CubeSat Constellation for Monitoring and Detection of Bushfires in Australia

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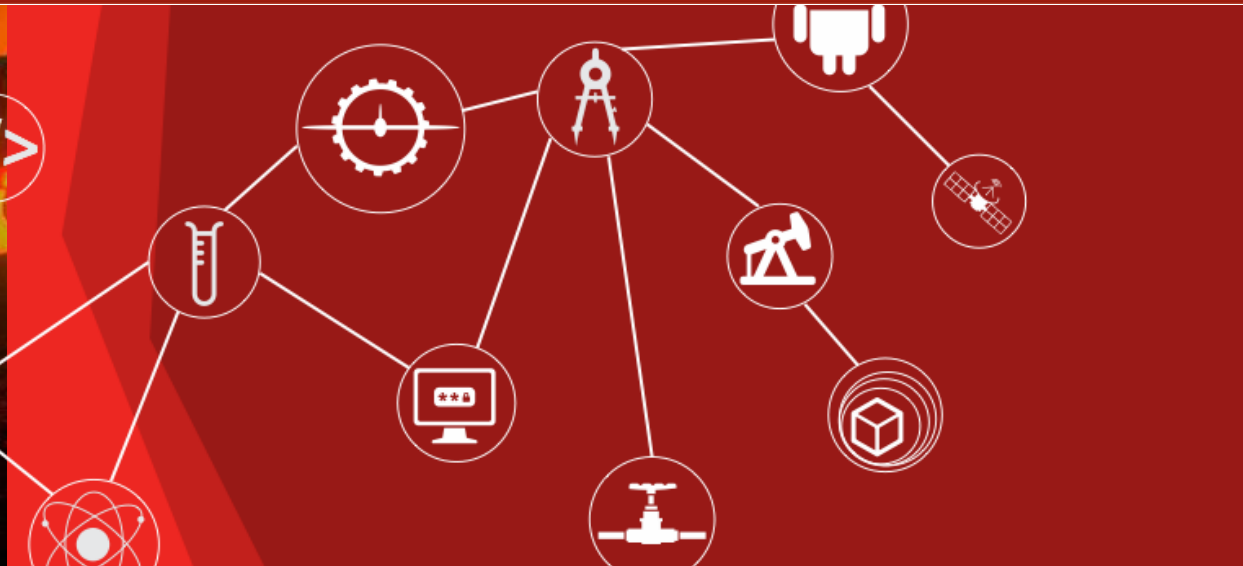
Never Stand Still | Engineering



Bushfires in Australia

Black Saturday Bushfires

Winmalee Bushfires 2013

abc.net.au

Mt Stromlo Fire

physics.anu.edu

Existing Systems

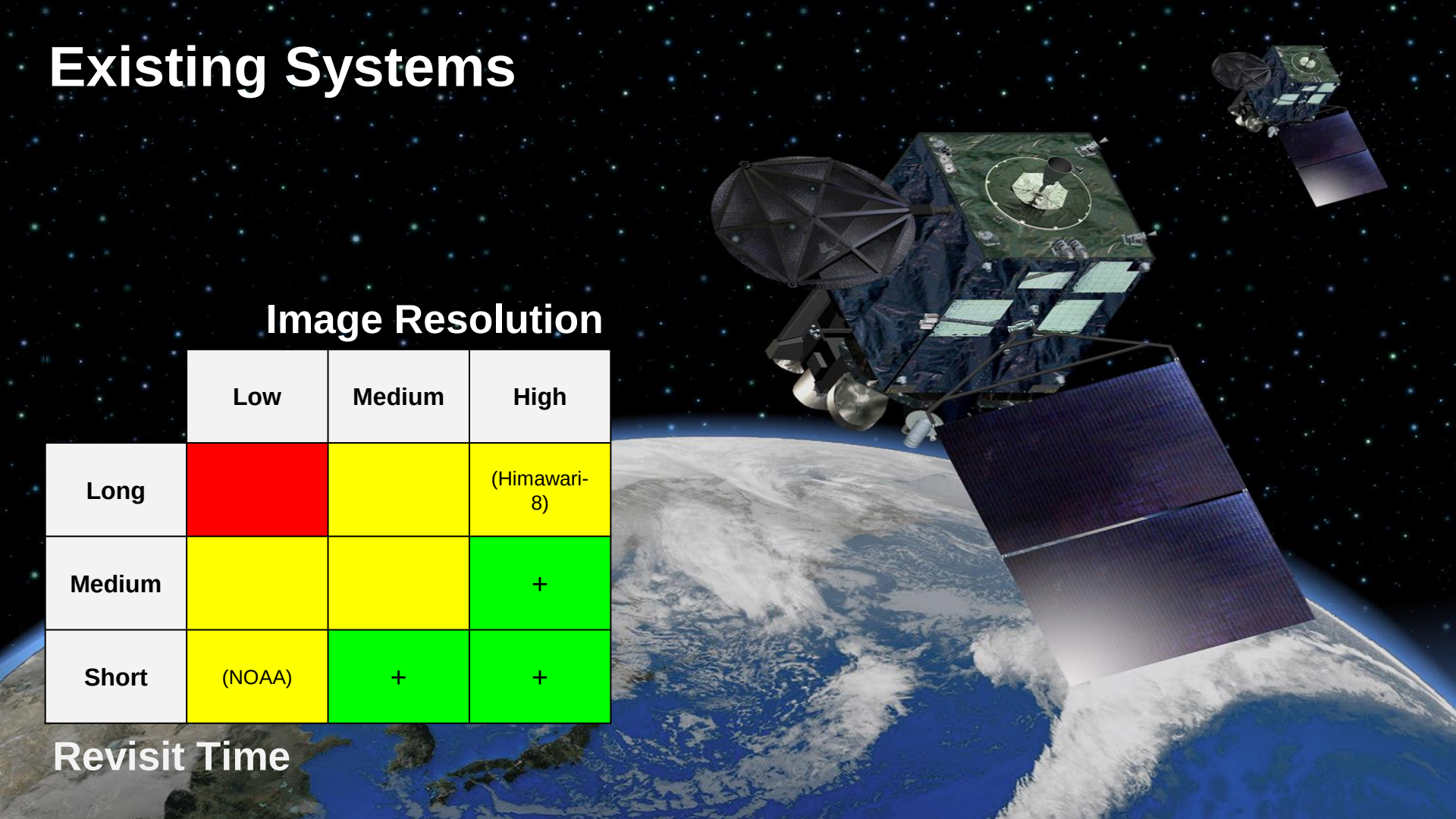
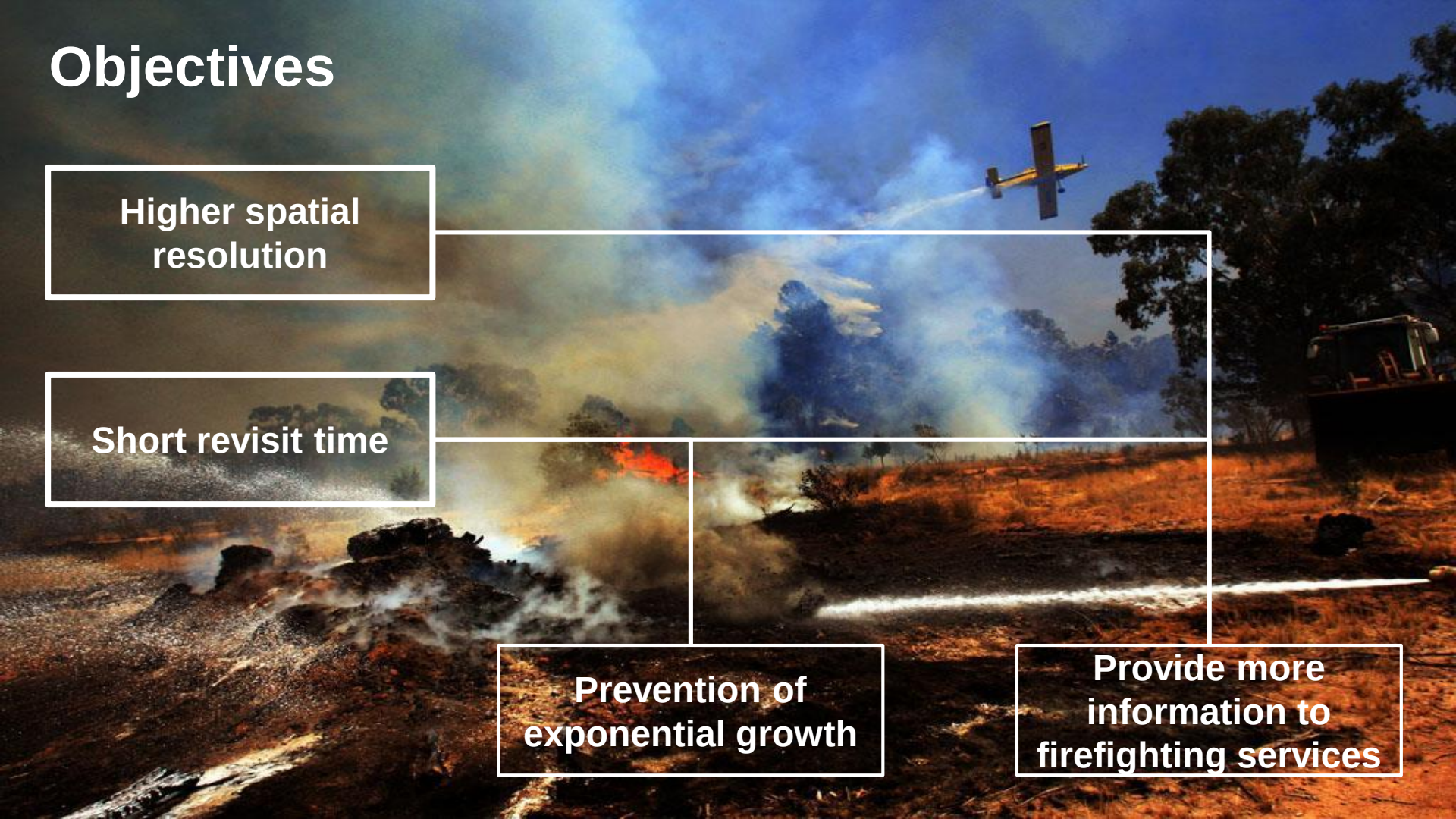


Image Resolution

Revisit Time	Low	Medium	High
Long			(Himawari-8)
Medium			+
Short	(NOAA)	+	+

Objectives



Higher spatial resolution

Short revisit time

Prevention of exponential growth

Provide more information to firefighting services

Need for Spatial Precision

Need for Spatial Precision

Need for Early Detection Before Exponential Growth

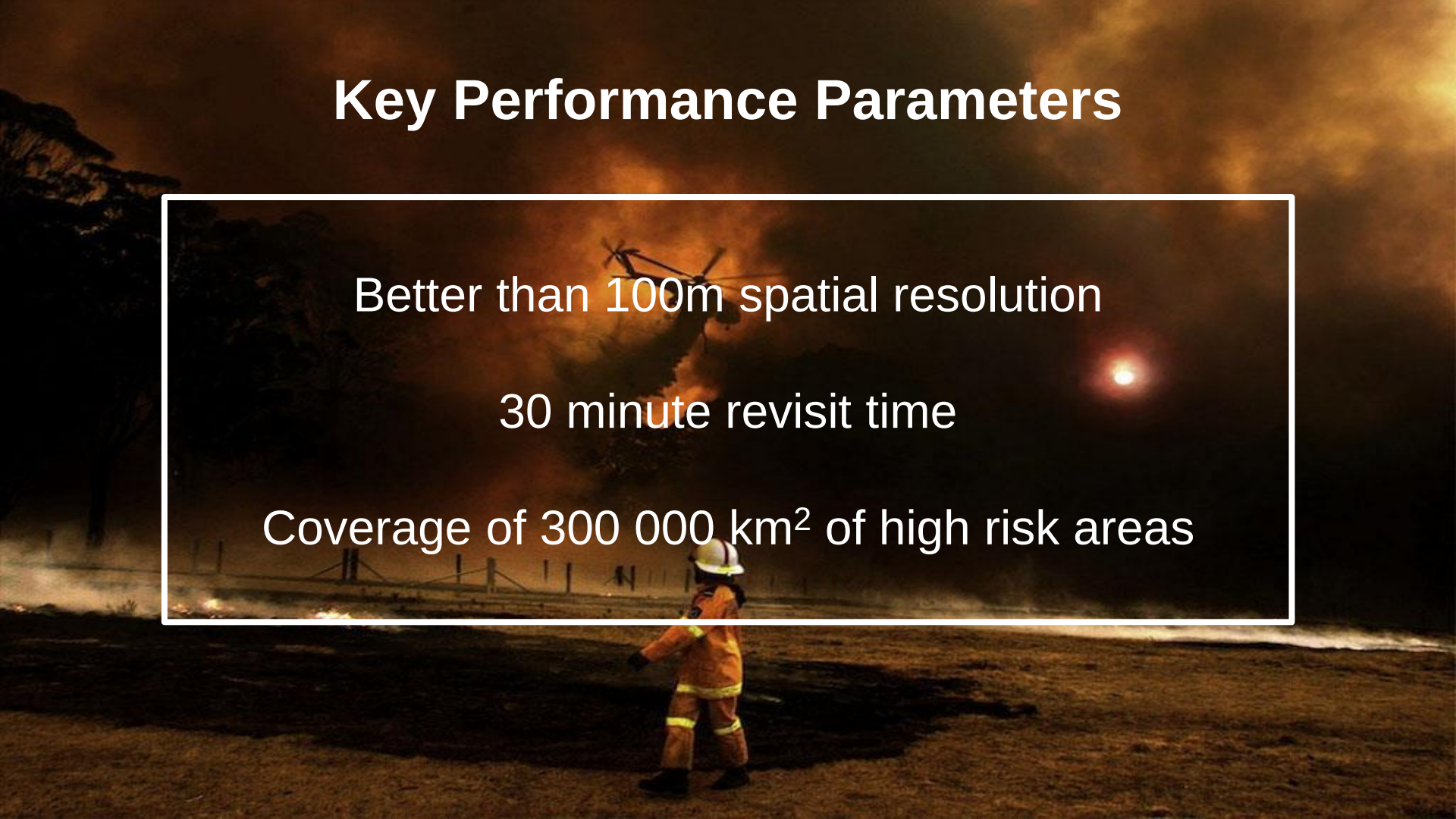
30 minutes

Key Performance Parameters

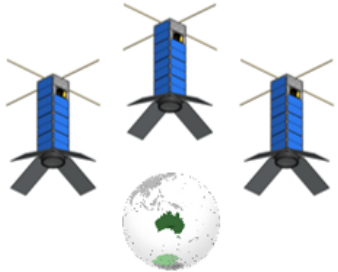
Better than 100m spatial resolution

30 minute revisit time

Coverage of 300 000 km^2 of high risk areas



Concept of Operations



Space Segment

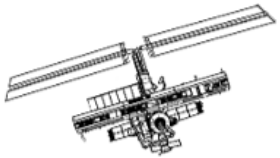
Satellite scans Australia

2

Satellite receives coordinates from ground station

Ground station receives imaging data from satellite

1



Data from large weather satellites such as Himawari-8

Information available to the general public

Information sent to fire command

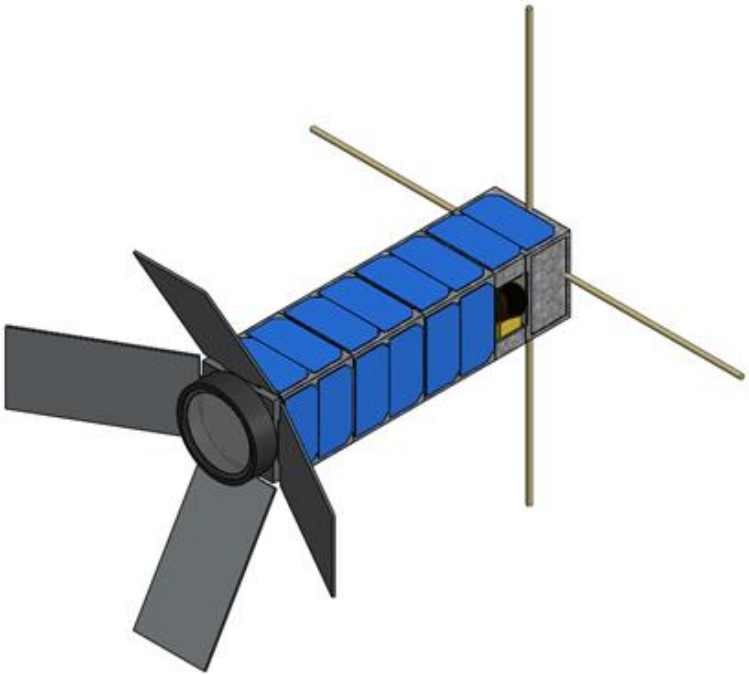
Data from government organisations and fire risk analysts

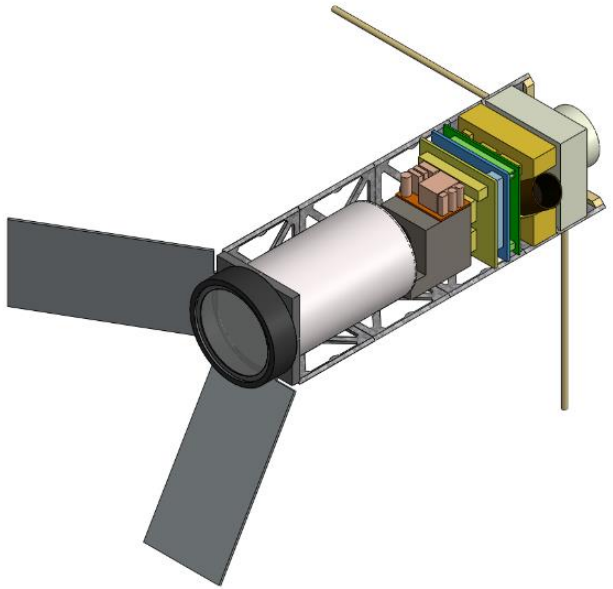
Ground Segment

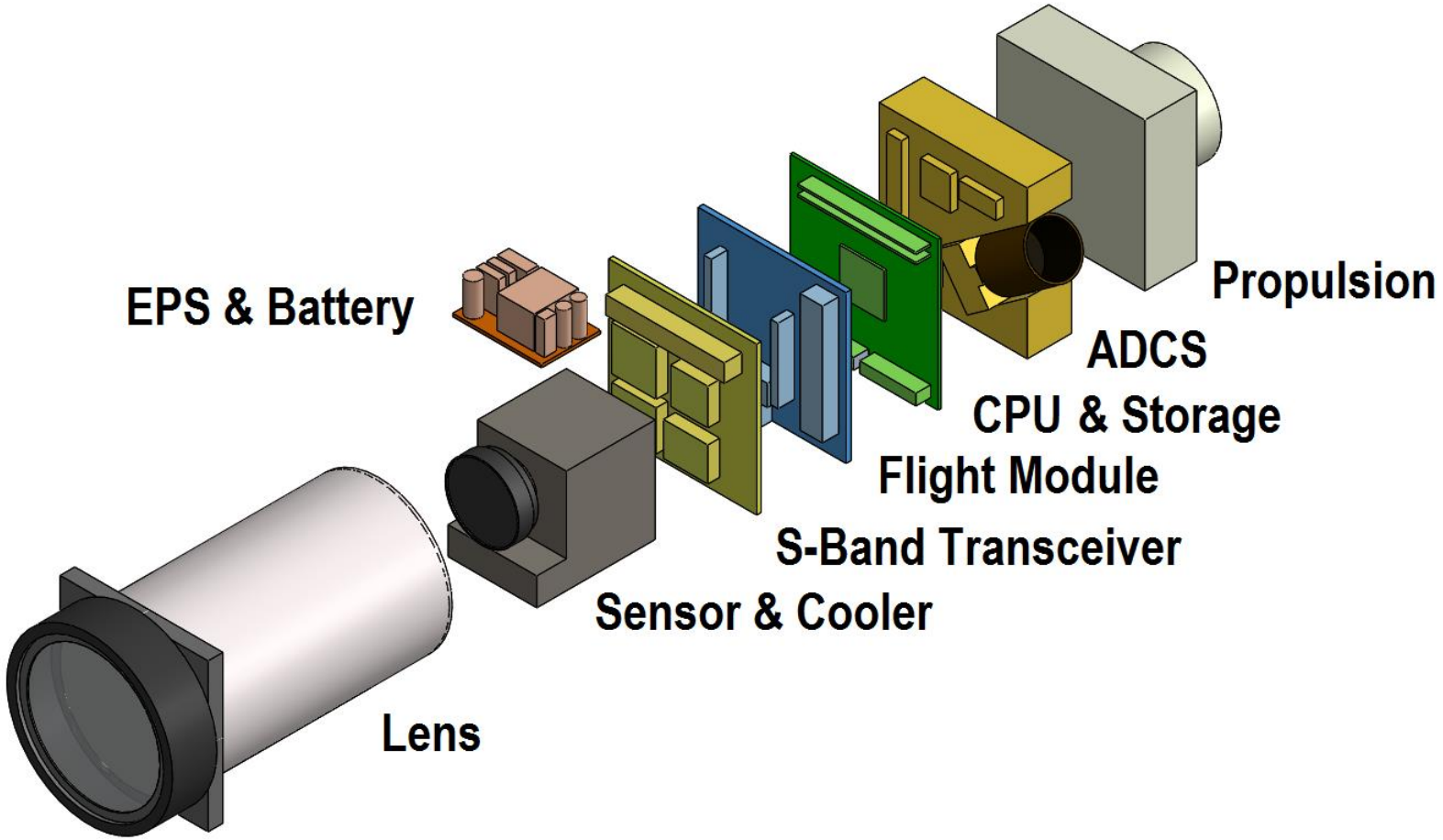
Ground stations located around Australia
Data centres to host imaging data
Fire and risk analysis

3

Space Segment






EPS & Battery
Propulsion
ADCS
CPU & Storage
Flight Module
S-Band Transceiver
Sensor & Cooler
Lens

Imaging Payload

Sensor

- nBn sensor for mid-wave infrared sensing
- higher resolution than mature sensor technologies (pixel pitch of 12 μm)
- COTS, but needs space environmental testing

Quazir HD Hot Camera Core

Lens

- Wide aperture 200mm IR lens (physical length ~126mm)
- Single focus (as imaging at > twice the hyper-focal distance, light is collimated)

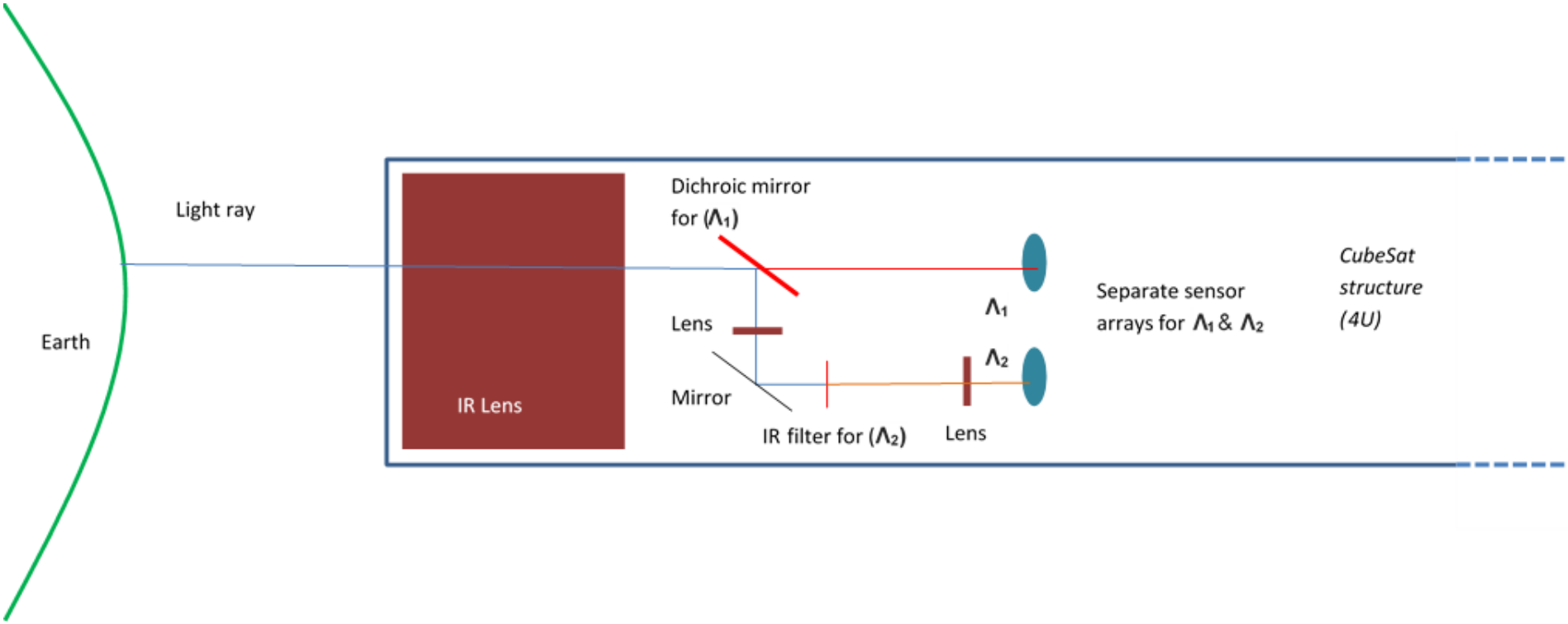
Spatial Resolution (Key Performance Parameter)

	Parameter	***Value***
Sensor	Pixel pitch	12µm
	Pixel array size	1280*1024
Lens	Focal length	200mm
	Diameter	110mm
Orbit	Altitude	561.24km

Considering the Rayleigh criterion for diffraction limited resolution at 2.9µm gives:

- **Ground Sampling Distance (Resolution) - 87m**
- Swath Size - 100 km x 90 km

Multispectral Imaging Option



Other Major Components

ADCS - Hyperion iADCS 100, 3 axis control with 1 degree of accuracy

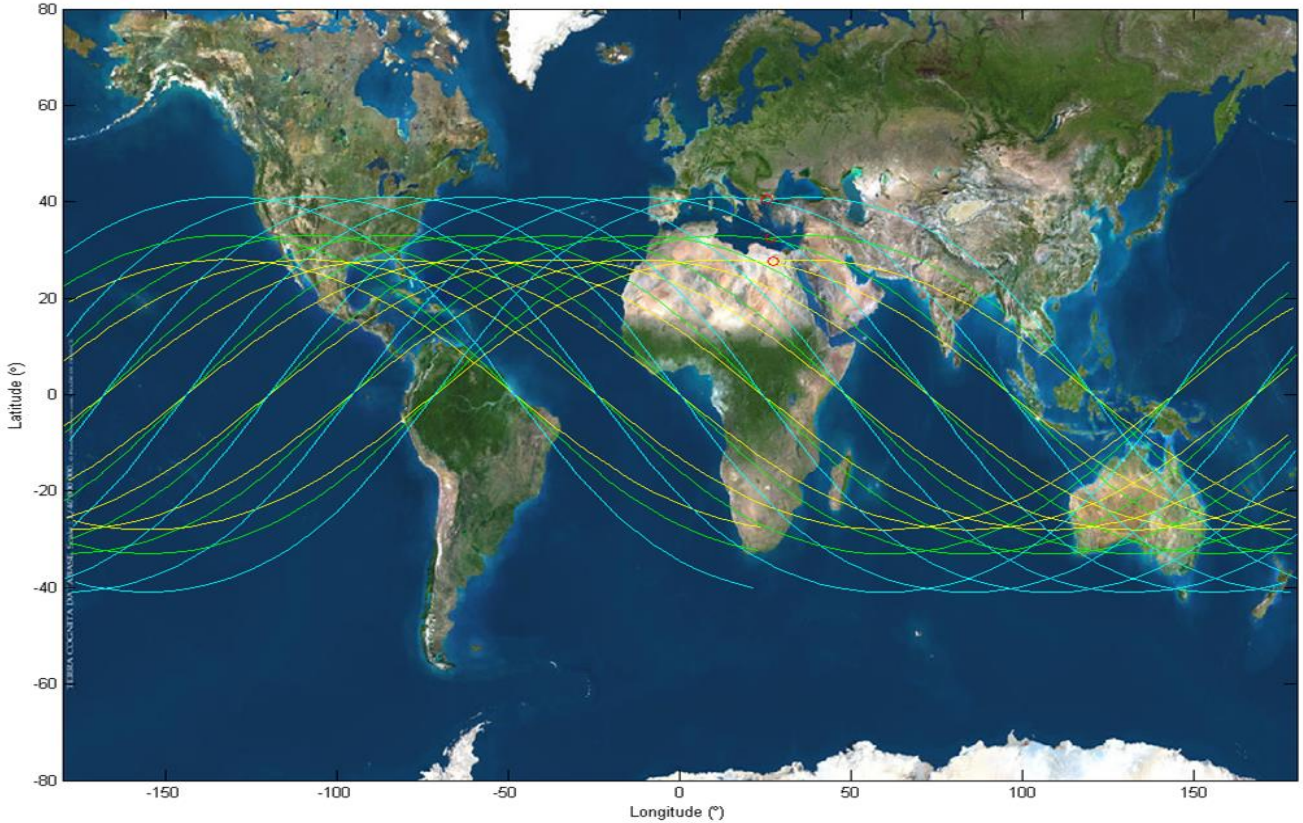
OBDH - S-band 1Mbps transfer with 64GB storage

Power - Pumpkin Solar Panels (4U fixed, 3U deployable)

- *Generation*: 22W (average)
- *Usage*: 10W during downlink, 12W during imaging

Propulsion - Busek pulsed plasma thruster

Orbit Description



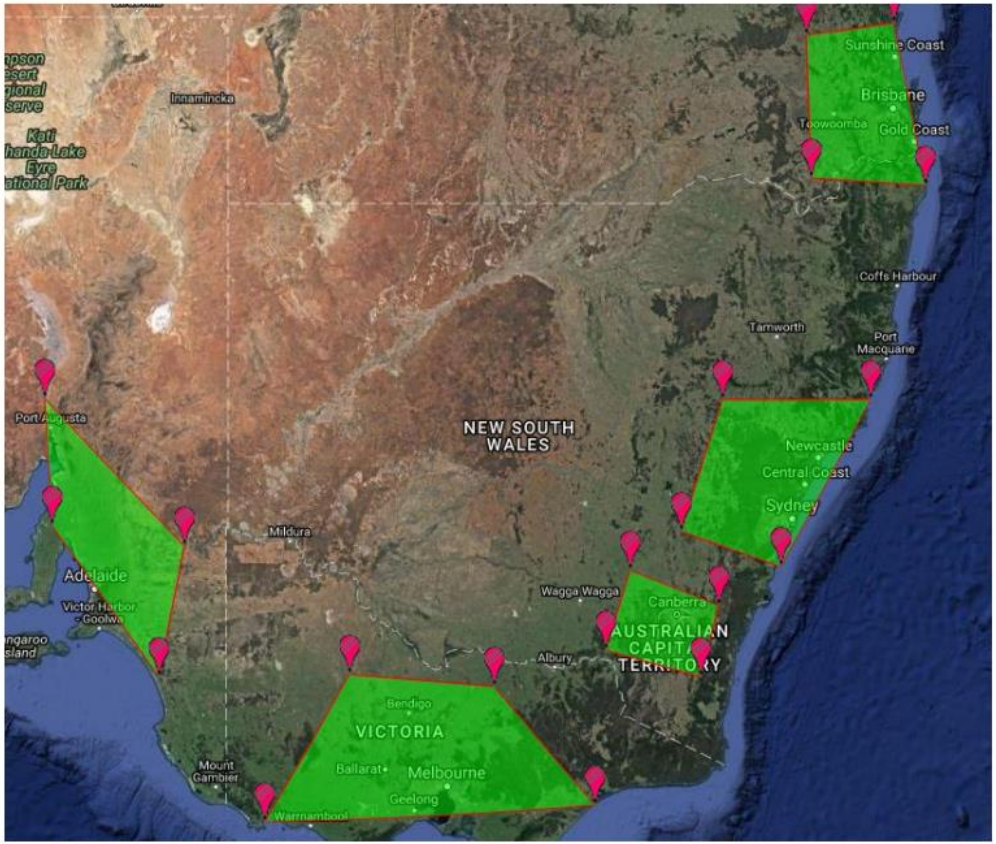
Altitude: 561.25km

A possible inclination configuration chosen to cover the east coast of Australia

Revisit Time and Coverage

Key high risk target zones near metropolitan and semi-urban areas

Total prioritised imaging area of 300,000km^2



Revisit Time (Key Performance Parameter)

1. Define coverage areas.
2. Estimate area each satellite will sweep on each pass.
3. Assume 25% of imaging area is redundant.

48 satellites yields revisit time of 18 min

Propulsion System

Pulsed plasma thruster with 140 grams of PTFE fuel gives total **Δ**V = 170m/s.

Altitude maintenance - requires **Δ**V ~ 3m/s/yr

De-orbit - **Δ**V of 120m/s required to reach mean altitude of 250km.

Deorbit

Deorbiting from 560km altitude with apogee centred burn arcs.

Trip time = 30 days

Implementation

Project Management

ACSER
AUSTRALIAN CENTRE FOR SPACE ENGINEERING RESEARCH

Ground Stations

Australian Government
Bureau of Meteorology

CSIRO

Public Information

HighFire Risk Project

Australian Government
Geoscience Australia

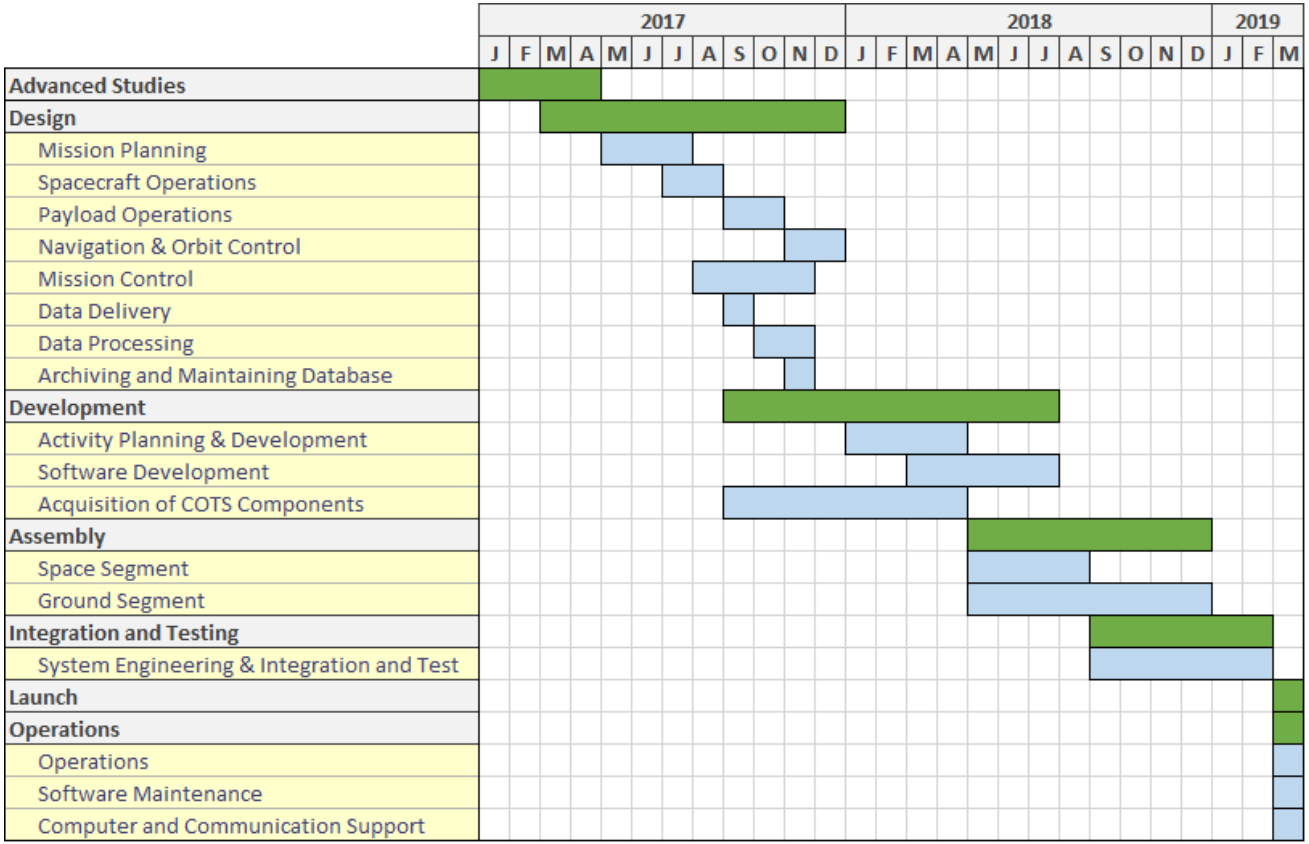
My FireWatch

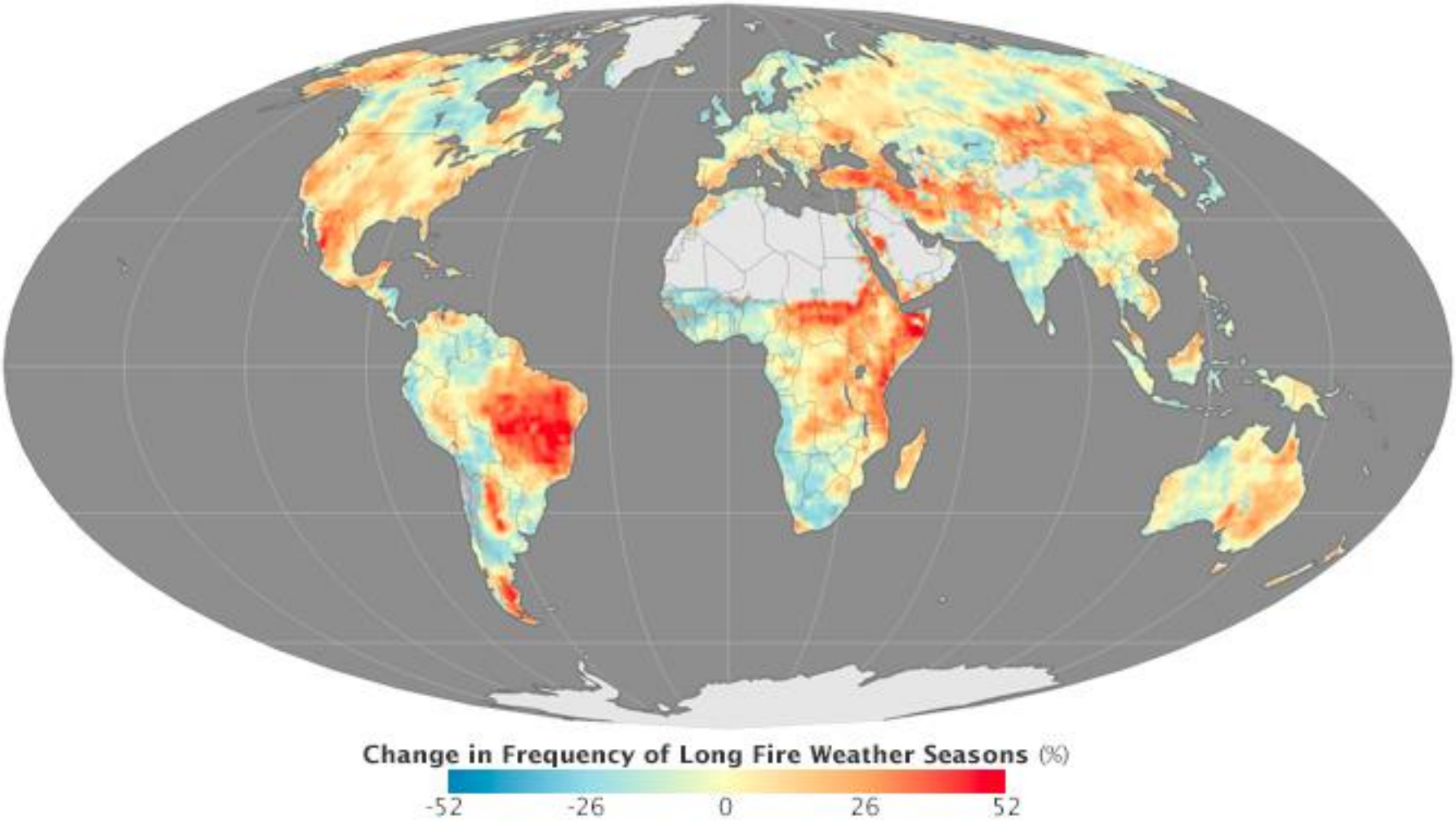
Landgate

Life Cycle Cost

Parameter	**Cost (AUD $)**
Personnel and management (over initial 2 years)	2,500,000
Ground station equipment	250,000
COTS components and build (48 CubeSats)	6,000,000
Launch (300kg class)	8,000,000
Total	**20,000,000**
Life Cycle Cost (per year, after initial period)	**2,000,000**

Mission Schedule





http://earthobservatory.nasa.gov/IOTD/view.php?id=86268

Appendix Slide - Revisit Time

1. Define coverage areas
2. Estimate area each satellite will sweep on each pass (A_{ij}).
3. $$T_{rep} = \frac{60 \times 24 \times A_{req}}{R_f \sum_{i=1}^{N} \sum_{j=1}^{p_i} A_{ij}},$$

where p_i to be the number of passes the ith satellite makes over the imaging area and R_f is the redundancy factor, a measure of how much imaged data area is not important.