AuSRoS

Australian School of Robotic Systems

Agriculture Robotics – from research to commercialisation (and back again)

THE UNIVERSITY OF SYDNEY
Australian Centre for Robotics
Salah Sukkarieh

Why Farm Robots?

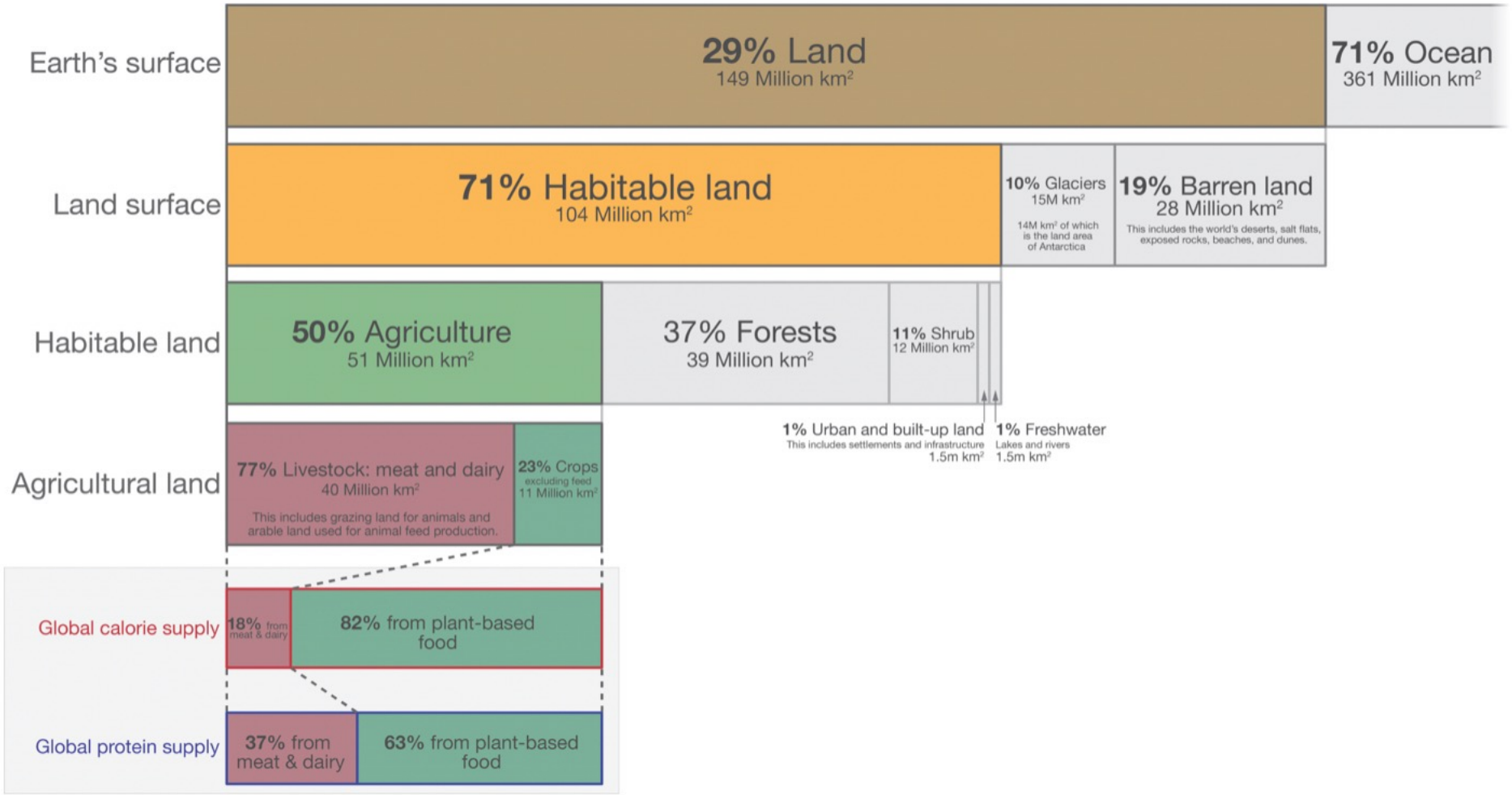
Economic, Environmental, Social

THE UNIVERSITY OF SYDNEY

Australian Centre for Robotics

Global land use for food production

Our World in Data

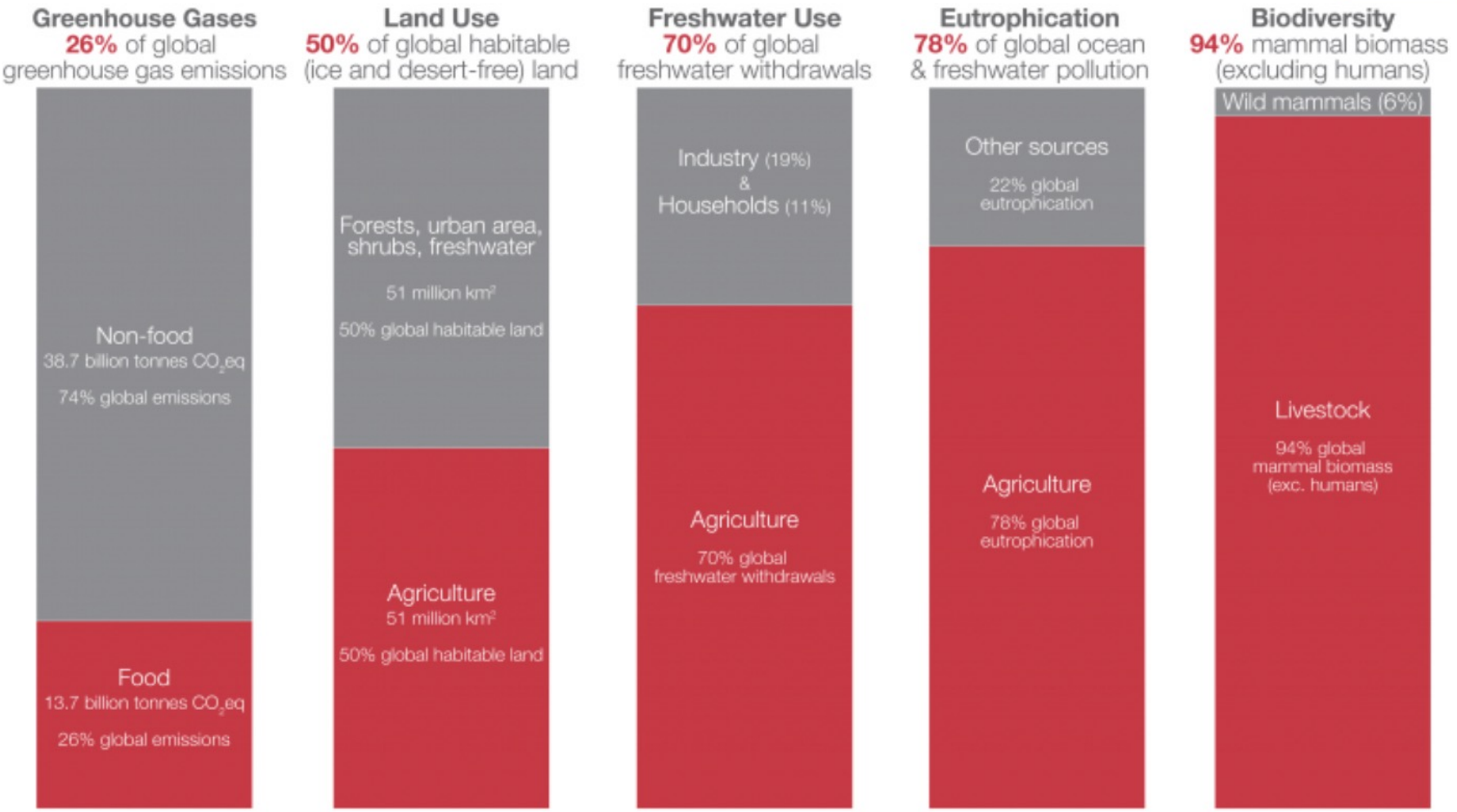


Data source: UN Food and Agriculture Organization (FAO)

OurWorldinData.org – Research and data to make progress against the world's largest problems.

What are the environmental impacts of food and agriculture?

Our World in Data



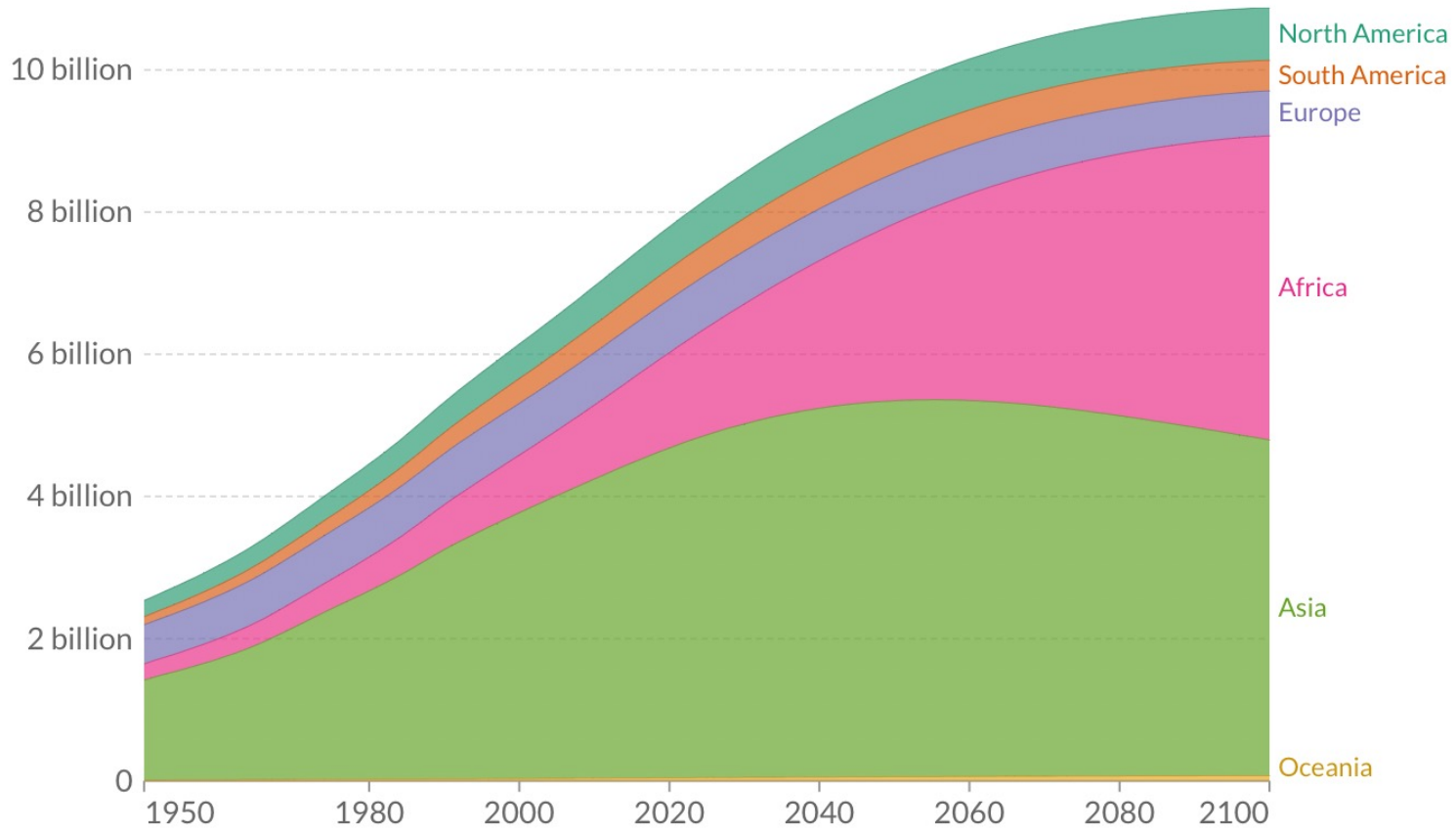
Data sources: Poore & Nemecek (2018); UN FAO; UN AQUASTAT; Bar-On et al. (2018).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

World population by region

Projected population to 2100 is based on the UN's medium population scenario.

Our World in Data

Relative



Source: Gapminder (v6), HYDE (v3.2), UN (2019)

OurWorldInData.org/world-population-growth • CC BY

CHART | TABLE | SOURCES | DOWNLOAD

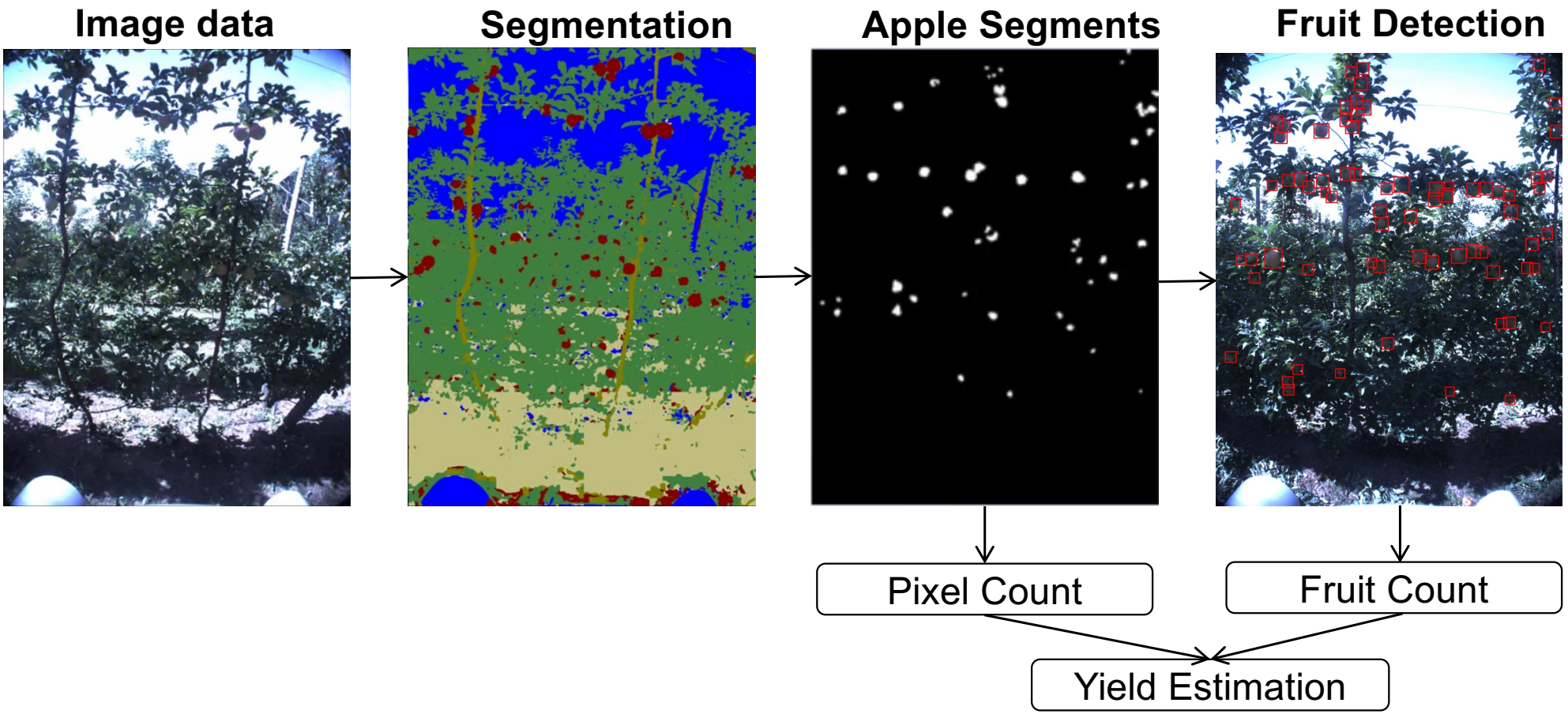
Tree Crop Intelligence

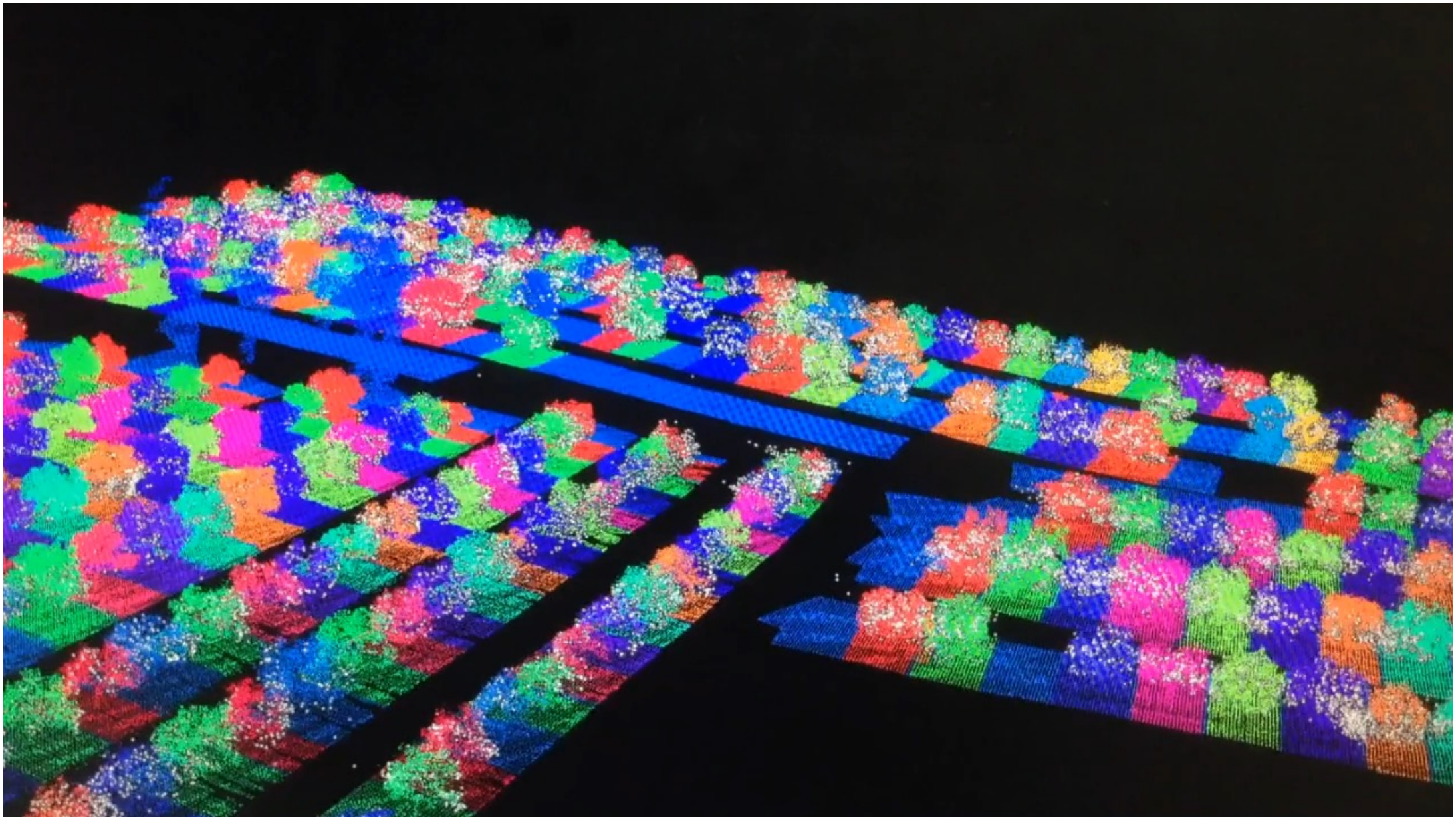
Automated data analytic solutions for the tree crop industry

THE UNIVERSITY OF SYDNEY

Australian Centre for Robotics

Yield estimation





THE UNIVERSITY OF SYDNEY

Autonomous Fruit Harvesting Trial

Jasper Brown, Thomas Ingram, Eric Dreischerf,
Khalid Rafique, Salah Sukkarieh


THE UNIVERSITY OF
SYDNEY
Australian
Centre for
Field Robotics
Horticulture
Innovation
Australia
RIPPA on an Apple Orchard
Three Bridges, VIC

Row Crops

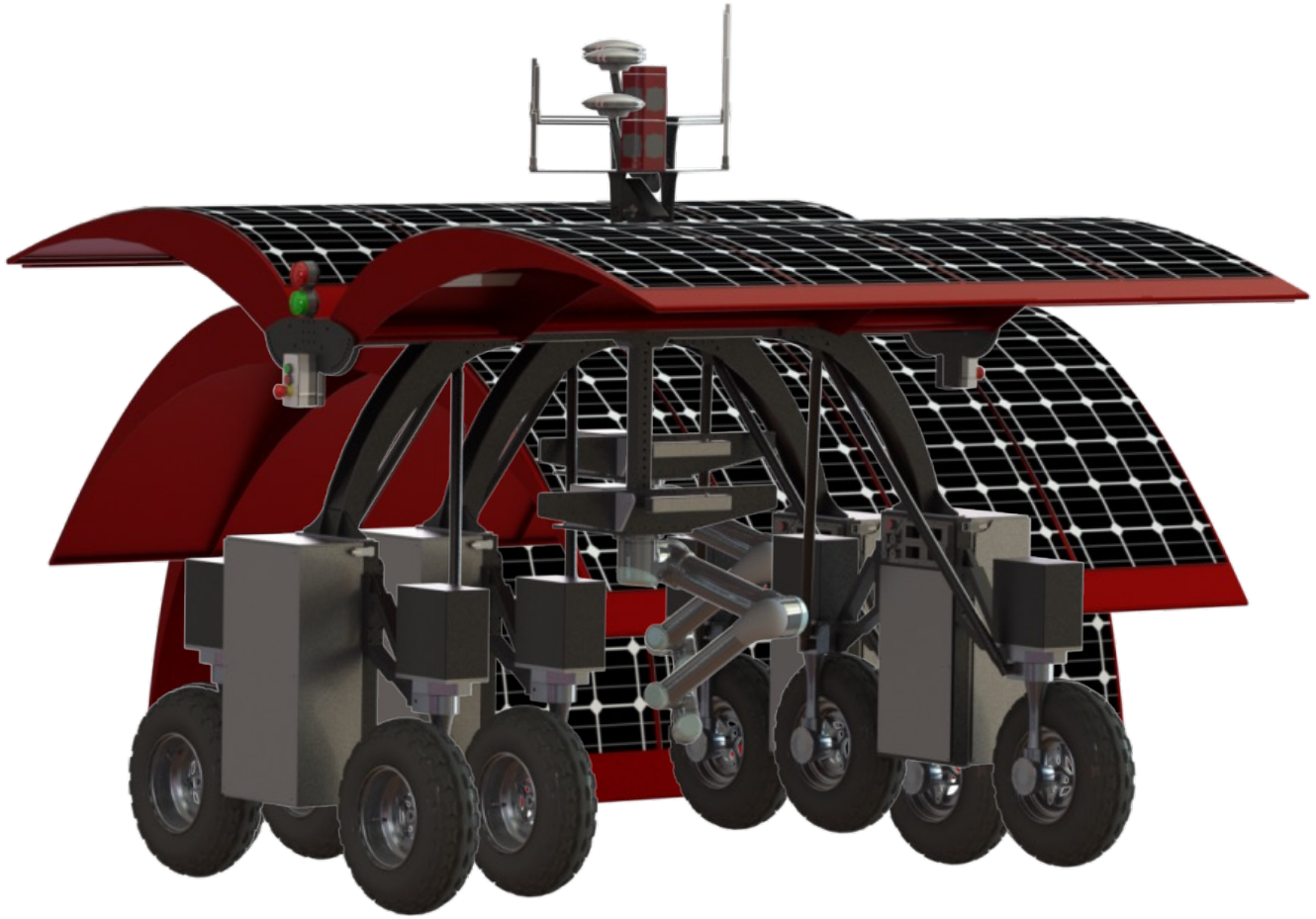
Robotics, data analytics and decision support systems for the vegetable industry

THE UNIVERSITY OF SYDNEY

Australian Centre for Robotics


THE UNIVERSITY OF SYDNEY

Configurable Research Platform




THE UNIVERSI
SYDN
Australian C
for Robotics

Different soil and micro-climate trials

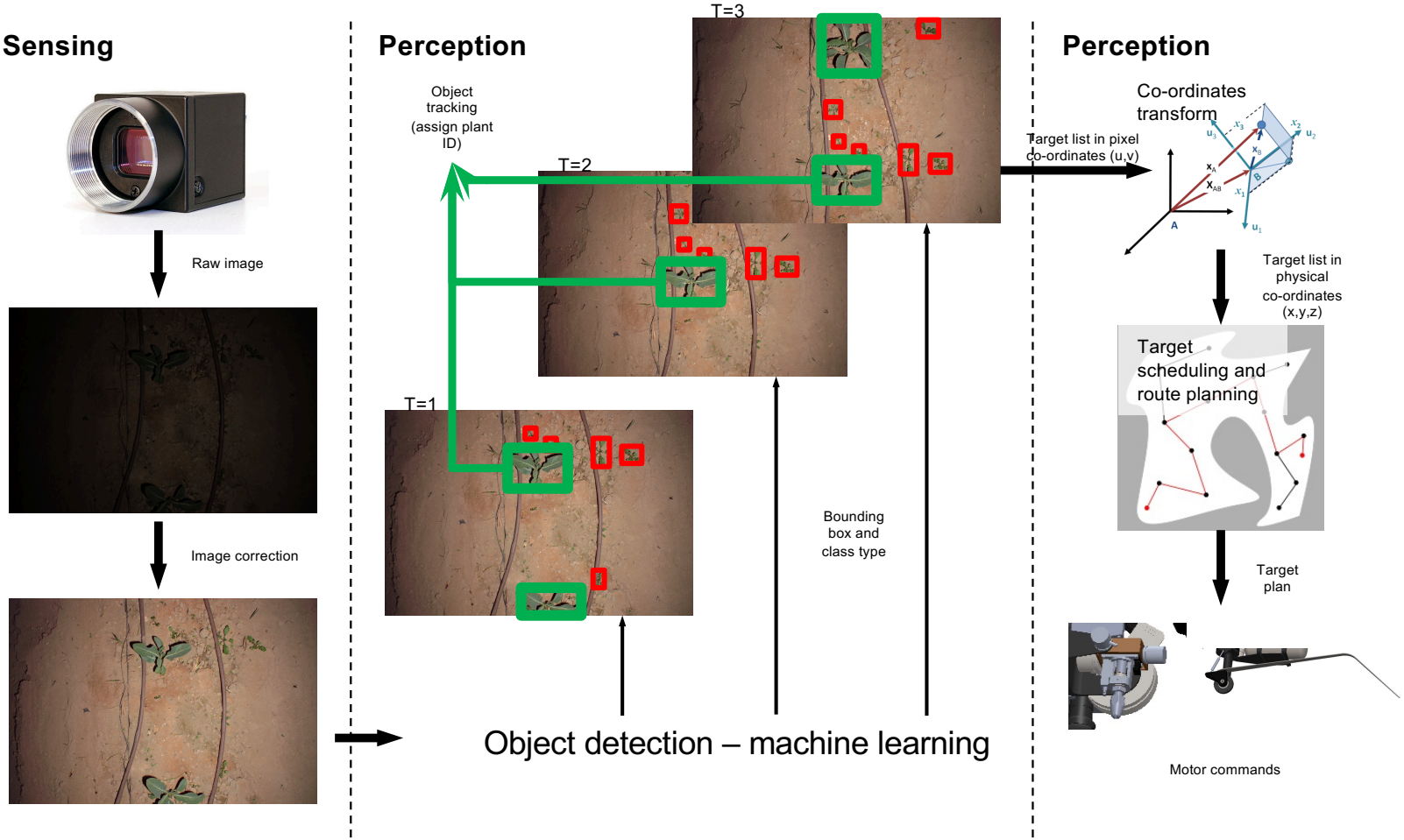
THE UNIVERSITY OF SYDNEY

Horticulture Innovation Australia

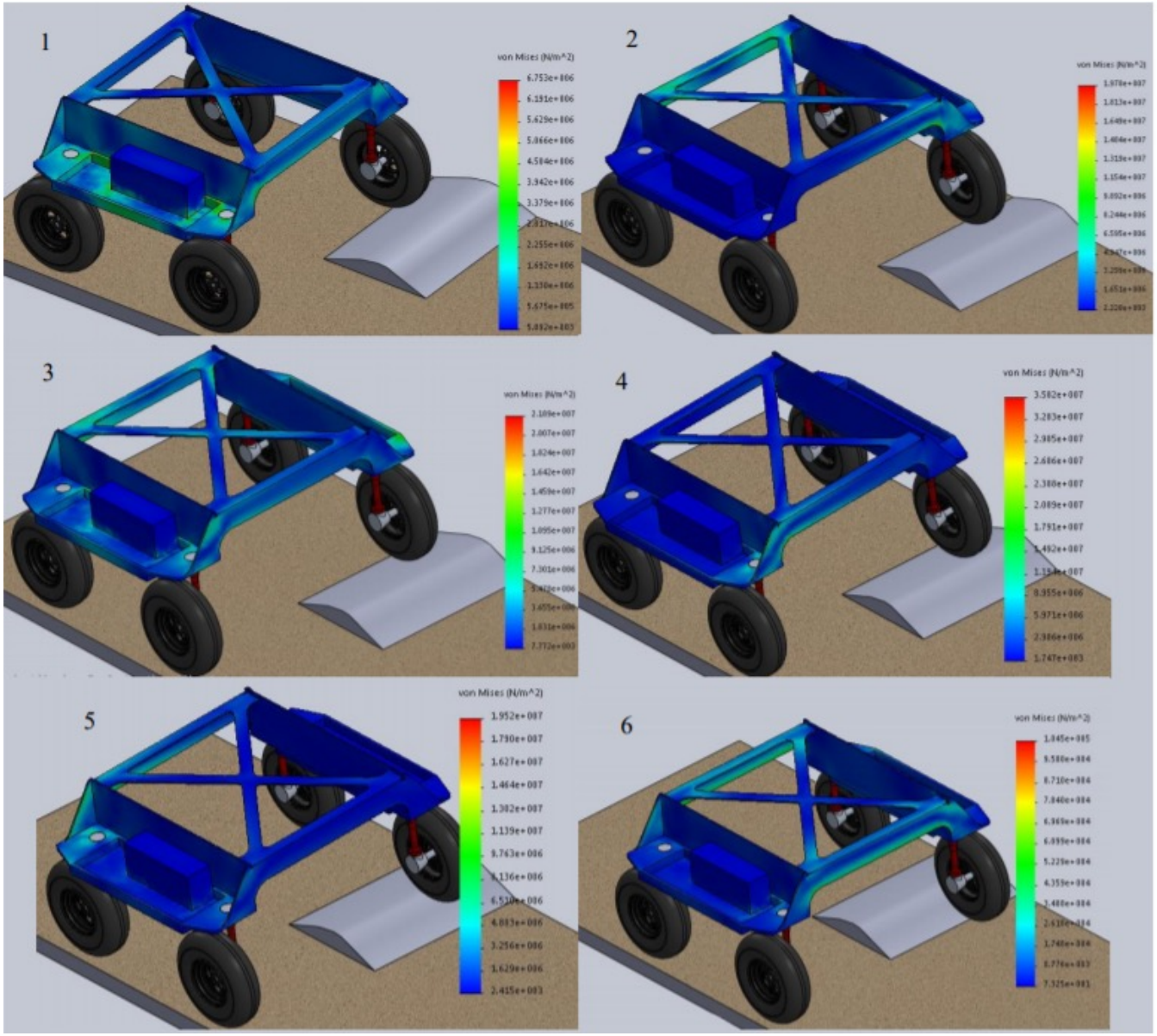
RIPPA Endurance Trial, Cowra

06 April 2016

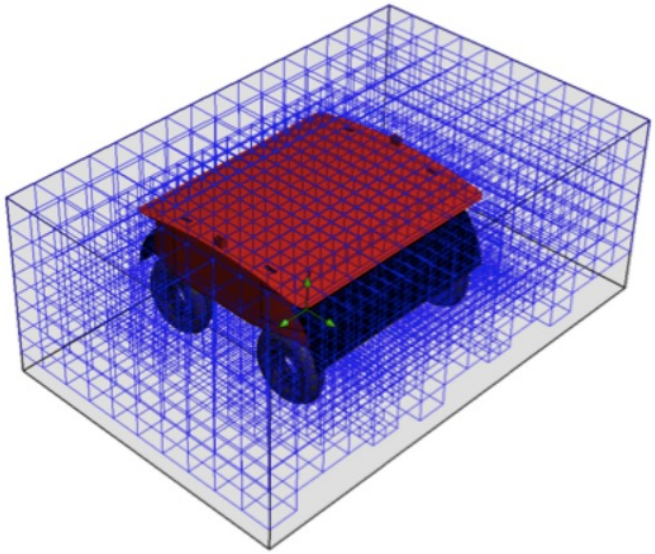
Autonomous weeding – software pipeline

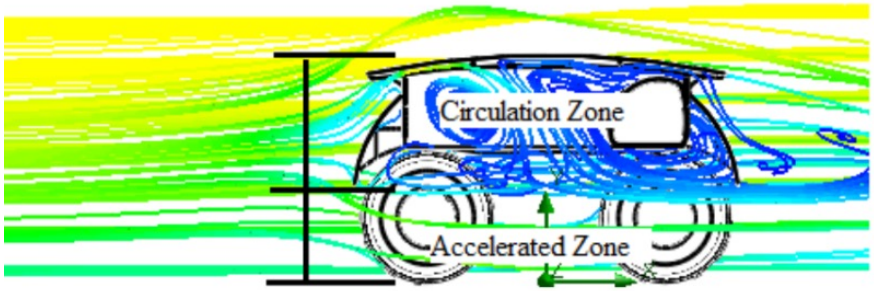


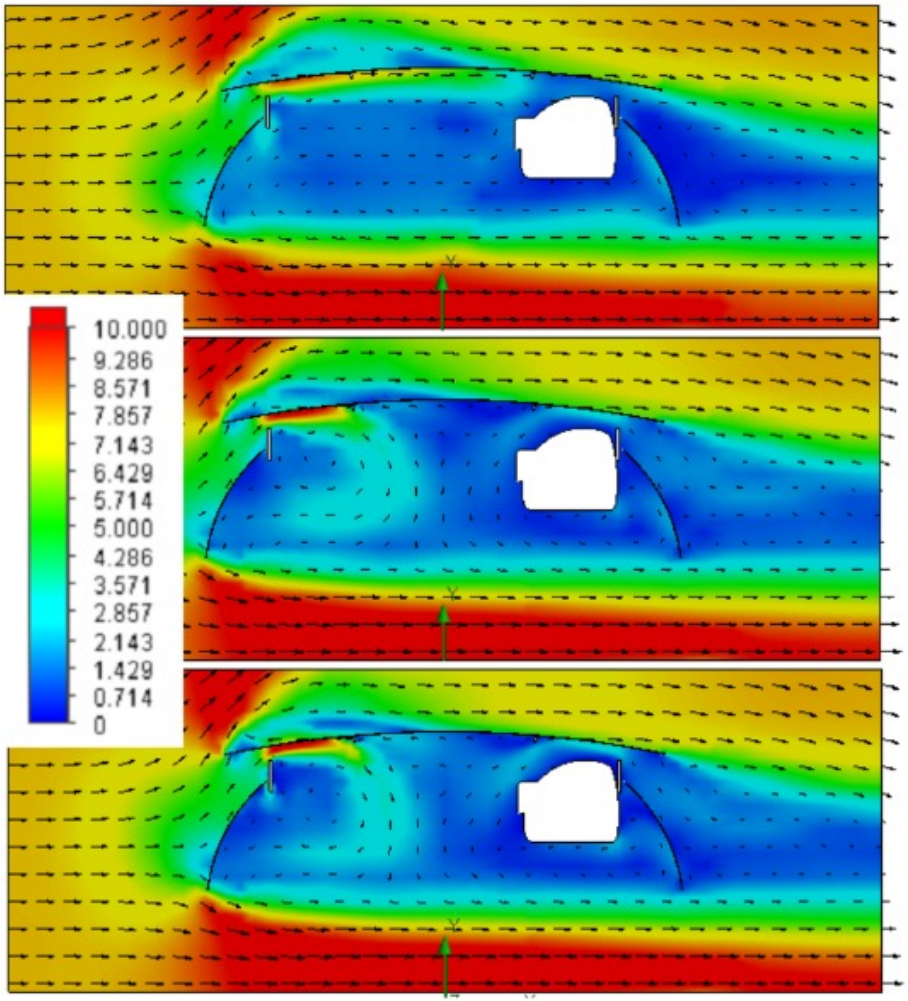
Robotic Platform



Spot Spraying








THE UNIVERSITY OF SYDNEY
Horticulture Innovation Australia
Autonomous Row Following
Lettuce, Lindenow, VIC, Australia

Out of the Lab

Increasing the TRL of the overall system

THE UNIVERSITY OF SYDNEY

Australian Centre for Robotics

Undertaken extensive commercial studies

Summary Crop Marginal Benefits

The crop marginal benefits are the savings to fertiliser, chemicals, harvesting that is non-freight related, irrigation and marketable yield improvements. Therefore, marginal benefits from robots for each crop are:

- Carrots: ~$2,100 per ha
- Green beans: ~$2,000 per ha
- Onions: ~$4,900 per ha
- Pumpkins: ~$1,900 per ha.

Onions have the largest margin benefit from robots largely du to the harvesting benefits. It been assumed that the gr margin benefits are the all varieties of green b spring, summer and a

1. Spinach
2. Broccoli
3. Onions
4. Carrots
5. Beans

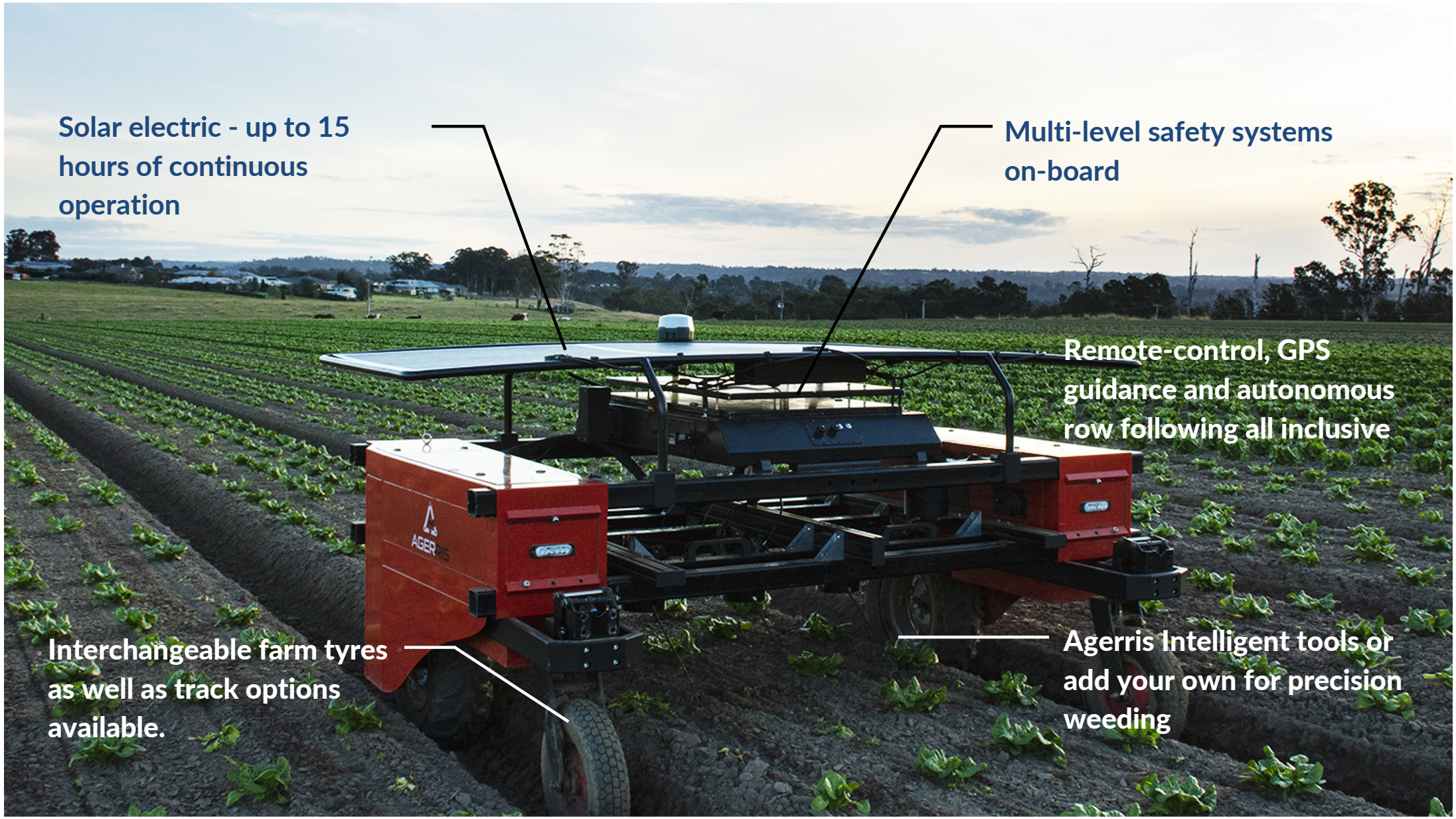
SUMMARY MARGINAL BENEFITS

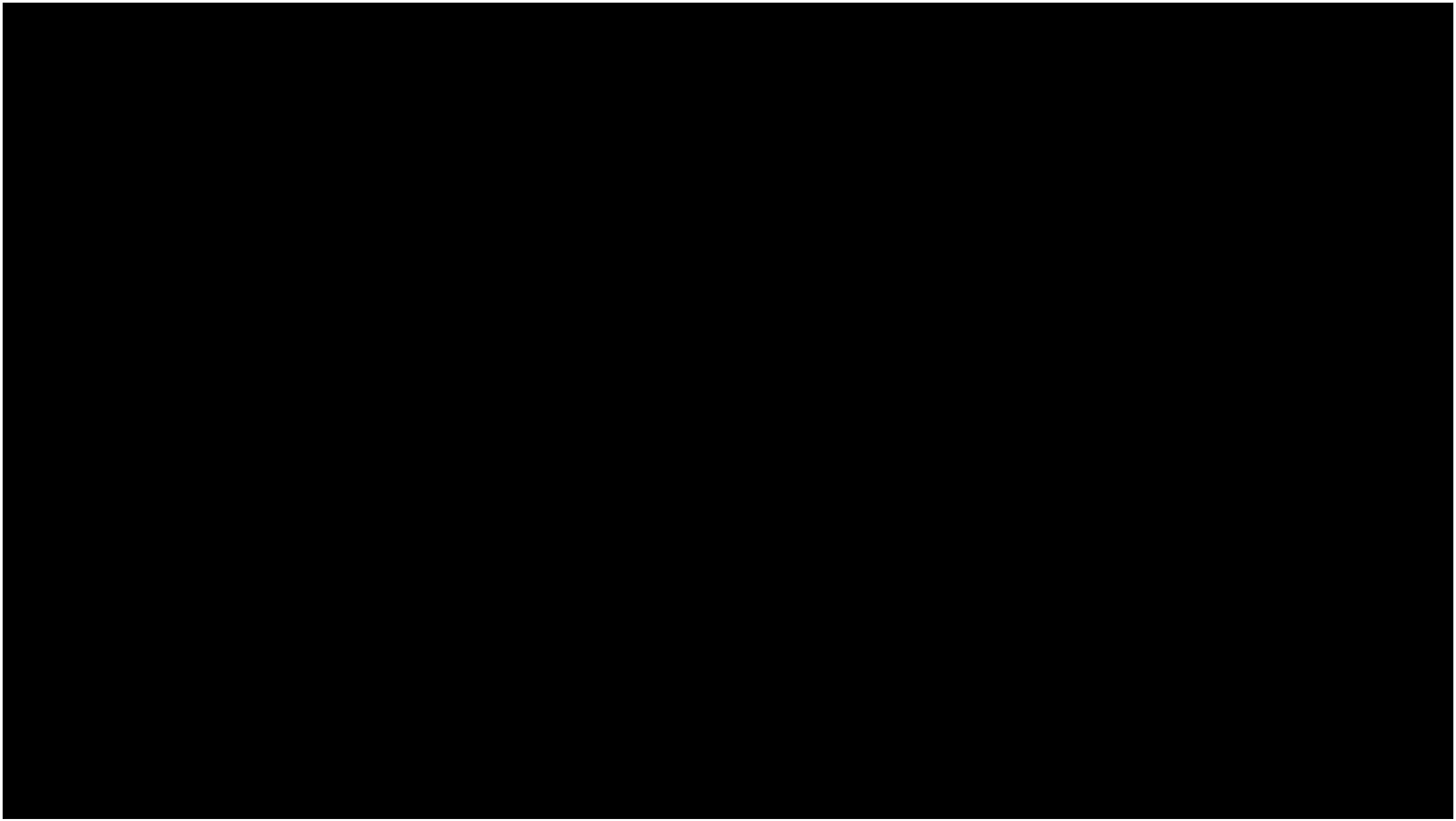
The marginal benefits from robots are:

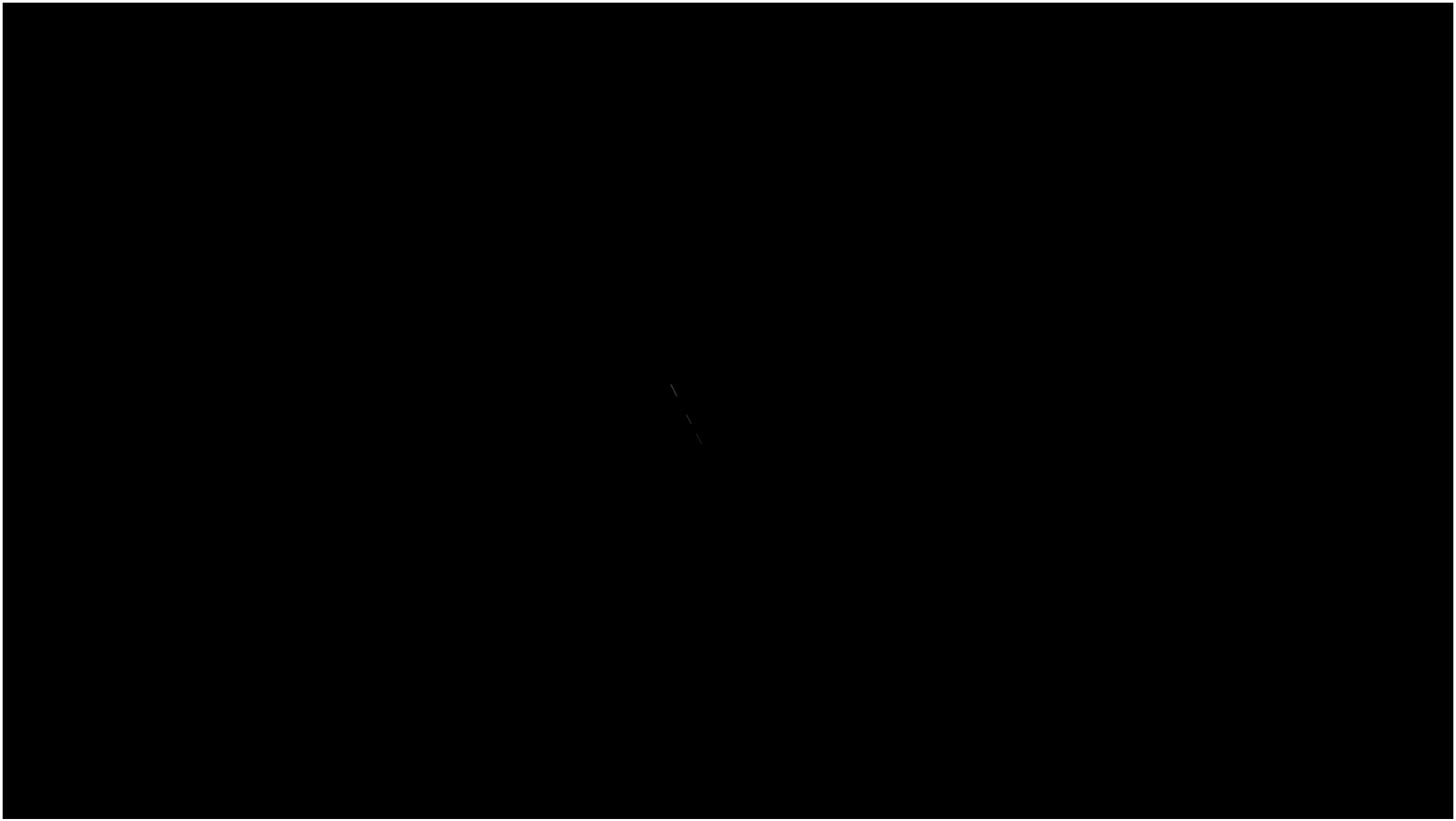
- Broccoli: $4,000per ha
- Carrots: $1,500 per ha
- Beans: $1,000 per ha
- Onions: $2,500 per ha
- Spinach: $4,500 per ha.

This is based on the gross margins provided by the Northern Tasmanian farm.

To optimise the benefits of the robot on the farm, the robot will be utilised in the following order:


Solar electric - up to 15 hours of continuous operation
Multi-level safety systems on-board
Remote-control, GPS guidance and autonomous row following all inclusive
Interchangeable farm tyres as well as track options available.
Agerris Intelligent tools or add your own for precision weeding





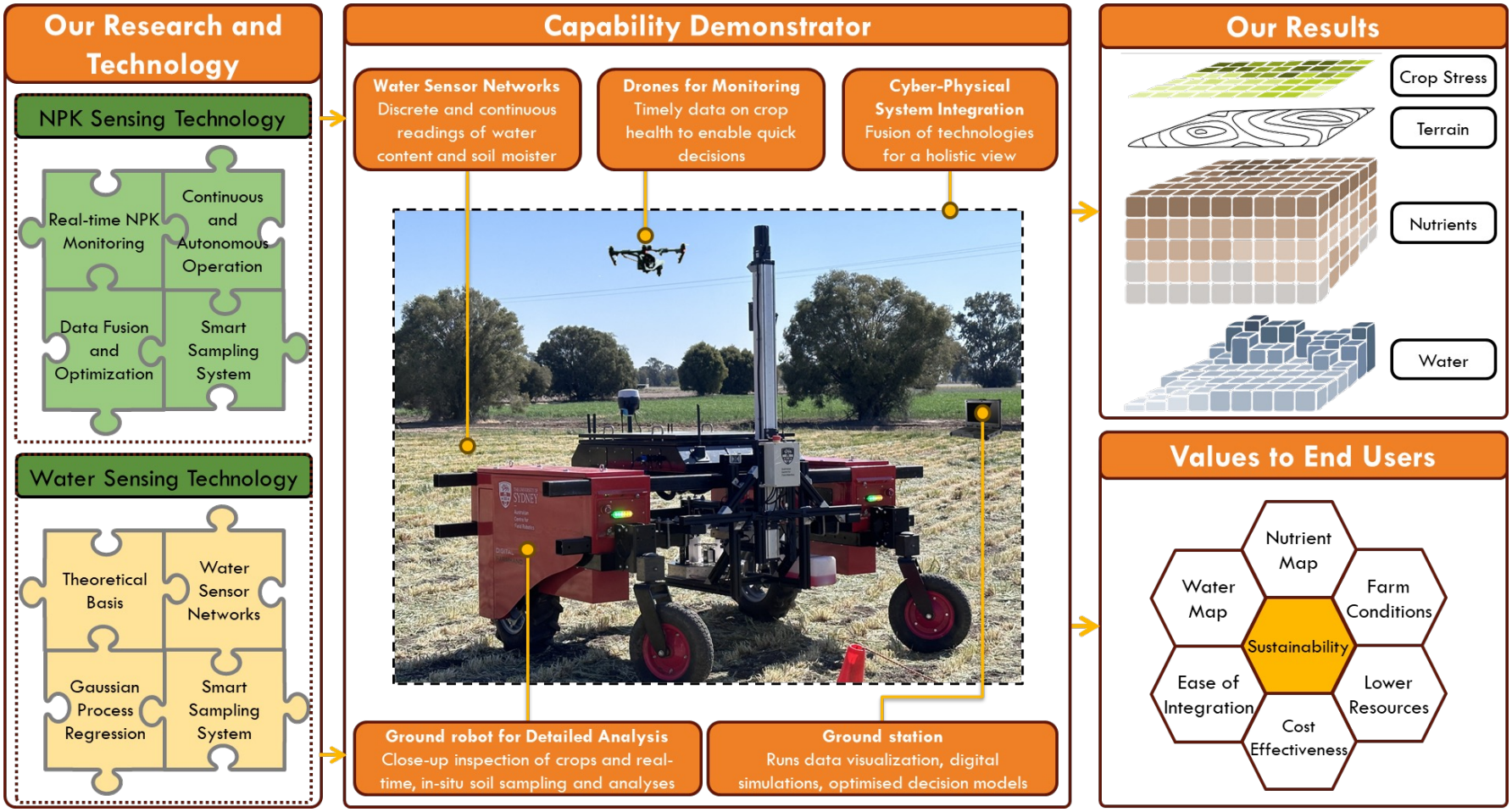
Round 2

Back to R&D

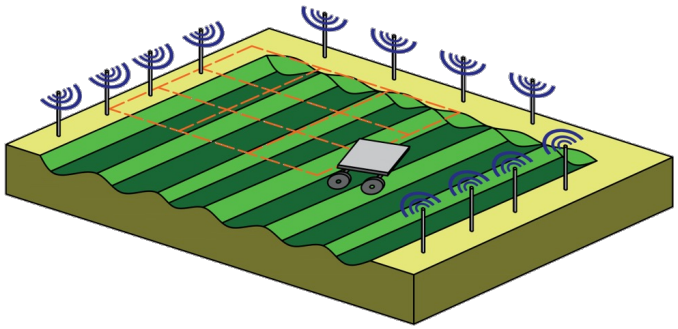
THE UNIVERSITY OF
SYDNEY

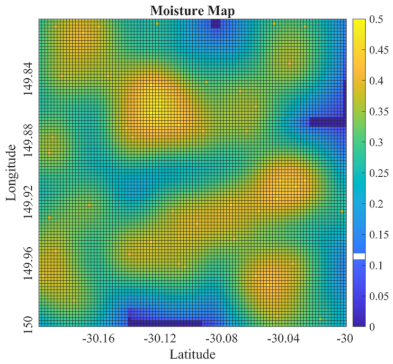
Australian Centre
for Robotics

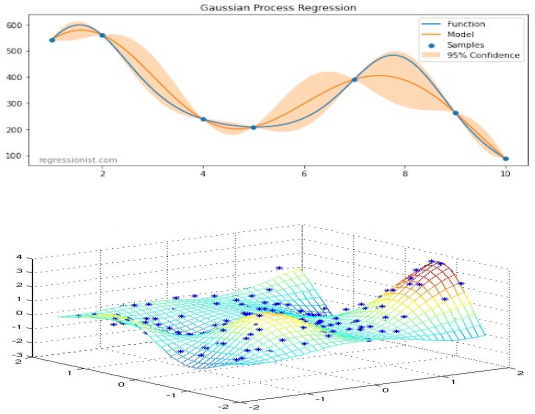
Integrated Water/Soil/Crop



Water Sensing Technology







Small Holder Farmers

Supporting Communities

THE UNIVERSITY OF
SYDNEY

Australian Centre
for Robotics


The di-wheel consists of two powered wheel modules joined by an expandable central shaft.


ISEKI-AGRINDO
ISEKI-AGRINDO


Farmhand travels down row crop collecting data

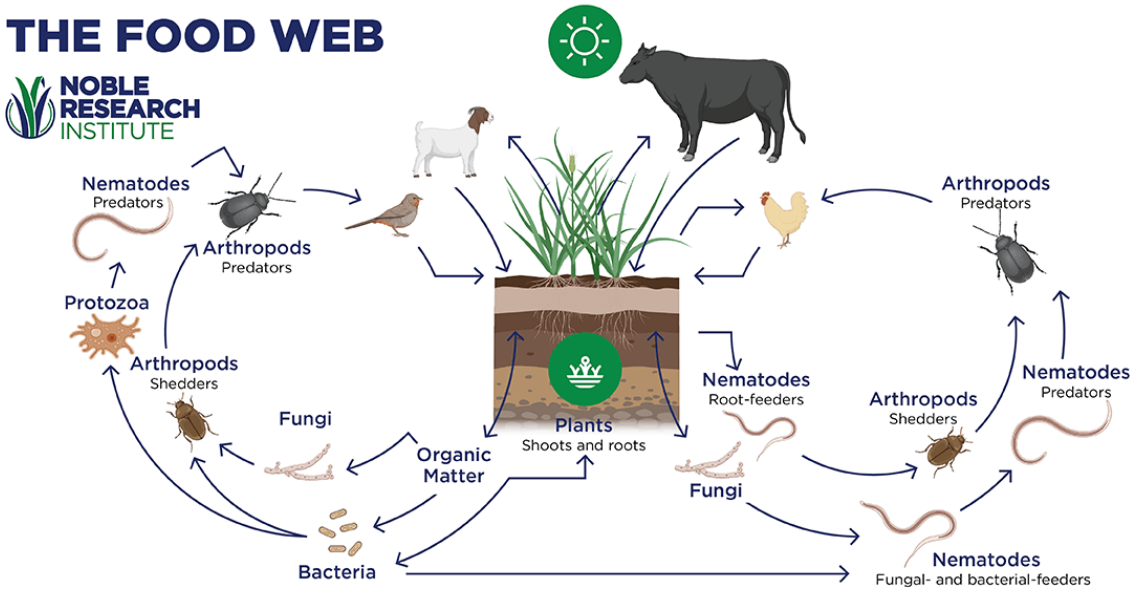
Grazing Livestock

Robotics and intelligent systems for monitoring grazing livestock health and movement, and pasture quality and quantity.

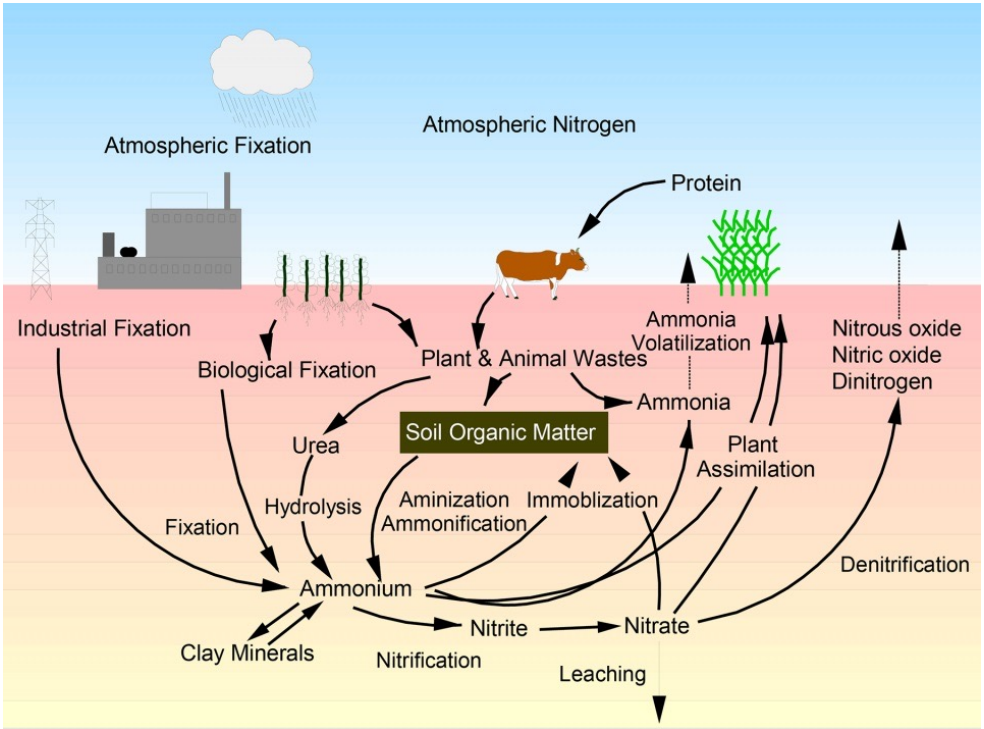
THE UNIVERSITY OF SYDNEY

Australian Centre for Robotics

Soil / Pasture / Animal



https://www.noble.org/regenerative-agriculture/how-to-help-the-nutrient-cycle/



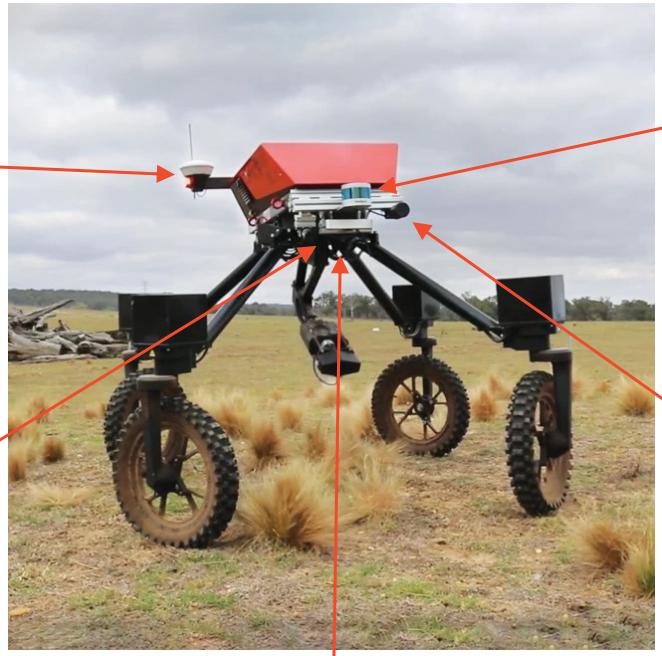
https://dsfamilyfarm.com/cow-icon-of-nutrient-cycles/

SwagBot Characteristics

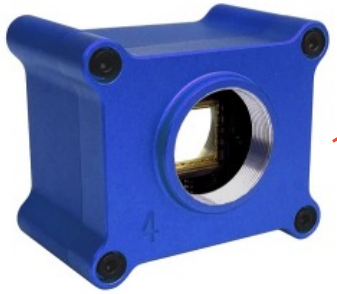
Specification	Value
Dimensions (LxWxH)	1.80m x 1.81m x 1.88m
Wheel Track	1.26m
Wheel Base	1.29m
Wheel Radius	0.26m
Weight	220 kg
Maximum Speed	4.4 m/s (16 kph)
Max. Operating Time	~3 hrs
Drive Power	2760 W (rated)

SwagBot On-Board Sensing

GPS



LIDAR

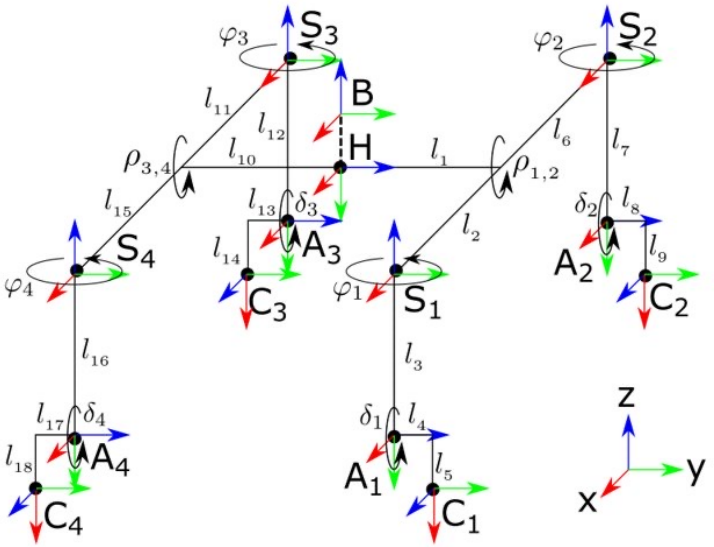


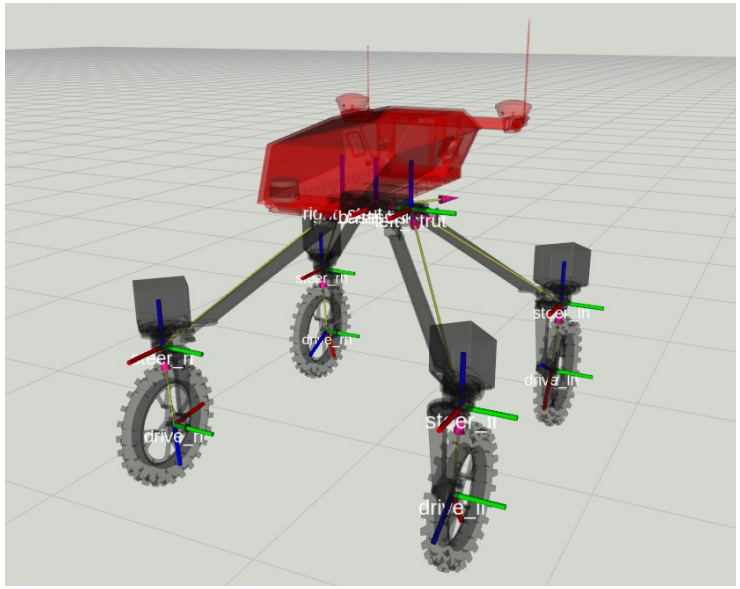
Multispectral Camera

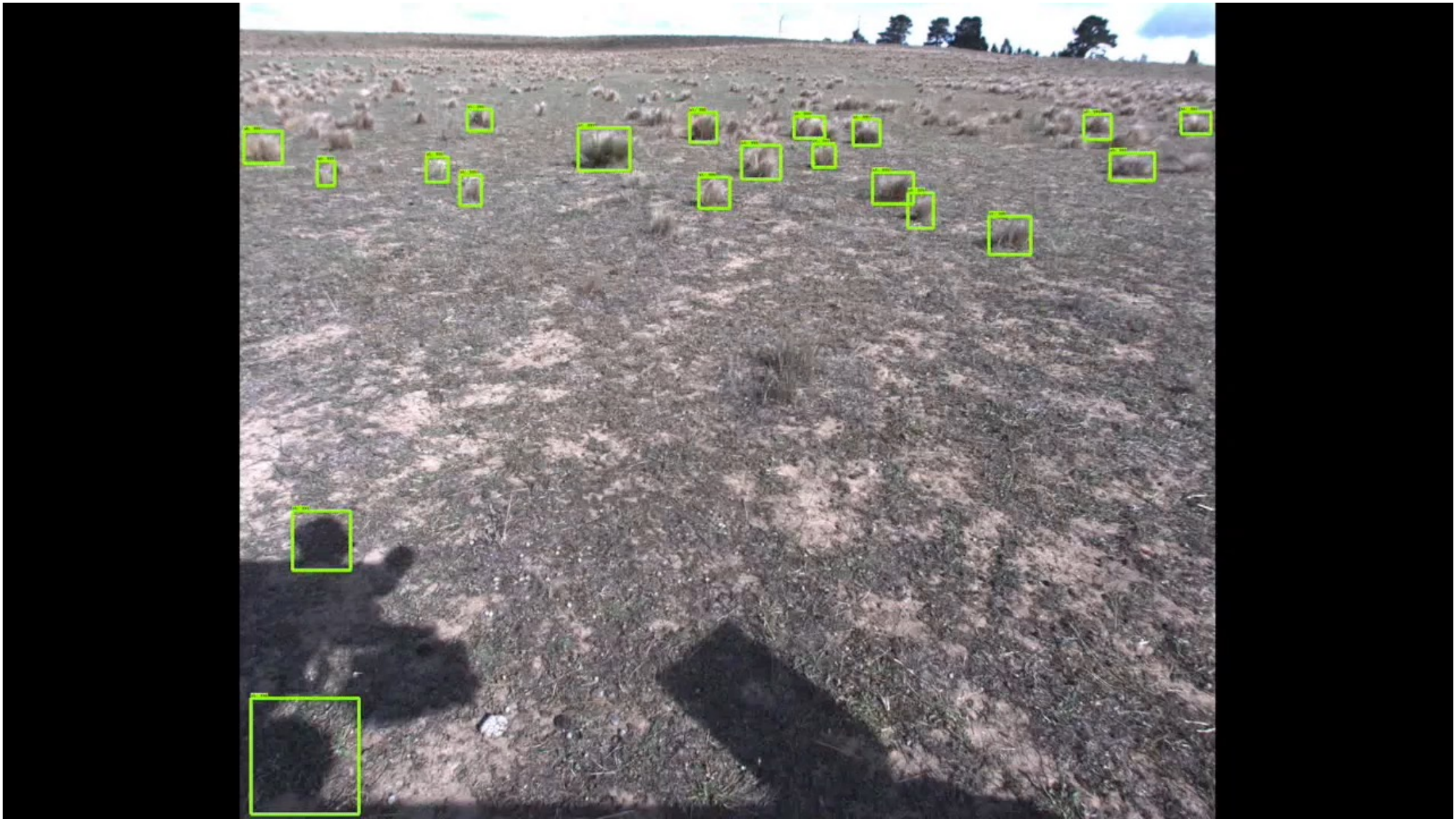
Depth Camera

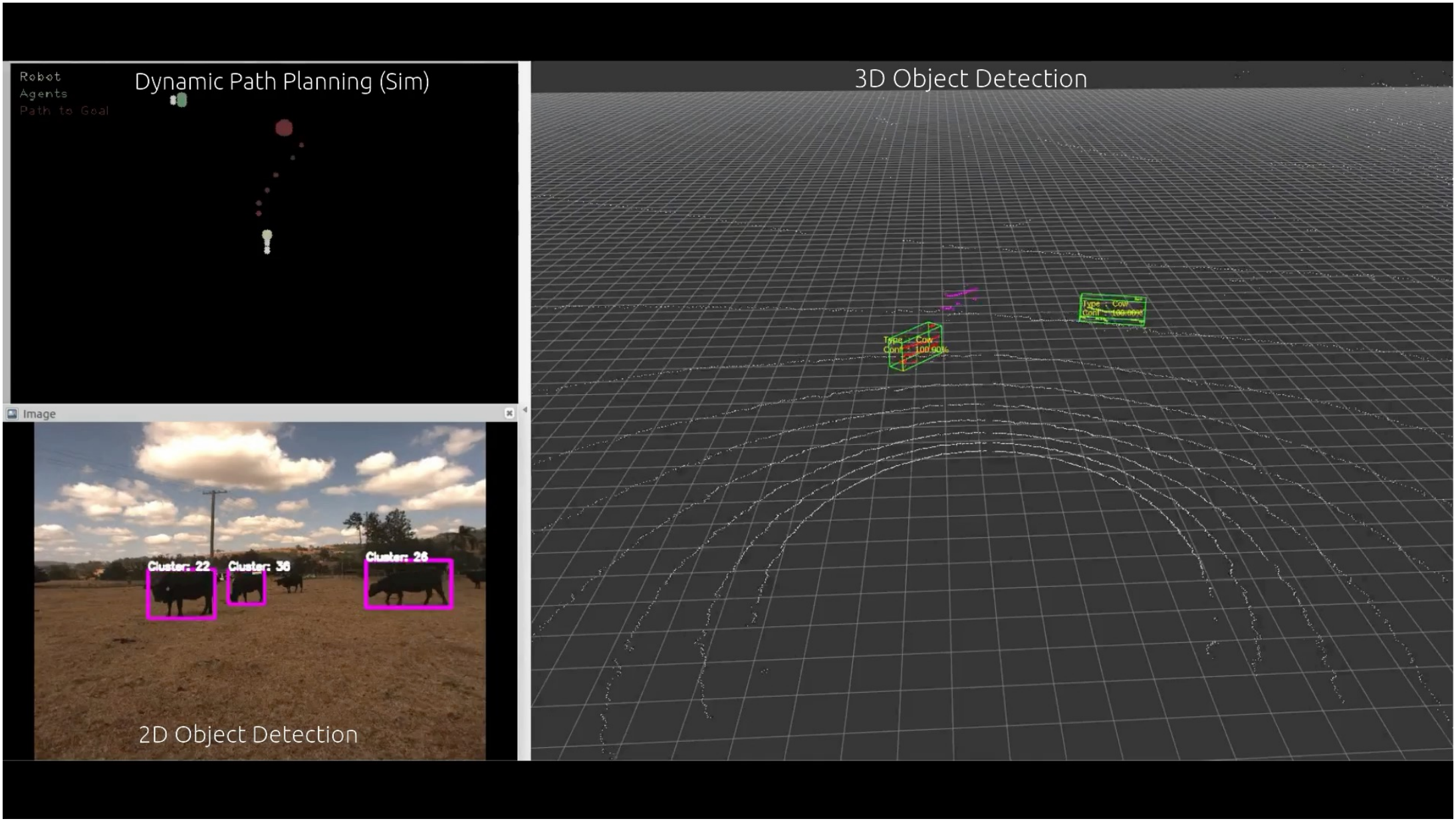
Color Camera

SwagBot Dynamic Modelling

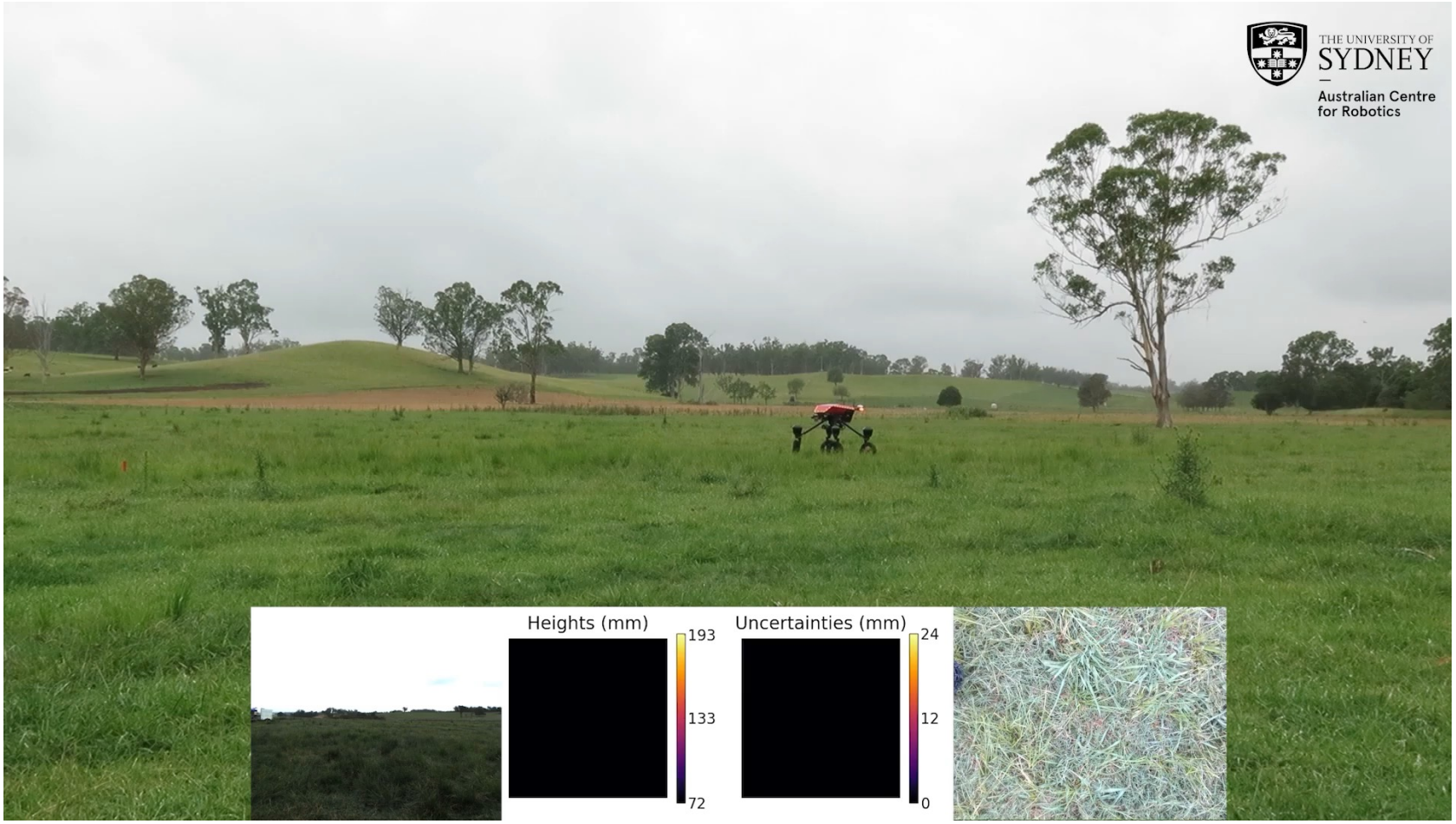







Robot
Agents
Path to Goal
Dynamic Path Planning (Sim)
Image
Cluster: 22
Cluster: 38
Cluster: 26
2D Object Detection
3D Object Detection

Informative Pasture Sampling



Intelligent sampling for soil PH assessment

Molasses Trial
Hunter Valley, September 2017

Next Steps

The Agriculture Digital Twin for Understanding and Managing our Soil, Water, Food and Fibre Assets

THE UNIVERSITY OF SYDNEY

Australian Centre for Robotics

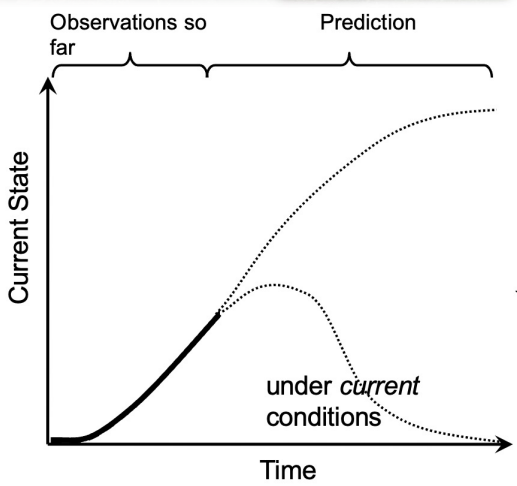
- Real-Time with limited compute
- Harvesting aids
- Cooperative control and Co-Decision
- Whole of system optimization
- Novel mobile platforms

Action Flow

Digital Twin

- Coupling ML and Bio Models
- Co-Learning human and machine
- Edge Compute
- Decentralised Data Fusion limited Comms
- Unstructured and Multi-res spatio-temporal modelling

Information Flow



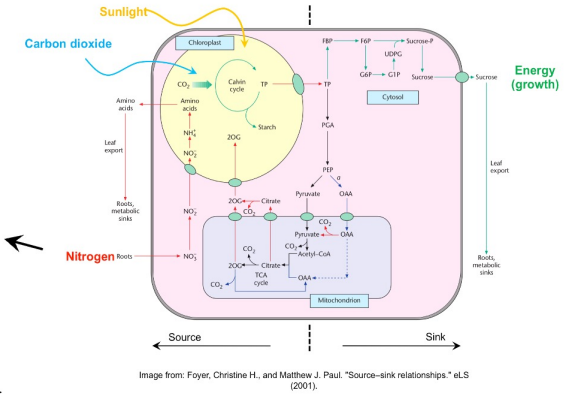


Image from: Foyer, Christine H., and Matthew J. Paul. "Source–sink relationships." eLS (2001).

AuSRoS

Australian School of Robotic Systems

Agriculture Robotics –
from research to commercialisation (and back again)