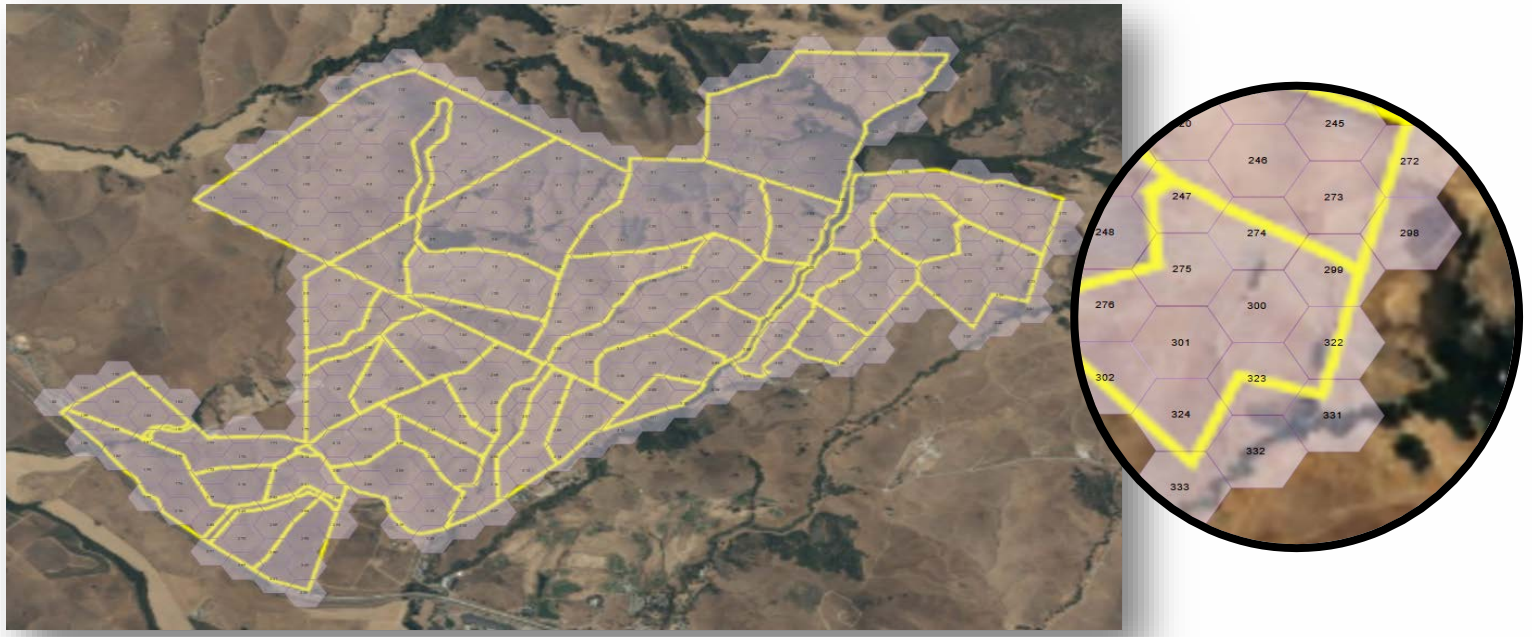
1. Identify Nodes
2. Heuristic Approach to Minimize Number of Nodes
3. Traditional TSP Solution

Tiling

- Hexagonal Lattice
- Heuristic approach to minimize nodes

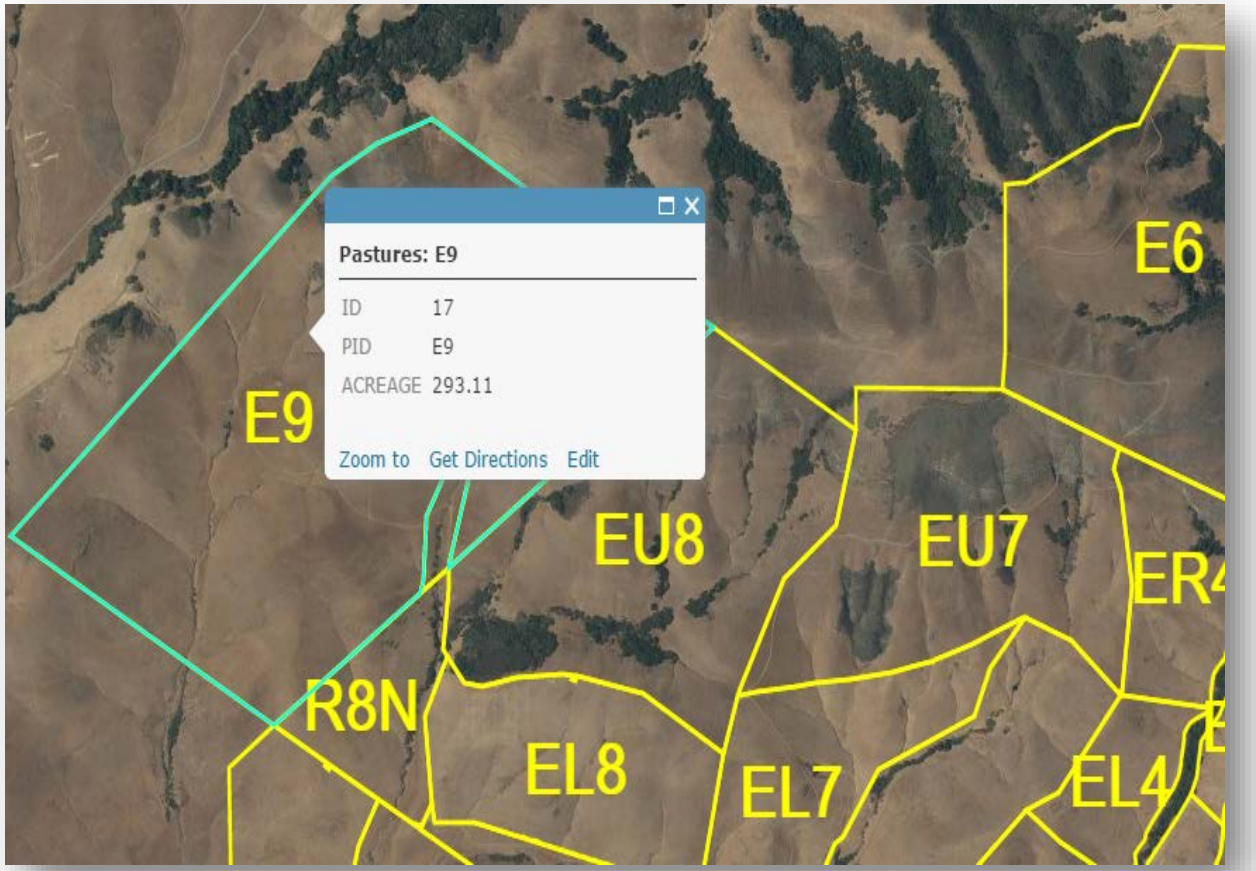






Minimum Number of Nodes Visited

$$293.11 \text{ acres} \times \frac{43{,}560 \text{ft}^2}{1 \text{ acre}} \times \frac{\text{area scanned per node}}{384{,}845 \text{ft}^2} \approx 33 \textit{ nodes}$$



Traveling Salesman Problem

Objective Function

$Minimize \sum c_{ij}x_{ij}$

- $subject\ to$
  - $\sum_i x_{ij} = 1\ \forall_i$
  - $\sum_j x_{ji} = 1\ \forall_j$
  - $0 \leq x_{ij} \leq 1\ x_{ij}$ (integer)
  - $u_i \_ u_j + nx_{ij} \leq n-1, \forall i,j \in N - \{1\}, i \neq j$

Variables

$$x_{ij} = \begin{cases} 1\ if\ arc\ ij\ is\ in\ the\ tour \\ 0\ otherwise \end{cases}$$

u: sequence in which node i is visited
n: number of nodes in tour
N: total number of nodes
c: arc length

Pasture E9

Path Length

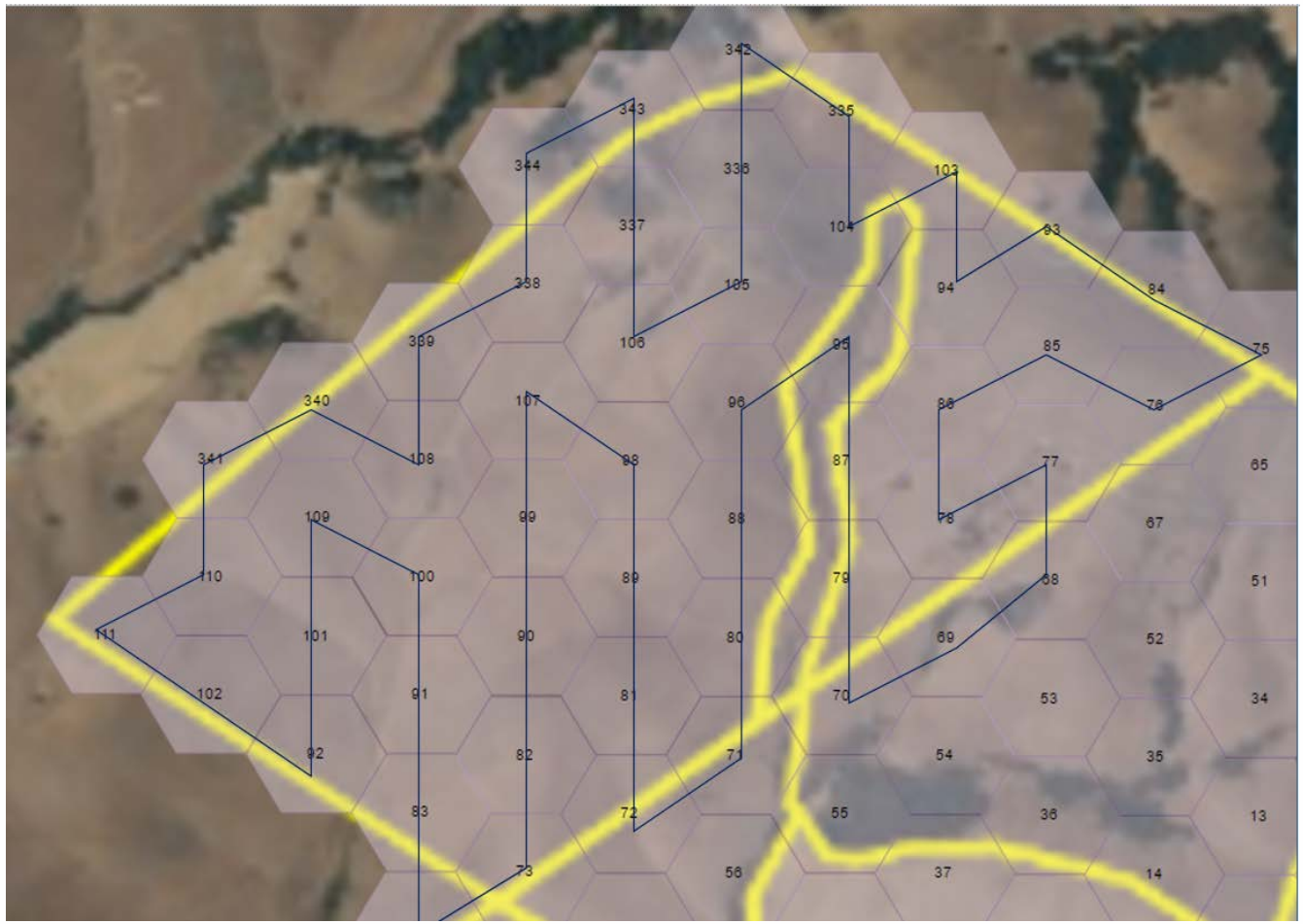
32,129.5ft

Flight Time

32,129.5ft x (52.5ft/s x 60s/min)

+ Ascent /Descent Time

= **10.21 minutes**



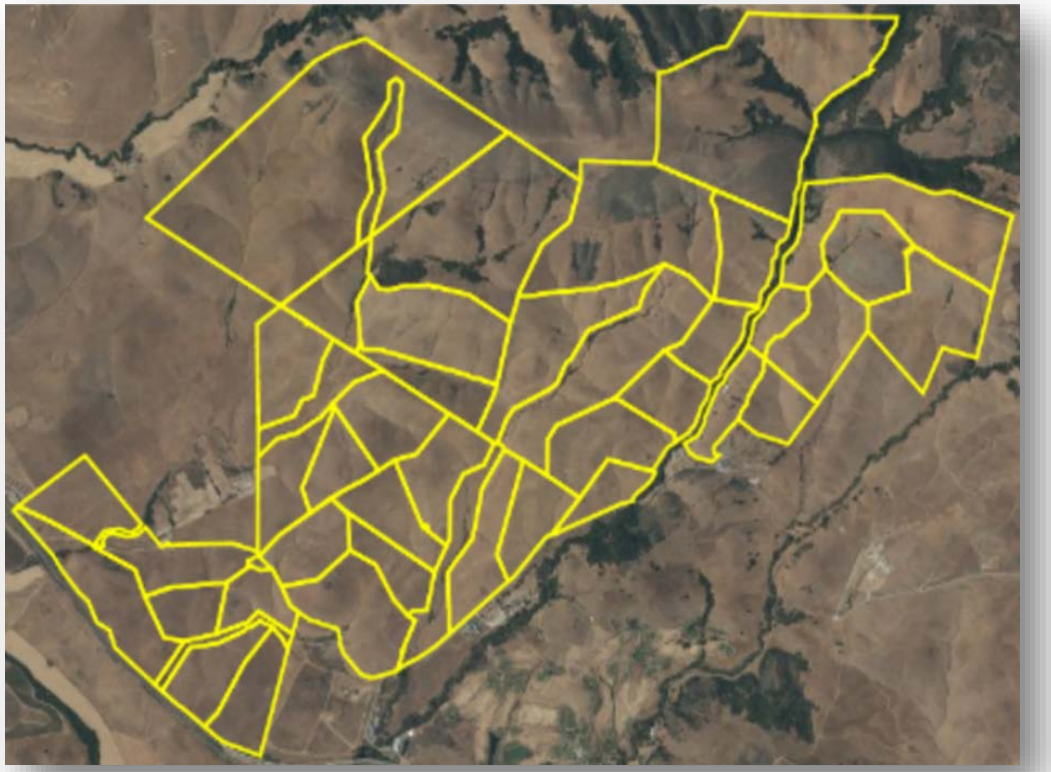
Walters & Escuela Ranches

Minimum Number of Nodes Visited

$$2562 \text{ acres} \times \frac{43{,}560\text{ft}^2}{1 \text{ acre}} \times \frac{\text{area scanned per node}}{384{,}845\text{ft}^2} \approx \mathbf{290}\ \boldsymbol{nodes}$$

Time to Travel to all Nodes

$$290 \text{ nodes} \times 700\text{ft between nodes} \div \frac{52.5\text{ft}}{s} = \mathbf{64.47}\ \boldsymbol{min}$$

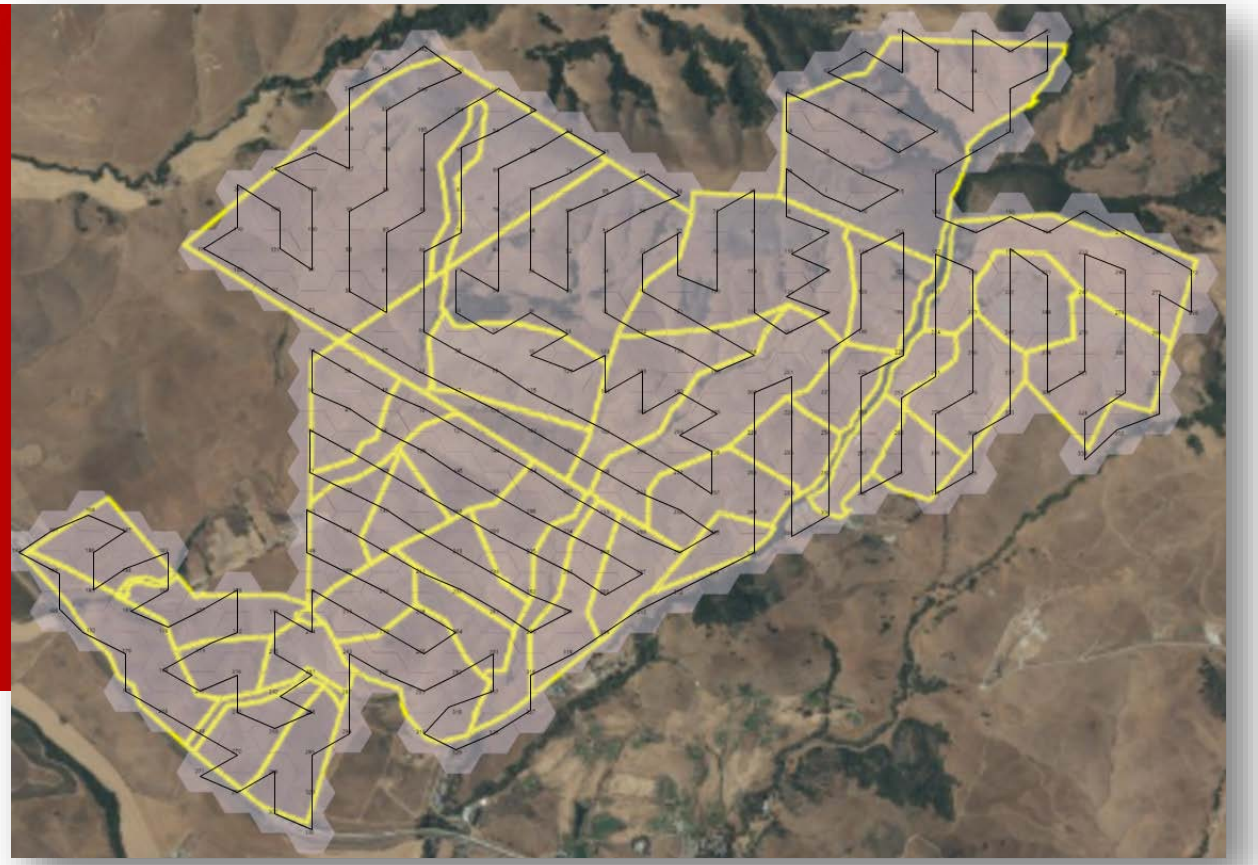


Traditional Grazing

205,508ft

65 min total flight time

5 Flights



Future @ PolyGAIT

- R&D Goals
  - Leading edge technological innovation and process development, additional industries
  - Hands-on educational methods producing top performing, collaborative, industry leaders
- Collaboration
  - Global & Inclusive
  - Cross-Disciplinary
  - Cross-Profit (Non-Profit w/For Profit)

Thank you!!!

THANK YOU

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