AN INTEGRATED APPROACH FOR EARLY FIRE DETECTION AND SUPPRESSION

Bushfire Research Centre of Excellence

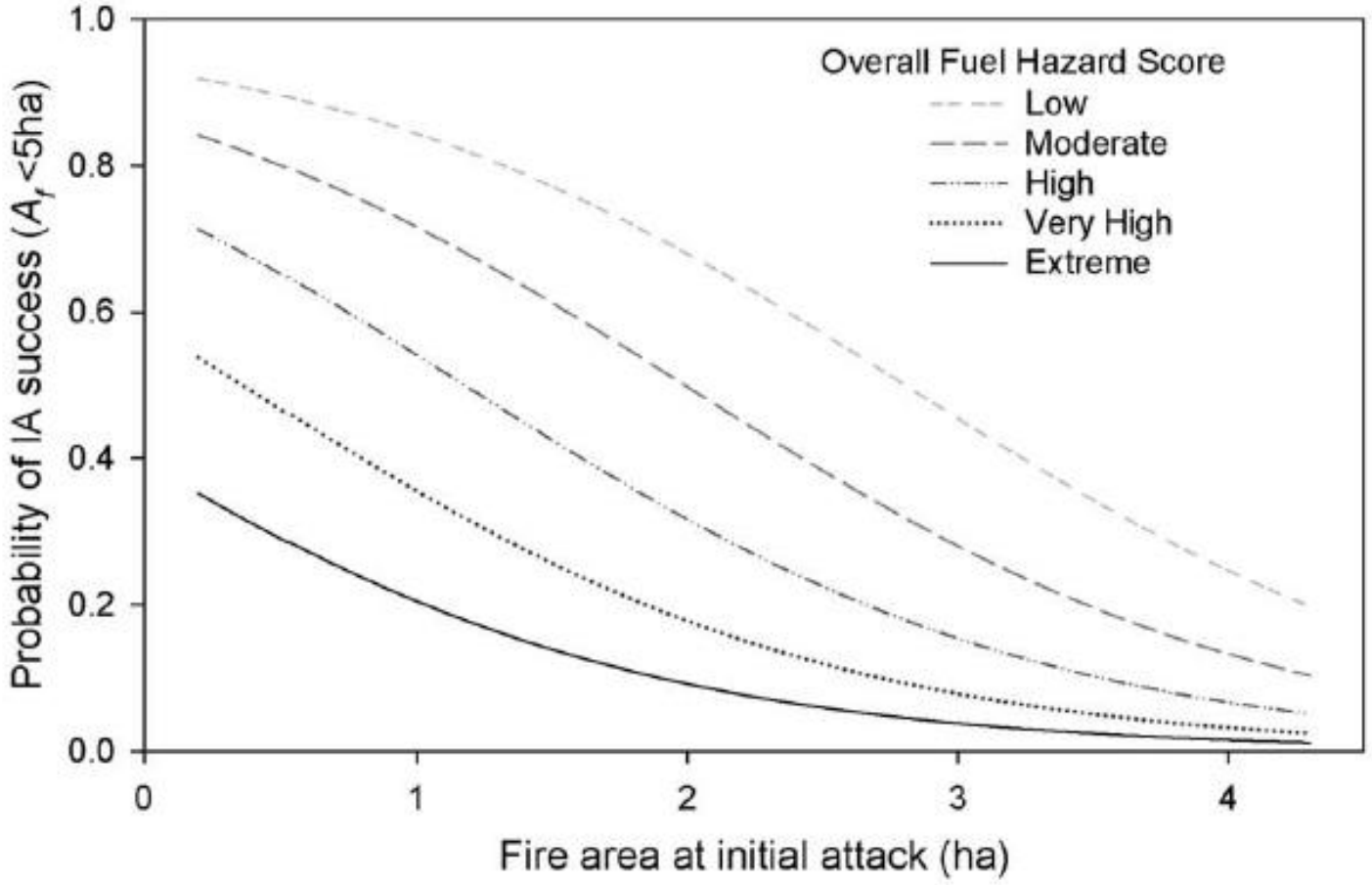
A/PROF MARTA YEBRA

DIRECTOR, BUSHFIRE RESEARCH CENTRE OF EXCELLENCE

Supported by

Australian National University | OPTUS

EARLY DETECTION OF IGNITIONS IS CRITICAL TO THE PREVENTION OF LARGE BUSHFIRES



(Plucinski, 2012)

LIGHTNING IGNITIONS

- Account for a large proportion of the total area burned (80-90% in NSW & VIC).
- Occur across the landscape, often in remote, inaccessible bushland late in the day
- Individual thunderstorms may contain thousands of lightning strikes
- Checking and validating all possible ignitions after a dry lightning storm is a critical, time consuming and dangerous task.
- Availability of crew fire-spotting/firefighting aircraft may be limited to daylight hours due to safety concerns, resourcing, and night-flying restrictions
- Fires can smoulder inside a tree or its root system, producing little if any smoke, for hours, days or even months

OUR VISION

A paradigm change in bushfire management where early ignitions are accurately and reliably detected and suppressed before they become catastrophic and uncontrollable

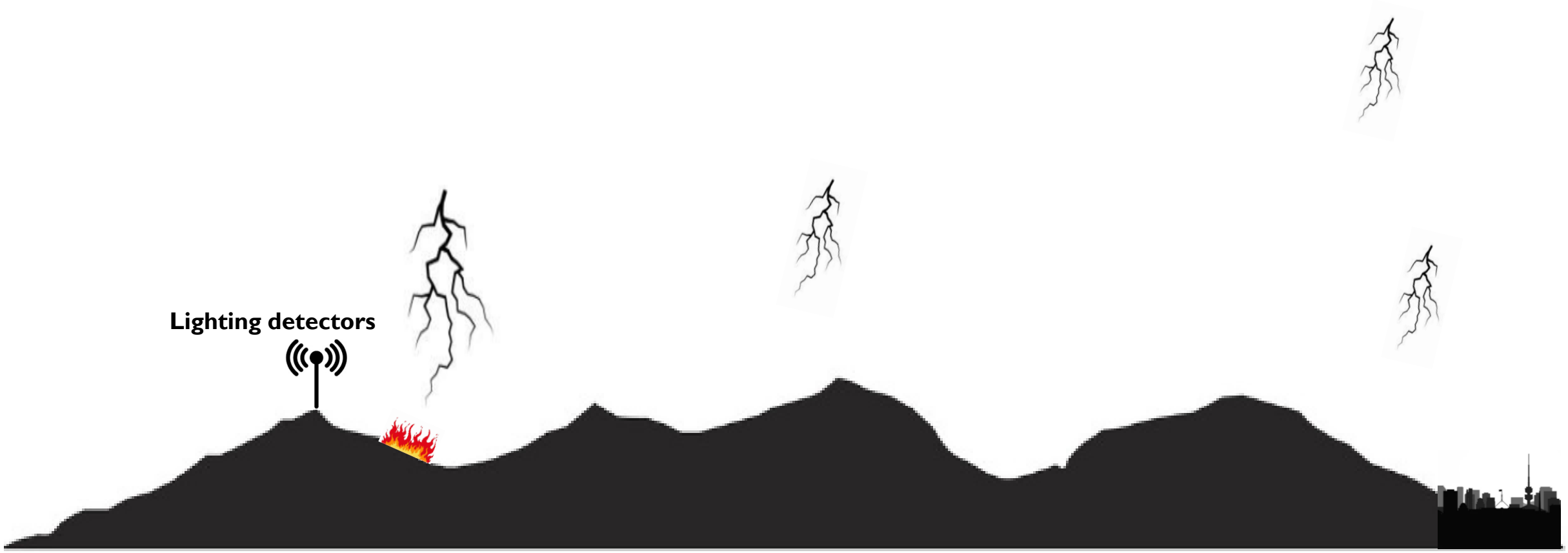
We will achieve this through:

- Undertaking advanced research and development
- Demonstrating technological capabilities
- Engaging in thought leadership
- Advocating for and shaping standards and regulations
- Providing independent evaluation and benchmarking
- Supporting innovation

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION

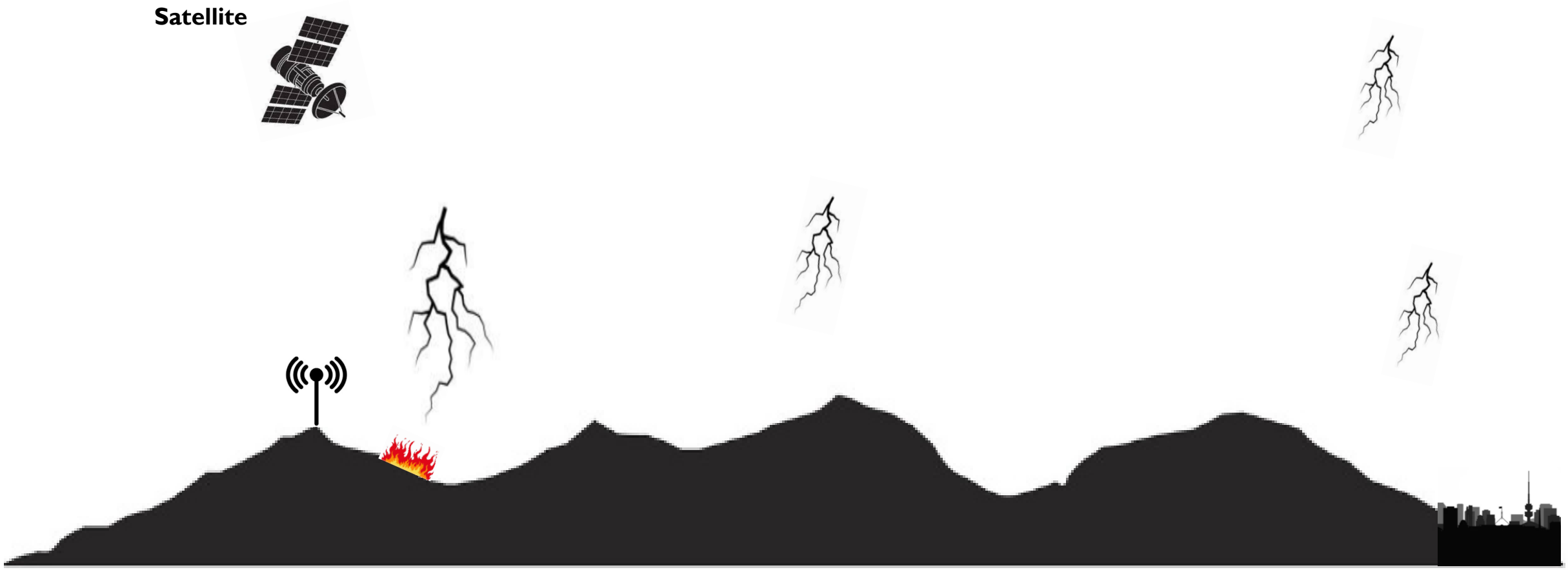
Yebra et al. 2021, AJEM

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



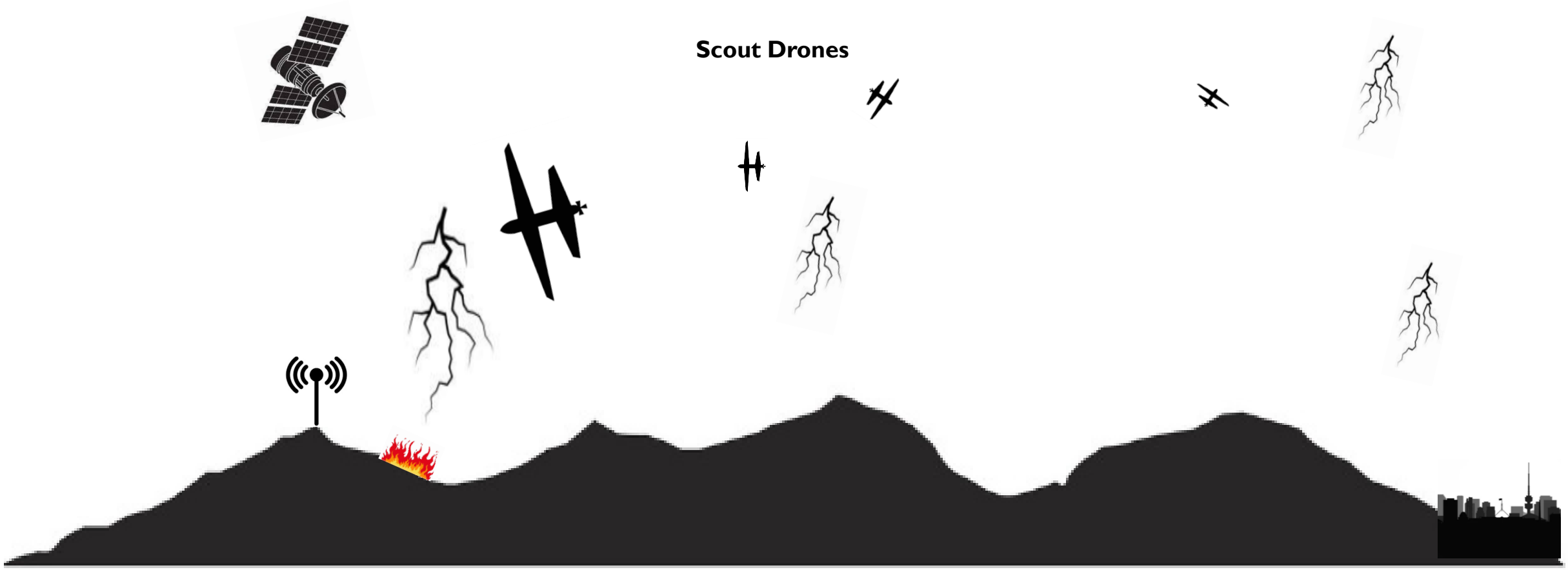
Yebra et al. 2021, AJEM

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



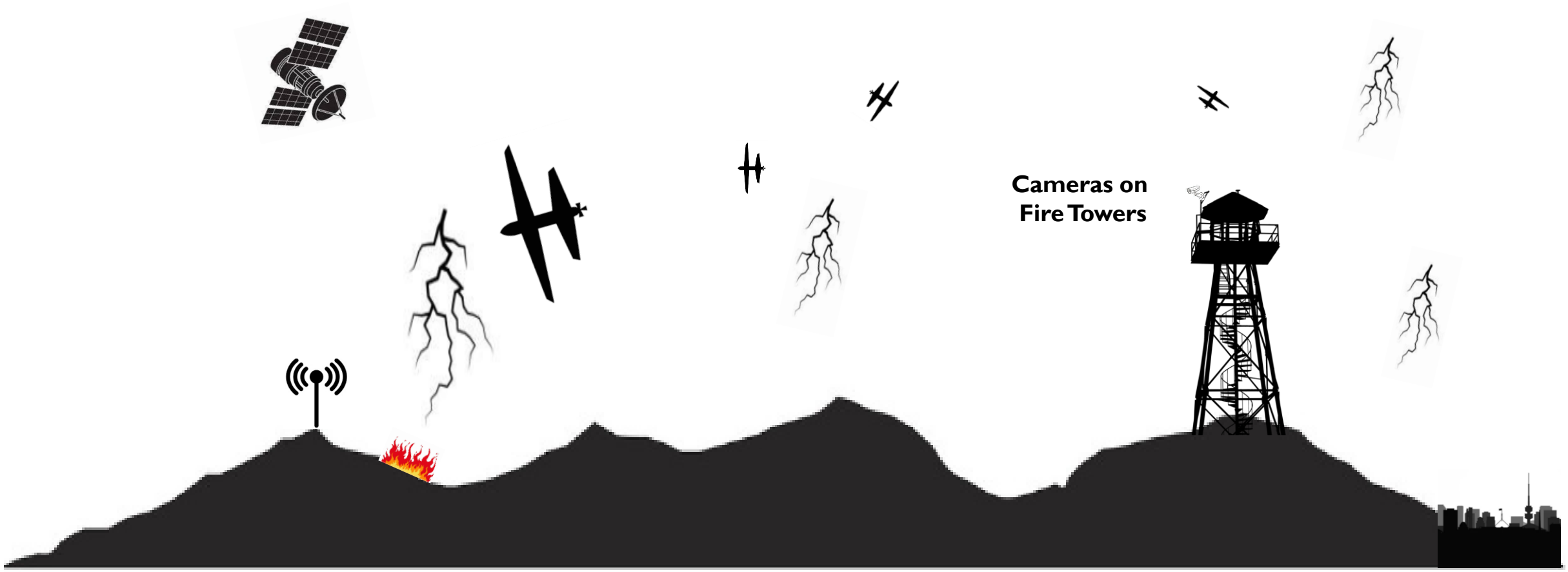
Yebra et al. 2021, AJEM

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



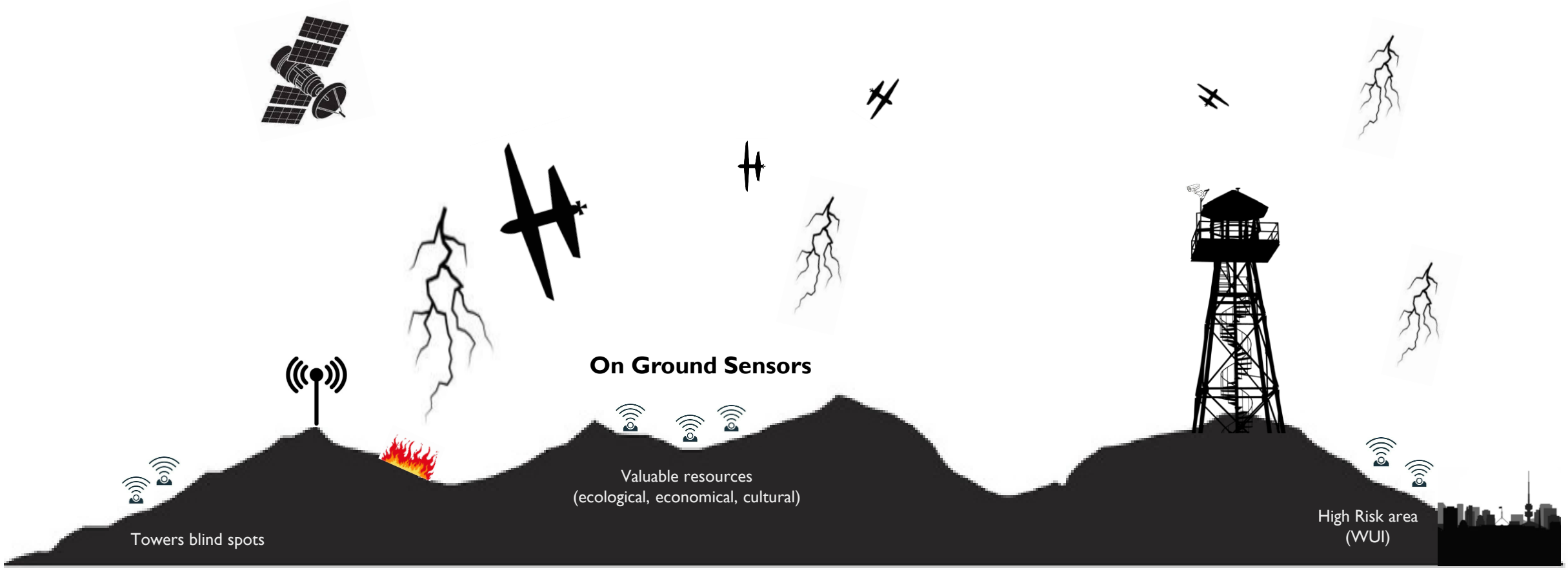
Yebra et al. 2021, AJEM

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



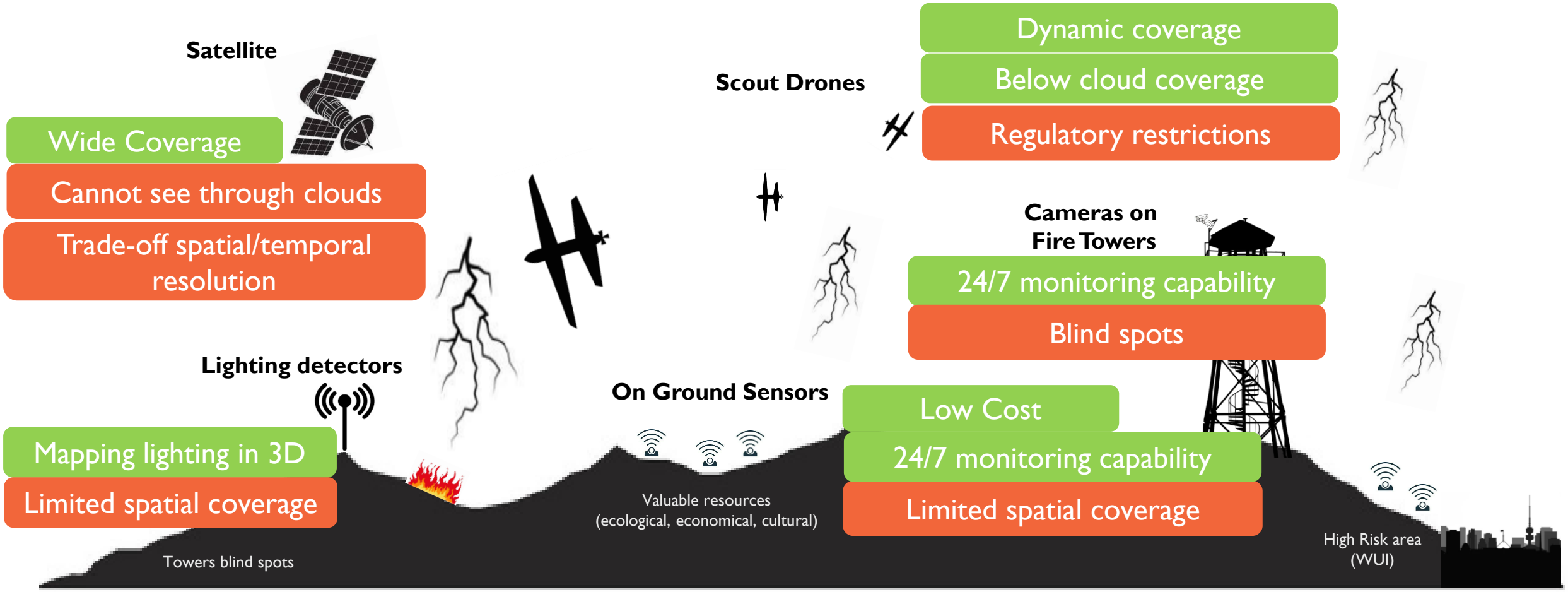
Yebra et al. 2021, AJEM

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



Yebra et al. 2021, AJEM

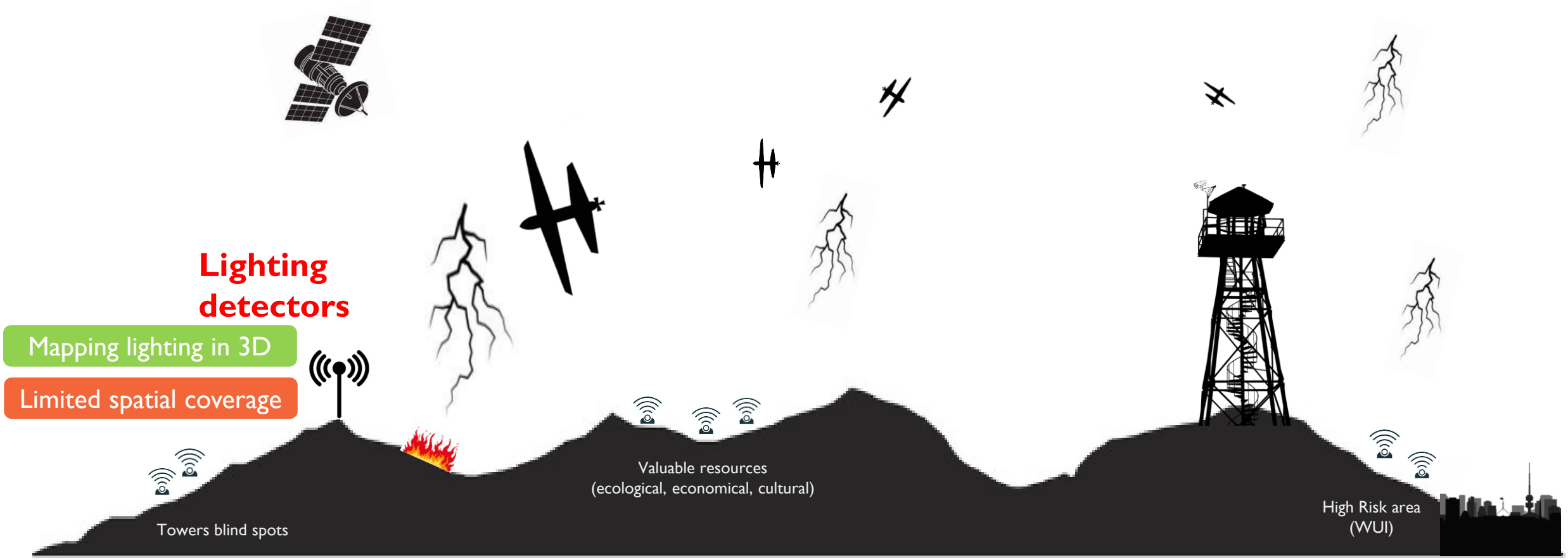
LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



Yebra et al. 2021, AJEM

Evaluation and Integration

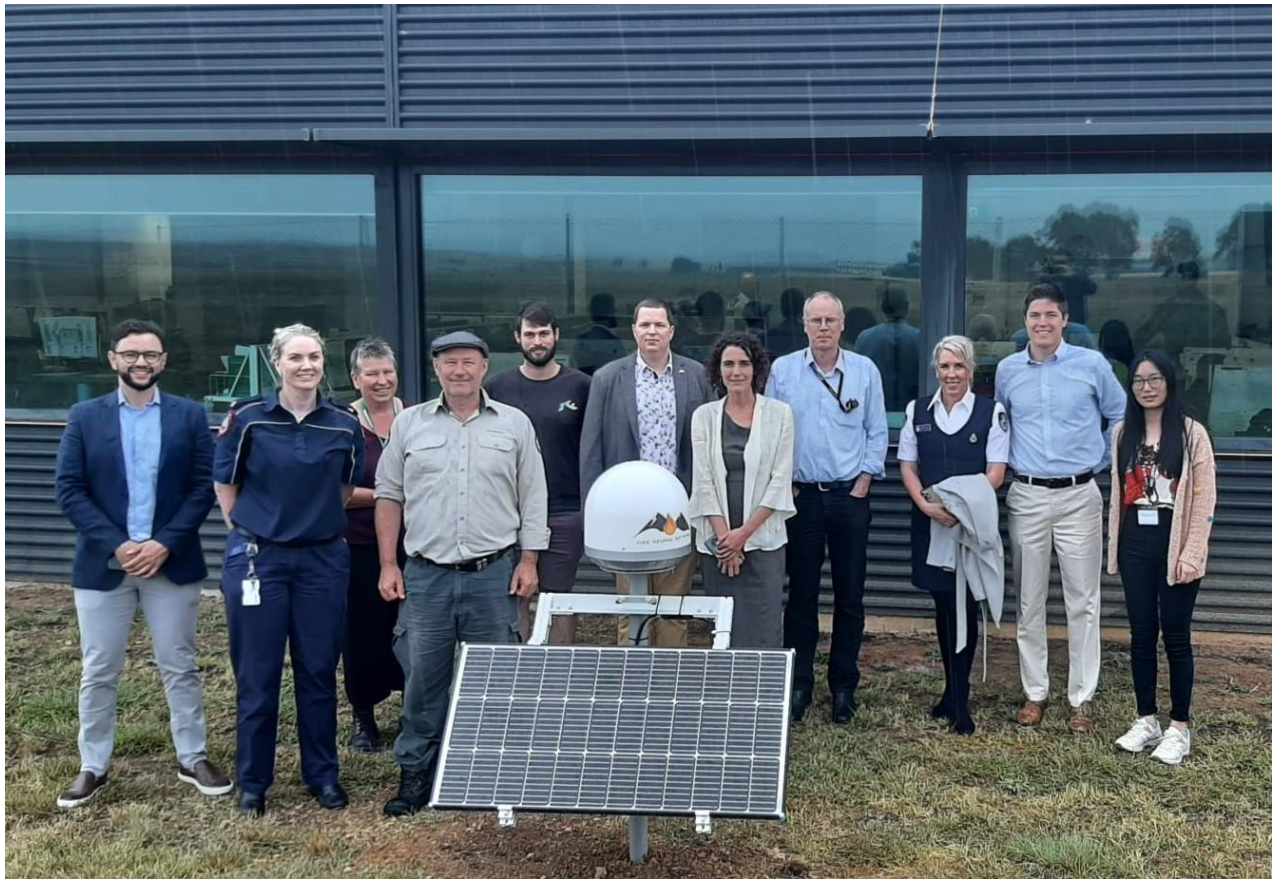
LAYERS OF TECHNOLOGY FOR IGNITION DETECTION

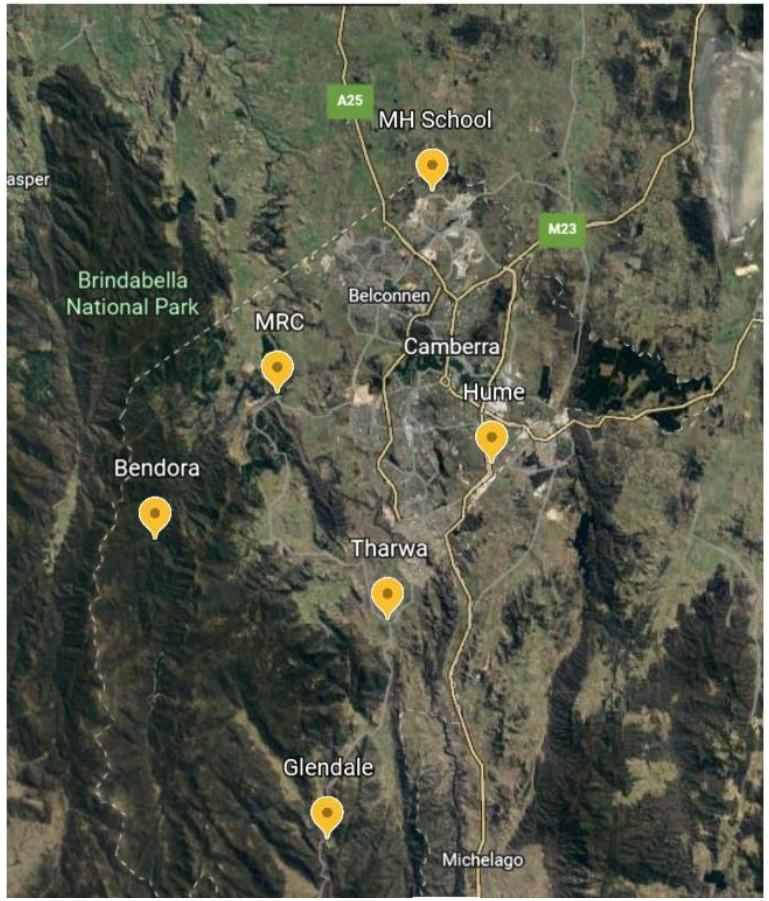


Yebra et al. 2021, AJEM

LIGHTNING DETECTORS - PROGRESS

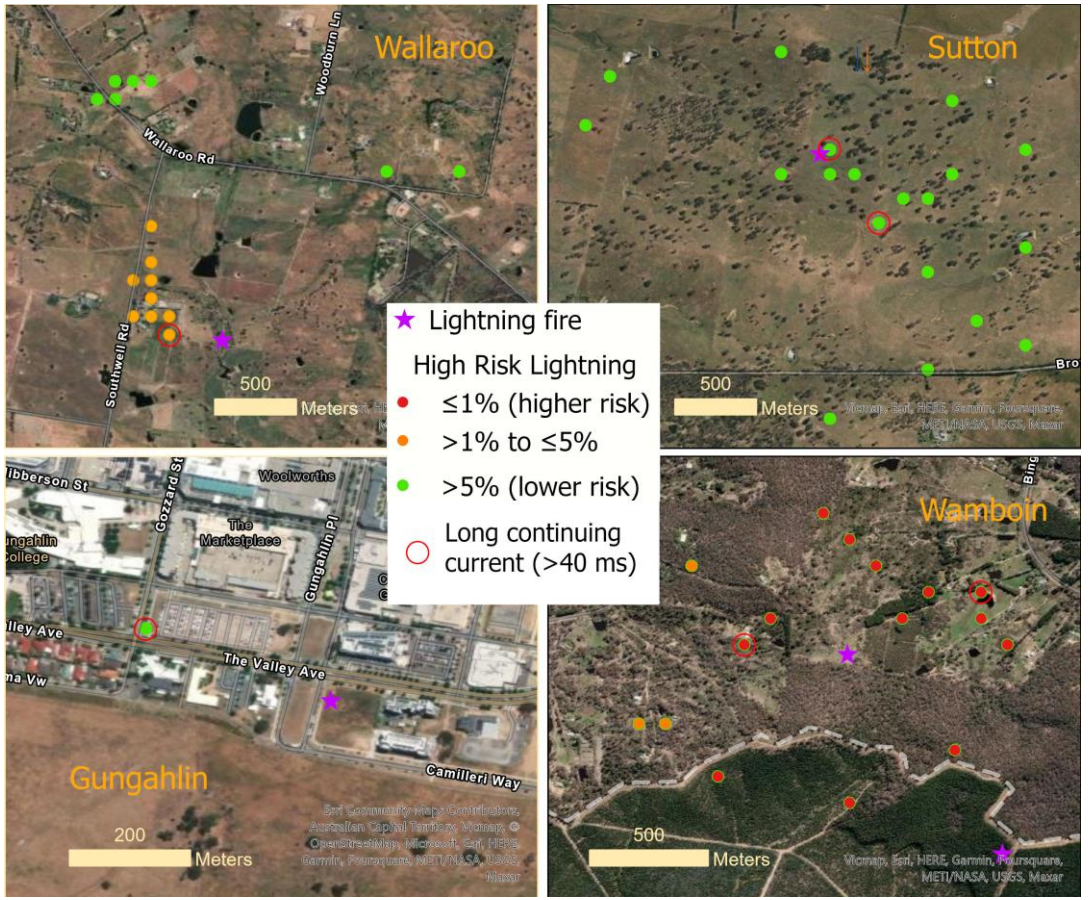
What we have accomplished



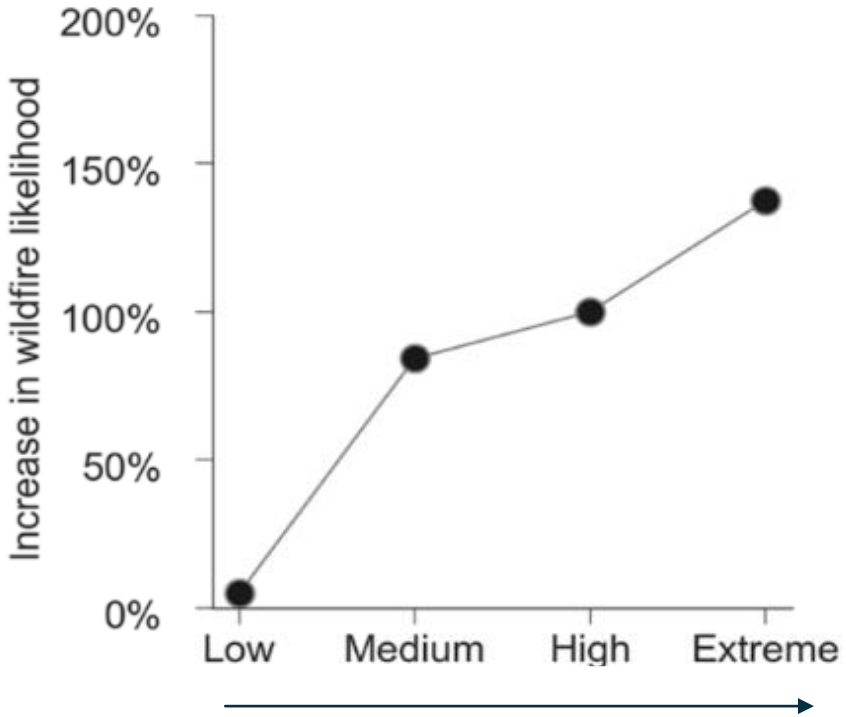


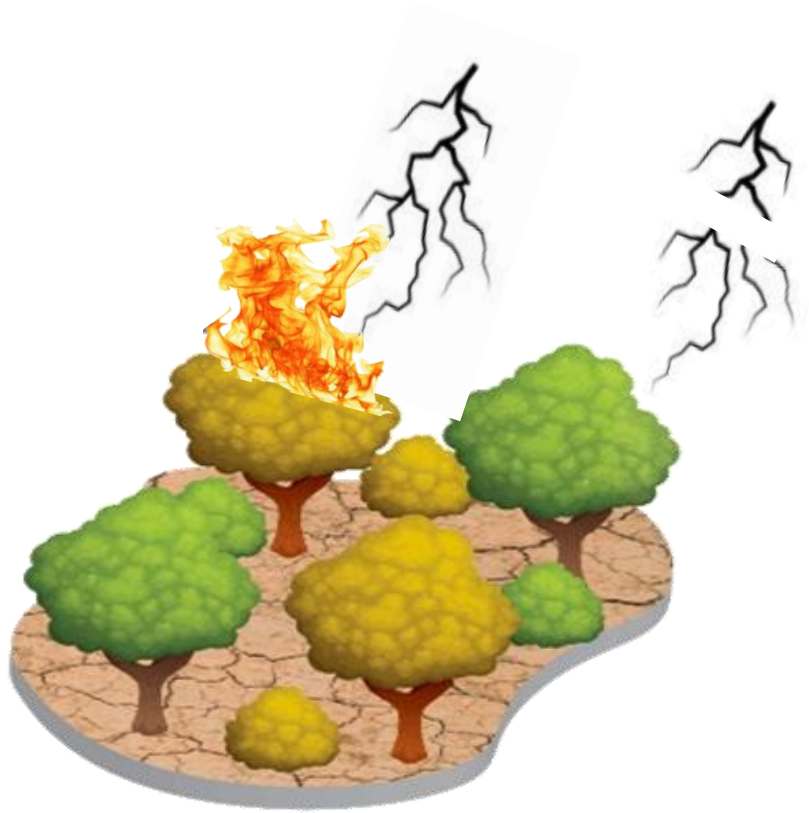
LIGHTNING DETECTORS - PROGRESS

Successful identification of High-Risk Lightning at 4 actual fires



ESCALATING VEGETATION STRESS FUELS LIGHTNING FIRE





Rao et al., 2023 (GRL)

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION

Satellite

Wide Coverage

Cannot "see" through clouds

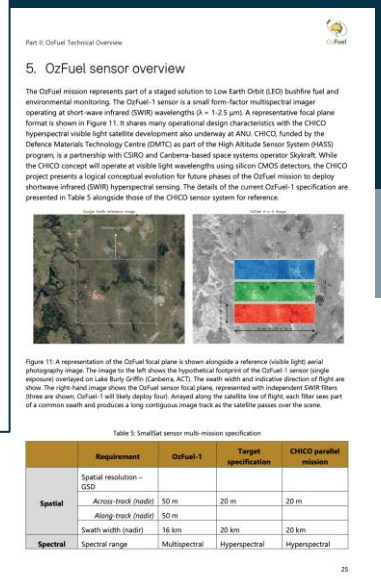
Trade-off spatial/temporal resolution

Yebra et al. 2021, AJEM

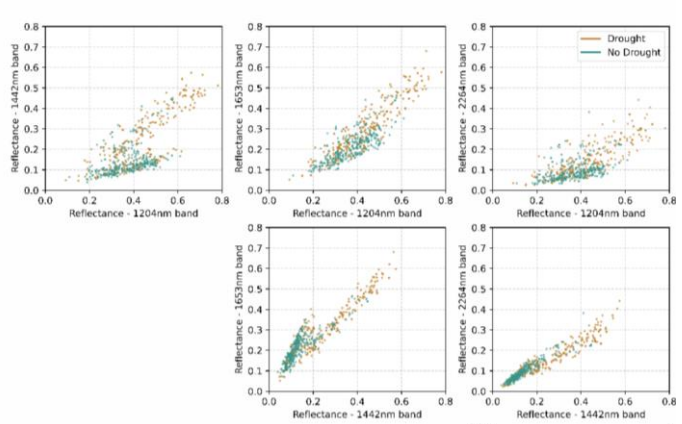
OZFUEL SATELLITE

What we have accomplished

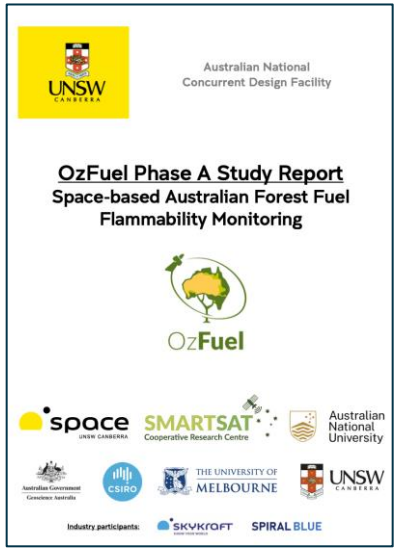
- Phase A report
  - Outline of the Concept of Operations

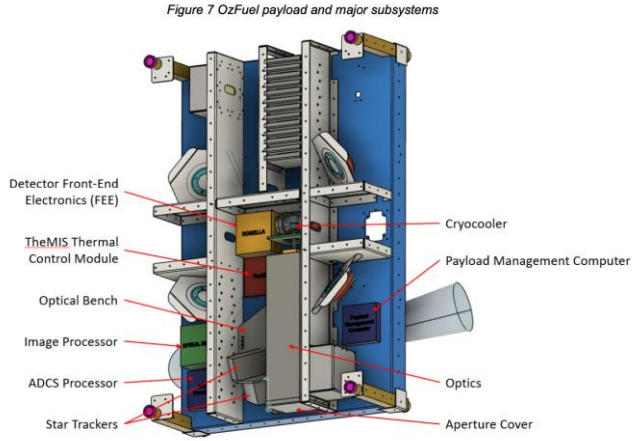


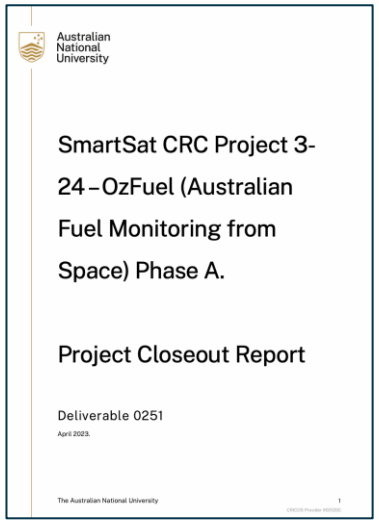
- Compiled the first spectral and biochemical database of flammability traits in eucalypt forests.



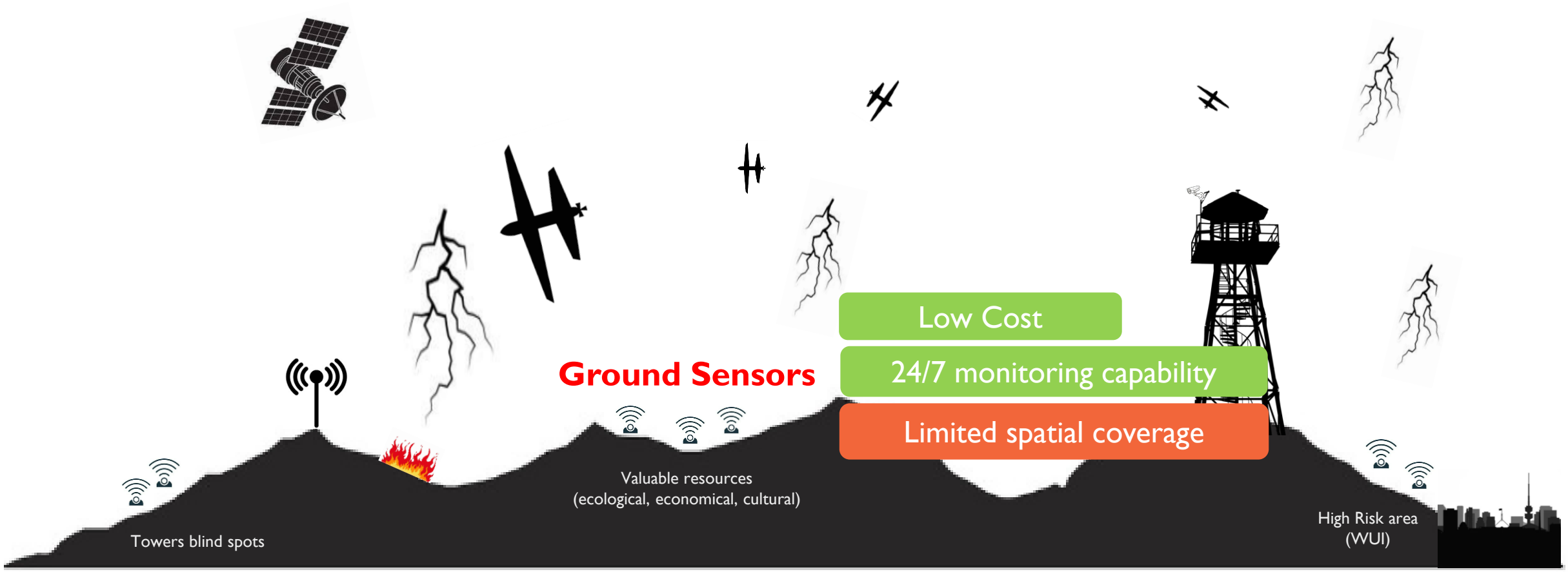
- Phase A mission concept analysis







LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



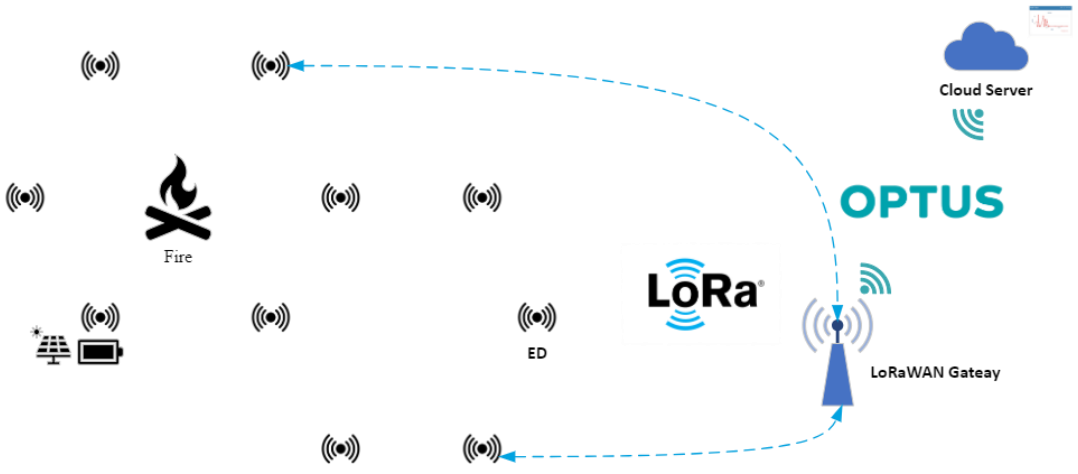
Yebra et al. 2021, AJEM

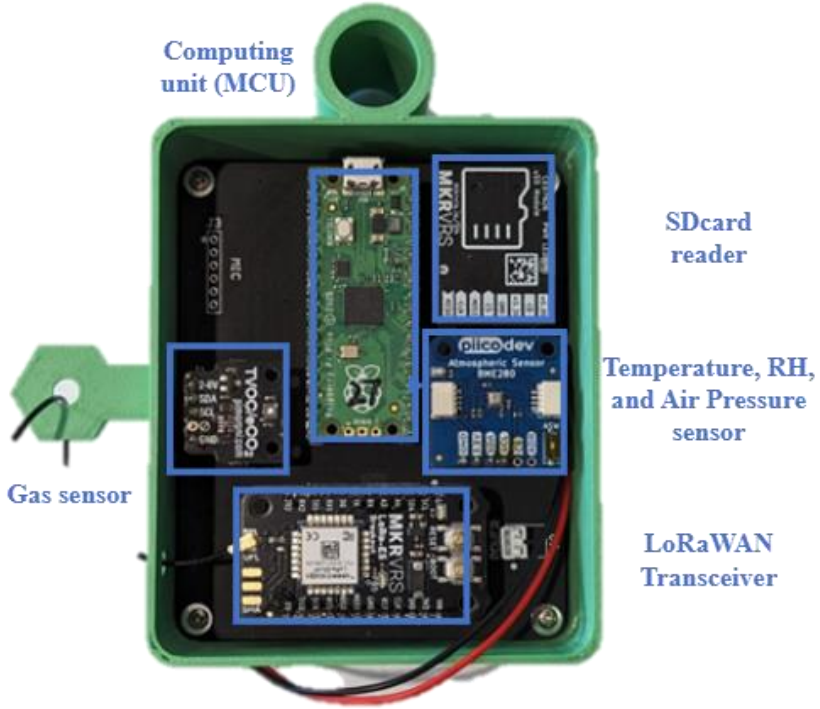
IOT GROUND SENSOR NETWORKS

What we have accomplished

- Successfully developed the proto-type sensor node to raise initial alarm
  - Periodic Environmental Monitoring: Update every 15 minutes
  - Active Reporting: Update every 7 seconds

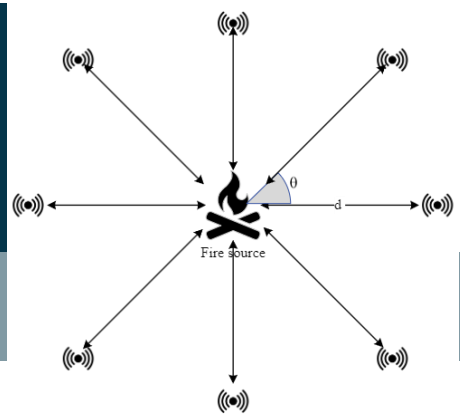
    https://thingspeak.com/channels/2241158
- Collected data from 7 experimental burns and 6 prescribed burns

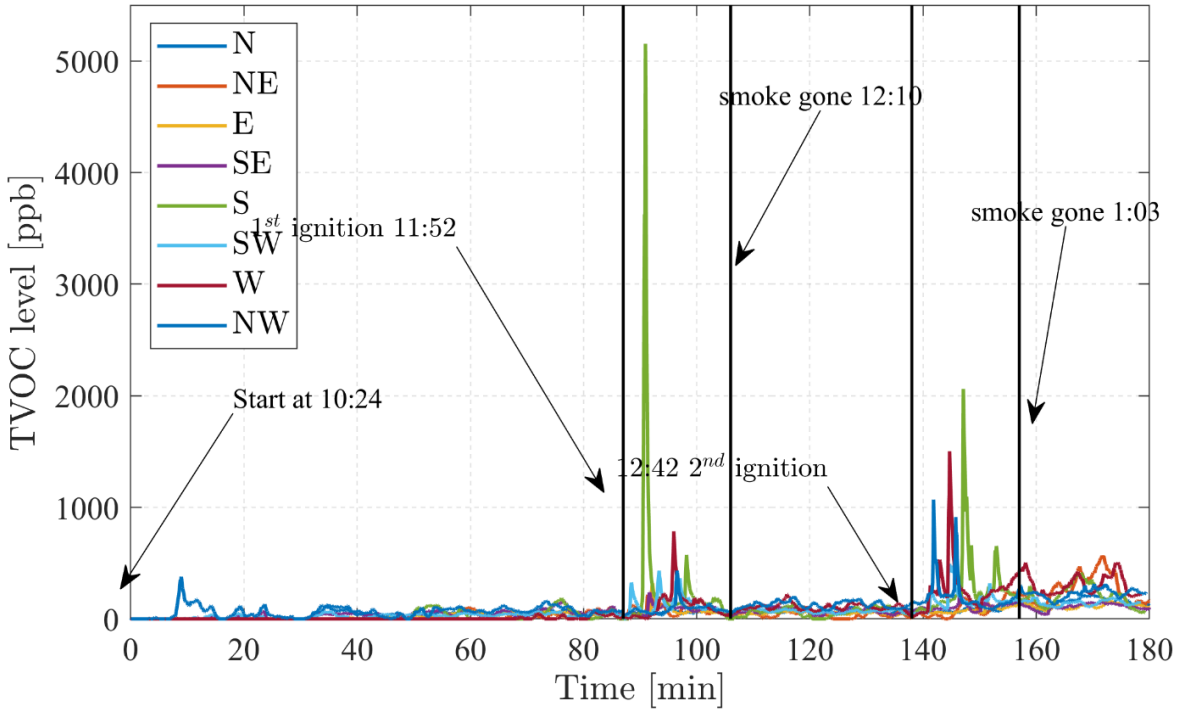


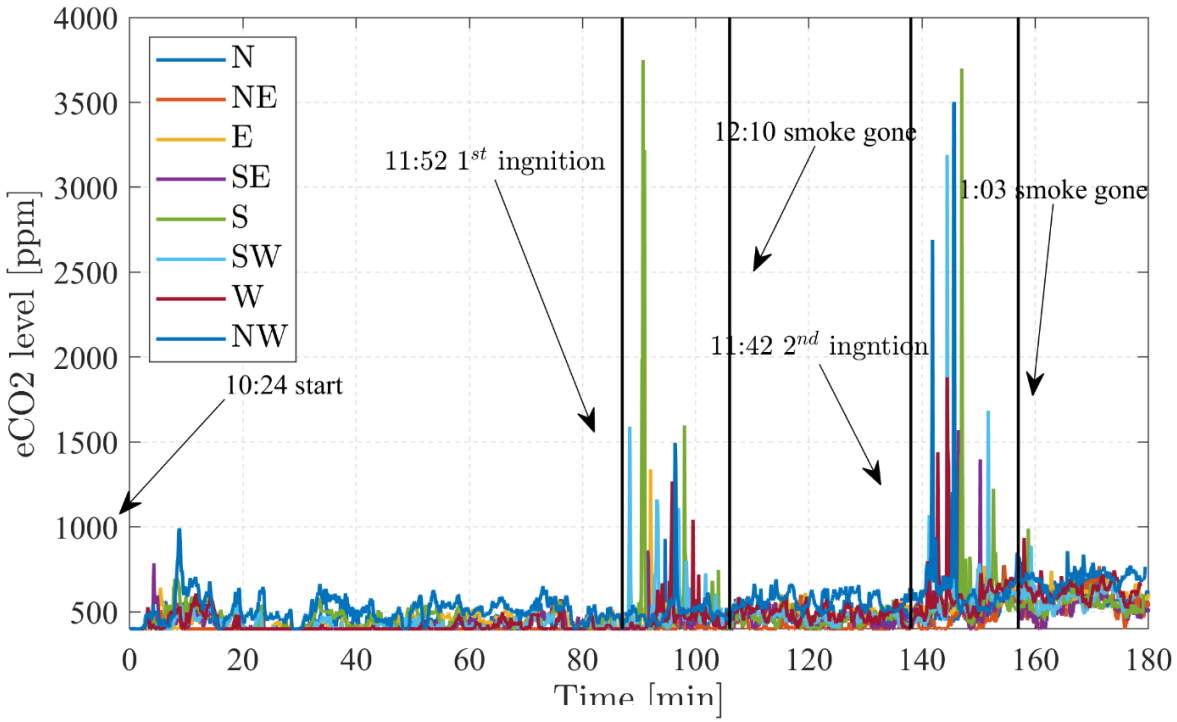


IOT SENSOR NETWORKS

What we have accomplished

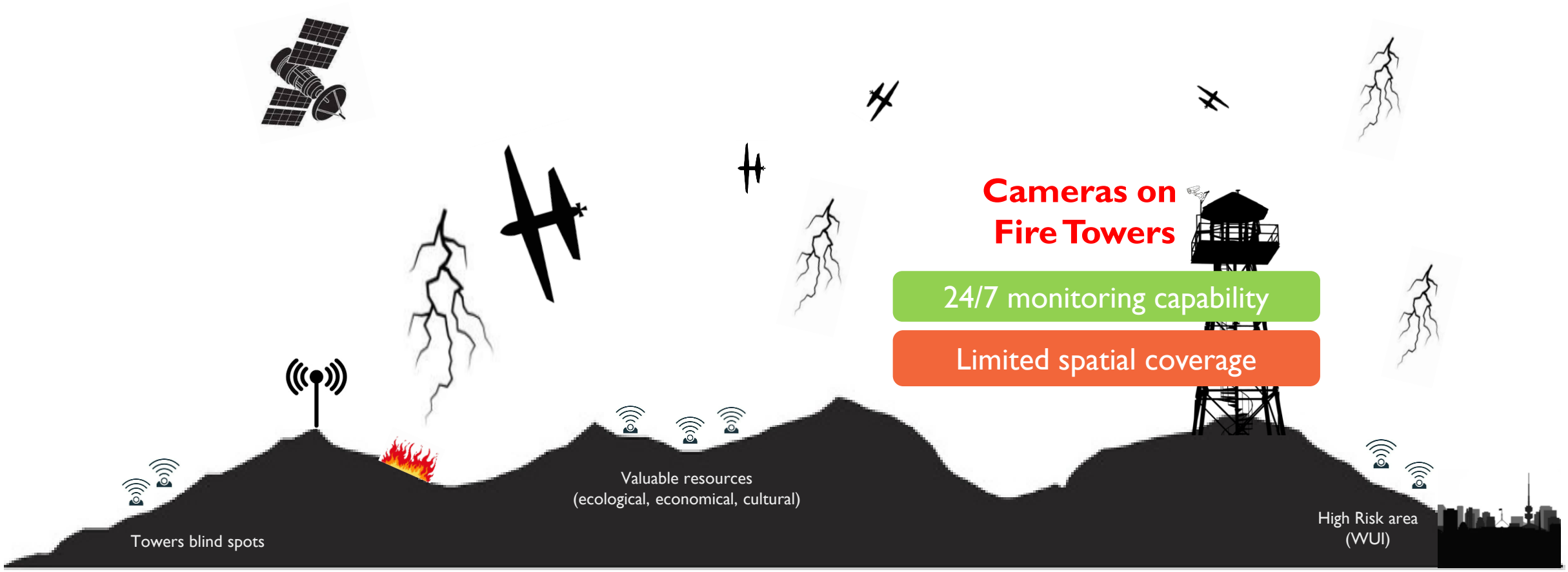






Measurements of sensor nodes
at 30 m from the fire source

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



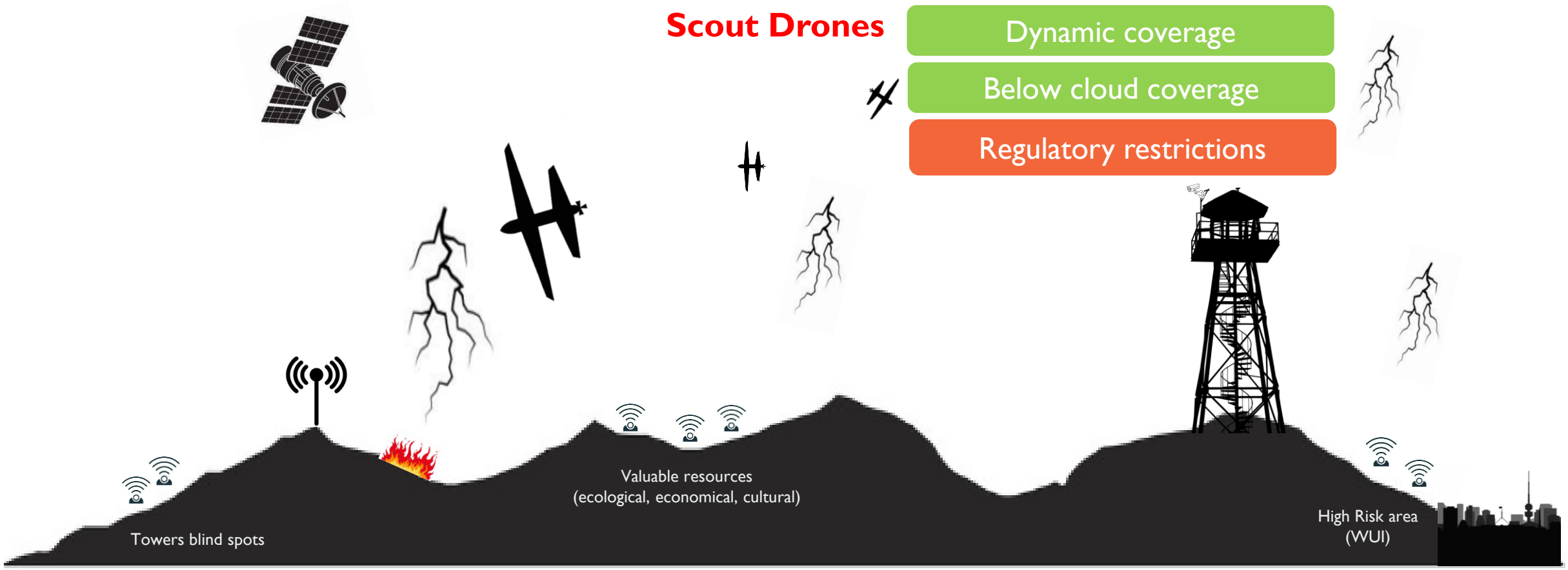
Yebra et al. 2021, AJEM

CAMERA-BASED VIDEO ANALYTICS

What we have accomplished

- Successfully built detection/segmentation models to detect fires (our segmentation)
- New state-of-the-art uncertainty estimation (we know when we are unsure)
  (Liu, et al, Model Calibration in Dense Classification with Adaptive Label Perturbation, ICCV'23)
- Need to generate a publicly available dataset of smoke-detecting camera imagery

LAYERS OF TECHNOLOGY FOR IGNITION DETECTION



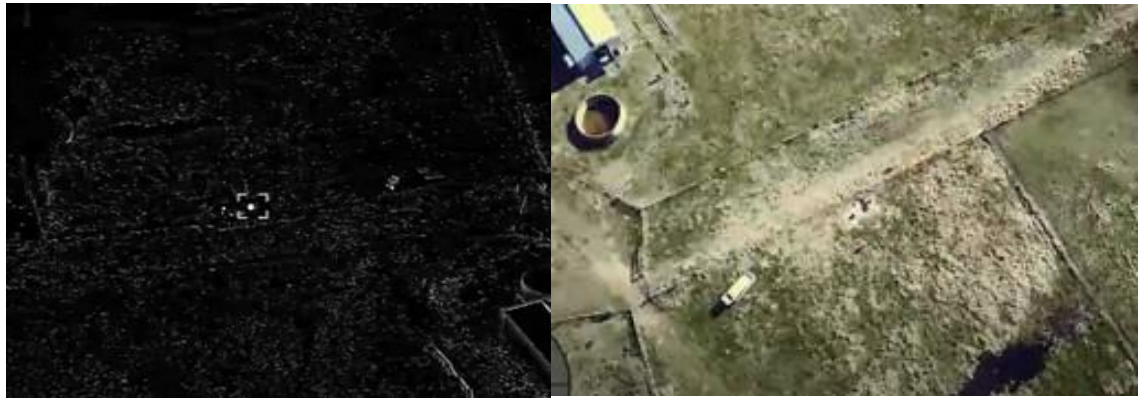
Yebra et al. 2021, AJEM

SCOUT DRONES

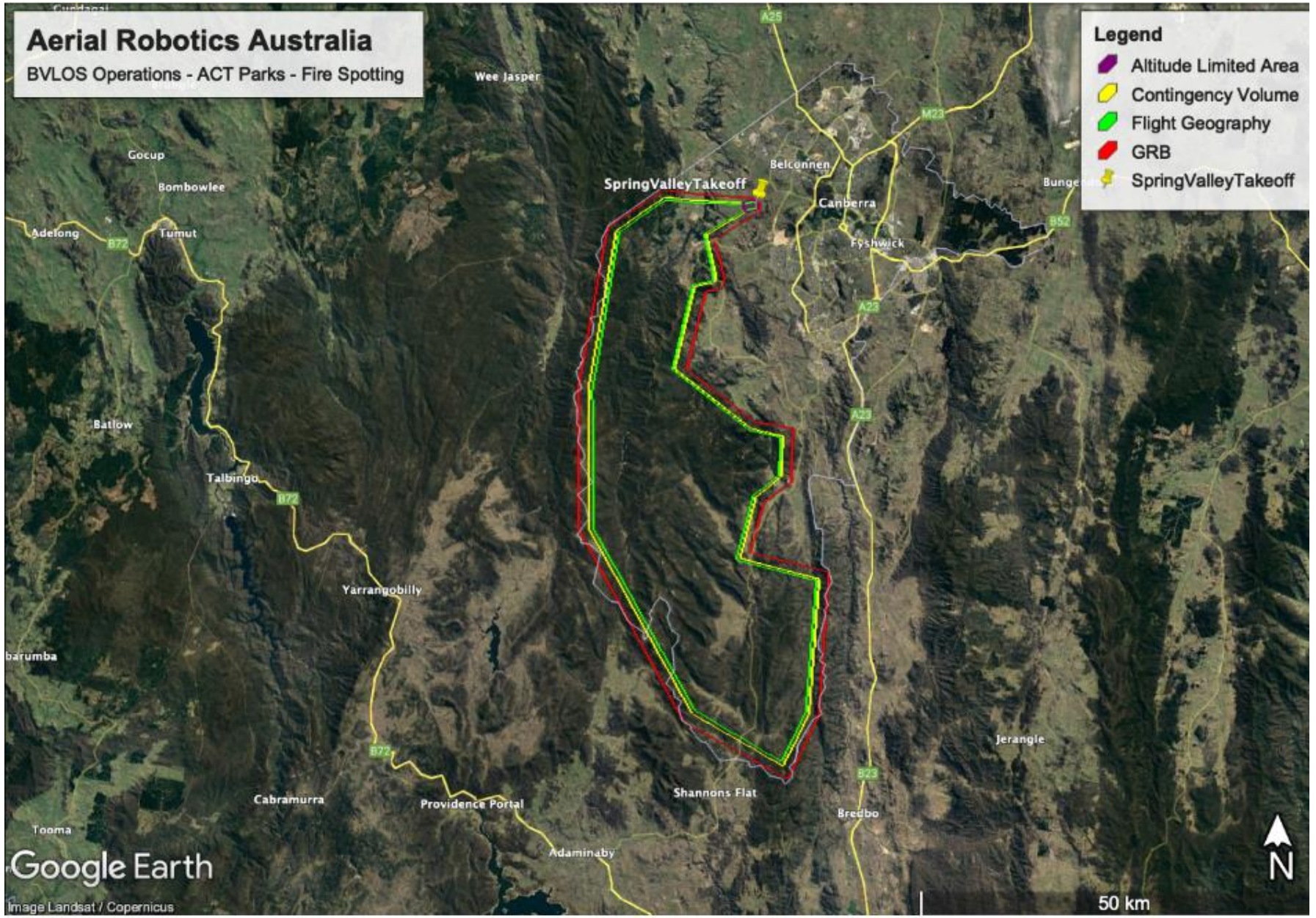
What we have accomplished

- Ongoing development of capability of Ottano platform working with Carbonix.
- Evaluation of thermal SIYI ZT30 camera and gimbal in flight conditions for small fires and heaters
- Development of manuals and procedures for EVLOS
- Obtained accreditation with CASA for EVLOS

Carbonix Ottano drone during tech demo in Oct.



Thermal and RGB image of gas heater during an experimental flight


Aerial Robotics Australia
BVLOS Operations - ACT Parks - Fire Spotting
Legend
Altitude Limited Area
Contingency Volume
Flight Geography
GRB
SpringValleyTakeoff
SpringValleyTakeoff
Wee Jasper
Gocup
Bombowlee
Adelong
Tumut
Batlow
Talbingo
Yarrangobilly
Cabramurra
Providence Portal
Tooma
Adaminaby
Belconnen
Canberra
Fyshwick
Shannons Flat
Bredbo
Jerangle
Google Earth
Image Landsat / Copernicus
50 km
N

EVALUATION

What our project will accomplish long-term

Inform the strategic and complementary deployment of each detection platform

- Determine where and when each technology can detect and locate fires
- Quantify spatial and temporal variation in fire risk

EVALUATION

Stratify ignitions by the factor that influence detections

1. Topography, vegetation structure, weather, time of day
2. Proximity to detection sources
3. Fuel, climate and weather, season

Validation Toolbox

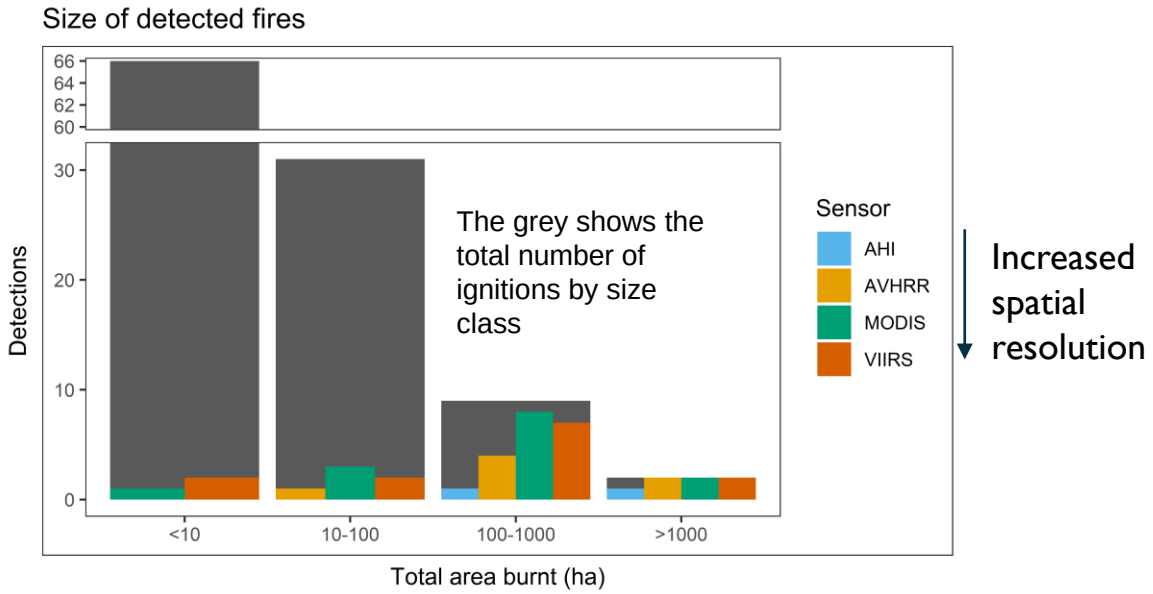
1. Prescribed burns/Bushfires
2. Experimental fires
3. Patio heater/Smokeshield Smoke machine

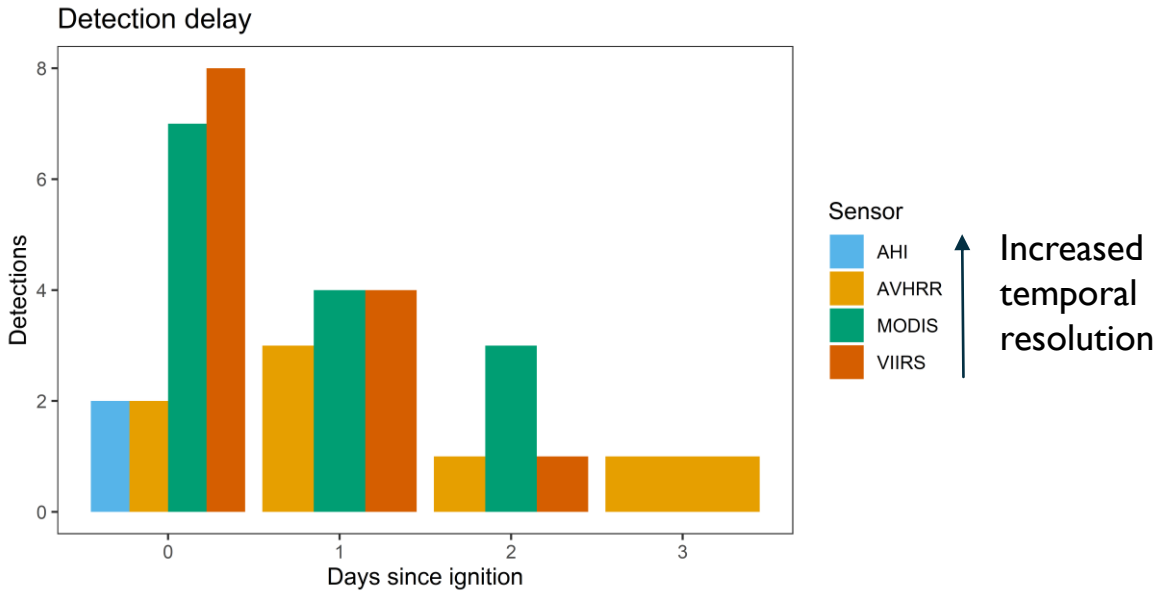
Artificial fire signals

Experimental Burns

Planned burns (ACT PCS)

PERFORMANCE OF EXISTING OPERATIONAL SATELLITES GA'S SENTINEL SYSTEM





- Most satellites can detect the biggest fires but the smaller fires are mainly detected by those satellites with better ground.
- Most small fires are missed.

- Most satellites able to detect ignitions within <1 day since ignition
- AHI is the only satellite that provides sub daily images but has the worst spatial resolution what explain the low detection rate

The are 108 fires in the database

FIRE SUPPRESSION

What we have accomplished

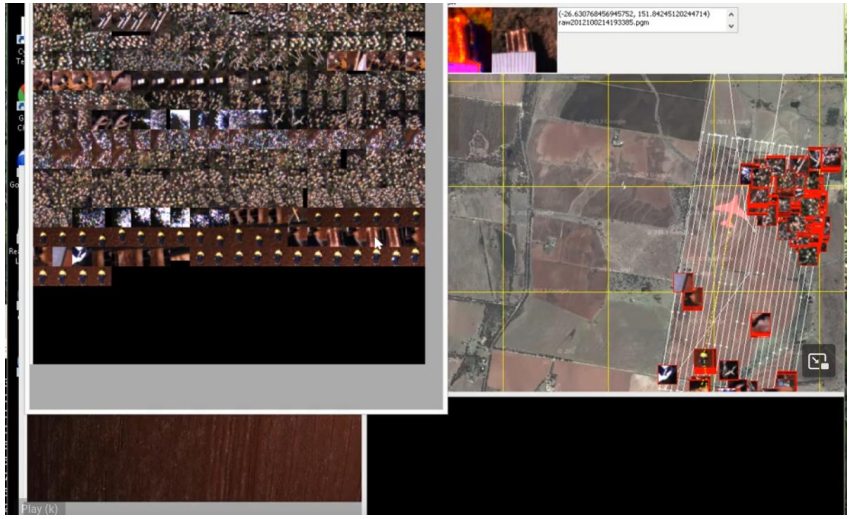
- Water bomb technology
  - Scoped to be cheap (disposable electronics, cardboard airframe)
  - Designed to be dropped from low tech vehicles and self-targeting (crop dusters, flight trainers, etc) [Cessna 172 has a payload of 395kg]
  - Design to be dropped from cargo vehicle from high altitude [P3-Orion carries 8 tons]
- Honours project (2021) developed a 2kg water glider to demonstrate potential.

INTEGRATION

What our project will accomplish long-term

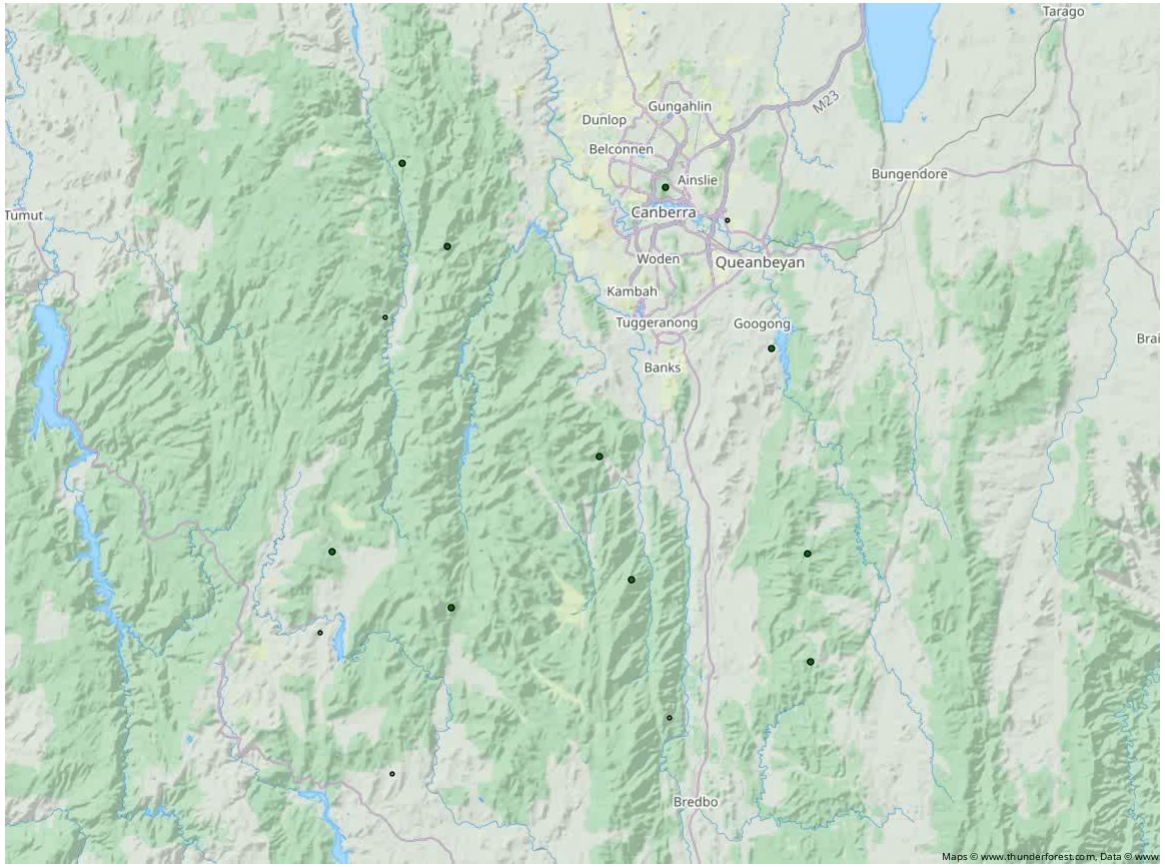
This project considers the challenge of integration of technology for early detection and suppression of ignitions in deep bushland. It will encompass

- Coordination between different physical technology levels.
- Algorithms and Data Fusion that integrate multiple data streams to support high level decision making.
- Control and communication for scheduling resources.
- Human Machine Interaction studies to ensure technology supports existing human control and command structures.



Data visualization interface developed for outback Joe competition. Multiple images are displayed in mosaic and on map to provide an effective interface for machine aided human analysis.

INTEGRATION



Lightning strikes (a total of 309 strikes)

Drones (85km/h speed with 8 hour flight time)

-- Drones trajectories

2,358 Km^2

INTEGRATION

What we have accomplished

- Registered as "Bushfire Research Centre of Excellence" in the XPrize Autonomous Wildfire Response track.
  - Teams have 10 minutes to autonomously detect and suppress a high-risk fire in a 1000 km2, environmentally challenging area.
  - Partnering with OPTUS, Carbonix, FNN, Advanced Navigation, and more …
- Built understanding across multiple technological domains involved in bushfire detection and suppression.
- Built relationships with bushfire experts to make the technology useful after the competition.

Bushfire Research
Centre of Excellence

THANK YOU

Bushfire Research Centre of Excellence

FIRE NEURAL NETWORK

MONASH University

Australian National University

Stanford University

ADVANCED NAVIGATION

CARBONIX

FIRETECH CONNECT

NSSN NSW Smart Sensing Network

fireurisk

ORORA TECHNOLOGIES

Nova Systems

Natural Hazards Research Australia

SMARTSAT COOPERATIVE RESEARCH CENTRE

BUSHFIRE & NATURAL HAZARDS RESEARCH CENTRE

THANKYOU

Bushfire Research Centre of Excellence

Contact Us

A/Prof Marta Yebra

Director, Bushfire Research Centre of Excellence

Fenner School of Environment & Society

School of Engineering

Institute for Space

Email: bushfire.rcoe@anu.edu.au

Phone: +61-2-612 54107

Twitter/X: @BushfireRCoE

LinkedIn: Bushfire Research Centre of Excellence

After the Orroral Valley Fire @ Marta Yebra