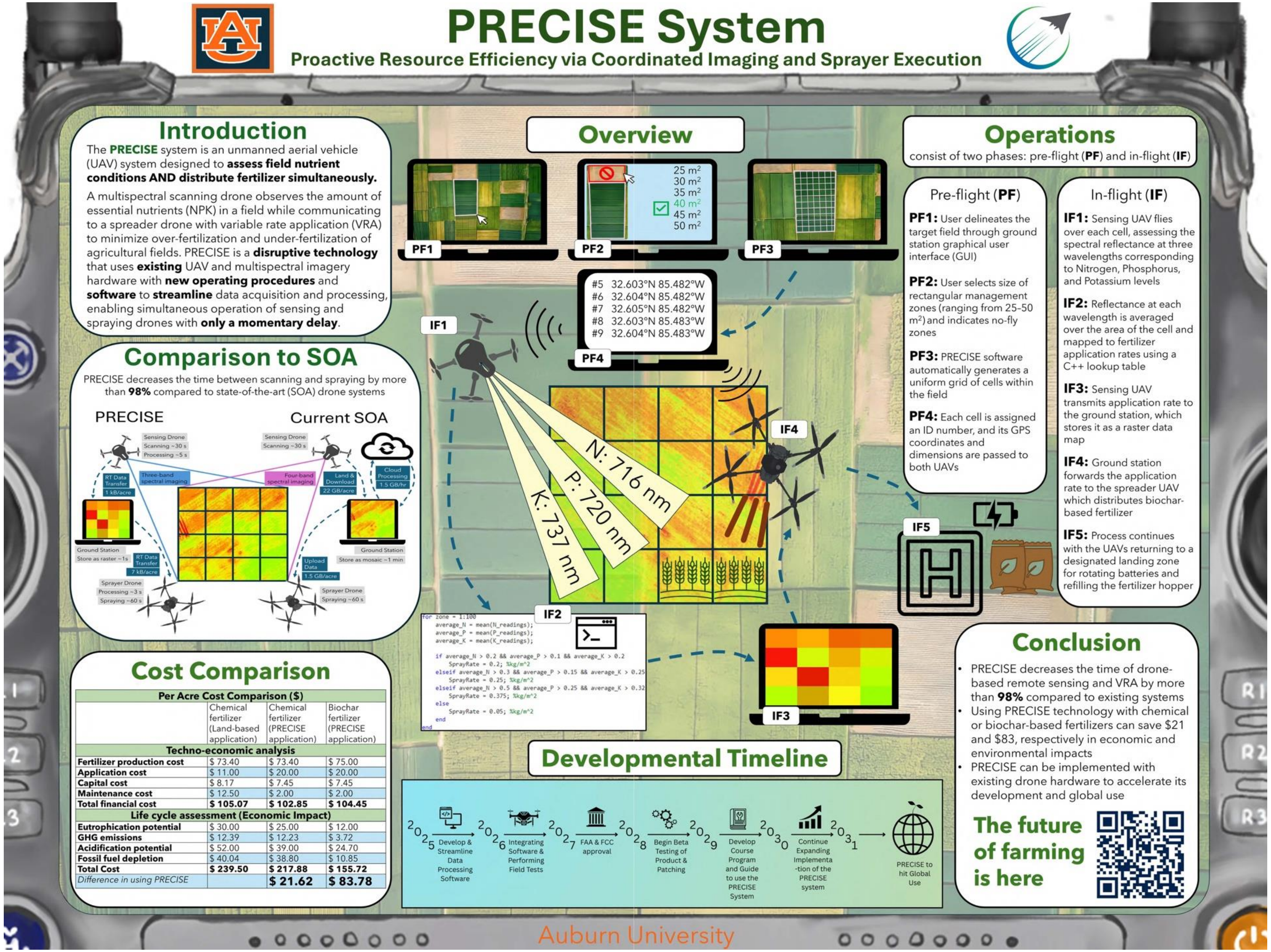
GATEWAYS TO BLUESKIES

Auburn University

“Proactive Resource Efficiency via Coordinated Imaging and Sprayer Execution (PRECISE System)”



The Auburn University Presentation will begin at 8:50 AM Pacific Time.
View the 2025 Finalists’ Infographics: https://blueskies.nianet.org/finalists/

AUBURN ENGINEERING

GATEWAYS TO BLUESKIES

PRECISE SYSTEM

Proactive Resource Efficiency via Coordinated Imaging and Sprayer Execution

Department of Biosystems Engineering

Auburn University

Faculty Advisors: Tanzeel Rehman, Jeremy M. Pickens

Meet our team

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Biosystems Engineering

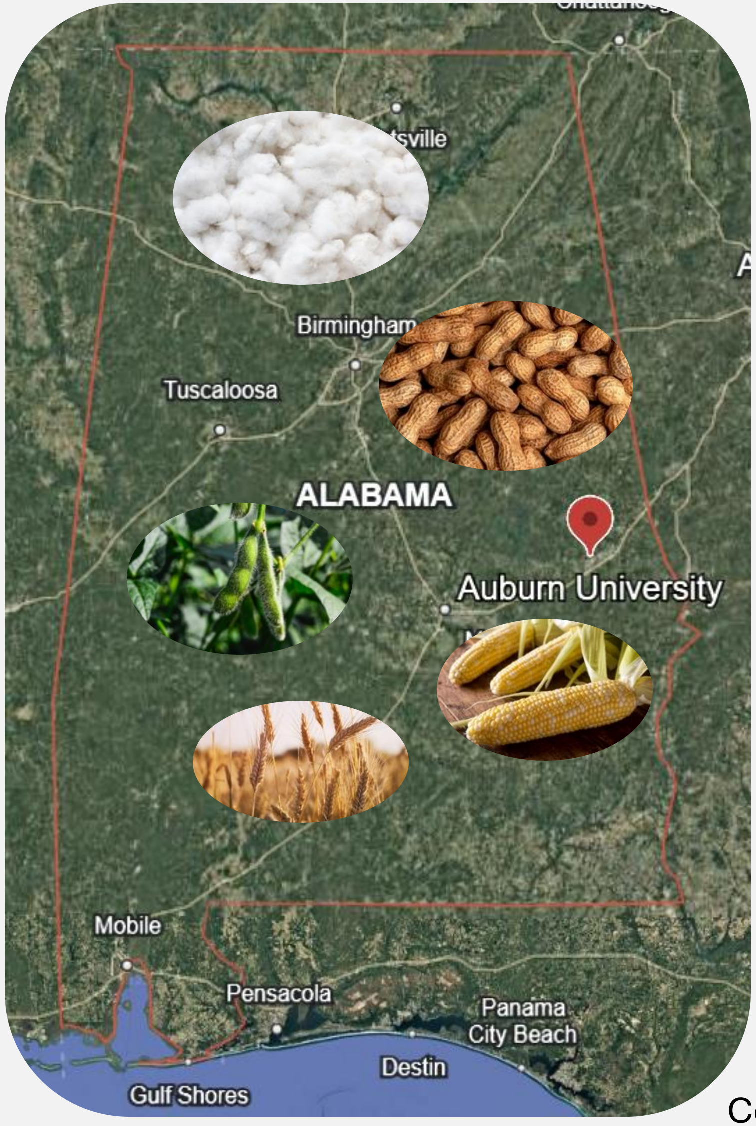
Advisor: Dr. Tanzeel Rehman
Biosystems Engineering

Advisor: Dr. Jeremy M. Pickens
Horticulture

Outline

- Introduction & Background
- Problem statement
- Proposed solution
- Interoperability with existing systems
- Pathway to implementation
- Business case
- Benefits: farmers and the environment

Agriculture in AL:



Courtesy: Google Earth

15%
50%

State's GDP
Jobs

Courtesy: Google Earth

FERTILIZERS

Current fertilizer consumption in United States is 20.5 million metric tons [1]

To maintain high crop productivity, we need lots of fertilizer

WATERVERSE

NIH

Regulation of eutrophication susceptibility in

Two Alabama rivers named among 10 most endangered in the country

Published: Apr. 21, 2022, 11:49 a.m.

Nutrient Pollution on the Coosa River

Nonpoint Source Pollution

Alabama US Agriculture Eutrophication

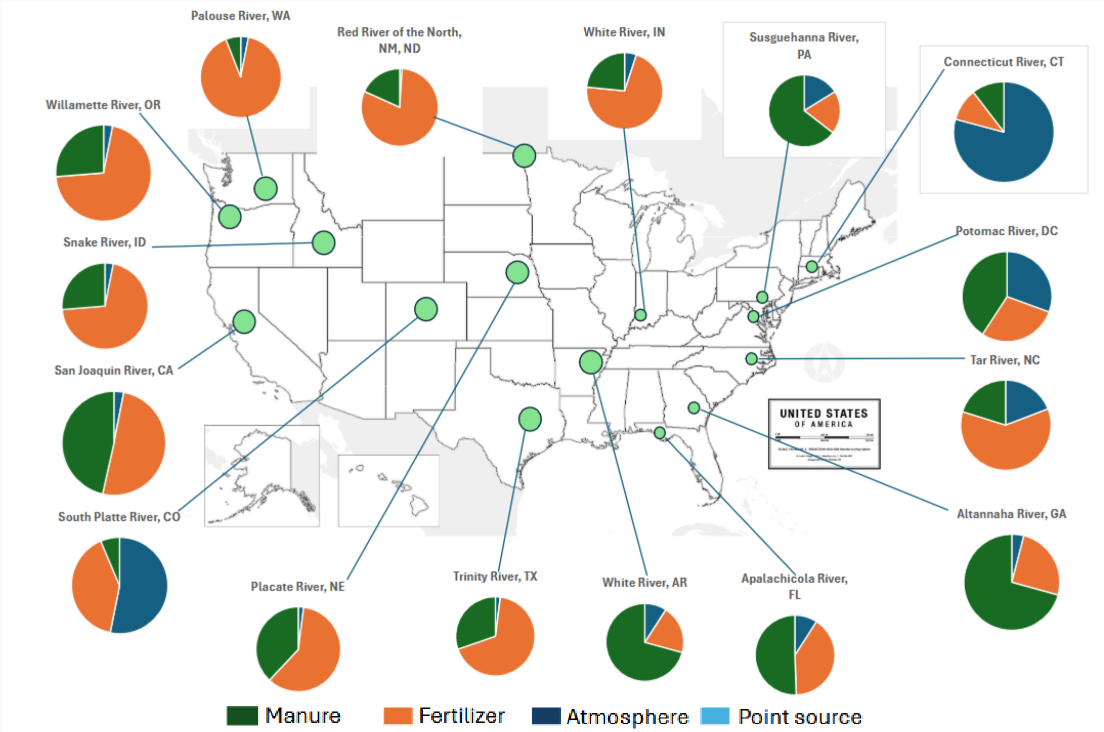
NEWS

Latest EPA assessment shows almost no improvement in river and stream nitrogen pollution

Published: Jan. 21, 2024, 9:02 a.m.

Environmental concern

Courtesy: americanoceans.org



Nutrient pollution sources [2]

Why does it matter?

50% of available freshwater is impacted by nutrient pollution

With 40% elevated phosphorus level and 30% elevated nitrogen level [3][4]

Poor water quality

Fish kills

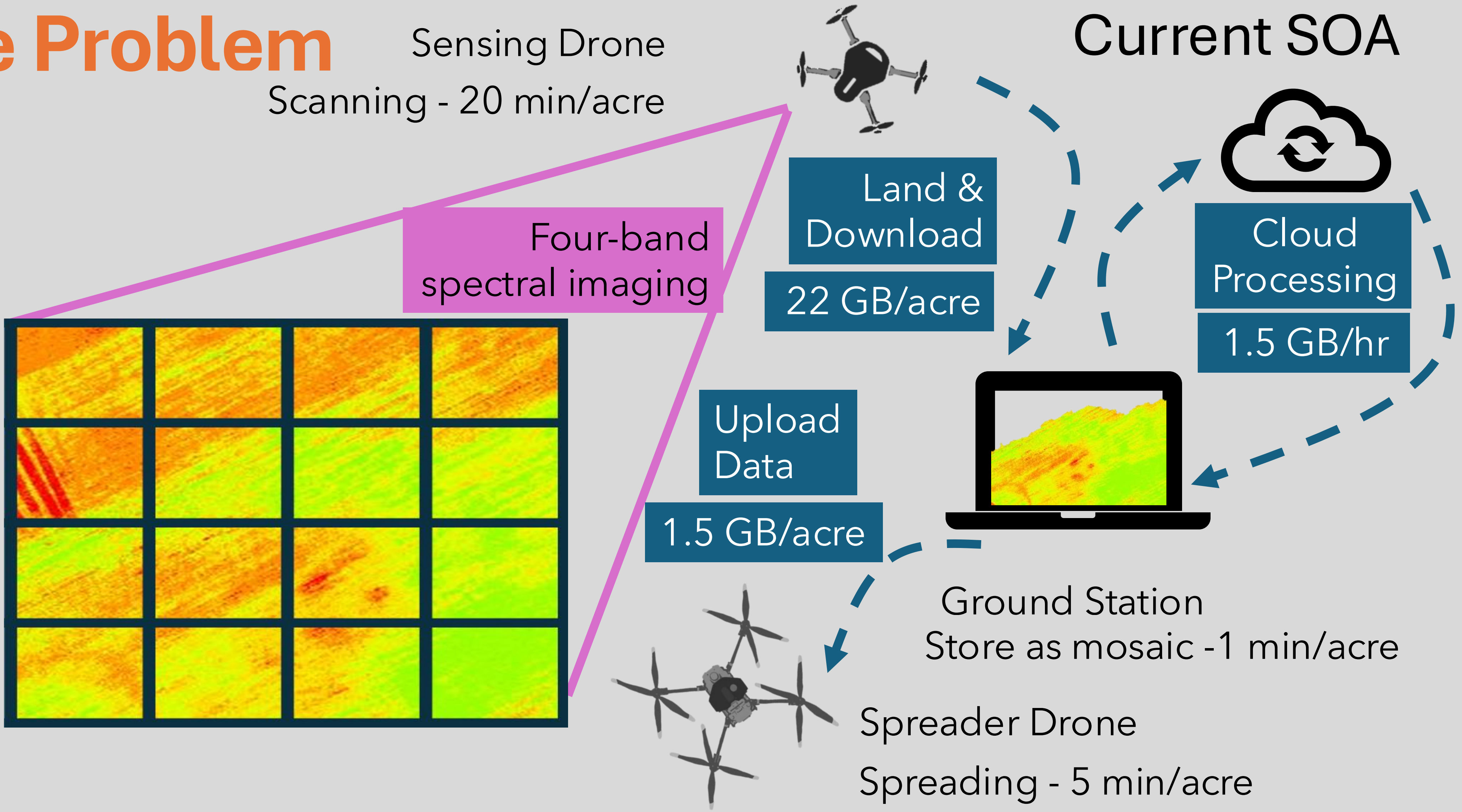
Economic losses

Health issues

Poor recreational activities on the river

The Problem

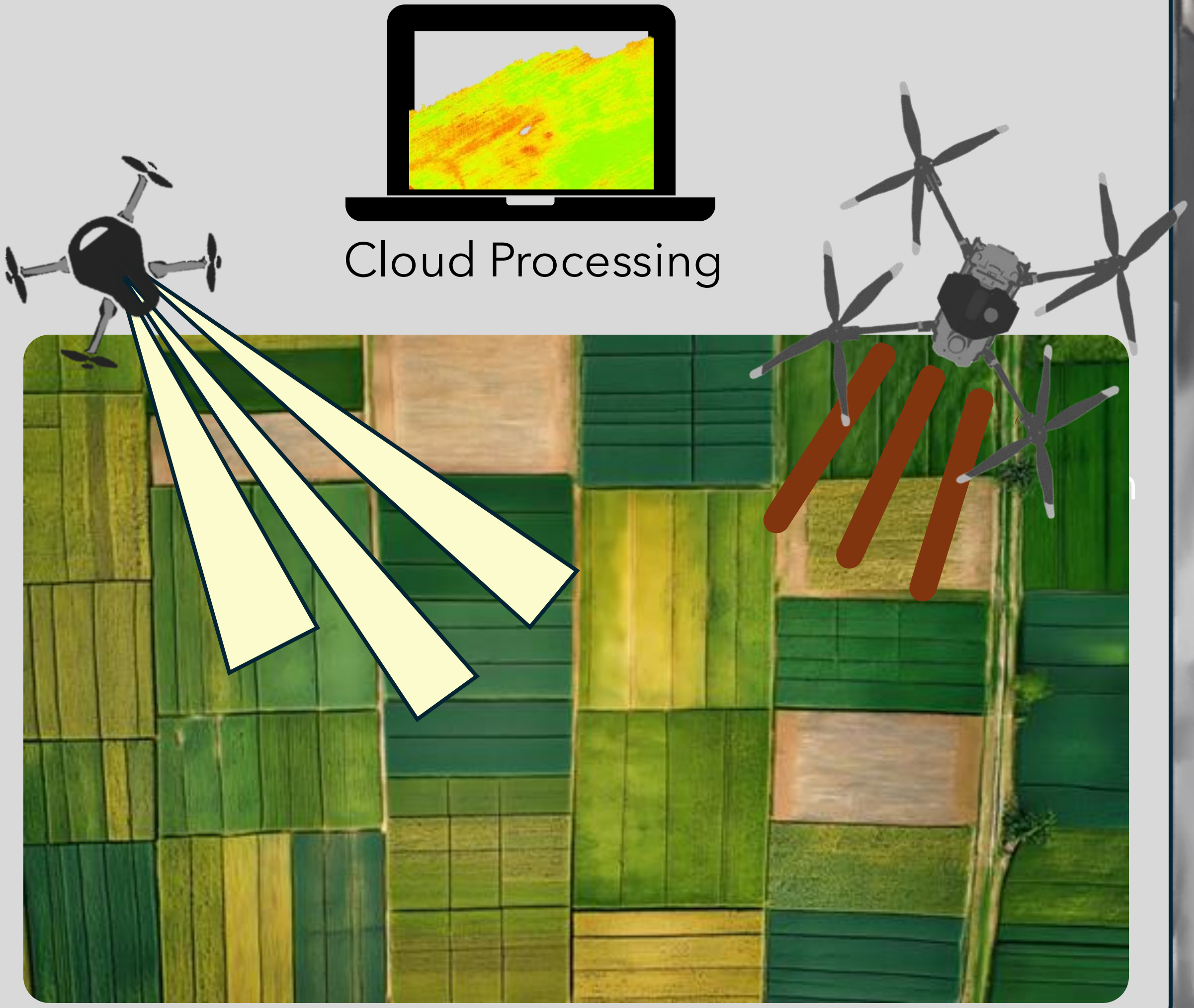
Current SOA



Time analysis of SOA

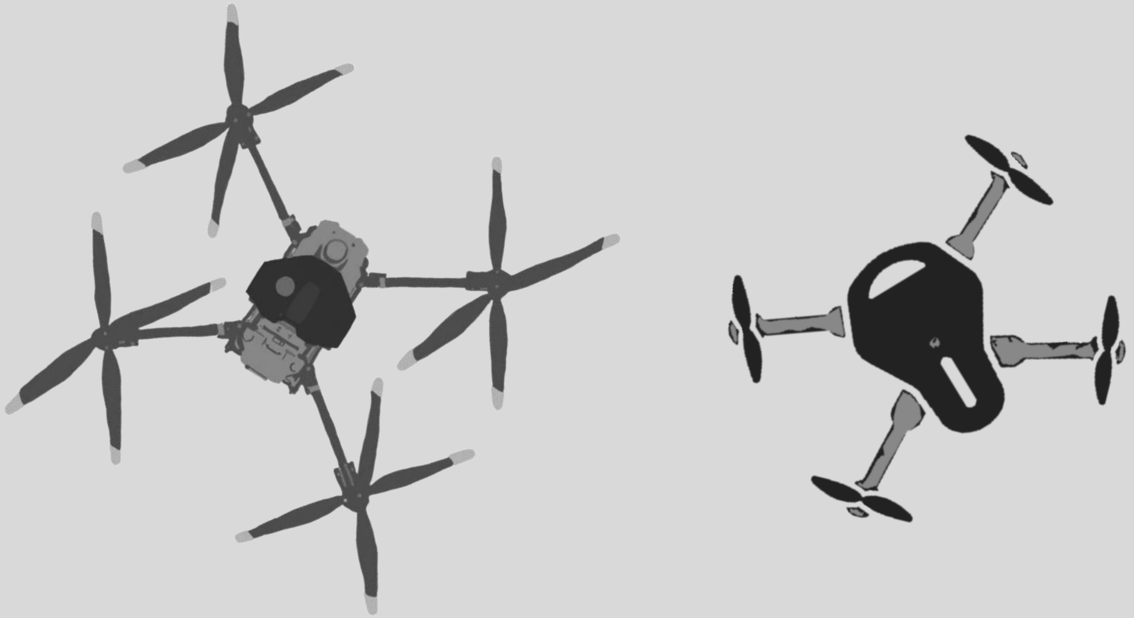
- With an average farm size being 464 acres, time required is upwards of ~7500 hours, which is not feasible.

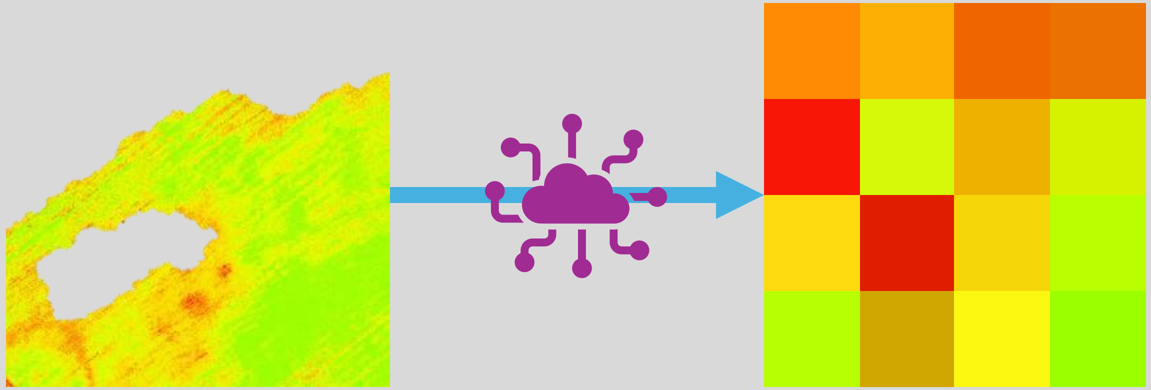
Step	Time per task (per Acre)
Field scan	~20 min
Data extraction	~10 min
Cloud Processing	~15 hours
Variable Rate Generation	~15 min
Upload Data	~5 min
Spreading Time	~5 min
Cumulative time	**~16 hours**



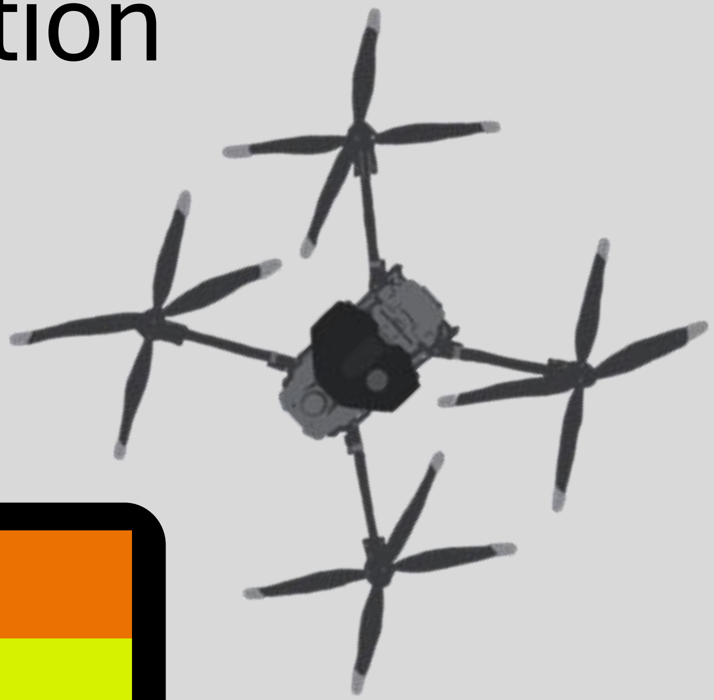
A PRECISE Solution

Proactive
Resource
Efficiency via
Coordinated
Imaging and
Sprayer
Execution





A PRECISE Solution



Operations consist of two phases:

1. **Pre-flight (PF)**
2. **In-flight (IF)**

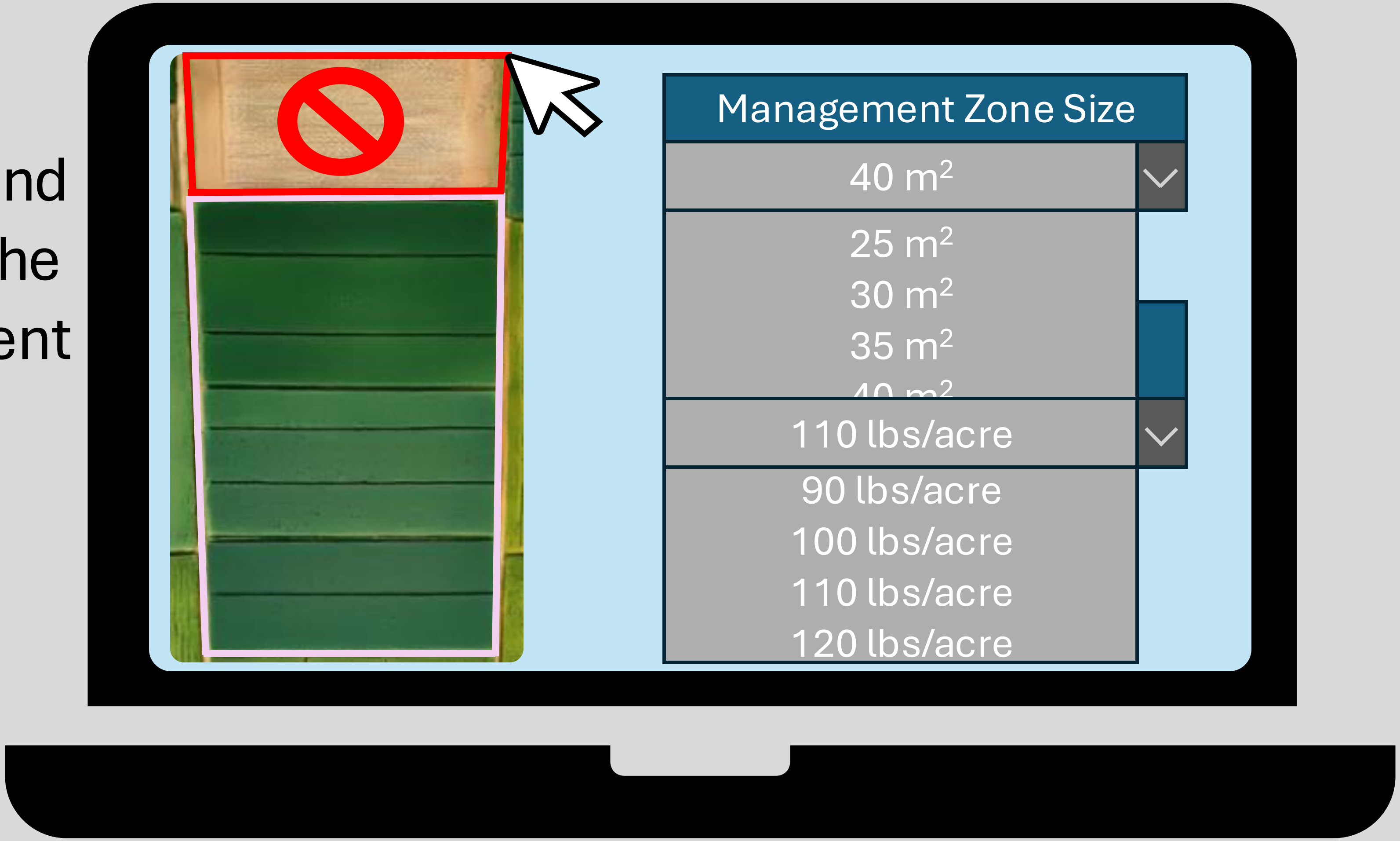
PF1 – Target Delineation

Select target region(s) via the ground station graphical user interface

1 minute

PF2 – Parameter Selection

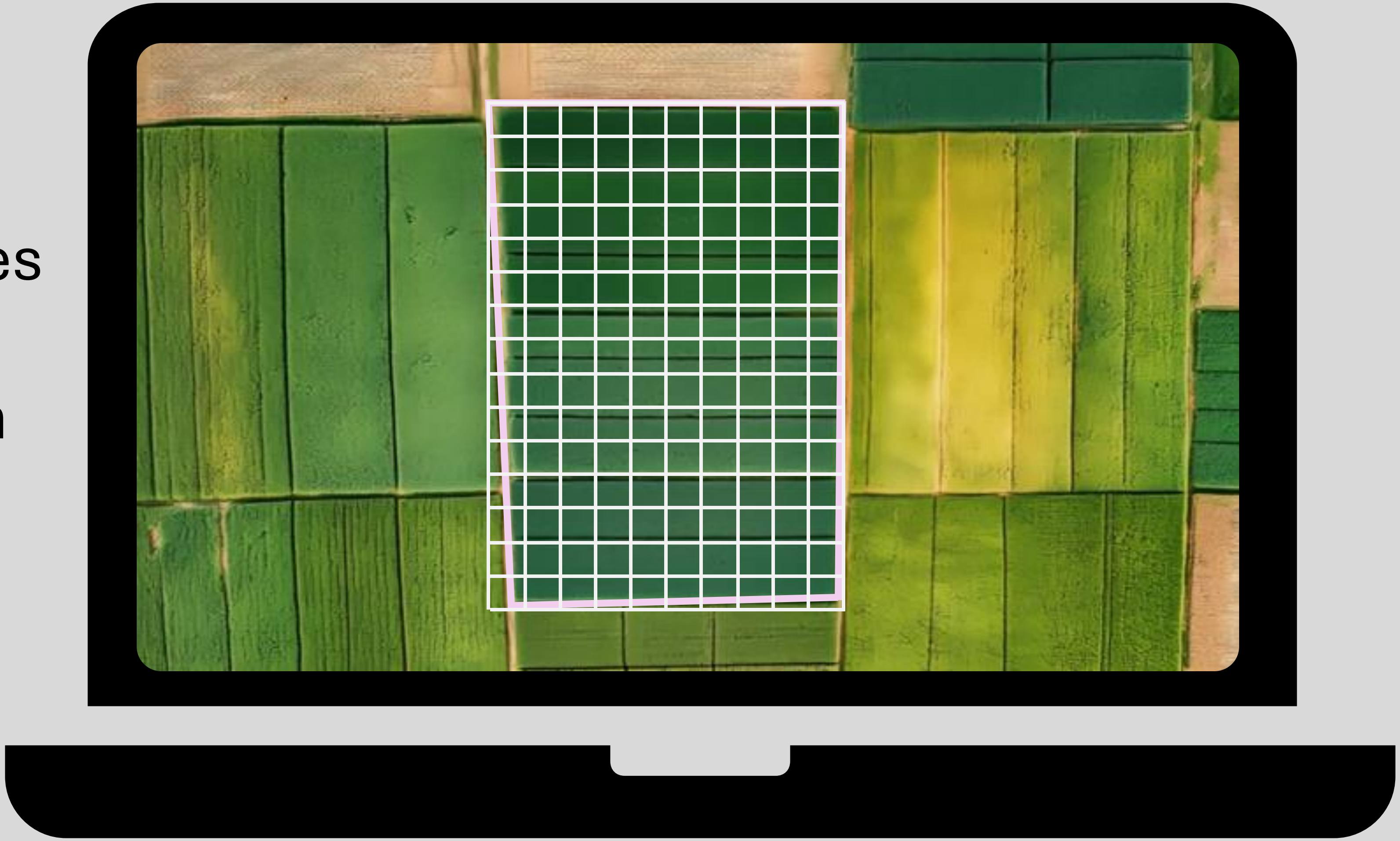
Indicate no-fly zones and select desired size of the rectangular management zones and fertilizer application rates



2 minutes

PF3 – Automatic Grid Generation

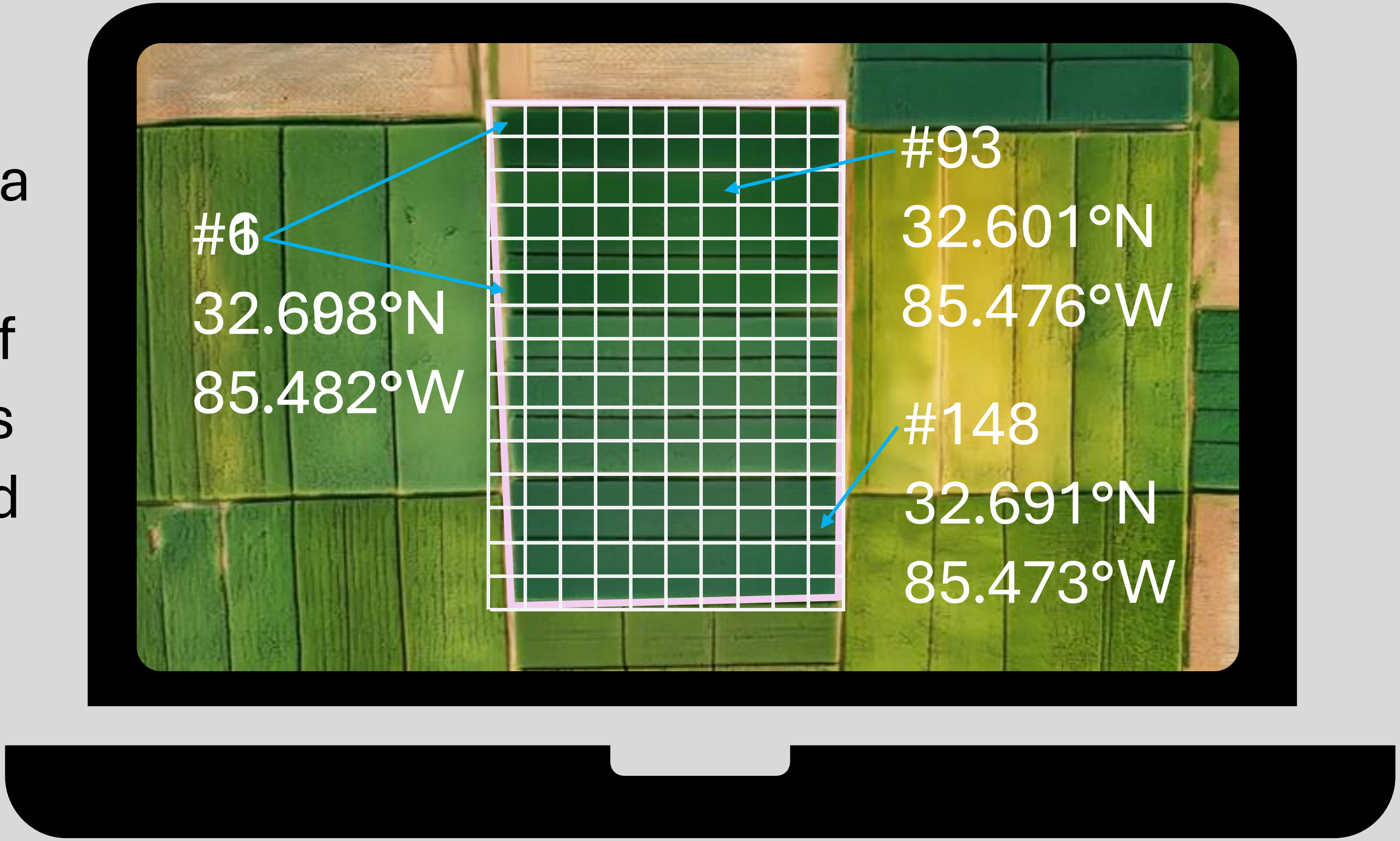
PRECISE software automatically generates a uniform grid of cells within the target region



1 minute
per acre

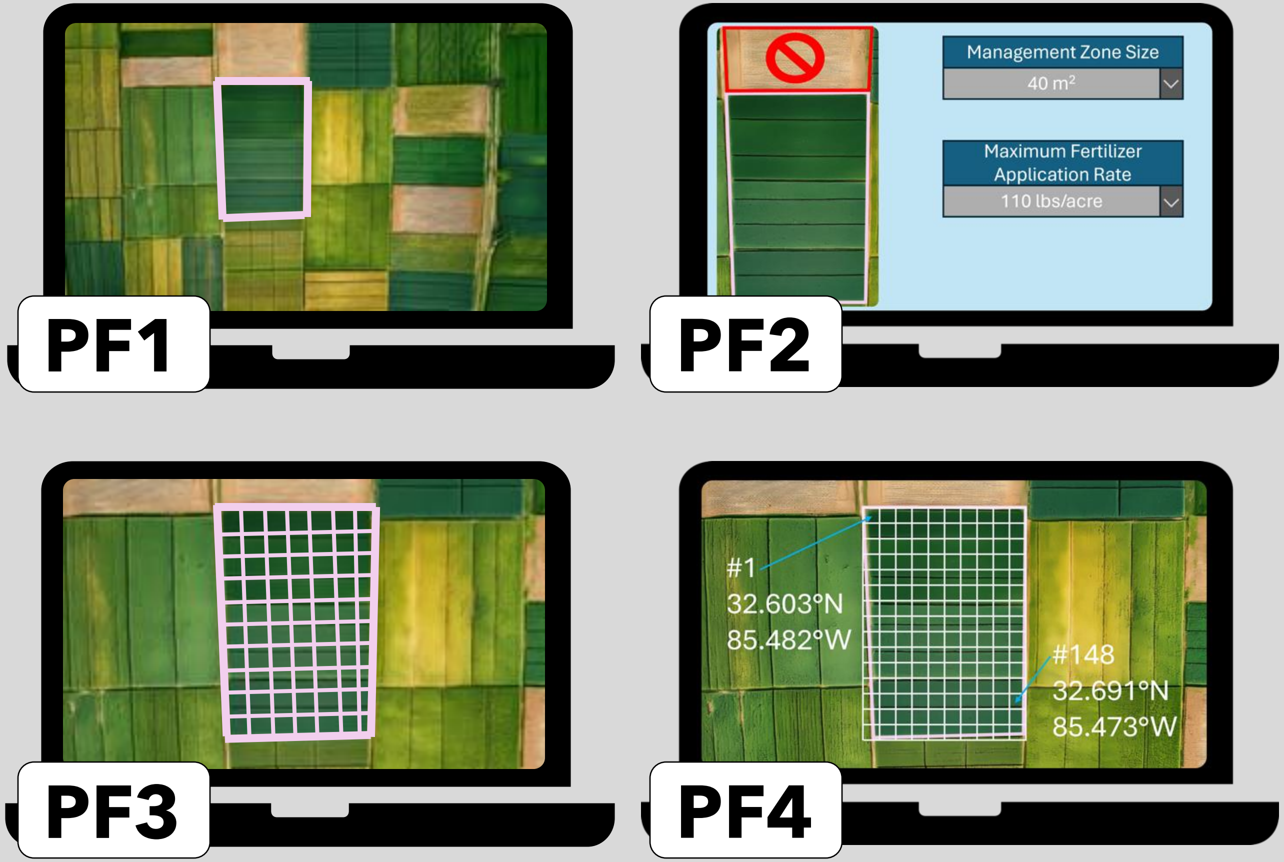
PF4 – Data Transfer to UAVs

Each zone is assigned a unique ID number, and the GPS coordinates of its center along with its dimensions are passed to both UAVs

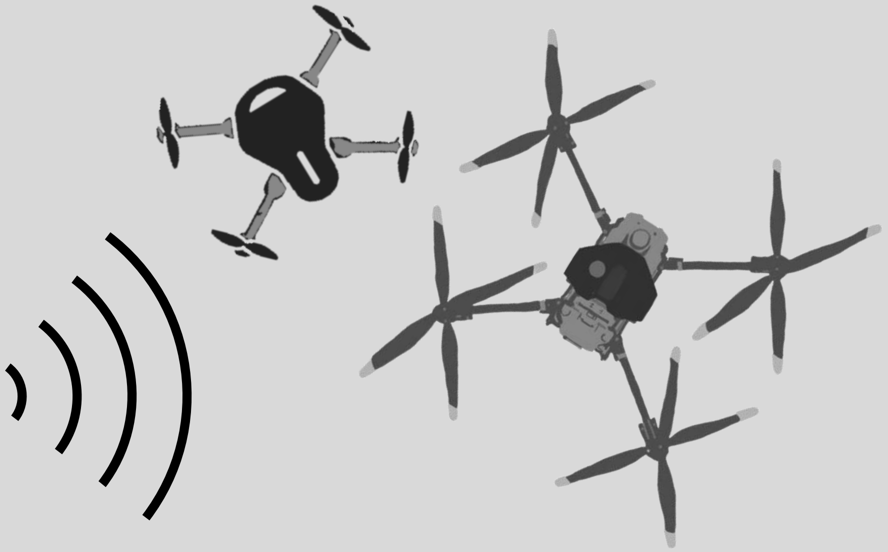


1 minute per acre

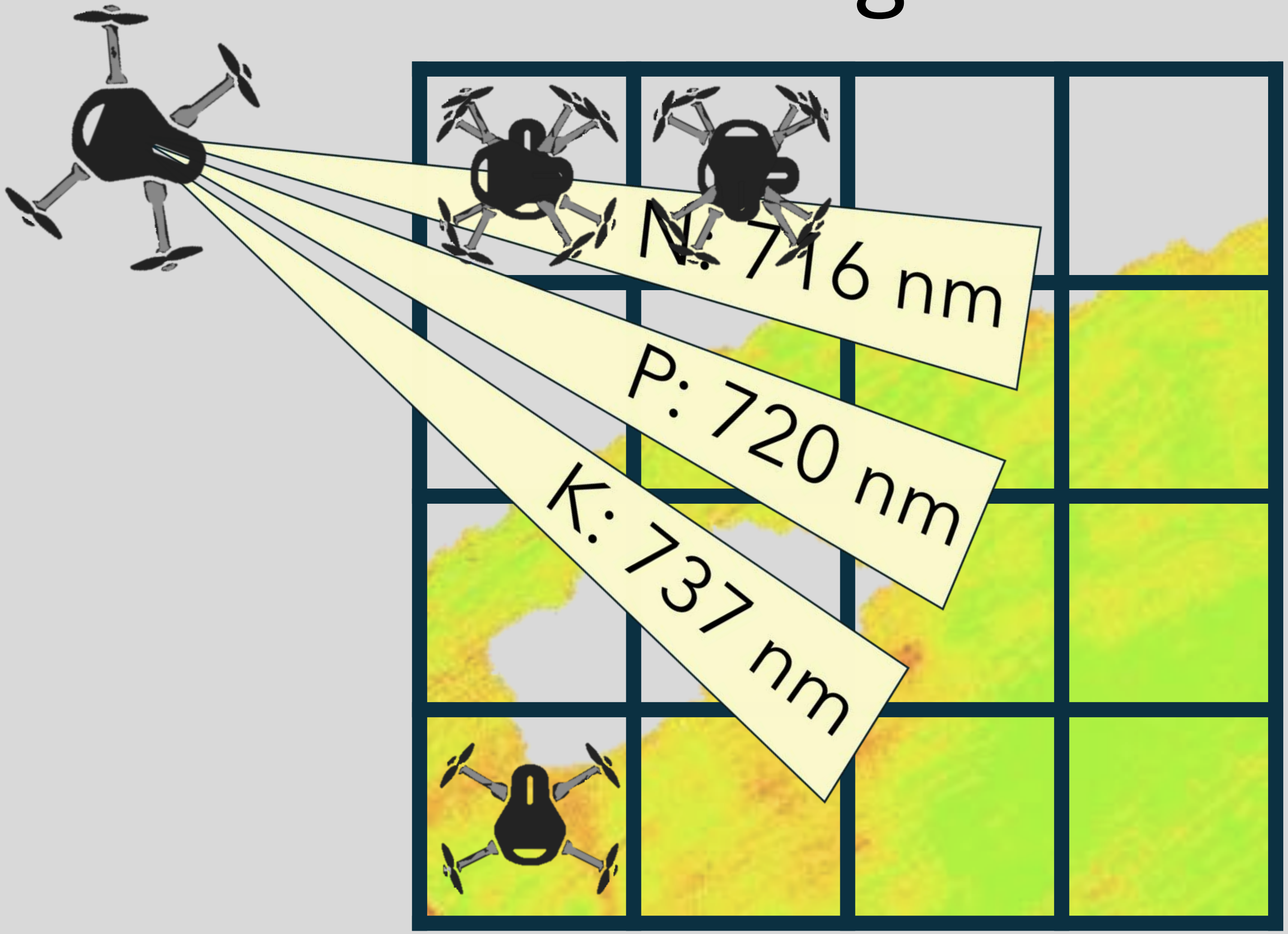
Pre-Flight Operations



Step	Time per task (per Acre)
Target Delineation	~1 min
Parameter Selection	~2 min
Grid Generation	~1 min
Data Transfer to UAVs	~1 min
Cumulative PF time	**~5 min**



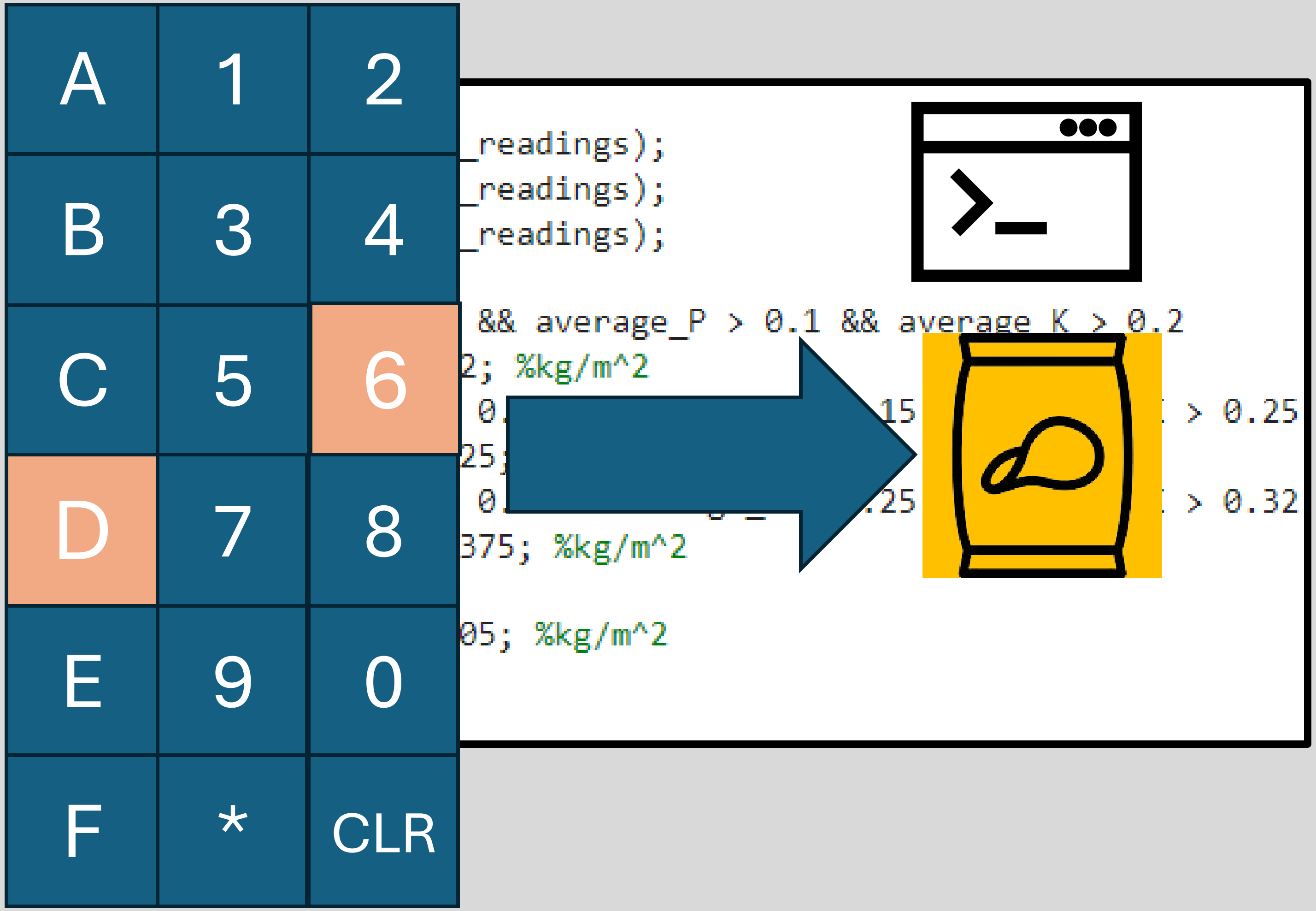
IF1 – Remote Sensing



The sensing UAV flies over each management zone in succession and, using a 3-band spectral camera, assesses the nutrient levels in the field

10 minutes per acre

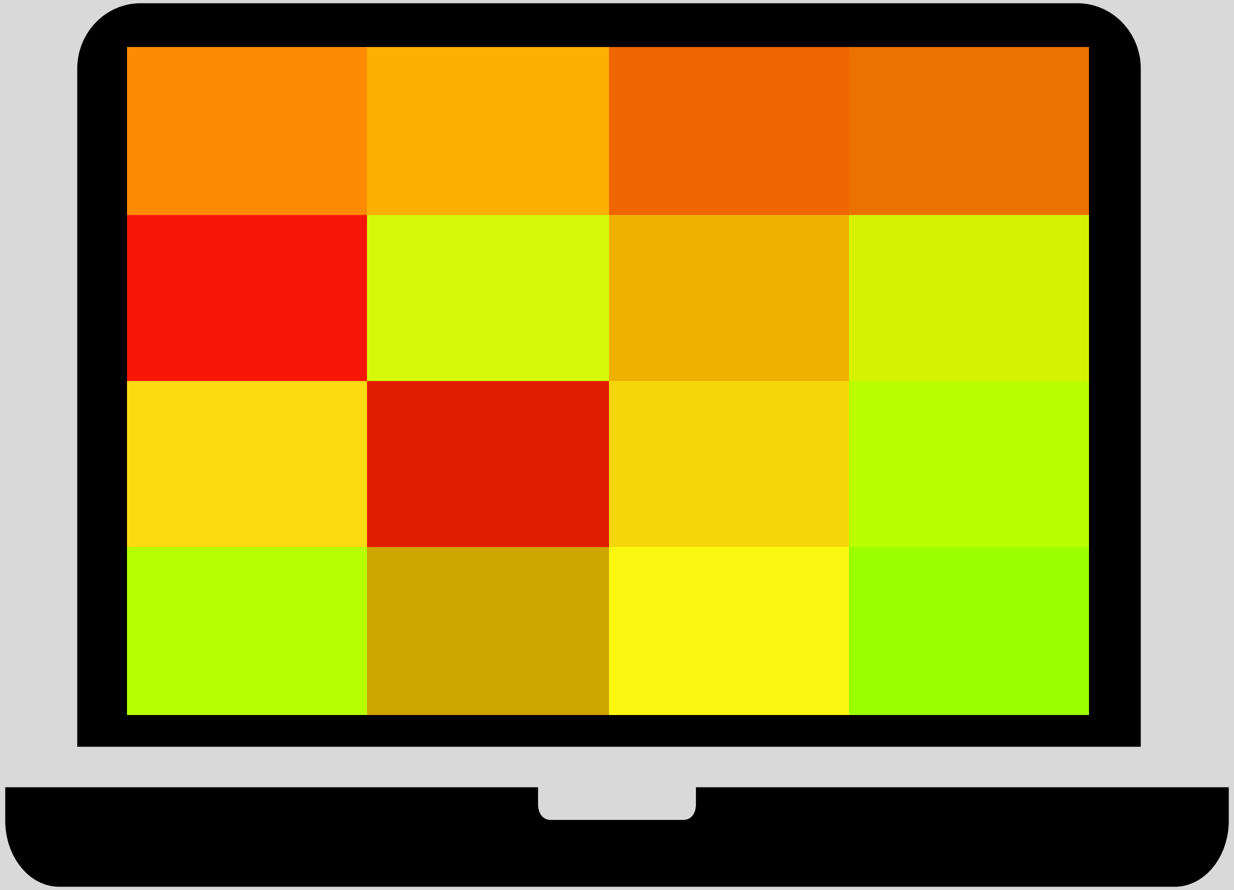
IF2 – Onboard Data Processing



The spectral reflectance at each wavelength is area-averaged and converted into fertilizer application rates using a C++ lookup table

30 seconds per acre

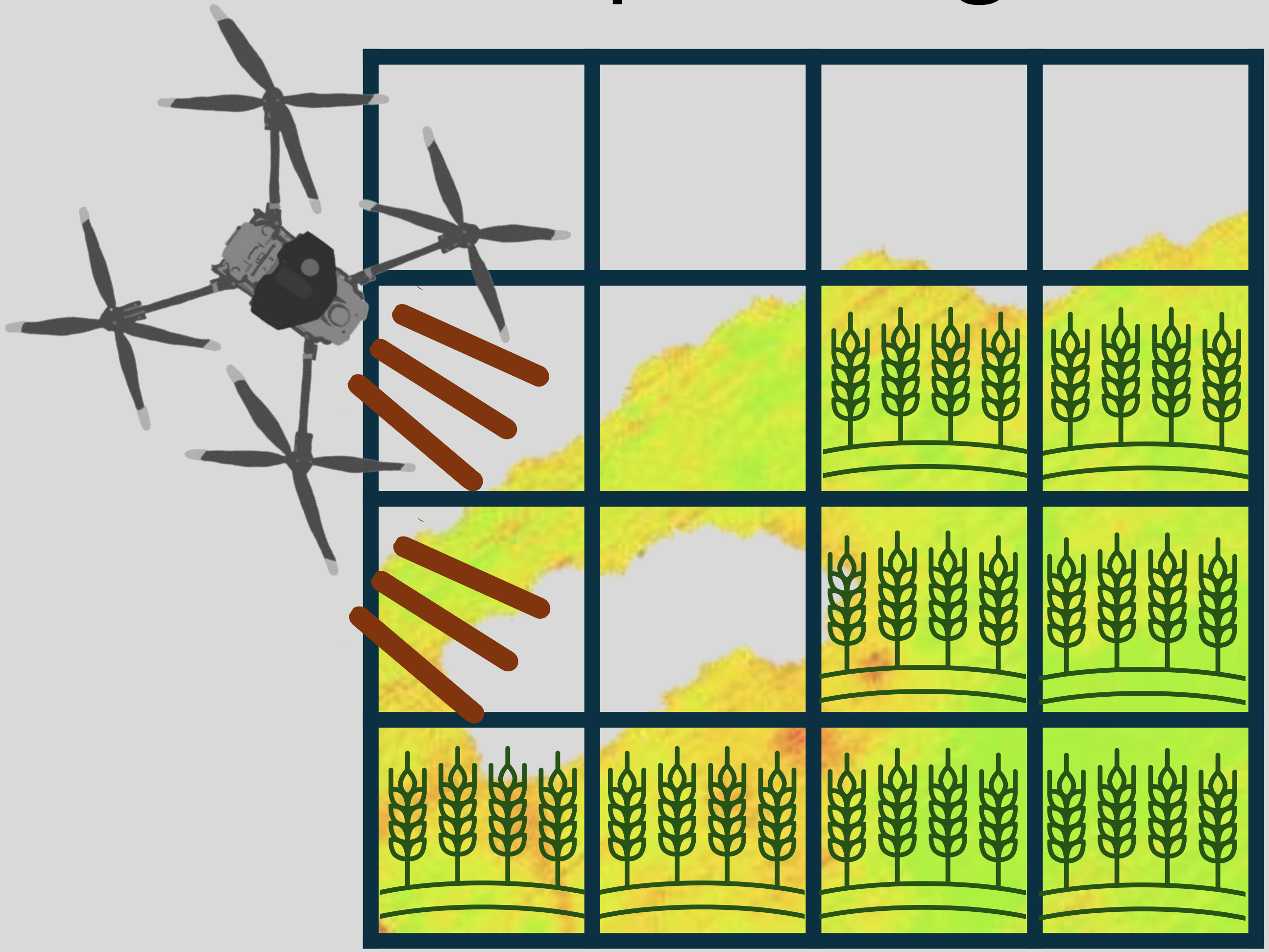
IF3 – Raster Data Map Generation



The target fertilizer application rates are forwarded from the sensing UAV to the ground station, which stores it as a raster data map

30 seconds per acre

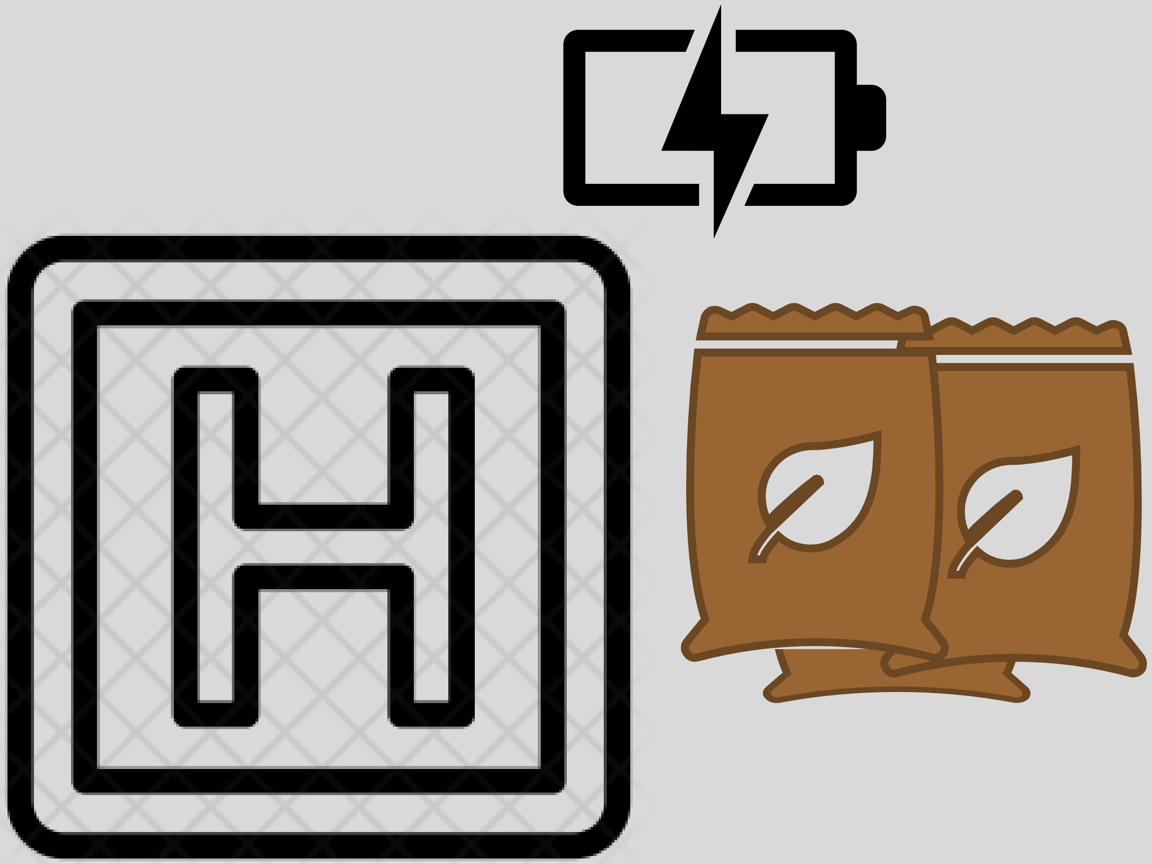
IF4 – Fertilizer Spreading



The ground station forwards the fertilizer application rates to the spreader UAV, which then distributes the proper amount of fertilizer to each zone

5 minutes per acre

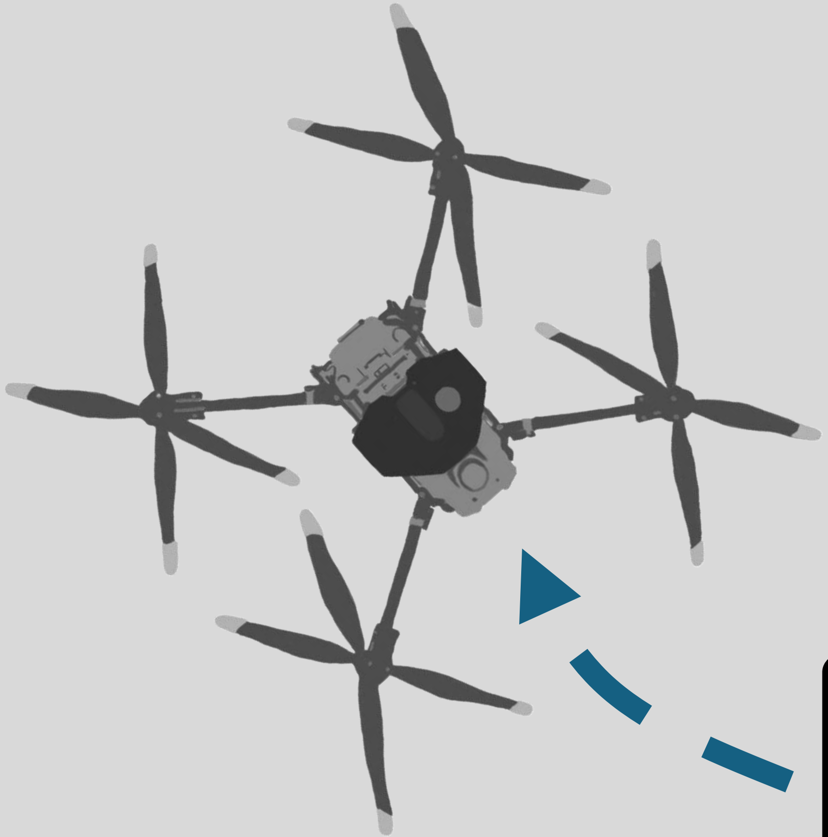
IF5 – Battery Exchange and Hopper Refilling



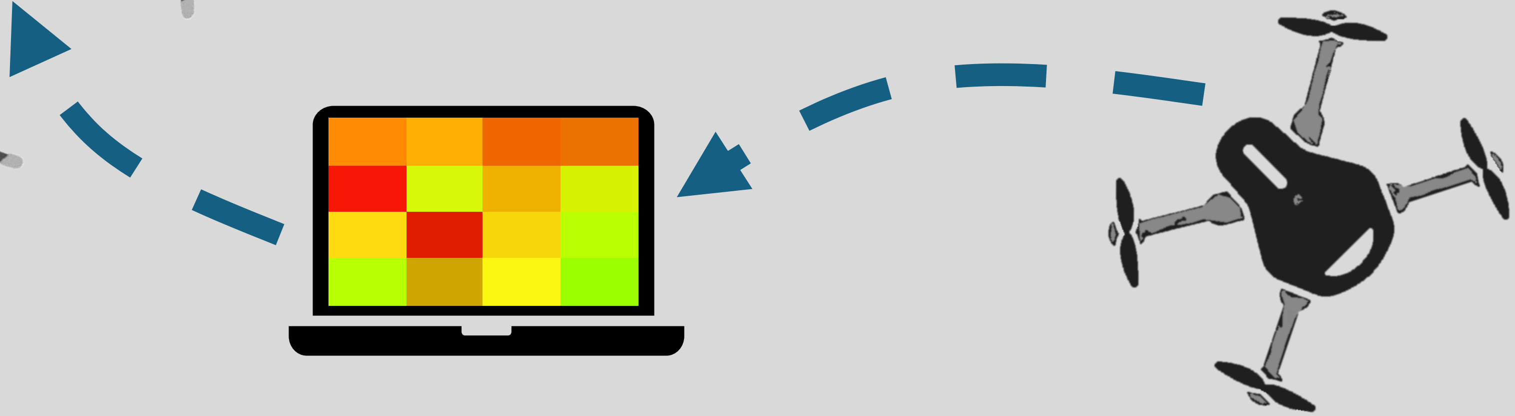
The ground station forwards the fertilizer application rates to the spreader UAV, which then distributes the proper amount of fertilizer to each zone

2 minutes per acre

In-Flight Operations



Step	Time per task (per Acre)
Remote Sensing	~10 min
Onboard Data Processing	~30 sec
Raster Map Generation	~30 sec
Fertilizer Spreading	~5 min
Battery Exchange	~2 min
Cumulative IF time	**~18 min**



PRECISE vs. SOA

Step	Time per task (per Acre)
Field scan	~20 min
Data extraction	~10 min
Cloud Processing	~15 hours
Variable Rate Generation	~15 min
Upload Data	~5 min
Spreading Time	~10 min
Cumulative time	**~16 hours**

Step	Time per task (per Acre)
Target Delineation	~1 min
Parameter Selection	~2 min
Grid Generation	~1 min
Data Transfer to UAVs	~1 min
Cumulative PF time	~5 min
Remote Sensing	~10 min
Onboard Data Processing	~30 sec
Raster Map Generation	~30 sec
Fertilizer Spreading	~5 min
Battery Exchange	~2 min
Cumulative IF time	~18 min
Total cumulative time	~23 min

PRECISE and Tractors

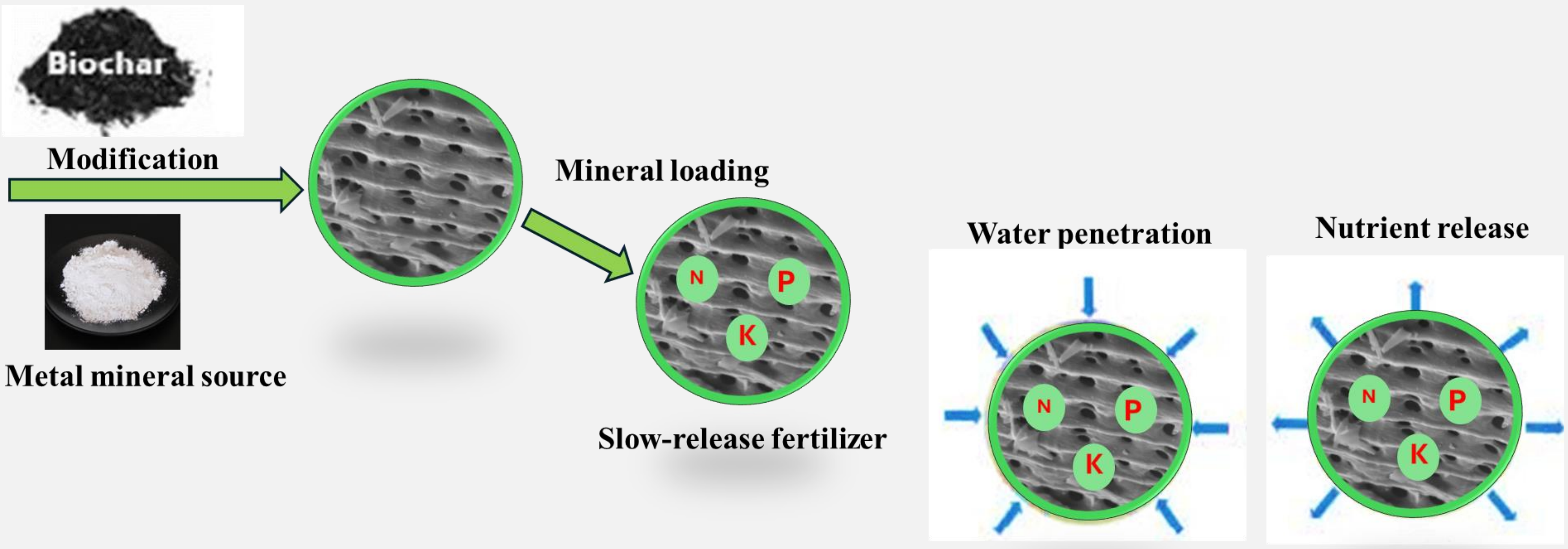
$

~90,000

$$$$

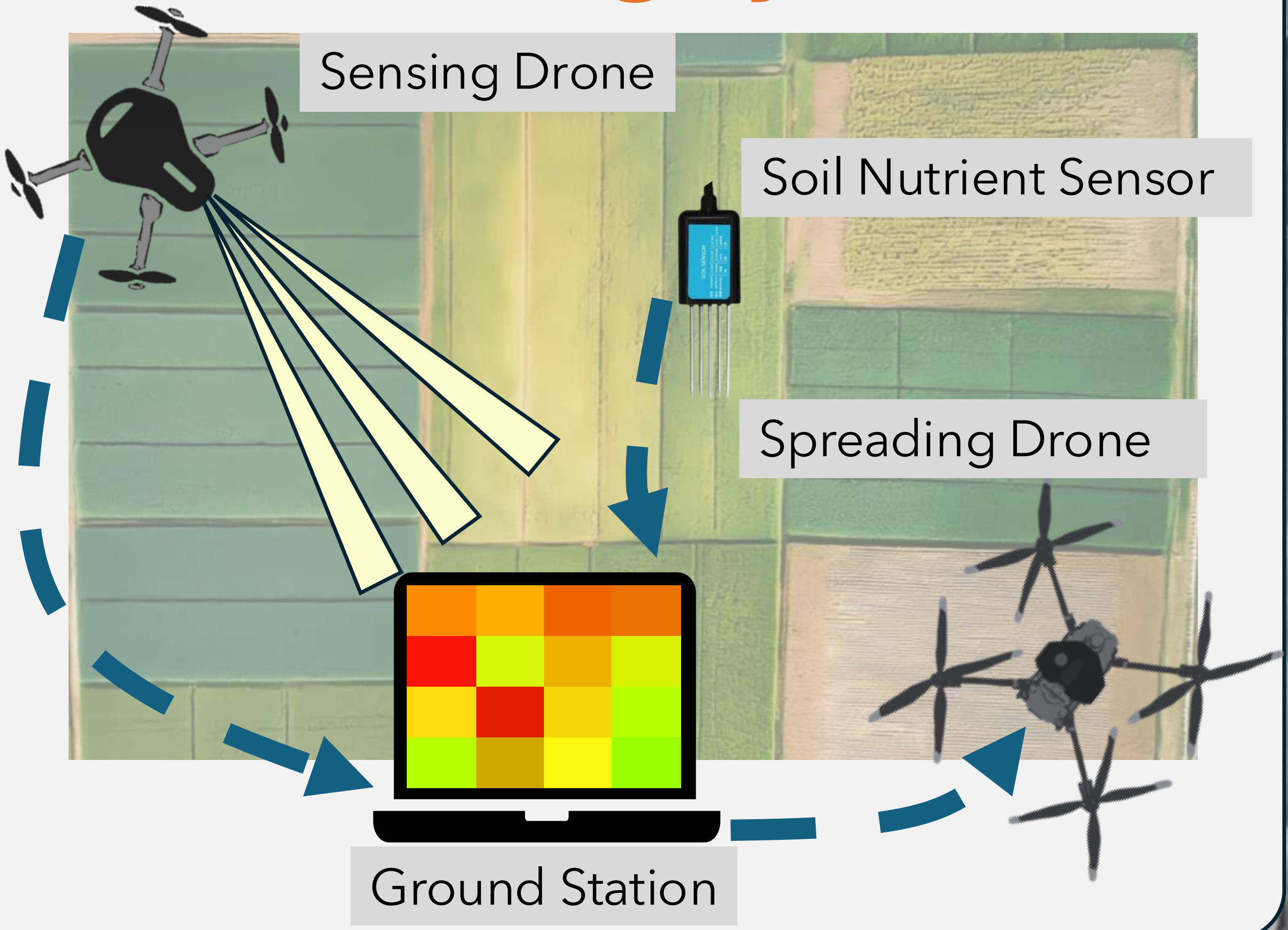
~$400,000

Solution: Biochar-based fertilizer



Interoperability With Existing Systems

- **Local Data Storage**
- **Flexible Hardware Integration**
- **Adaptable Application**
- **Enhanced Accessibility**



Pathway to PRECISE

2025
- Develop streamlined data processing software
- Open communication with drone manufacturing companies for collaboration

2026
- Integrate PRECISE software with existing drone hardware
- Initial field tests and software debugging

2027
- Complete software integration, field testing, and system validation
- Begin soliciting FAA & FCC for permit approval

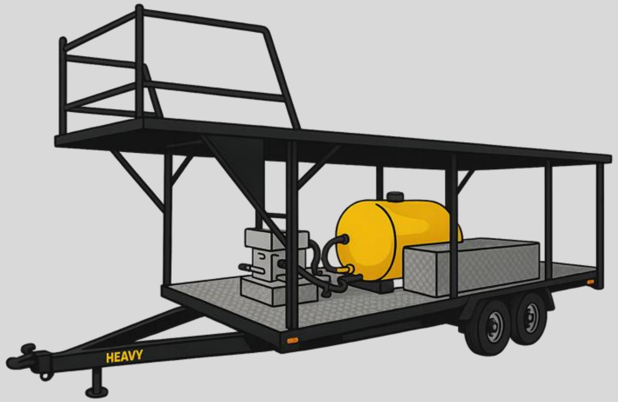
2028
- Finalize governmental regulatory approval
- Begin pushing system out to beta testers and patch software as needed

2029
- Develop training courses, user support network, and field assistance programs
- Begin full-scale rollout of PRECISE system in the US

2030
- Begin foreign government permit approval process
- Continue expanding implementation of PRECISE system

2031
- Begin rollout of PRECISE system globally
- Translate training courses and user support programs into foreign languages

Price for PRECISE

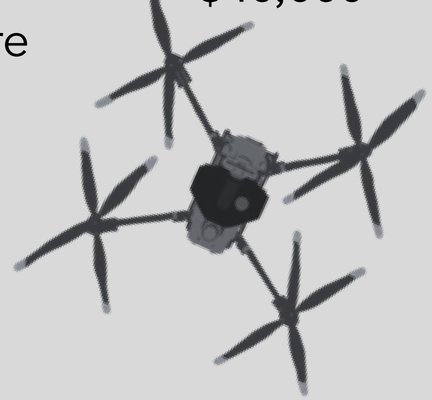


Ground Station Trailer
~$38,000

Imagery UAV
~$10,000

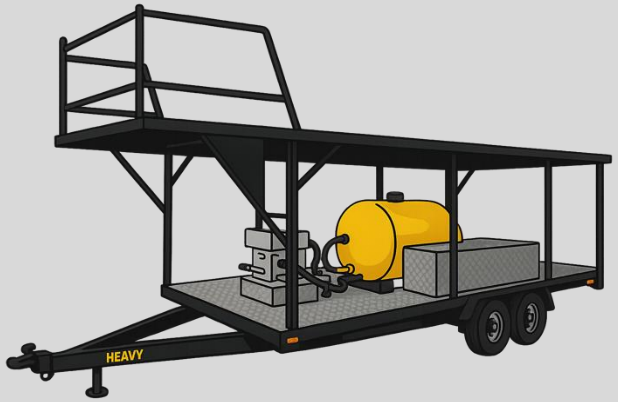
Ground Station Hardware
~$2,000

Spreader UAV
~$40,000



The Total Cost of hardware, up to $90,000

Price for pre-existing set up



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~$38,000

Imagery UAV
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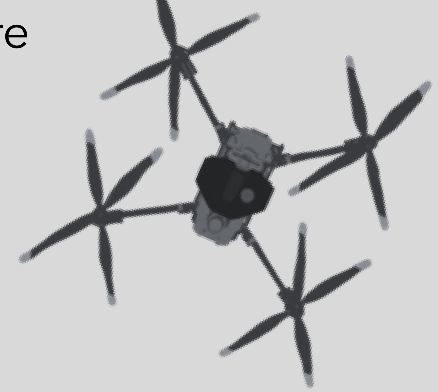
Ground Station Hardware
~$2,000

Spreader UAV
~$40,000



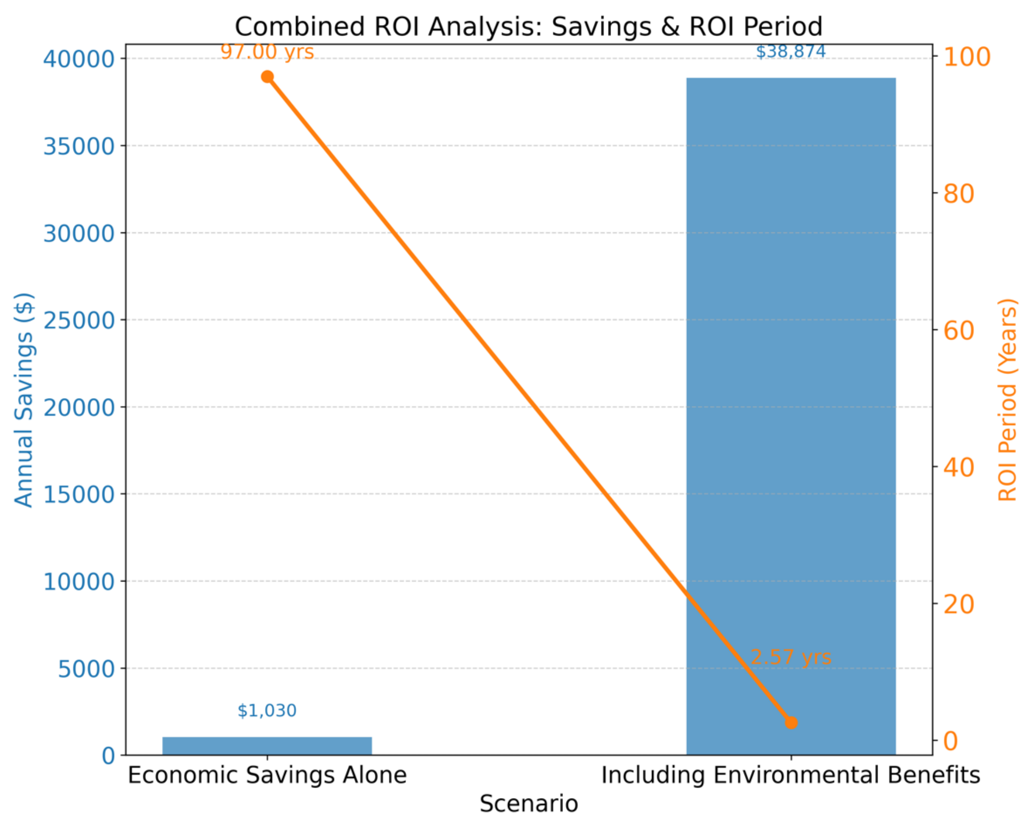
The Total Cost of hardware, less than $10,000 for an imagery drone with the onboard processor.

Business case

Per Acre Cost Comparison ($)			
	Chemical fertilizer (Land-based application)	Chemical fertilizer (PRECISE application)	Biochar-based fertilizer (PRECISE application)
Techno-economic analysis			
Fertilizer production cost	$ 73.40	$ 73.40	$ 75.00
Application cost	$ 11.00	$ 20.00	$ 20.00
Capital cost	$ 8.17	$ 7.45	$ 7.45
Maintenance cost	$ 12.50	$ 2.00	$ 2.00
Total financial cost	$ 105.07	$ 102.85	$ 104.45
Economic Impact			
Eutrophication potential	$ 30.00	$ 25.00	$ 12.00
GHG emissions	$ 12.39	$ 12.23	$ 3.72
Acidification potential	$ 52.00	$ 39.00	$ 24.70
Fossil fuel depletion	$ 40.04	$ 38.80	$ 10.85
Total Cost	$ 239.50	$ 217.88	$ 155.72
Difference in using PRECISE		**$ 21.62**	**$ 83.78**

Return on investment (ROI)

Savings using PRECISE (Biochar-based fertilizer application) is $83.78 per acre



Incorporating environmental impacts drastically shortens ROI to under 3 years.

Our Goal:

The Ideal:

Decrease Eutrophication

PRECISION Agriculture

Maintain Current Agricultural Demands

Benefits of Precision Agriculture

Farmers

- Reduce Fertilizer wastage
- Saves time and money
- Better long-term investment

Environment

- Reduces nutrient pollution
- Saves the local ecosystem
- Longevity of your land

PRECISION E

The Agsystem

by

AUBURN UNIVERSITY

References

1. Statistica (2025).Consumption of agricultural fertilizers in the United States from 2010 to 2022, by nutrient. Retrieved from https://www.statista.com/statistics/1330021/fertilizer-consumption-by-nutrient
2. USGS. (1996). *Nutrients in the Nation's Waters: Identifying Problems and Progress A National Water-Quality Assessment of Nutrients*. https://pubs.usgs.gov/fs/fs218-96/index.html#figure1

3. Jessen, Christian. (2013). Effects of Simulated Eutrophication and Overfishing on Coral Reef Invertebrates, Algae and Microbes in the Red Sea.

4. Manuel J. Nutrient pollution: a persistent threat to waterways. Environ Health Perspect. 2014 Nov;122(11):A304-9. doi: 10.1289/ehp.122-A304. Erratum in: Environ Health Perspect. 2014 Dec;122(12):A323. PMID: 25360879; PMCID: PMC4216153.

Appendix

Life cycle assessment Per Acre Comparison			
	Chemical fertilizer (Land-based application)	Chemical fertilizer (PRECISE application)	Biochar-based fertilizer (PRECISE application)
Eutrophication potential (kg PO_4^{3-}-eq)	3.00	2.50	1.20
GHG emissions (kg CO_2-eq/acre)	3.10	3.06	0.93
Acidification potential (kg SO_2-eq/acre)	4.00	3.00	1.90
Fossil fuel depletion (litres/acre)	10.85	10.51	2.94

GPS

Low-GPS or GPS-denied environments:

Integrate additional localization techniques to maintain stable and accurate UAV operations:

These include visual-inertial odometry (VIO),
LiDAR-based SLAM, and
RTK-GPS fallback systems.

Spreading Accuracy Without GPS:

We can rely on visual landmarks, structured flight paths, and real-time image-based feedback.

The UAV can use multispectral cameras and VIO to localize itself relative to the crop canopy and dynamically adjust its application rate and position.

NASA'S GATEWAYS TO BLUESKIES

2025 AgAir: Aviation Solutions for Agriculture Forum