MLSysOps: Enhancing Targeted Weed Spraying with Drone-Tractor Collaboration
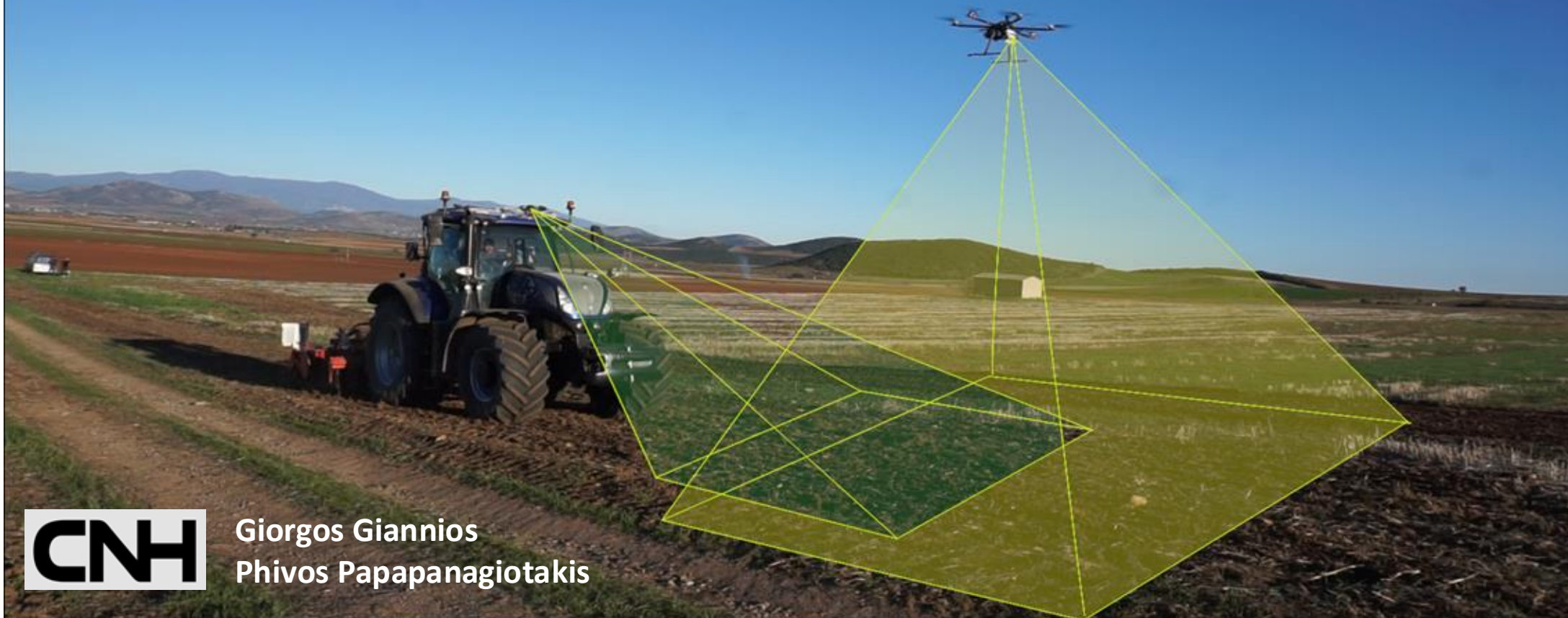
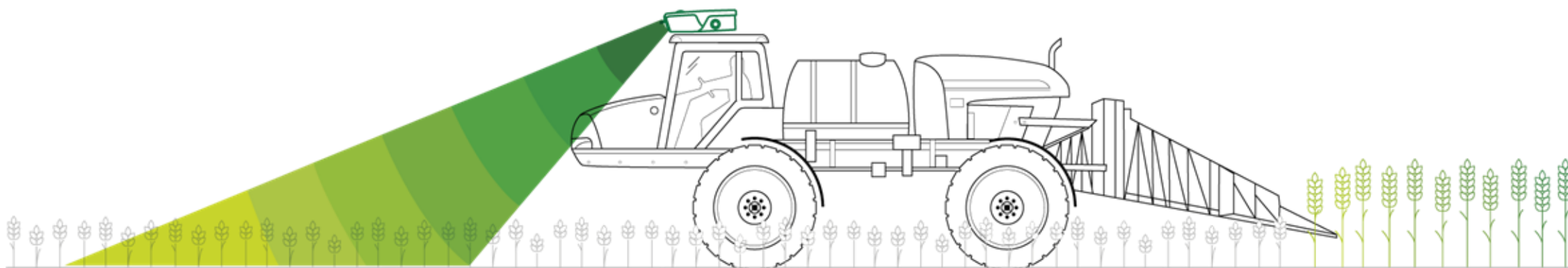**Giorgos Giannios**
Phivos Papapanagiotakis

About Augmenta

2 REAL-TIME ANALYSIS

NVIDIA edge computing with powerful GPU translates data from cameras and sensors to field insights and actions

4 Extensive DATASET

Data collection for all operations

1 STATE OF THE ART PERCEPTION

Multispectral stereo machine vision

(a) identifies plants health

(b) detects weeds

3 DIRECT MACHINE CONTROL

Retrofit to any modern machinery, for zero overhead operation.

Spot Spraying Application

Safe Mode Mechanism

Tractor Camera View

Safe mode: All nozzles are spraying !
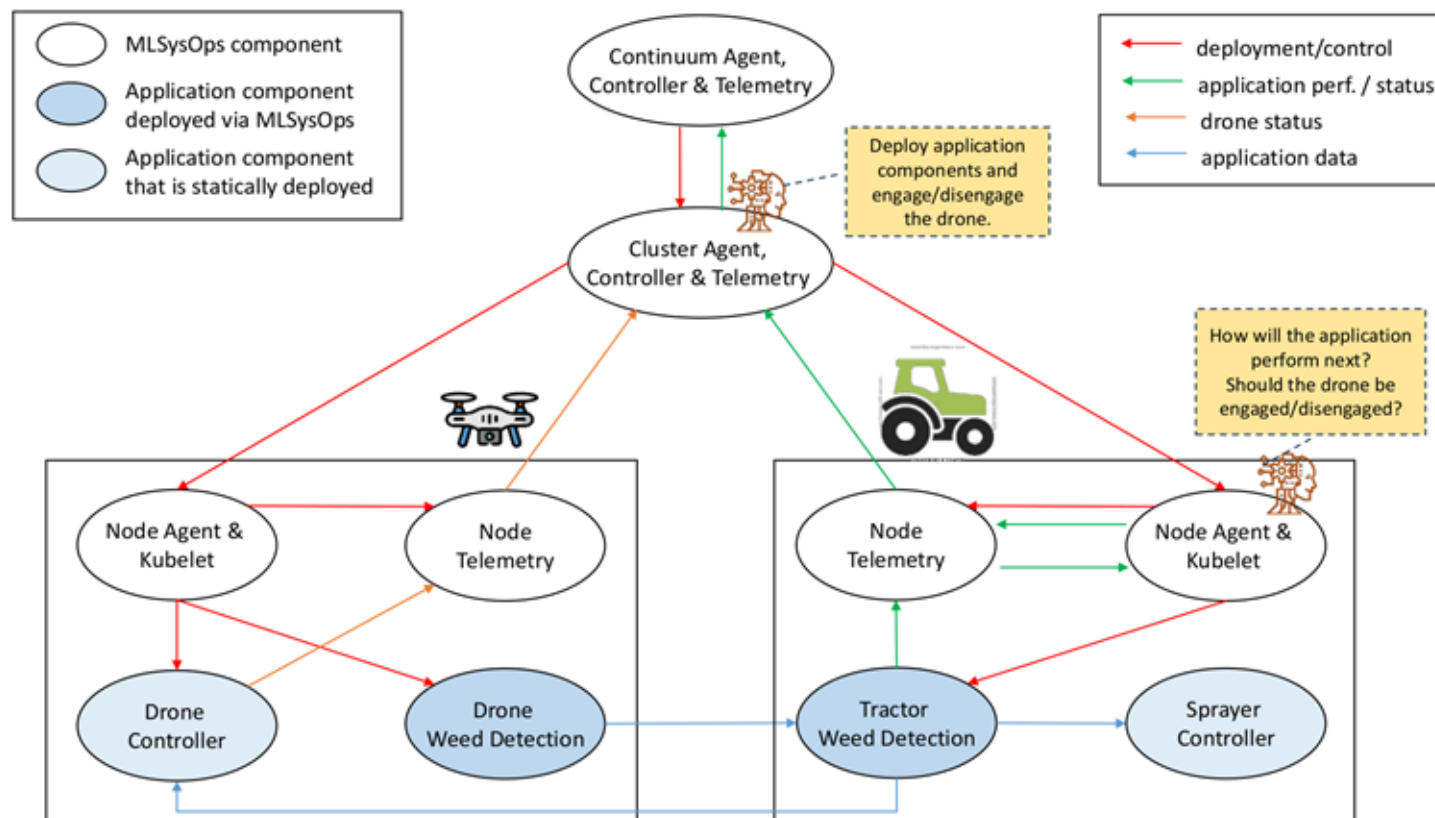
Drone Solution

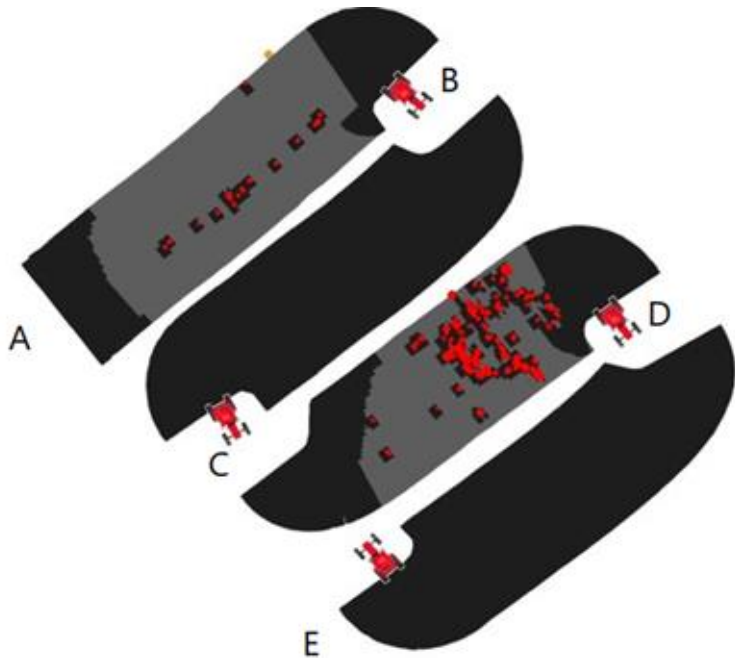Tractor Camera View

Drone Camera View
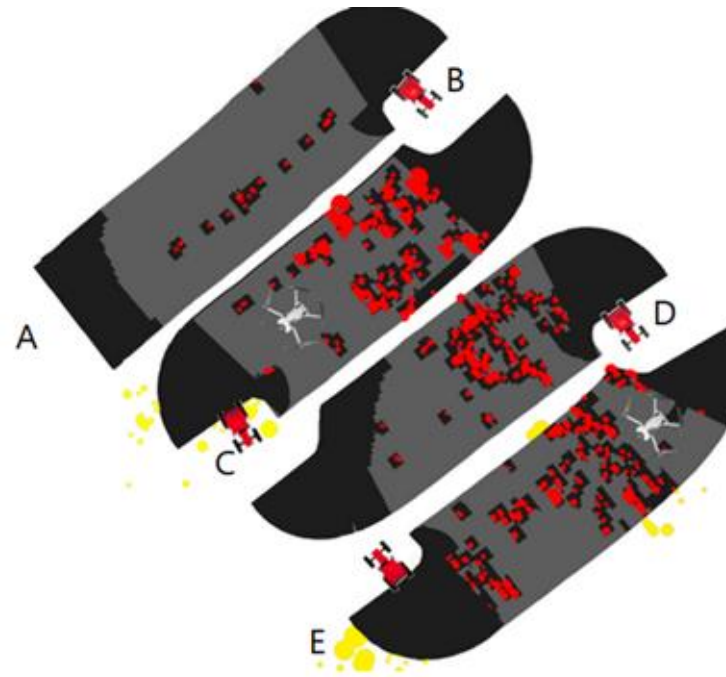
MLSysOps Framework

- A **Continuum Agent** manages multiple Cluster Agents

- A **Cluster Agents** manages a Tractor-Drone Node pair

- The **Tractor Node** runs the **primary weed detection** & hosts the **ML model**: *"How will the weed detection perform next? Should the drone be engaged/disengaged?"*

- The **Drone Node** is deployed by the Cluster Agent and runs the **complementary weed detection** when requested

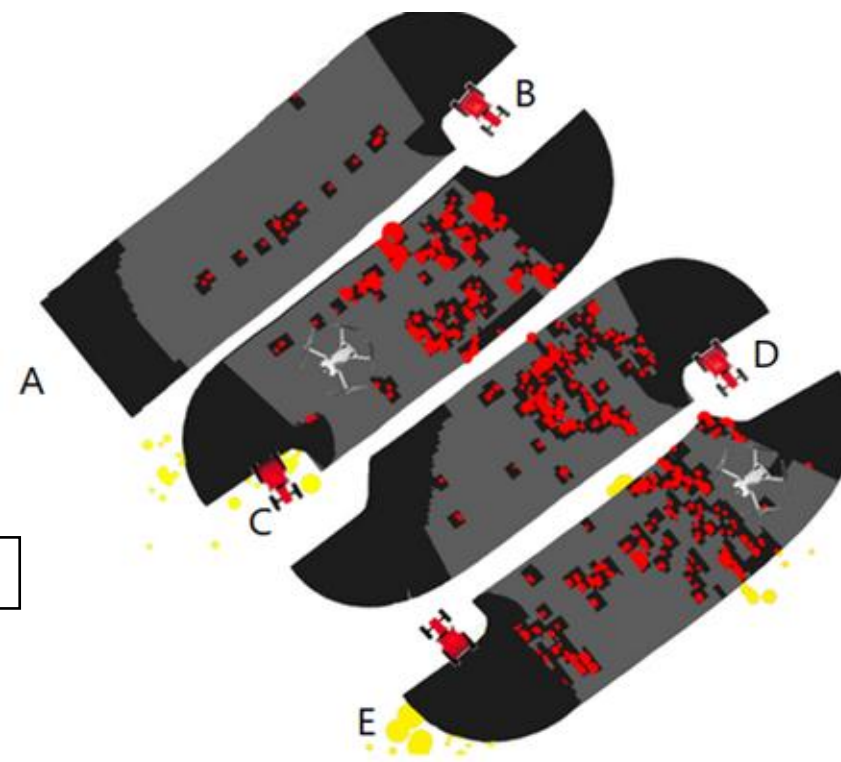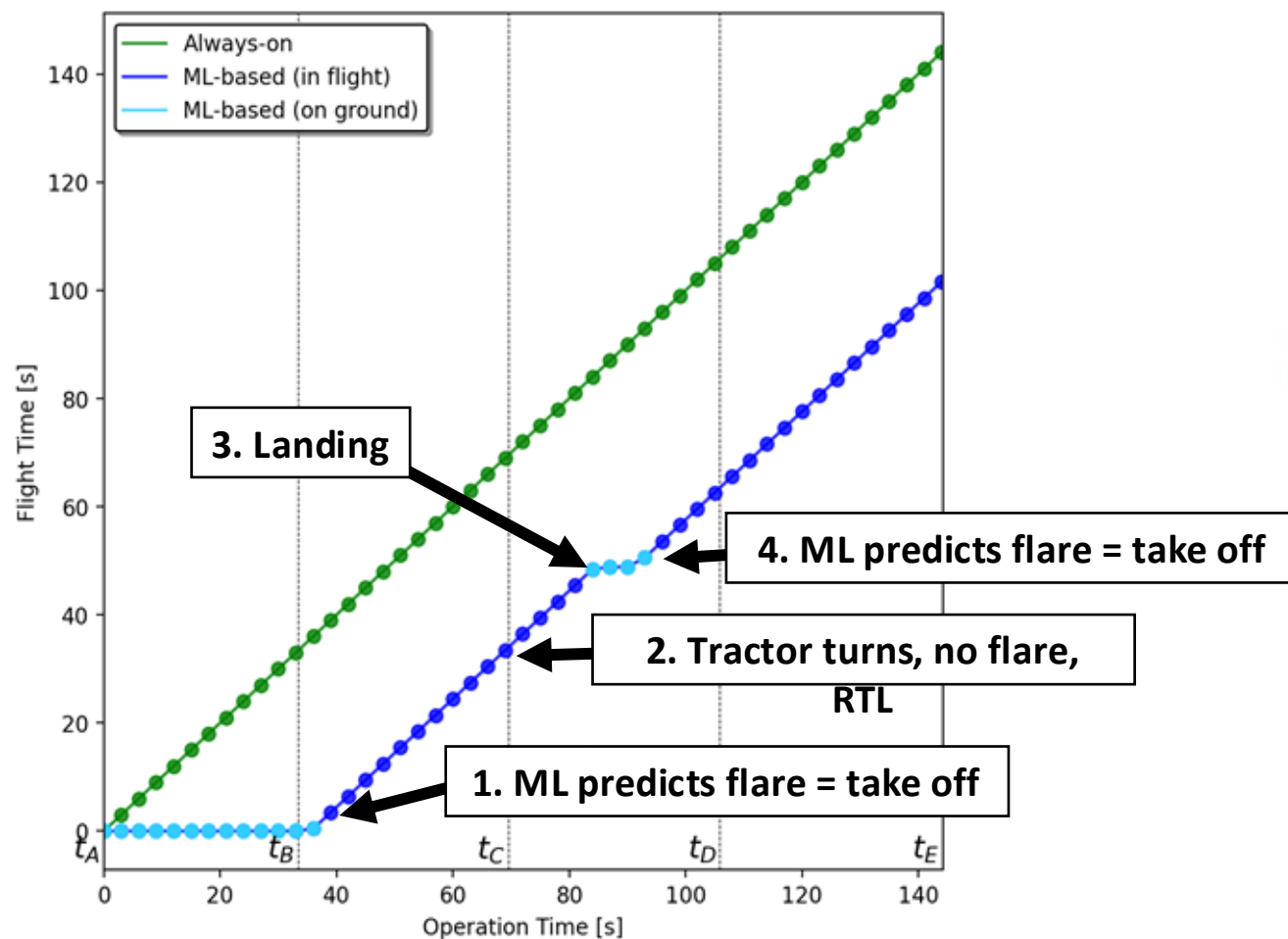# Results [1/2]: Safe Mode Duration Reduction

Without MLSysOps

With MLSysOps

With MLSysOps: Safe Mode Duration Reduction

Pt	Operation time (sec)	Safe mode duration (sec)	Safe mode percentage (%)
A	00.00	00.00	-
B	33.34	10.15	30.44
C	69.57	24.78 (**-21.59**)	35.62 (**-31.03**)
D	105.82	37.03 (**-23.64**)	34.99 (**-22.34**)
E	144.2	50.03 (**-49.03**)	34.69 (**-34.01**)

ML-based drone engagement **reduced Safe Mode Duration by 49.5%**

Results [2/2]: Drone Battery Management

Reduced Flight Time by **38.6%**

Summary

- MLSysOps validated end-to-end in agricultural fields.

- ML-based drone engagement reduces safe mode time by ~50%.

- Effective operation time increases by ~11% on a typical day.
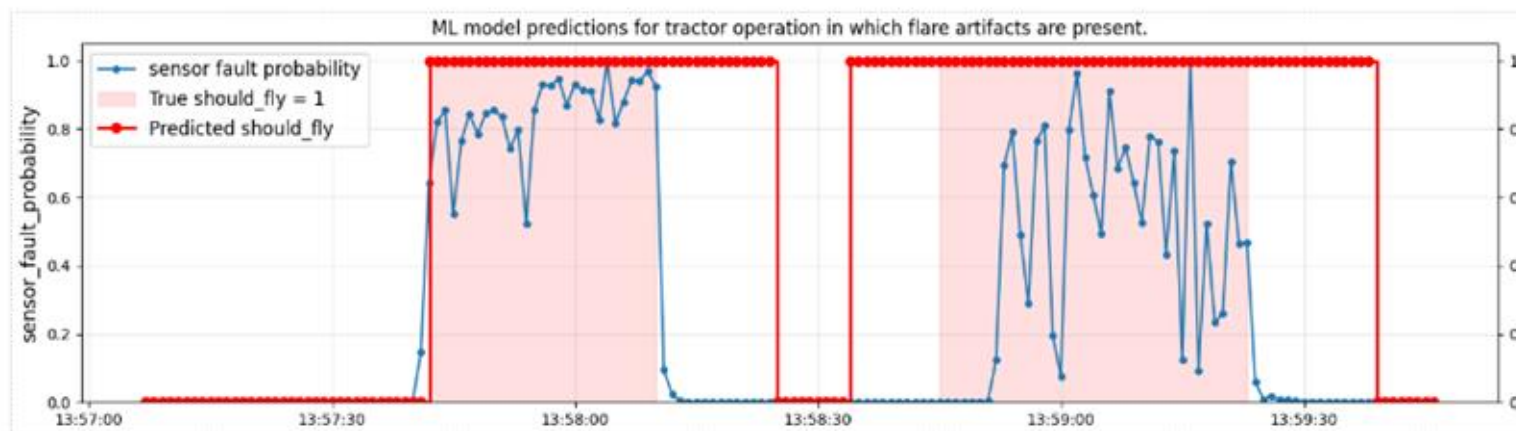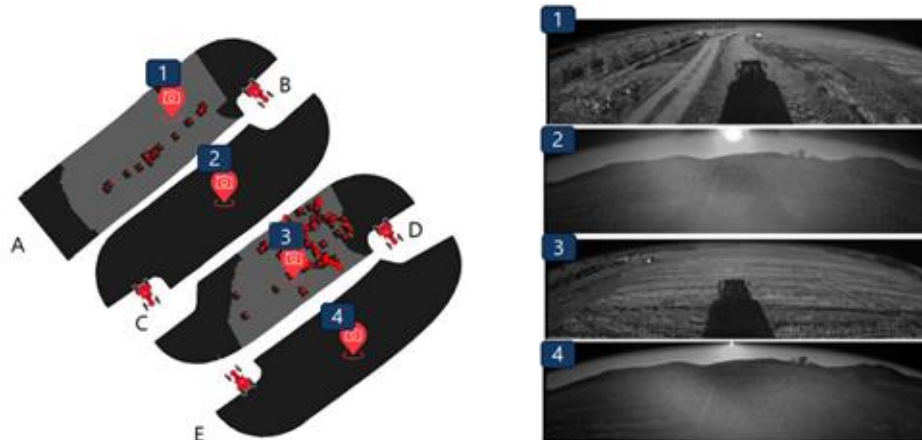
- Energy efficiency improved via reduced drone flight.

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Data/Metrics for ML

Name	Data Type	QoS	Description
Quality Indicator 1	Int	> 50	Number of data correspondences between samples
Quality Indicator 2	Int	> 50	Number of data points used to compute localization components
Field Indicator 1	Int	N/A	Number of detected weeds
Field Indicator 2	Float	< 0.1	Fraction of field under environmental variation
Sensor Fault Probability 1	Float	< 0.3	Probability of the camera sensor being affected by the sun
Environment Sensor 1	Float	> 600	Measurement of environmental conditions as recorded by the onboard sensor
Processing Performance	Float	> 15	Average processing performance over time
Success Rate	Float	1.0	Fraction of successfully processed samples
Heading	Double	N/A	Instant heading of the vehicle in radians
Velocity	Double	$\in [2, 10]$	Instant velocity of the vehicle in m/s
Latitude	Double	N/A	GPS coordinate of the vehicle in degrees
Longitude	Double	N/A	GPS coordinate of the vehicle in degrees
Altitude	Double	N/A	GPS coordinate of the vehicle in meters

ML inference

ML model predictions for tractor operation in which flare artifacts are present.

Demo Videos

- Field Operation Videos:

    o [Drone-tractor operation (static camera)](#)

    o [Drone tractor detection](#)