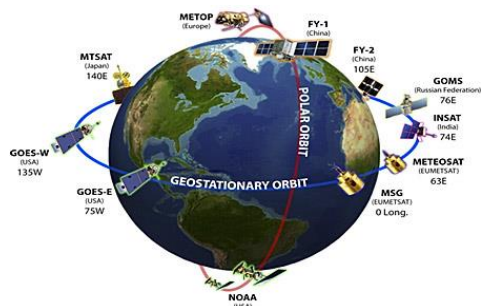


Australian Calibration & Validation Activities Visible & Infrared Earth Observation: Status – Planned



GRWG/GDWG Web Meeting
GSICS VIS/NIR sub-group Monthly Web Meeting
September 2021, 7- 9 AM (USA-EDT)

Prof. Stuart Phinn



Earth Observation
Australia





THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

CREATE CHANGE

Acknowledgement of Country

I would like to begin by acknowledging the Traditional Custodians of the lands and waters across Australia on which we work and meet today, and pay my respects to their Elders past and present.

I extend that respect to Aboriginal and Torres Strait Islander peoples here today.

I specifically acknowledge the traditional custodians of the Quandamooka, Turrbal and Yugara lands and waters, where I live, work and teach.

I offer my respect to their elders past, present and emerging as we work towards a just, equitable and reconciled Australia, and one where we recognise and build our shared knowledge and experiences.

Background - *A Guidance Through Time* by Quandamooka artists Casey Coolwell and Kyra Mancktelow for The University of Queensland Reconciliation Action Plan



Australian Calibration & Validation Activities Visible & Infrared Earth Observation: Status – Planned

Contributors:

Geosciences Australia	- Medhavy Thankapan, David Hudson, Guy Byrne
Bureau of Meteorology	- Agnes Lane, Helen Beggs, Alain Protat, Yi Huang
CSIRO	- Cindy Ong, Tim Malthus, Thomas Schroeder
Maitec	- Stefan Maier
TERN	
IMOS/Curtin Univ.	- David Antoine
FrontierSi	- Jasmine Muir, Brendan McAtee

+ a large number of collaborators from all organisations!



Contents :

1. Aims
2. Australia and GSICS Mission and Roles
3. Australia Earth Observation and Space Agency ?
4. Visible – IR Calibration
5. Visible – IR Validation
6. Potential ways forwards ?



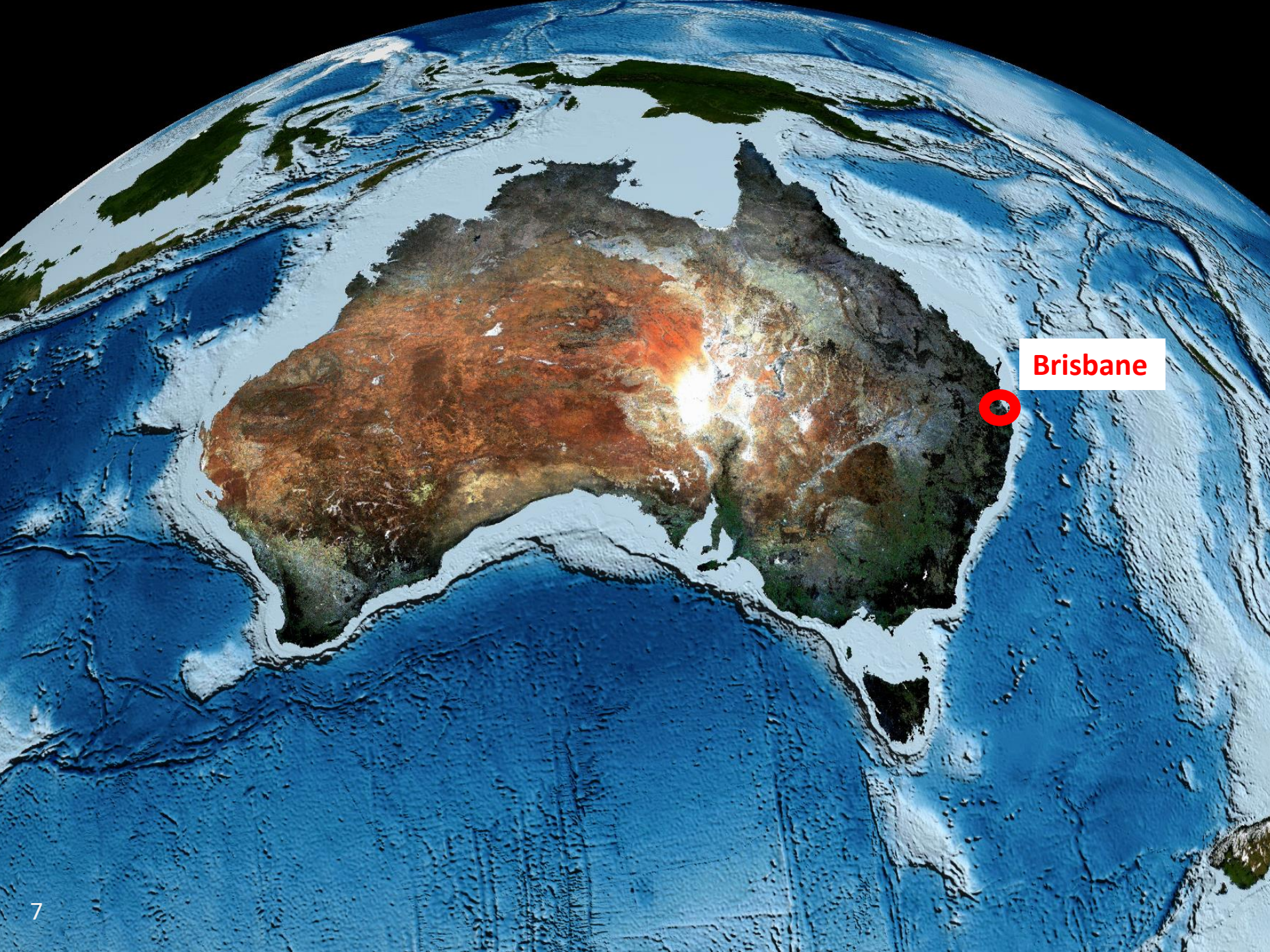
Aims

- To provide a high level outline of current and planned satellite earth observation calibration and validation activities, for visible to middle-infrared (350 – 2500 nm) conducted by the Australian Earth Observation Community, and supported by the Australian Space Agency
- Note - *Australian Earth Observation Community* =
 - State/Territory and National Government Agencies
 - Defence Agencies
 - Private industry (start-up, small-medium enterprise, multi-national:
 - Universities
 - Others....

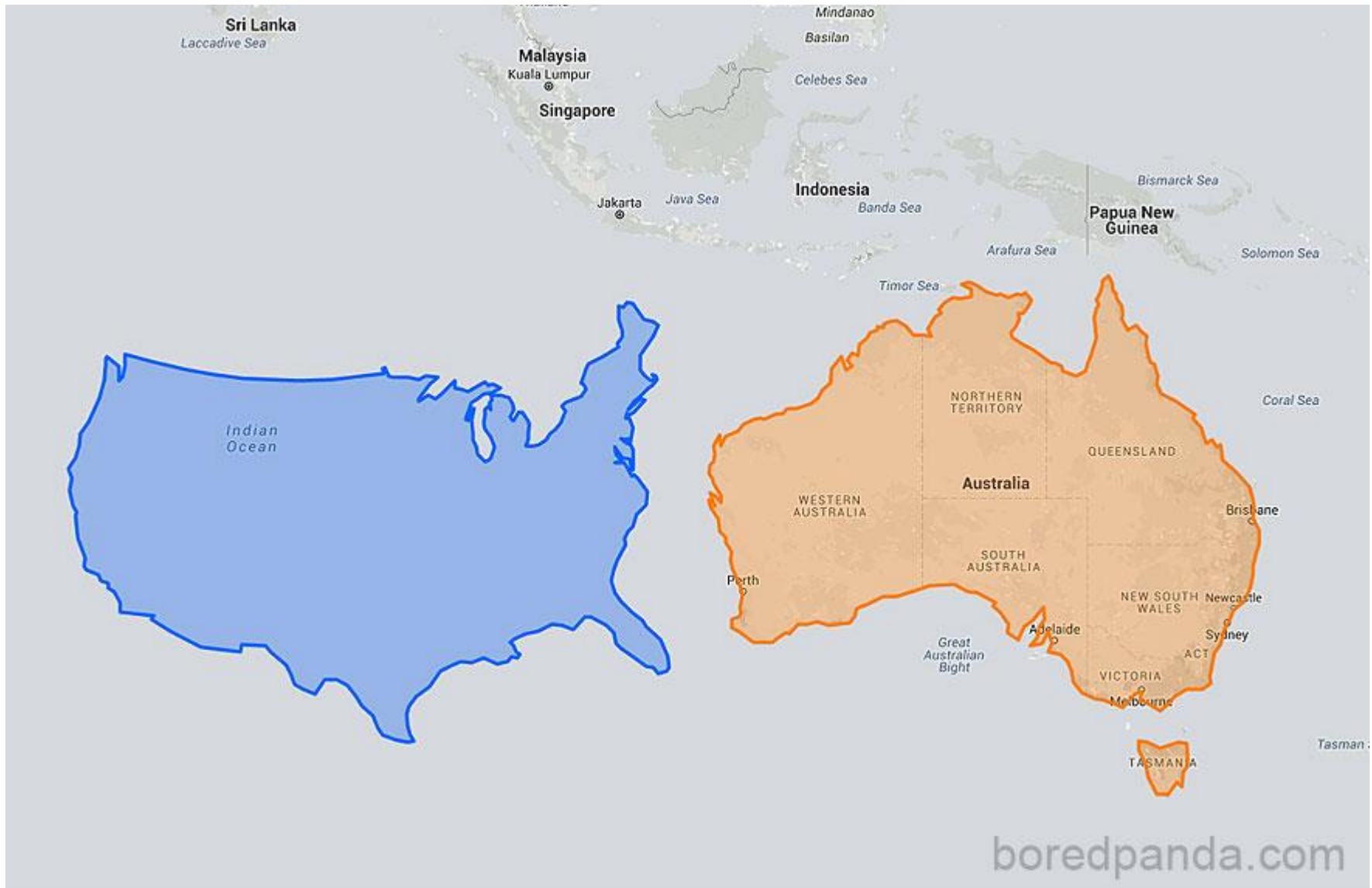


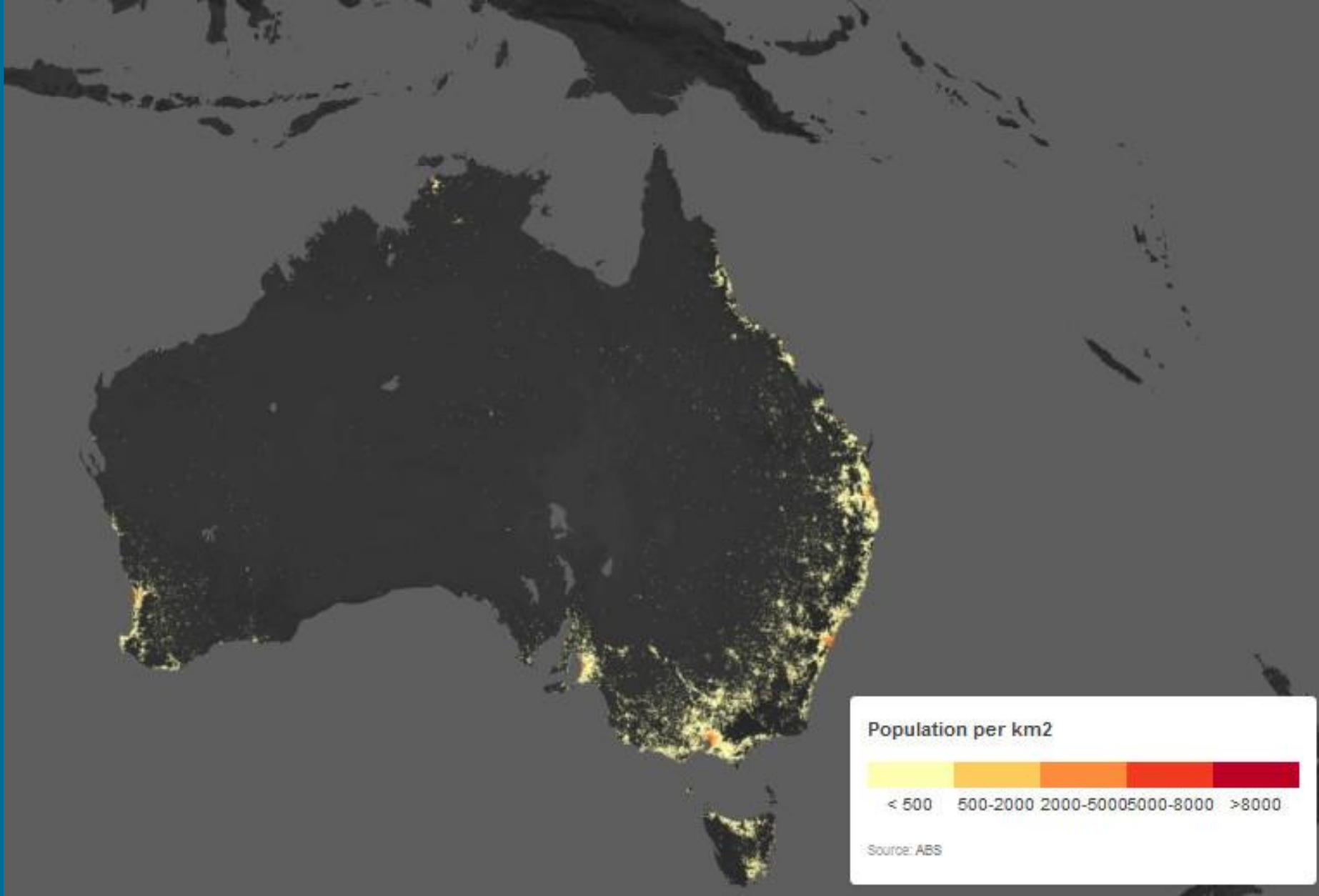
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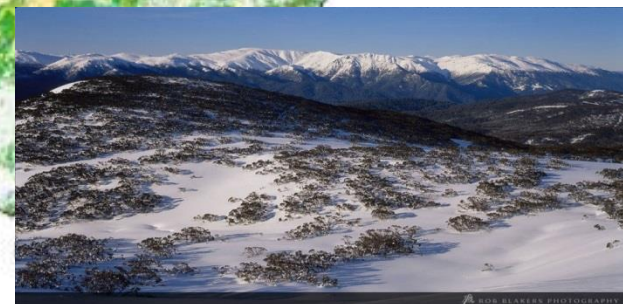
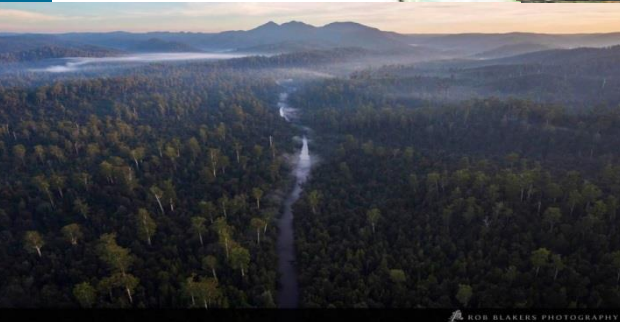
1. Aims
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Brisbane







- Woodlands
- Other Forests and Woodlands
 - Open Woodlands
 - Shrublands and Grasslands
 - Inland Aquatic
 - Cleared

- My biased view of “Earth Observation” Research

Field measurements

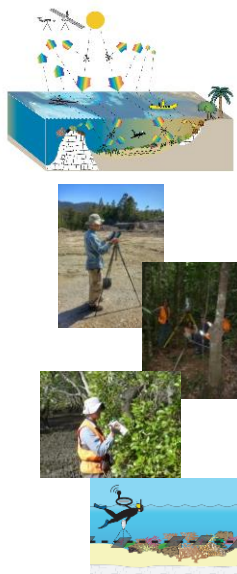
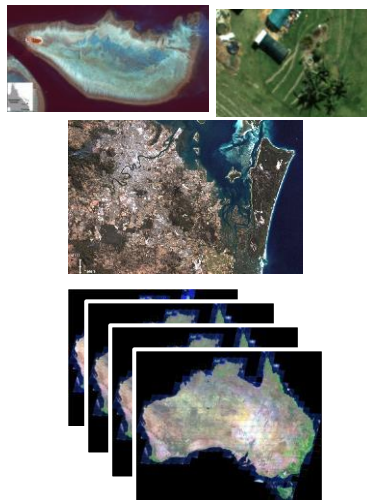


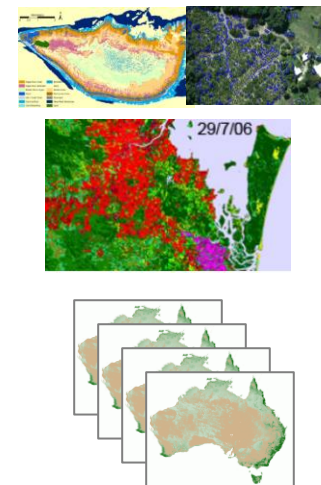
Image measurements (drone-airborne-satellite)



Workflows + services development (image processing)



Images to information



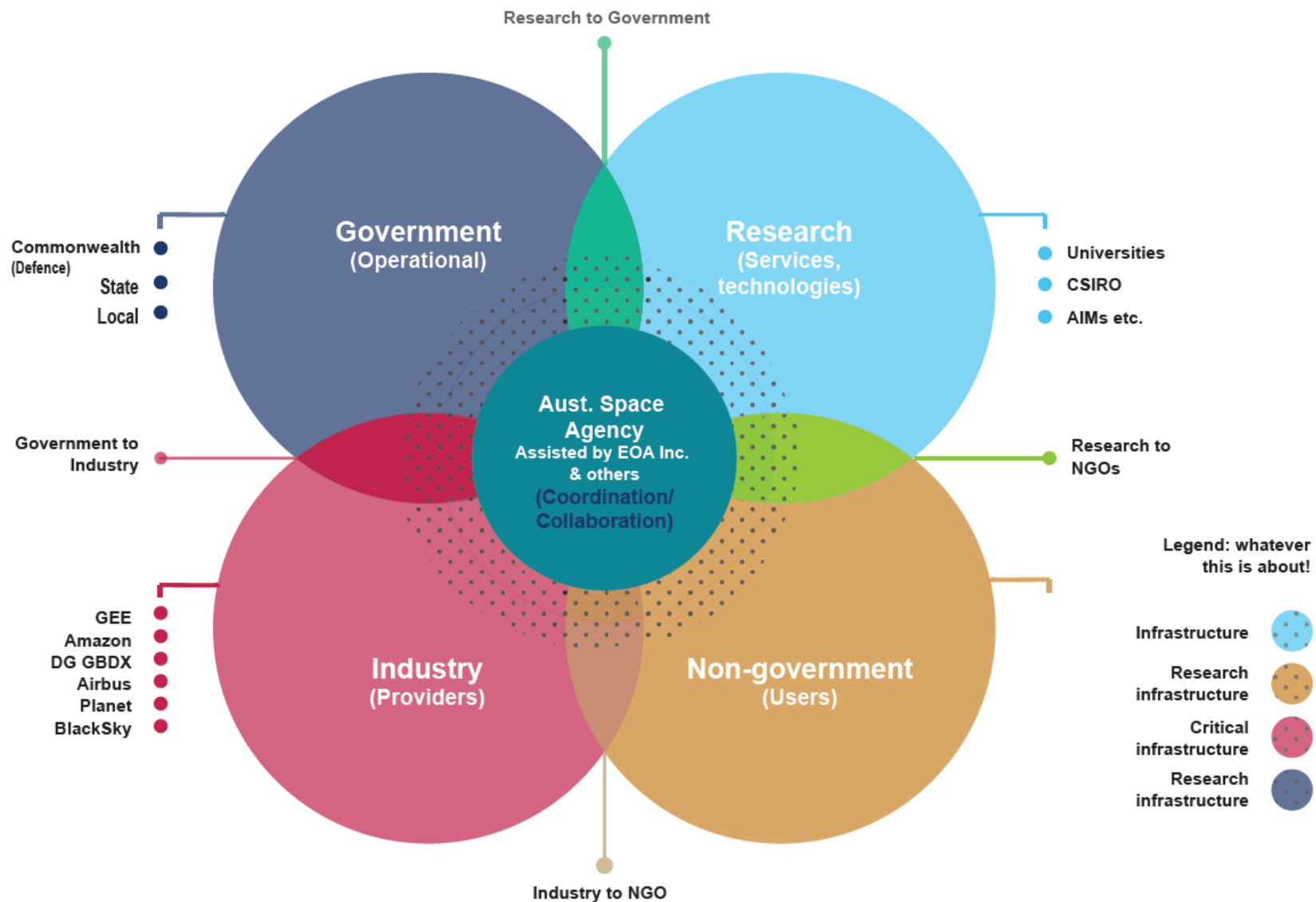
Applications- Impacts





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Earth Observation
Australia Inc.

www.eoa.org.au



- 600+ members
- All national + state agencies
- 4 Industry Rep. Groups



Outcomes: 2017-2021

Implementation from – 2017:

- EO included in Research Infrastructure
- Digital Earth Australia
- EO as part of Aust. Space Agency
- EO as part of QLD Space Strategy
- Formal national EO coordination
- Earth Observation for Government Network
- Advancing EO Forum 2021/22

5 national priorities of the Plan
to build Australia's EO capacity

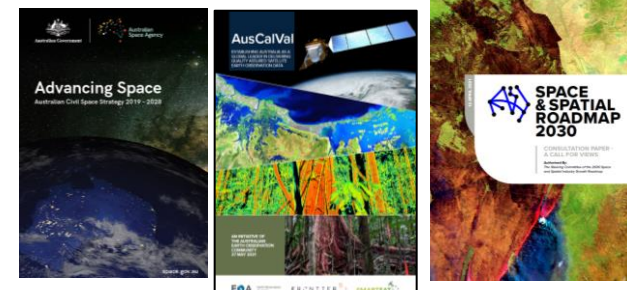


Continued National Coordination
Priorities + Actions



Advancing Earth Observation Forum
Revised 2021 and 2022 Events

www.earthobsforum.org

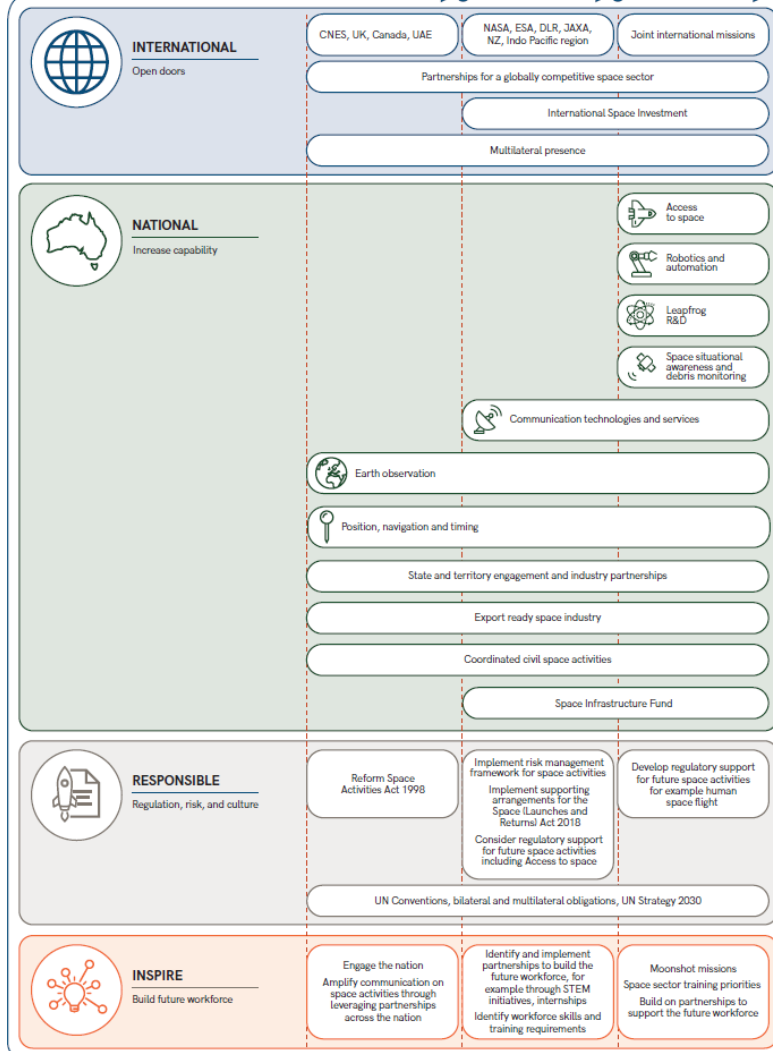


Advancing Space

Australian Civil Space Strategy 2019 – 2028

space.gov.au

AUSTRALIAN CIVIL SPACE STRATEGY 2019-2028: IMPLEMENTATION





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Calibration activities ?

- Pre-launch?
- Post-launch?
- No information provided

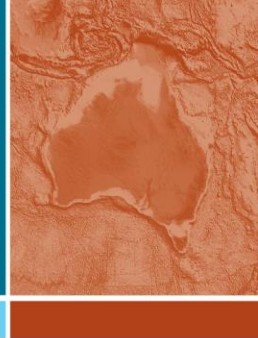


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Australian Government
Geoscience Australia



Geoscience Australia Agency Report

Medhavy Thankappan

medhavy.thankappan@ga.gov.au

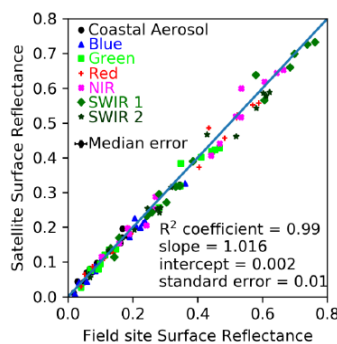
Continental Surface Reflectance Validation Phase 1 - Status

Data Collection

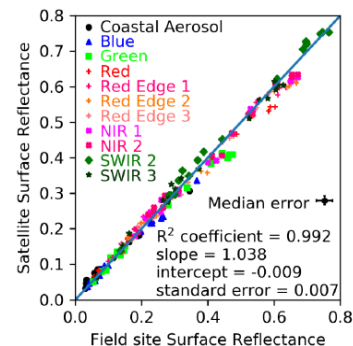
	Site	Count	L8	S2A	S2B
1	Blanchetown - SA	1		1	
2	Dharawal - NSW	1	1		
3	Dookie - VIC	5	2	2	1
4	Fowler's Gap - NSW	2	1	1	
5	Heron Island - QLD	1		1	
6	Lake George - NSW	10	3	3	4
7	Lake Hume - NSW	1	1		
8	Lake Lefroy - WA	2	1	1	
9	Litchfield - NT	1		1	
10	Mitchell Downs - QLD	6	2	2	2
12	Mullion - NSW	5	1	2	2
11	Narrabundah - ACT	4	1	2	1
13	Pinnacles - WA	10	3	5	2
14	Winton - QLD	6	2	2	2
	Total	55	18	23	14

Summary Results

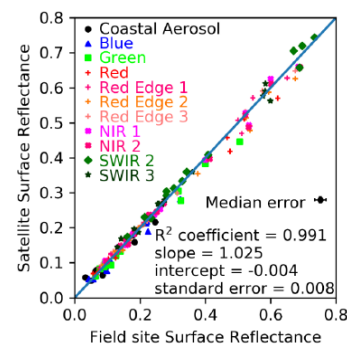
Landsat-8



Sentinel-2A



Sentinel-2B



SR Validation - Phase 1 Wrap up

Australian bushfires
and COVID
impacted on field
data acquisitions

Publish Phase 1
technical data
summary report

Establish National
Spectral Database
and publish field
spectral data



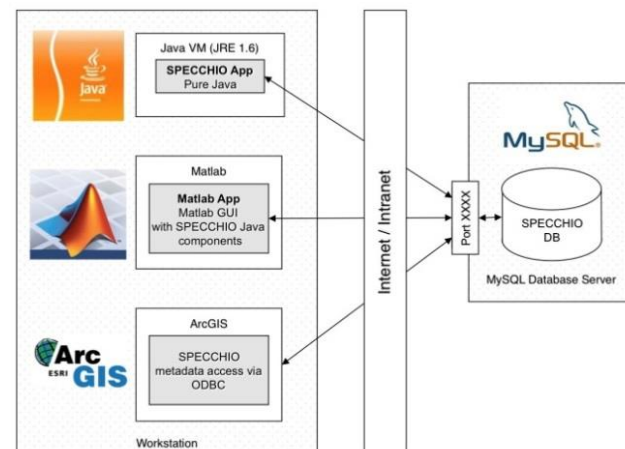
DEA - Analysis Ready Data

Phase 1 Validation Project



Technical Data Summary

Guy Byrne, Andrew Walsh, Medhavy Thankappan, Mark Broomhall and Eric Hay



Validation with Flame Spectrometer mounted on Drone

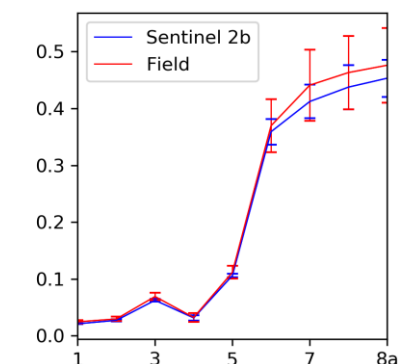
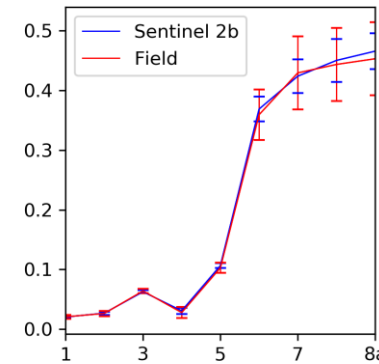
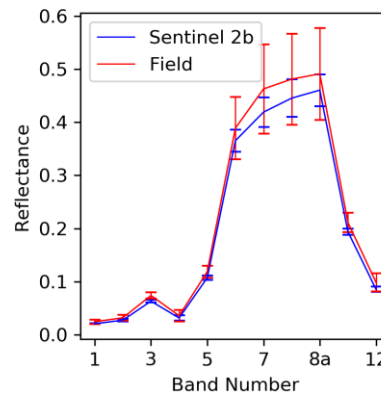
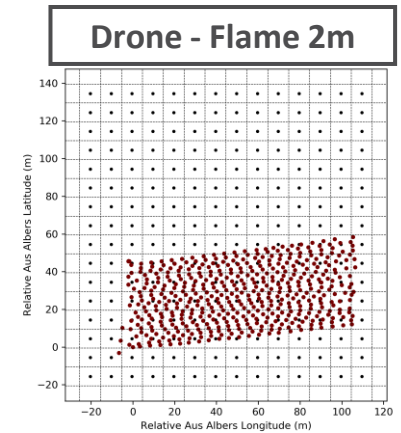
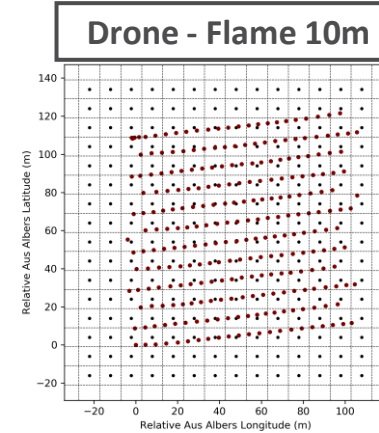
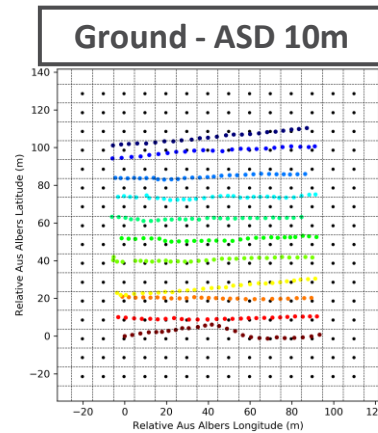
Local drone based spectrometer trials were done

Example shown for synchronous data takes with Sentinel 2B

ASD + Flame spectrometers used in tandem

Results for data takes at 10m and 2m spacing

Drone based BRDF characterisation is also being planned



North Australian Satellite Validation Facility (NASVF)

located in the monsoonal north of Australia approx. 80km south of Darwin

operational:

- canopy/understorey Leaf Area Index (LAI) + Cover (automated + regular campaigns)
- soil moisture/temperature sensor network
- top-of-canopy radiance/reflectance (regular campaigns)

in development:

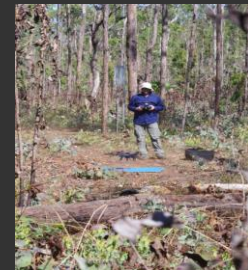
- Fraction Absorbed Photosynthetic Active Radiation (fAPAR) sensor network
- sky camera
- atmospheric particulate matter (PM1, PM2.5, PM4, PM10)
- total column atmospheric water vapour
- aerosol optical thickness

ancillary:

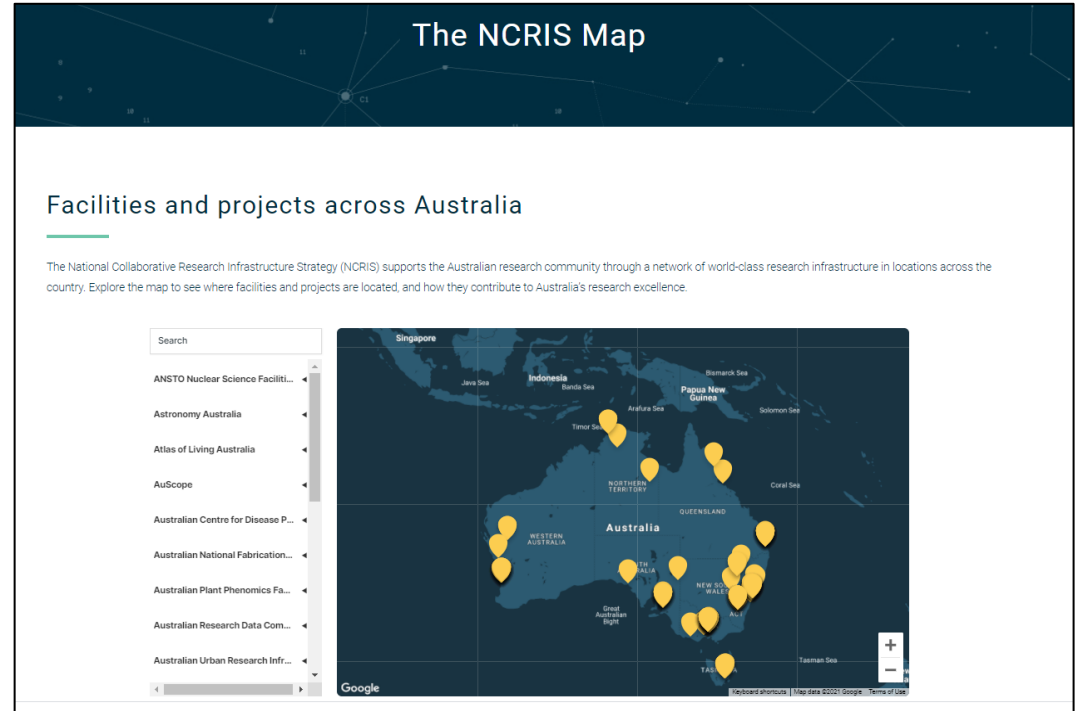
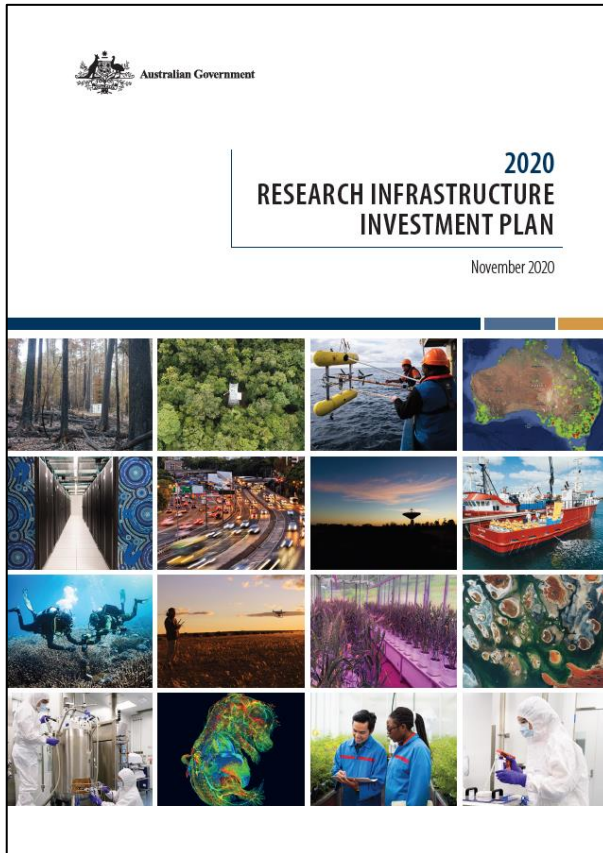
- rainfall
- temperature
- humidity

Contact:

Dr Stefan W Maier
stefan.maier@maitec.com.au
<https://www.ozcalval.org>



National Collaborative Research Infrastructure



<https://2021nriroadmap.dese.gov.au/>

National Collaborative Research Infrastructure

Australia's Land Ecosystem Observatory

We measure key terrestrial ecosystem attributes over time from continental scale to field sites at hundreds of representative locations and openly provide model-ready data that enable researchers to detect and interpret changes in ecosystems.



TERN delivers quality data, tools and expertise to researchers who are working to understand Australia's environment and so enable its management for sustainable social and economic benefit.

IMOS Integrated Marine Observing System



IMOS undertakes systematic and sustained observing of Australia's marine estate



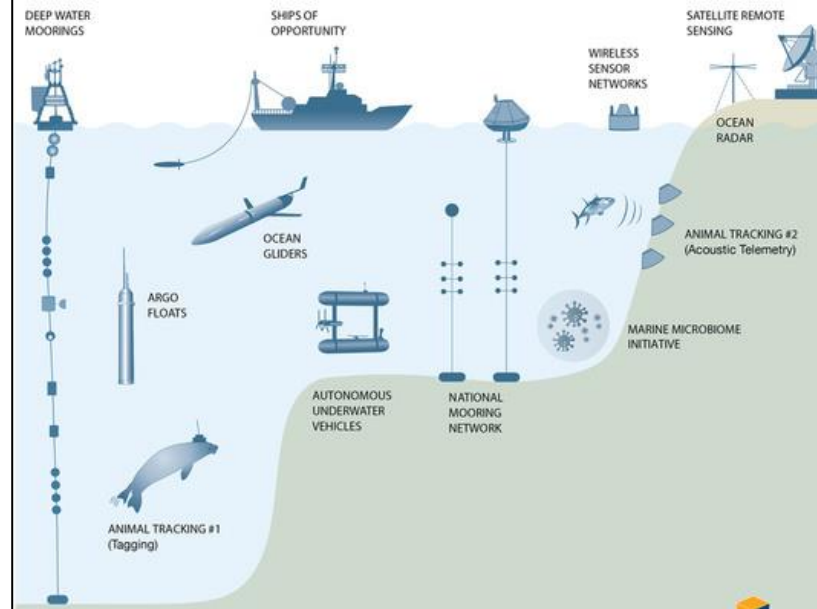
Operates a portfolio of platform-based facilities to acquire ocean observations



Plans its operations through internationally peer-reviewed science processes



Engages with users across universities, governments and industries to drive uptake and impact

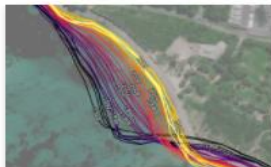


NCRIS
National Research
Infrastructure for Australia
An Australian Government Initiative

www.imos.org.au



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DEA Coastlines



Digital Earth Australia Hotspots



DEA Waterbodies



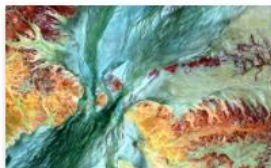
National Intertidal Digital Elevation Model



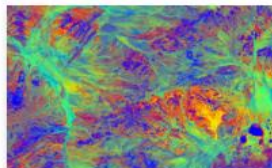
Intertidal Extents Model



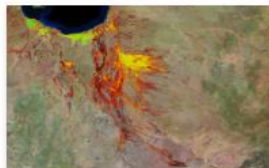
High and Low Tide Composites



Landsat Surface Reflectance



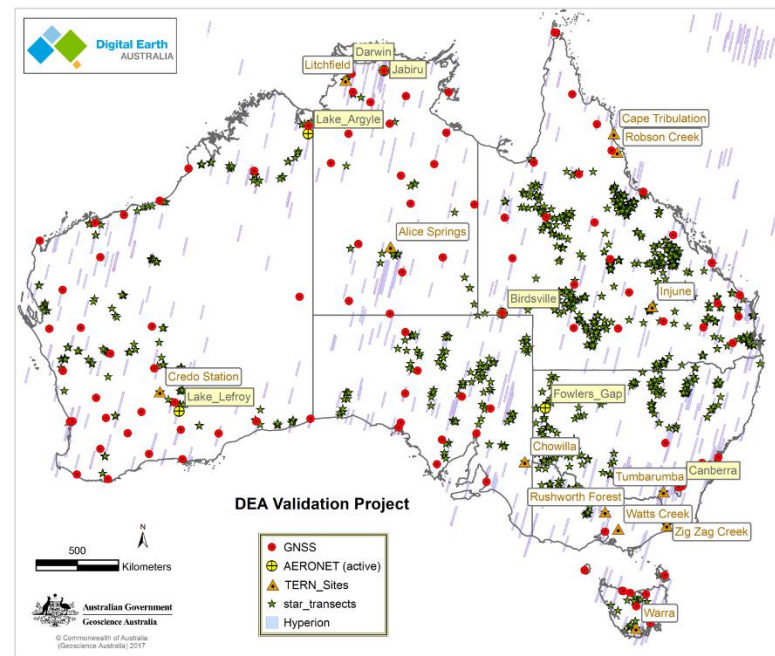
Fractional Cover



Water Observations from Space



Dynamic Land Cover Dataset



including; biophysical data, IBRA regions, state and national sampling sites, (active and historic), USGS test sites, data archives and portals, image archives (satellite and airborne) WRS and DEA tile boundaries.



Australian Government
Geoscience Australia



Current Australia's Ocean Colour Radiometry Cal/val activities

David Antoine, Curtin University

Thomas Schroeder, CSIRO O&A

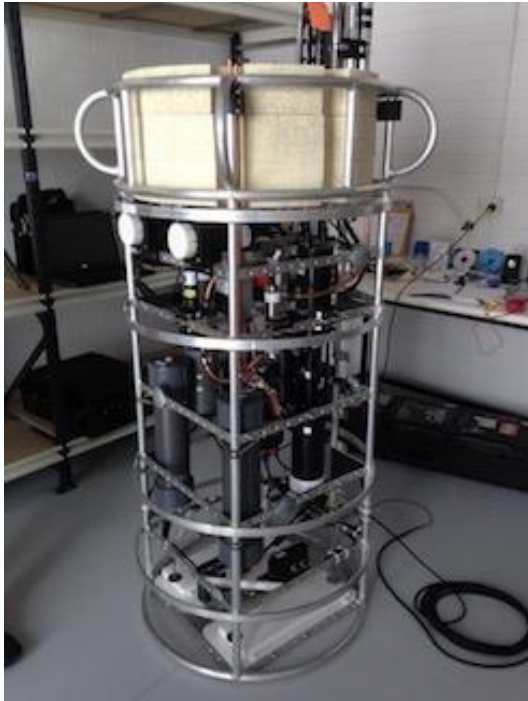


Curtin University



Composite image (March 2017) of the phytoplankton biomass around Australia, from observations of the ESA Sentinel3 "OLCI" sensor. RSSRG algorithms applied on 6×10^8 pixels using Pawsey computing resources and the Australia "Copernicus data Hub"

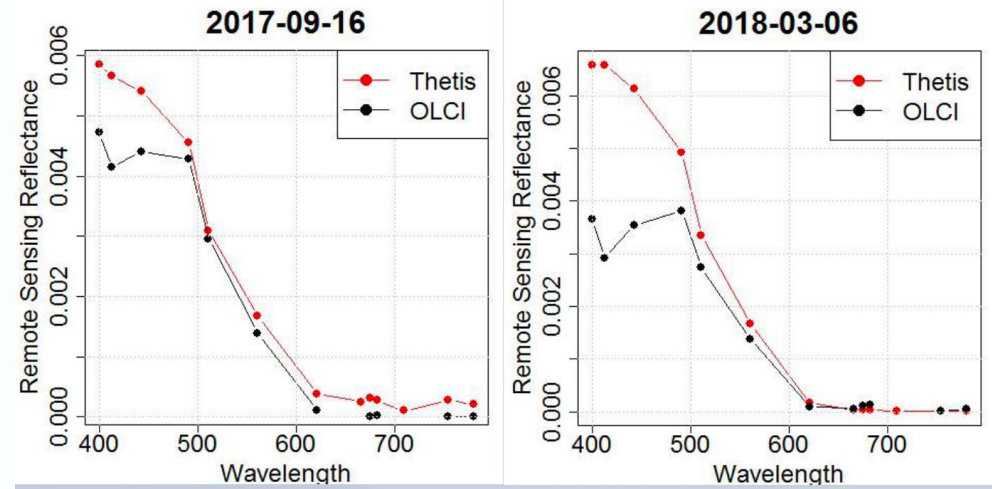
In-situ profiling mooring for ocean colour cal/val



Deployment of the WETLabs Thetis moored profiler near Rottnest Island, off the coast of Perth, Australia.



System provides real-time data of optical properties, environmental parameters and phytoplankton characteristics via a 3G Telemetry system each time it completes a profile of the water column (60 m bottom depth).



Match-ups between Thetis Satlantic OCR Radiometers and Sentinel3–OLCI instrument by Intern student Jorrit Scholze.

IMOS Ocean Colour Validation

Contact: Thomas.Schroeder@csiro.au

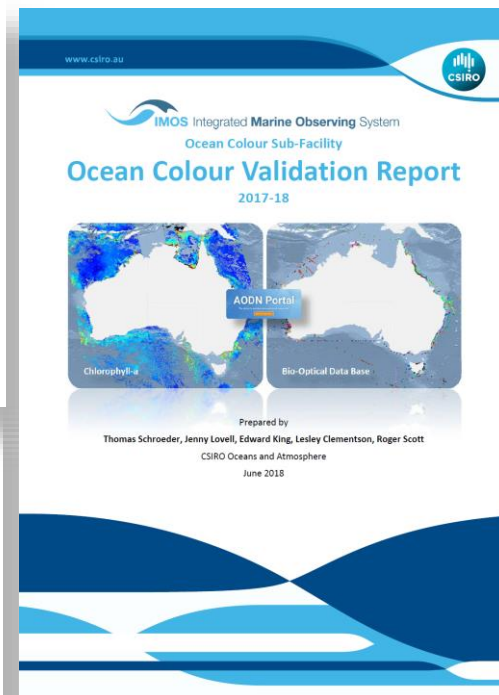
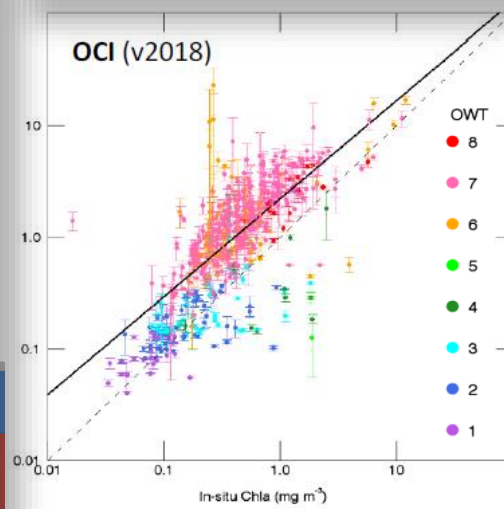
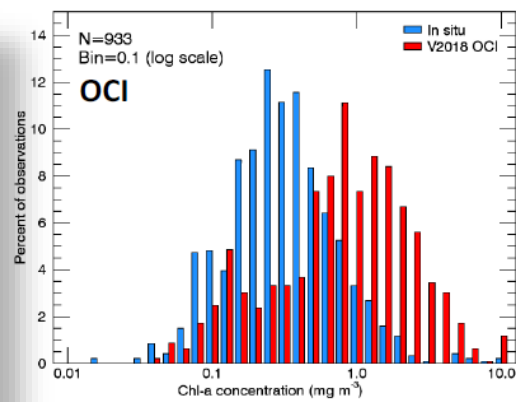
Sub-facility generates daily Level-3 (gridded) ocean colour products from MODIS-Aqua and VIIRS

Product validation using IMOS Bio-optical Database – freely available via AODN

Match-up are separated into Optical Water Types (Moore et al. 2009)

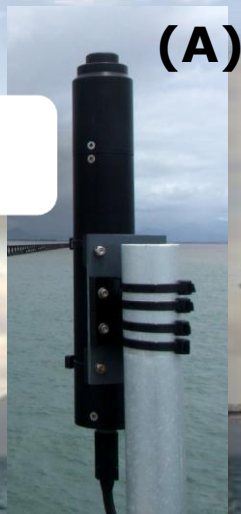
Annual validation reports

The screenshot shows the AODN Open Access to Ocean Data portal. The header includes the AODN logo and the text "Open Access to Ocean Data" and "Australian Ocean Data Network". Below the header is a navigation bar with three steps: "1 Select a Data Collection", "2 Create a Subset", and "3 Download". The "2 Create a Subset" step is active. The interface includes a map of Australia with various data points plotted. On the left, there are filters for "Spatial" (Bounding Box, N, E, S, W) and "Temporal" (From, To). Below these are "Others" filters for "Cruise Identifier", "Data Type", and "Vessel Name". At the bottom, there are "Previous" and "Next" buttons.



Overview above-water measurements

Satlantic
Spectral irradiance



Webcam
Sky and Sea



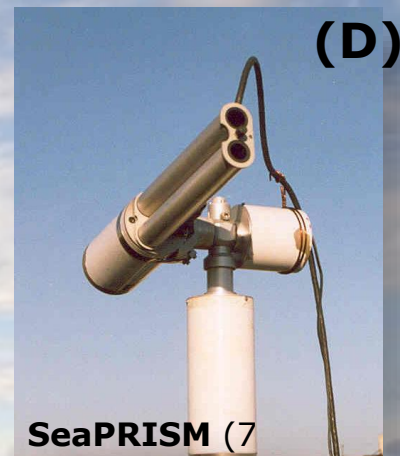
Weather Station

Temperature
Pressure
Humidity
Dew point
Wind speed
etc

(A)



(D)



SeaPRISM (7 wavelengths)
Water-leaving radiance

Aerosol optical thickness
Aerosol absorption

Aerosol size distribution
Refractive index

Single scattering albedo
Phasefunction

Water vapor
Spectral flux

Radiative forcing



Contact: Thomas.Schroeder@csiro.au

Overview in-water optical measurements

WetStar fluorometer

CDOM absorption
Chlorophyll-a
Uranine
Phycoerythrin

Automatic winch controller

keeps cage at a constant depth

ACs (80 wavelengths)

Total absorption
Total attenuation

WQM

Temperature
Salinity
Depth
Dissolved oxygen
Turbidity
Back scattering
Chlorophyll fluorescence

DAPCS

Network enabled
real-time data
logger

BB9 (9 wavelengths)

Back-scattering

ACs switching unit
(filtered/unfiltered)

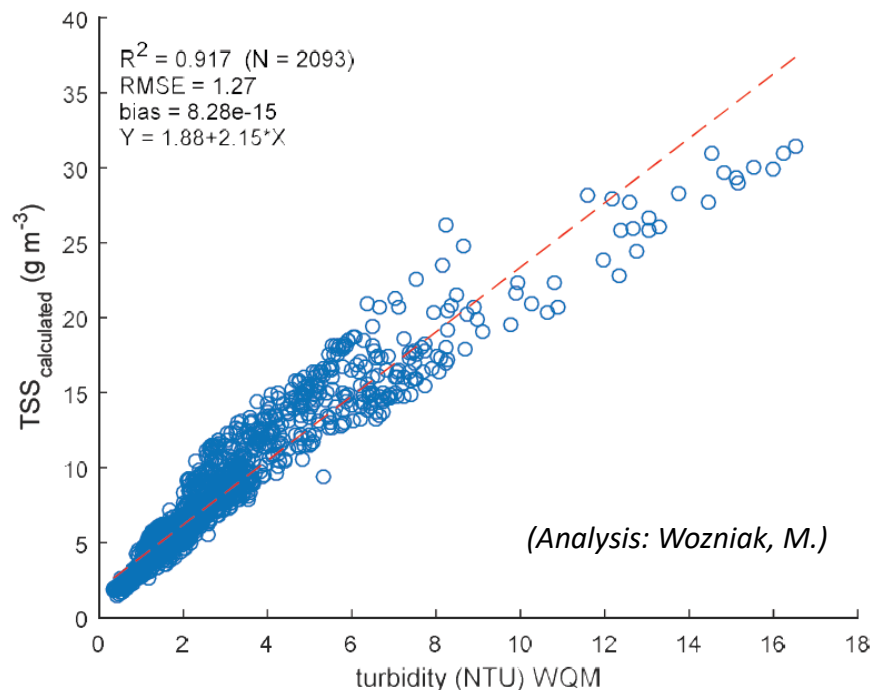
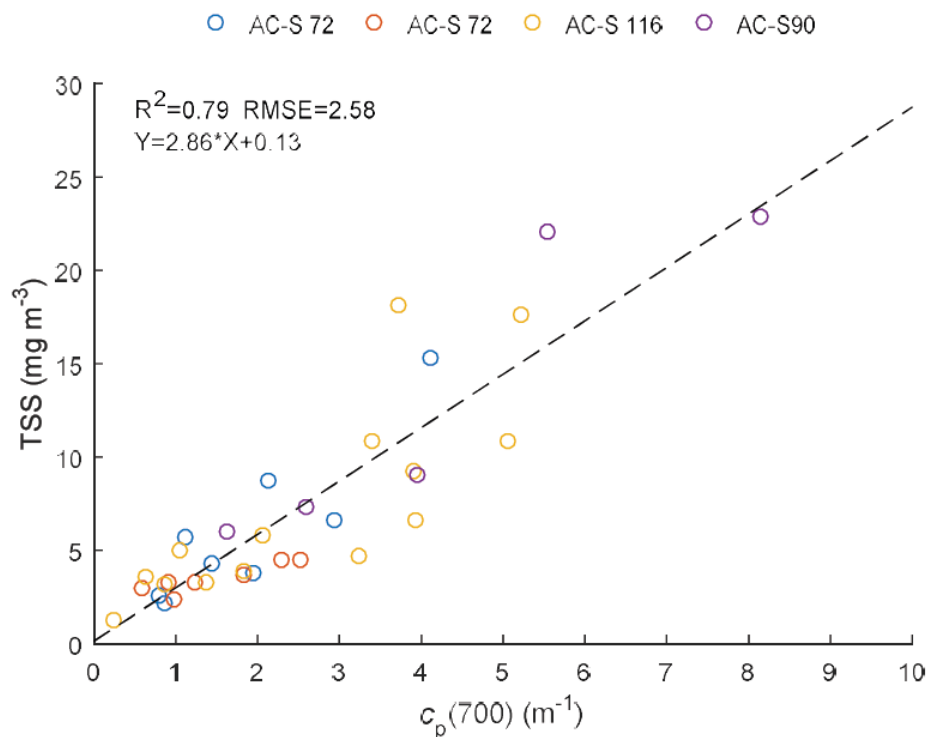
Fortnightly servicing and water sampling
optimized for satellite match-ups



Contact: Thomas.Schroeder@csiro.au

Lucinda Jetty – bio-optical relationships

Proxies to derive continuous concentration time series



Relationship between attenuation (AC-s) and lab TSS used to calculate TSS from WQM

In addition regression of AC-s absorption at 678 nm vs HPLC chlorophyll.

Relationships will be used to derive a **continuous time water quality series** of TSS and chlorophyll-a from in-water optical AC-s and WQM measurements.

LJCO is variable coastal site

Tidal range 0.2-4 m

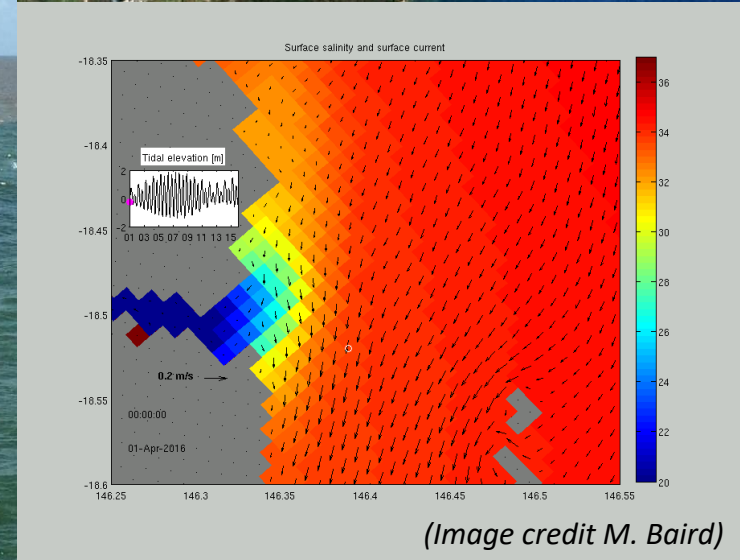
Water temperature 22-31°C

Salinity 27-36.5

TSS 1.17-35.7 g m⁻³

CDOM 0.22-6.35 mg m⁻³

Chl-a 0.01-0.49 m⁻¹



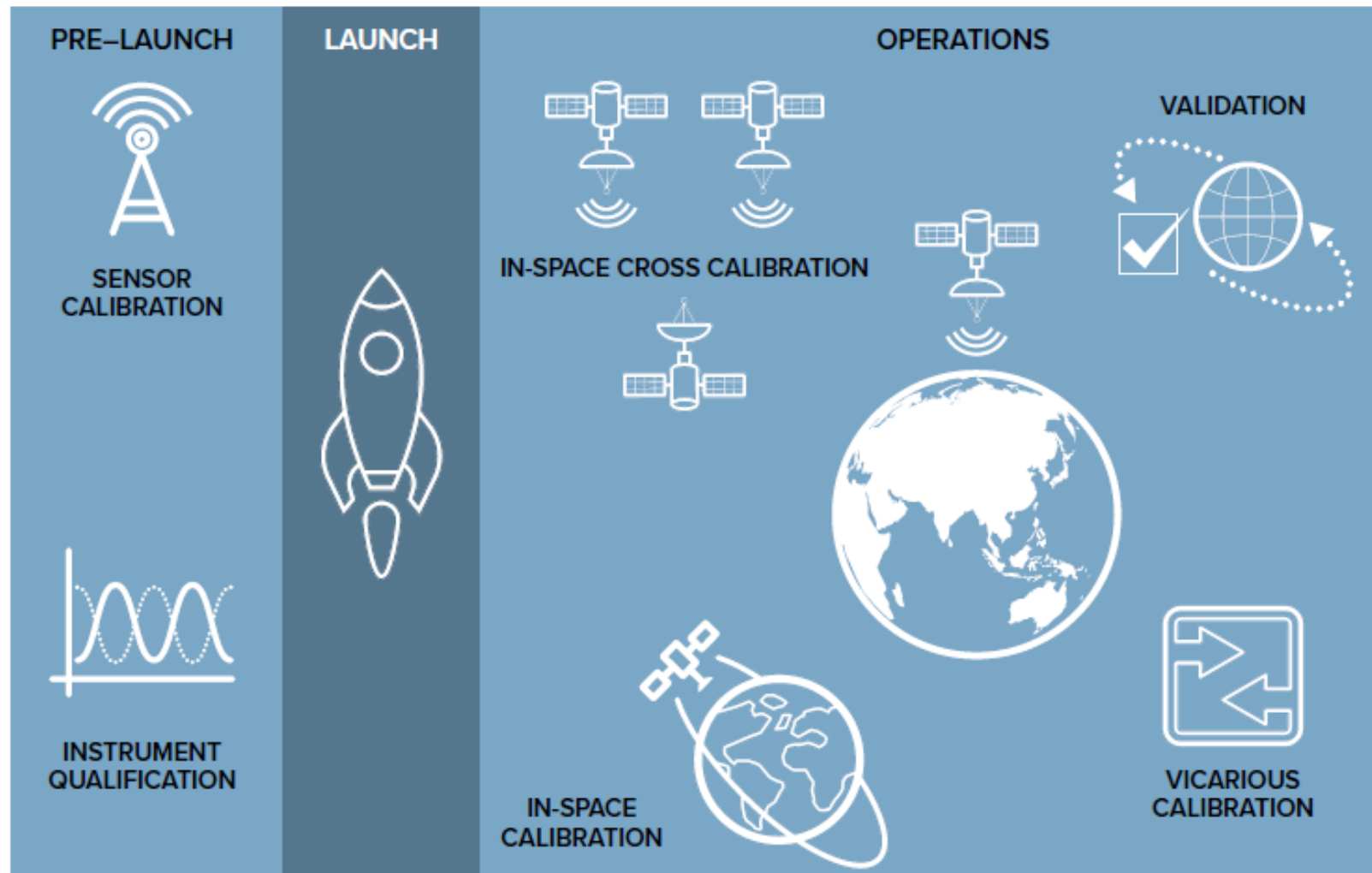
(Image credit D. Boadle)



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QUALITY ASSURANCE FOR EARTH OBSERVATION SATELLITES

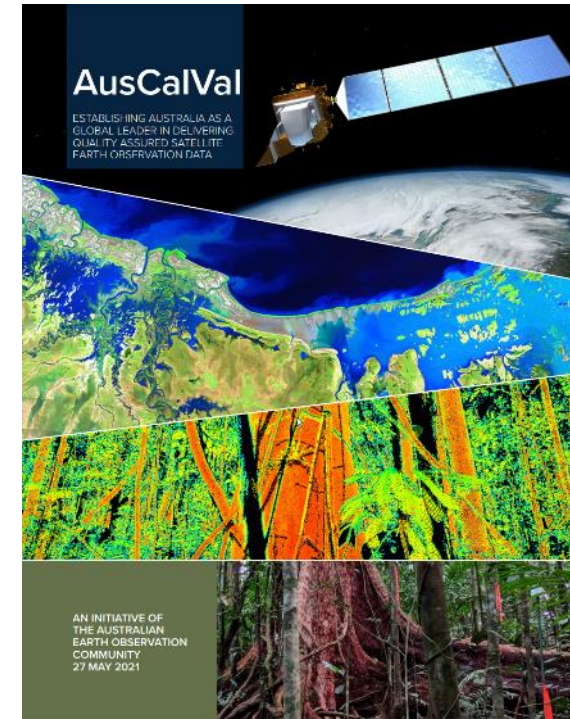


AusCalVal: Establishing Australia as a Global Leader in Delivering Quality Assured Satellite Earth Observation Data

This strategy has four components:

1. a coordination body to oversee operations, communication and access to data, facilities and expertise;
2. a comprehensive, operational and research network of calibration and validation facilities across Australia;
3. an open source suite of quality assurance tools leading to a data integrity monitoring service for all satellite operators; and,
4. an Australian owned and operated series of Satellite Cross-Calibration Radiometers to provide improved accuracy and consistency between optical satellites.

<https://frontiersi.com.au/auscalval/>



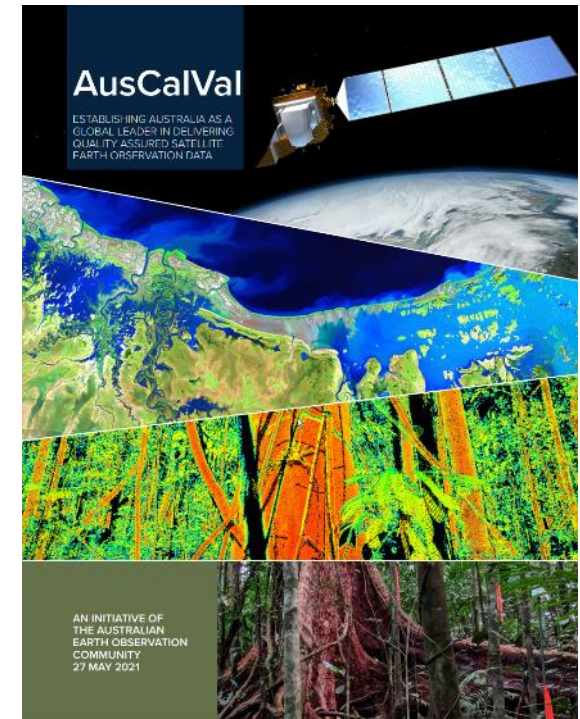
EOA Earth Observation
Australia

FRONTIER S
T >

SMARTSAT
Cooperative Research Centre

EXISTING AND PROPOSED CALIBRATION AND VALIDATION SITES

Type	Existing site	New site
Radar sensors	Site 1: QLD Corner Reflector Array	Site 2: NT Alice Springs or Woomera corner reflector network
Optical sensors	Site 3: WA Pinnacles Medium Spatial Resolution Bright Optical Vicarious Calibration Site 4: WA Lake Lefroy Medium Resolution Bright Optical Vicarious Calibration Site Site 5: National Optical Calibration Laboratory Facility	Site 6: Optical Coarse Spatial Resolution Vicarious Calibration Site Site 7: CORIO: Cotter Reservoir Inland Observatory (optical dark target)
Geometric calibration		Site 8: NT Alice Springs geometric calibration facility
Above and in-water biophysical properties	Site 9: QLD Lucinda Jetty Coastal Observatory	Site 10: TAS Bruny Island Aquatic Target Site 11: AquaWatch In-Situ Sensor Network Site 12: NT Darwin Harbour Aquatic Target Site 13: Rottneest Island blue water site
Atmospheric Composition	Site 14: AeroSpan Network (Internationally AERONET) Site 15: Total Carbon Column Observing Network TCCON	Site 16: Terrestrial Numerical Weather Prediction validation
Terrestrial landscapes/vegetation	Site 17: Terrestrial Ecosystem Research Network (TERN) SuperSites and associated sites Site 18: Cosmic Probe (CosmOz) Network Site 19: OzFlux Network Site 20: Endorsement of Australian sites for the Global Forest Biomass Reference System	
Ocean	Site 21: IMOS Site 22: SWOT (Bass Strait) Site 23: Ocean Numerical Weather Prediction validation Site 24: SWOT (GBR/SOFS/Albany) Site 25: SWOT (Mawson)	



EOA Earth Observation Australia

FRONTIERST

SMARTSAT Cooperative Research Centre



Australian Government
Geoscience Australia



Satellite Cross-Calibration Radiometers (SCR)

Presentation to Surface Biology and Geology (SBG) Calibration and Validation Working Group (CVWG)

30 July 2021

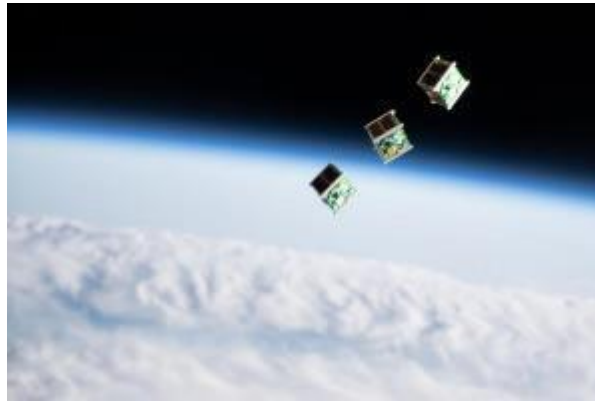
Dr David Hudson



Australia's strategic objectives



Securing our access to data



Uplifting our satellite manufacturing capability



Growing our app development industry

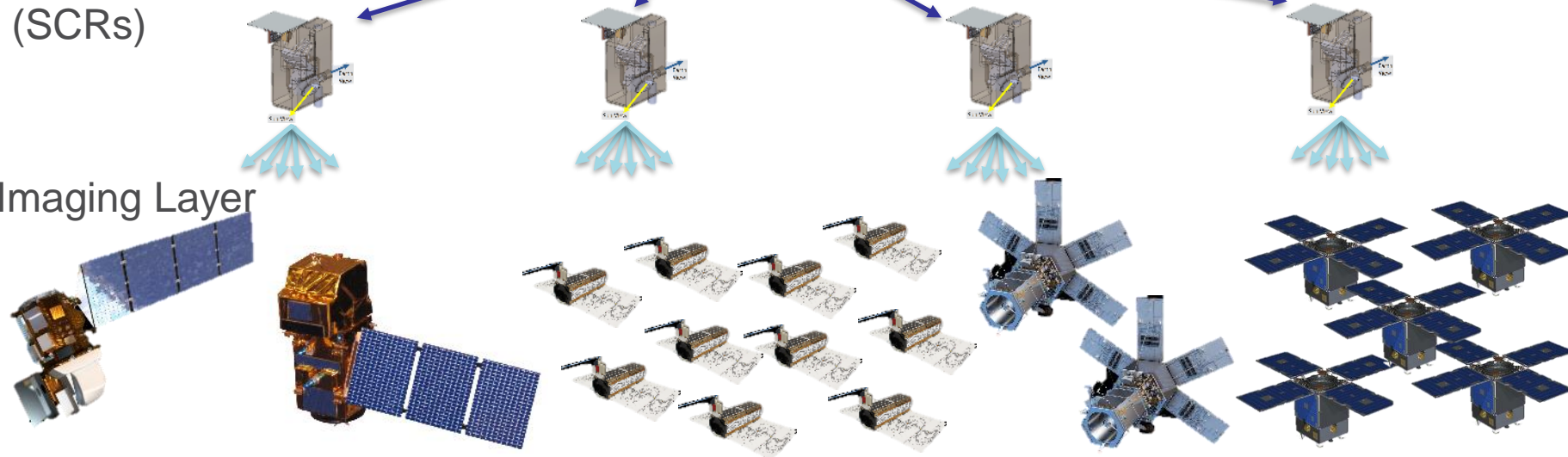
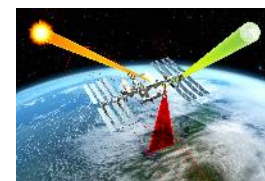
USGS Concept

- Primary Calibration Layer
- Transfer Calibration Layer (SCRs)
- Imaging Layer

TRUTHS



CLARREO Pathfinder



A feasibility study

- University of New South Wales's Australian National Concurrent Design Facility (ANCDF)
- From December 2020 to March 2021 a total of 40 experts from 13 organisations were consulted or participated in the study
- Finding:
 - Sure we could give that a crack
 - Be kinda hard though, we might need help

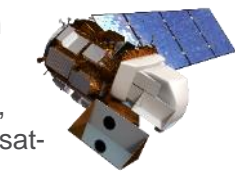
<https://unsw.adfa.edu.au/our-research/facilities/ancdf>



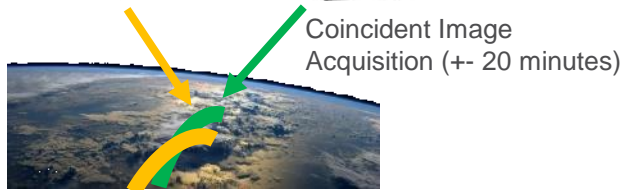
SCR Operations Concept Overview

Calibration sources

(CLARREO-PF, TRUTHS, Landsat-8, Landsat-9)



SCR satellites



Calibration Source Data



SCR Hyperspectral Data

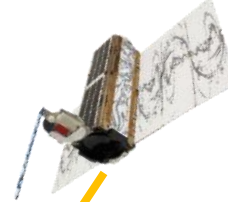


Synthetic Image

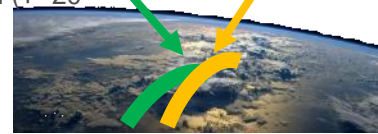


Stable and calibrated SCR ready for transfer

SCR satellites



Coincident Image Acquisition (+/- 20 minutes)



SCR Hyperspectral Data



Target Data



Synthetic Image



Corrections provided to target satellite operator for them to improve their data

Target satellites for cross calibration

Potential targets:

- Europe's Sentinel 2 series (2-4 satellites)
- India's Cartosat, IRS and Resourcesat series (15+ satellites)
- South Korea's Optical Kompsat series
- Planet's Doves (105+ satellites)
- Many other private sector smallsat constellations including Maxar, BlackSky, Satellogic, SpaceWill, Earth-i, Orbital Sidekick and LatConnect60

Australia's (current) specifications for SCR

Requirement	Breakthrough	Target
Spatial resolution -GSD (m)	100	100
Swath (km)-nadir	40	60
Spectral range (nm)	400-2400	350-2400
Spectral sampling interval (nm)	10	5
Number of bands (max)	200	410
Spectral resolution (FWHM) - DI (nm)	15	7.5
Spectral calibration accuracy (nm)	0.1	0.1
Radiometric accuracy (%)		
Pre-flight	3	2
On-orbit	5	3
Radiometric stability (%) over 30 days	0.2	0.2
Signal-to-Noise Ratio	> 150:1	> 150:1
Dynamic range - ADC (bits)	12	12
Orbit		
Type	Polar-SSO	Polar-SSO
Altitude (km)	550-705	550-705
Daily collection volume (GByte)* - uncompressed	117	360
Program risk classification (NASA)	Class D	Class C

Advancing Space

Australian Civil Space Strategy 2019 - 2028

space.gov.au



Seven interconnected roadmaps

The Civil Space Priority Areas are interconnected, reliant on cross-cutting technology areas, facilitated by non-technical enabling activities, and may be applied to many cross-cutting services. The roadmap for each Civil Space Priority Area details the significance of these factors to its implementation. The roadmaps nexus illustrates the strategic interplay of these important categories.

While the Australian Space Agency has an important role as a partner, facilitator and regulator, it is the initiative of the space sector that will drive the pursuit and capture of the identified opportunities.

ROADMAPS CONTEXT

Roadmaps nexus Identifying growth activities

CROSS-CUTTING TECHNOLOGY AREAS

Key technology areas from the broader economy have been identified that should underpin Australia's future space capability. Leveraging these will foster a more robust development pathway. Government, including the Australian Space Agency, is supporting this through its activities. For example, space has been identified as a national manufacturing priority.

Advanced manufacturing

Cybersecurity

Interoperability

Digitised and data driven systems engineering

Platform-based architectures

Artificial intelligence

NATIONAL CIVIL SPACE PRIORITY AREAS



Communications technologies and services



Earth observation



Robotics and automation on Earth and in space



Leapfrog R&D



Space situational awareness and debris monitoring



Position, navigation and timing



Access to space

CROSS-CUTTING SERVICES

Cross-cutting services are areas of high opportunity and enduring priority for the application of Australian space capability. They are based on both national need and market considerations. They each draw upon capabilities spanning more than one Civil Space Priority Area. Further service application areas are in scope but are considered within the domain of their relevant Civil Space Priority Area. Sourcing first customers for these applications is critical to capability realisation.

Disaster risk management

Remote industry, environment and resource management

Exploration services

Science services

National security

FACILITATORS

Investment and policy

Governance and coordination

Industry resilience, workforce and skills

Regulation and standards

Social licence and sustainability

Facilitators enable progress towards reaching the targeted capabilities. They provide the supporting conditions to contribute to addressing challenges identified by the Australian space sector and streamline the path to achieving the roadmap visions. Together, the implementation of these

facilitators will foster environments conducive to impactful research and development (R&D), and to a dynamic and robust commercially-focused ecosystem favourable to new business ventures.



Australian Calibration & Validation Activities Visible & Infrared Earth Observation: Status – Planned

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