

Steering Committee The First Decadal Plan for Australian Space Science 2008-2017

Space Science in Australia: Rationales and Summary of the Draft Decadal Plan

The Steering Committee
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“World-leading innovative space science and technology, strong education and outreach, and international collaborations that build Australia a long term, productive presence in Space”

ASDC 23 July 2008 [See www.physics.usyd.edu.au/~ncss for Draft Plan & other documents.]

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Outline

- Origins
- Executive Summary of the Draft Plan.
- Purview
- Current status
- Issues with Australia's status quo
- Draft Plan
 - Themes
 - ACCSS – Australian Coordination Committee for Space Science
 - Education, Training, Outreach & Community Building
 - Science & Technology Projects
- Why to invest in Australian space science now
- Summary.

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1. Origins

National Committee for Space Science (NCSS) formed by the Australian Academy of Science:

- Focus on science of and from space (solar system)
- Responsibilities are to
 - foster the science & community
 - advise Academy
 - manage overseas links.

Sept 2005 - NCSS announces Decadal Plan process
 Aug 2006 - End of initial Working Group period Over 100 people
 Feb 2008 - Draft Plan Released for Comment
 July - Sept - Final consultations / Townhall meeting
Late 2008 - Release of Plan

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2. Executive Summary of the Draft Plan

1. Science of space and science done from space.
2. Strong rationales for supporting Plan include inspirational education & training; human capital development; crucial services & technology, Uni-Govt-industry & inter-field links; strategic; world-leading science & tech.
3. Decadal investment into new large projects < \$140 M →
 - Less than \$1 / Australian / year & 0.02% of Fed 2006/7 surplus
 - New coordination body ACCSS
 - World-best Sun-to-ground science network (Spaceship Australis)
 - 2 novel world-class spacecraft missions (Lightning & Sundiver)
 - New program (ICFO) for Australians in international projects
4. Medium projects (ARC): radars → image analysis → hypersonics.
5. Education, Training, Outreach & Community projects.

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3. Purview of Space Science Plan

- **Solar system.**
- Science of space & science from space.

“Everything above the stratosphere”

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Purview

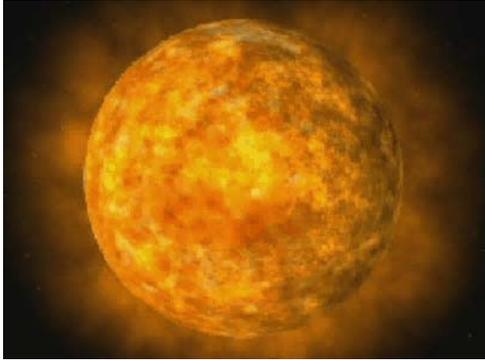
Space Science includes:

- space physics and space weather
- planetary geology / science
- remote sensing of Earth
- astrobiology
- space technology

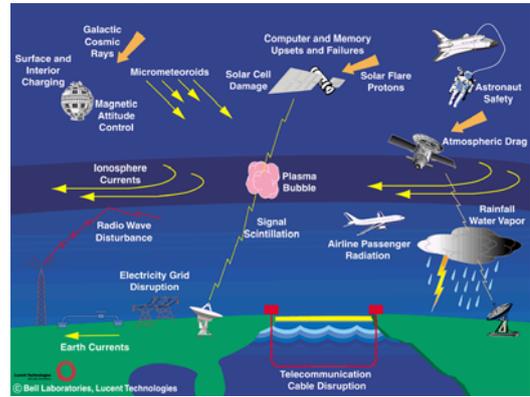
Draft Plan does not include “operational remote sensing”.

Astronomy ↔ extra-solar system, Earth Sciences ↔ surface & below.

i. Space Physics and Space Weather



Space Weather at Earth



ii) Planetary Science and iv) Astrobiology

How did we go from this?

Interstellar molecular cloud



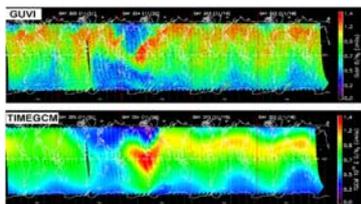
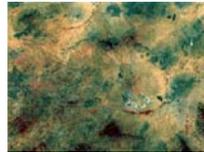
ii) Planetary Science and iv) Astrobiology

To this?



Starry Night

iii. Remote Sensing of Earth, planets...



Climate change, hazards, weather, defence, mining..

atmosphere, ionosphere, environment, space weather ...

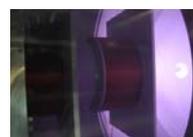
v. Space technology



Antarctica



TIGER radar



Plasma thruster (Astrium contract)



FedSat

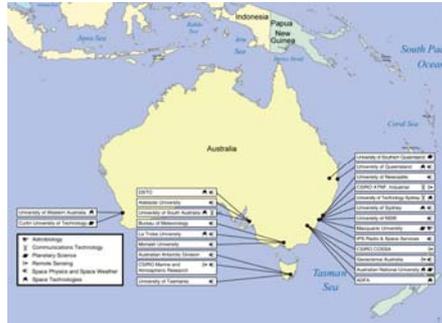


Hypersonics

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4. Current Status of Australian Space Science

Institutions and People



16 of 17 major Research Unis (U. Wof'gong) + VSSEC

- > 160 paid FTE academics & > 73 postgrad students in 2006
- > 24 scientists / technologists do NASA/ESA research outside jobs,
- Not including industry, DSTO, GA, and operational users (> 2000?)

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Global value and Recognition of Australian Space Science

Excellence compared with other fields & nations :

- Space science is Australia's most highly cited field of research ¹ - 38% more than articles by non-Australians.
- Geosciences is second (25%) ¹.
- Contributes to global literature at a rate 52% than Australia's average rate, with ~ 4400 papers in decade ¹.
- Leadership roles in over 20 international space-related sci. bodies.
- Australian-led examples of international collaborations include FedSat, TIGER radars, CSIRO-UK instrument on ESA's Envisat, World Data Centre for Solar-Terrestrial Science, HyShot & HIFIRE.
- Invitations for NASA's STEREO, ESA's Mars & Venus Express, Japan's Hayabusa, US AMPERE, hypersonics

¹ Thomson Scientific's 1996-2005 category "space science" includes Astronomy while "geosciences" includes atmospheric science and remote sensing.

5. Issues with Australia's Status Quo

- Shortage of > 20,000 scientists/engineers by 2013 ¹.
- Decreasing enrolments in science, maths, eng & tech.
- Space services increasingly vital to Govt, Industry, & Society → increasing importance of space weather.
- Few remote sensing instns calibrated for Aust. conditions.
- Missing link in research portfolio: ground → ? cosmos.
- Interdependence: ionosphere / space weather vital for optimal use of SKA and MWA – use to locate SKA here?
- Reputation brittle at UN and elsewhere.
- Unsustainable to be only a consumer & not a creator.

¹ July 2006 Australian Govt "Audit of science, engineering & technology skills"

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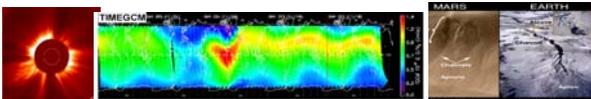
6. Draft Plan

- Themes
- ACCSS (Australian Coordination Committee for Space Science)
- Education, Training, Outreach & Community Building.
- Science & Technology Projects
 - Large
 - Spaceship Australis, ICFO, "Lightning", & Sundiver
 - Medium
 - Radars → thrusters → hypersonics → cosmochem → image analysis

6.2 Global Science Themes

[For several decades]

- Sun and Space to Earth (SSE)
 - Measure and understand space weather
- Plasma to Planets (P2P)
 - Evolution and properties of the solar system
- Remote Sensing from Space (RS):
 - Developing a quantitative knowledge of Techniques and applications of remote sensing to Earth etc.
- Life and Technology in Space (LIFTS)
 - Space technology, instruments & conditions for life and can exist elsewhere in space.

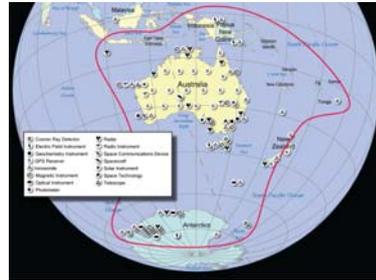


6.4 Education & Training Projects

- SS excellent for this: inspirational, interdisciplinary, fundamental & mathematical sciences.
 - Reduce shortages of trained S&T personnel
 - Increase attractiveness and efficacy of sci. & math. education
 - Inspire greater scientific literacy of the public, industry, and Govt.
- 1. Space Science Student Scheme** – a) improve linkages, b) increase students & collaborators for partners, c) better career pathways
 - 20 Hons, 20 Vacation, & 20 Postgrad Topup Scholarships per year.
 - Research joint between a University and a Govt / Ind. Partner.
 - Require substantial (> 10%) presence at Govt / Ind partner.
 - Annual comp organized by ACCSS - \$240K/yr from partners.
- 2. Assessing Education & Public Outreach Programs** \$100K/yr
- 3. Telepresence Learning for School, Undergrad & PG Students** \$100K/yr
- 4. Collaborative Postgraduate Degrees by Coursework and Research**

6.5.1 Spaceship Australis: \$8 M assets/land & \$12 M Operations/Modelling (2008 start)

“Global Leader in Space Weather”



“Unique Footprint, SH gap, & Global Collabs.”

Goal – Make Australia’s region (1/8th of the world) the best instrumented and modelled for measuring and predicting space weather and its diverse effects on Government, industry, society and our neighbours.

Fundamental S&T + services, builds capability & critical mass, unique, timely, low risk.

“Lightning-1 & -2”: (Launch 2012, End 2017; Cost \$40 - 50M)

“Global space weather”

“Propulsion & Tech”

Aust. Links: Unis, AAD, BoM, CSIRO, DSTO, GA, IPS, Industry



“Australian climate & environment monitoring”

“Contribution to GEOSS”

- Goals:**
- measure and model space weather,
 - demonstrate new Australian capabilities for space technology,
 - leverage strong overlap with Spaceship Australis & ground-truth testing,
 - Australian contributions to climate change and remote sensing.

World-class S&T + services, builds capability & critical mass, leverage, unique, timely..

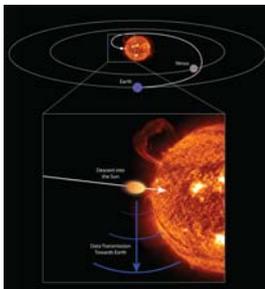
“IFCO (International Collaborations and Future Opportunities) Program” - \$15M, 2008-2015

- Means to enable Australian space scientists to participate officially in future international space projects.
- Current schemes inadequate: response, period, amount.
- Well placed for international space projects :
 - International Space Exploration Coordination Group (ISECG) – dusty plasmas, biology, radiation damage, Mars Analog Sites ...
 - Hayabusa II – Japanese sample return & cosmochemistry
 -
- Structure:** ACCSS manages via proposal system.

“Sundiver” - \$5M 2008/11 + \$40M 2012-2017

Visionary Grand Challenge

“Origin of hot corona & solar wind”



“Technology”

“Venusian climate”

- World firsts:**
- in situ investigation of the corona and inner solar wind via infalling spacecraft (grails of space + astro-physics),
 - zodiacal dust studies in situ + planetary science
 - propulsion demonstration ...

7. Why invest in the Space Science Decadal Plan? 1

- Status quo is inadequate: human capital, skilled services, sales, SKA support, space/hitech reputation, Antarctica ...
- One component of national research strategy.
- Inspirational education, training, & outreach.
- Crucial services & applied science for Govt, Ind & Society.
- Strategic & economic benefits for Nation.
- World-leading science & technology.
- Missing link in portfolio between Astro & Earth science.
- Mutual dependence & benefits Astro ↔ space ... SKA.
- Strong cross-linking with enabling sciences / maths / Engineering, Astronomy, Earth Sci...

ACCSS Links, Roles & Benefits

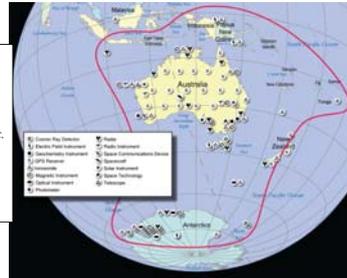


Cost ~ \$200 K/yr

ACCSS connects and leverages Australia's space science interests & assets into a national capability and links this to international groups and commercial entities.

"Spaceship Australis": \$7 M assets & \$10 M Operations (2008 start)

- Existing & New Assets:
1. Ionospheric Radars: TIGER + 3 DigiRadar
 2. Auroral meteoric radars: Buckland, Katherine
 3. Optical: Fabry-Perot
 4. GPS arrays, incl upgraded NCRIS assets
 5. Magnetometers: GA, SERC, IPS + Newcastle
 6. Ionosondes: IPS, DSTO
 7. Solar radio telescopes
 8. Cosmic ray detectors
 9. VLF detectors (AWSSOMER)
 10. SKA & MWA/LFD
 11. PILOT Antarctic telesc.



- Science:
- Dynamic ionosphere and atmosphere
 - GPS Tomography
 - Sun-Earth coupling & Space weather
 - Radar & wave physics
 - Theory & modeling
 - SKA & MWA
 - Sea state & climate
 - Orbital debris

Goal – Make Australia's region (1/8th of the world) the best instrumented and modelled for measuring and predicting space weather and its diverse effects on Government, industry, society and our neighbours.

Fundamental S&T + services, builds capability & critical mass, unique, timely, low risk.

"Lightning-1 & -2": (Launch 2012, End 2017; Cost \$40 -50 M)

- Proposed Assets & Instruments:
- 2 spacecraft, 1 equatorial, 1 inclined
 - Thermal plasma (electrons and ions)
 - Local electric and magnetic fields
 - Plasma waves and radio waves
 - GPS receivers
 - Ionospheric beacon for DSTO
 - Lightning and sprite imagers
 - Greenhouse gas concentrations
 - Atmospheric composition
 - Spectral imagers for remote sensing
 - Gravimetric gradient detectors
 - Magnetic gradient detectors
 - Plasma thrusters for propulsion
- Aust. Links: Unis, AAD, BoM, CSIRO, DSTO, GA, IPS, Industry



Science & Technology Goals:

- Atmospheric and ionospheric dynamics
- Space weather
- GPS tomography
- Lightning /global electrodynamics
- Climate change
- Remote sensing
- Ground-truth testing
- Gravity and magnetic maps
- Propulsion demonstrator
- New instruments
- International collaboration

Goals:

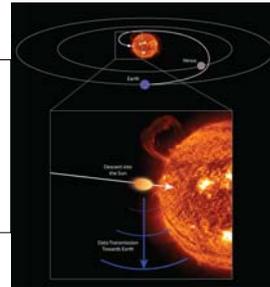
- measure and model equatorial ↔ high-latitude atmos-/ionosphere,
- demonstrate new Australian capabilities for space technology,
- leverage strong overlap with Spaceship Australis & ground-truth testing,
- Australian contributions to climate change and remote sensing.

World-class S&T + services, builds capability & critical mass, leverage, unique, timely..

"Sundiver" - \$5 M 2008/11 + \$40M 2012-2017

Visionary Grand Challenge

- Proposed Assets and Instruments:
- 1 or 2 spacecraft (redundancy)
 - Thermal plasma (electrons & ions)
 - Local electric and magnetic fields
 - Plasma waves & radio waves
 - Energetic particles
 - Solar wind composition
 - Dust experiment
 - Atmospheric composition
 - Spectral imagers - remote sensing
 - Gravimetric gradient detectors
 - Magnetic gradient detectors
 - Plasma thrusters for propulsion



Science & Technology Goals:

- Heating of the solar corona
- Origin of the solar wind
- CMEs, flares and space weather
- Composition
- Zodiacal dust distribution
- Remote sensing Venus
- Venusian greenhouse modeling
- Gravity & mag. maps of Venus
- Propulsion demonstrator
- International collaboration

- World firsts: (a) in situ investigation of the corona and inner solar wind via infalling spacecraft (grails of space + astro-physics), (b) zodiacal dust studies in situ + planetary science (c) propulsion demonstration ...

Medium Projects

- DigiRadar – fully digital HF radars \$2M
- Plasma thrusters - \$2M
- Hypersonics - \$5M
- Planetary Data & Image Analysis Facility - \$1M
- Mass Spectrometer Centre for Cosmochemistry - \$4 M.

4.2 National Research Priorities (NRPs)

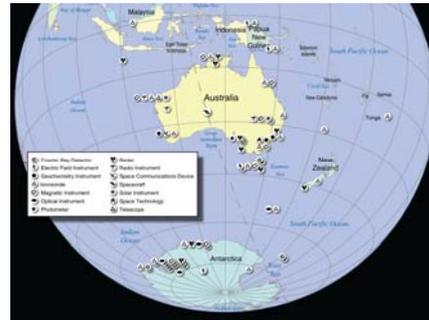
The Plan directly addresses all four NRPs and numerous Priority Goals, with science driving technology and v.v.

- NRP 3 "Frontier Technologies ..." via
 - PGs "Breakthrough science", "frontier technologies", "advanced materials", and "smart information use"
- NRP 4 "Safeguarding Australia" via
 - PGs "Critical infrastructure", "transformational defence technologies", and "protecting Australia from invasive diseases and pests"
- NRP 1 "An Environmentally Sustainable Australia" via
 - PGs "Responding to climate change and variability", "water – a critical resource", "overcoming soil loss ...", "transforming existing industries"
- NRP 2 "Promoting and Maintaining Good Health" via
 - PGs "Ageing well, ageing productively" and "preventative healthcare".

Community Building

- Vital to develop space science community into
 - a cohesive, sustainable, group that
 - takes responsibility for itself and
 - plans how to develop and optimize for max. sci. and nat. benefits
 - 1. ACCSS to link organizations interested in Space** – NCSS, NC Space Eng. Of Eng. Aust., Aust. Govt Space Forum, ASICC... in regular 1-day meetings approx twice per year.
 - 2. Annual space science conference or forum** – professional level, attract all SS, engineers, Govt, industry, educators & enthusiasts
 - 3. Speakers Bureau** – 10-20 media-trained people across SS&T. Possible extension to on-line Forum and Wiki pages.
 - 4. Science Meets Parliament Day** – make it a focus.
 - 5. International Space Week, enthusiast space groups, & Industry** – make 4-10 October a big yearly event for education and outreach.
- Funds – ACCSS \$200K/yr, rest ~ \$10K/yr at start)

Scientific Assets in Australian Space Science

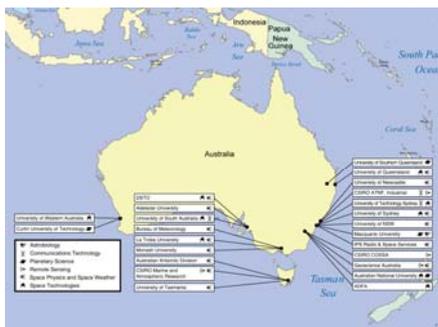


Replacement costs > \$56 M for Uni, IPS & part of AAD assets.

Remote sensing not included!

- Over 90 assets spread across Australasia.
- Not including NASA/ESA tracking stations, GPS or downlinks.
- Across all 5 foci for Unis + Govt units

Major Institutions & People in Aust. Space Science



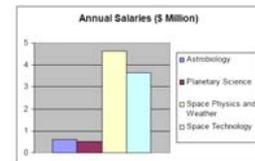
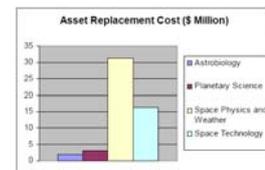
16 of 17 major Research Unis (U.Wol'gong)

+ VSSEC

- > 160 paid FTE academics & > 73 postgrad students in 2006
- > 24 scientists / technologists do NASA/ESA research outside jobs,
- Not including industry, DSTO, GA, and operational users (> 2000?)

Replacement Costs and Budgets

- Not including remote sensing.
- Partial cost to replace ground assets > \$56 M.
- Add FedSat → > \$91 M.
- SPW & ST dominate.
- Salaries for research > \$9 M.



6. Why to invest: Benefits of a national space effort

- Enhance and inspire Australia's human capital (education, training, skills, literacy, and global orientation/goals).
- Improved capabilities in space applications, technology, and services for both Public Good and Commercial entities.
- Increased sales & use of space technology and services.
- A complete and diversified research portfolio: space science links Earth science to Astronomy but also has many practical benefits.
- Optimize SKA proposal & science.
- Improved national reputation and strategic situation in global / space / Antarctic / high tech matters at UN and international fora.
- A unique point of contact to Australia's space capability.
- New discoveries in the fundamental science and technology of space, as well as crucial applied science and services.

Measurement of success?

How to measure success (hidden)

- Increase PhD, Masters, and Bachelors graduations.
- Australian examples of space science & technology in texts.
- Increased enrolments in Uni studies related to space (maths → science → eng → business etc.)
- Increased use & sales of Australian space services & technology.
- New invitations for Australia to contribute in global / space / Antarctic / high tech matters at UN and international fora.
- Enhanced interdisciplinary collaborations in Australian & globally.
- Requests from others to join Australian-led space projects.
- New invitations for major roles in international space projects.
- Increased citations and number of research publications.
- Increased prizes and recognition for Australian space efforts.

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3. Some history & differences with the past

1. Fourth nation to launch an orbiting spacecraft from territory.
2. FedSat 35 years later, in 2002.
3. Australian experts in many areas of space science / tech.
4. **Scientists: overall little community or shared research.**
5. No coordinated national space effort or self-management.
6. Govt judged investing in space science low priority.
7. No space agency or specific space effort / funding.
8. No single contact for companies / space agencies.
9. **Our solution: build a national space effort with clear national benefits via a Decadal Plan process.**
10. **First time community has a Plan on which Govt can build.**

8.4. Projects

- **Science & Technology** – can group into “Ground” and “Space” streams if desired.
 - 4 Large Projects (Spaceship Australis, Lightning, NISS, and Sundiver) – NCRIS ?
 - International Collaboration & Future Projects [ICFO] (ISECG, Hayabusa II,) – NCRIS ?
 - Medium projects (DigiRadar, Thrusters, Hypersonics, Planetary Data & Imaging, Cosmochemistry) – ARC Linkage etc.
 - Small Projects – ARC Discovery/Linkage grants.
- **Education & Training** – NISS, Industry, Unis, DEEWR, DIISR.
- **Community Building** – ACCSS.

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7. The Decadal Plan: status & process

Sept 2005 - NCSS announces Decadal Plan process

Aug 2006 - End of initial Working Group period

Feb 2008 - Draft Plan Released for Comment (30 April)

April - Submission to Senate Inquiry

July - Sept - Final consultations / Townhall meeting

Late 2008 - Release of Plan

Process

- **Steering Committee:** final responsibility for the development, writing, approval, and publication of the Decadal Plan.
- **Working Group:** researches a specific component of the Decadal Plan and then provides recommendations.
- Over 100 people involved to date.

6.1 Vision and Imperatives

- “World-leading innovative space science and technology, strong education and outreach, and international collaborations that build Australia a long term, productive presence in Space”

Imperatives are believed to be:

- **Actively nurture and manage** space science to produce more important scientific discoveries & technology.
- **Empower Australians to lead & participate** in acclaimed space projects to solve major problems.
- **Develop Australia a strong capability** in space science that benefits us in international/economic/environ. affairs.
- **Leverage** space science investment to benefit enabling sciences, educate/train citizens better, increase economic benefits of space services, & mitigate space disruptions.
- **Provide** Government, business & society with data to guide investment in space & obtain associated benefits.

Over 100 Participants from

Auspace	Australian Antarctic Division
ANU	British Aerospace Australia
Bureau of Meteorology	Bureau of Rural Science
Cisco Systems	COSSA
CRCSI	CSIRO
DSTO	Geoscience Australia
Gravitec	IPS Radio and Space Services
La Trobe University	Macquarie University
Mars Society of Australia	University of Adelaide
University of Newcastle	University of NSW
University of Queensland	University of Sydney
University of South Australia	University of Southern Queensland
University of Technology, Sydney	University of Western Australia
Vipac	WA Department of Land Inform.

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7. Discussion of Issues with AGSF

- Structure, Role, and Funding of ACCSS
- Remote sensing in the Plan
- Industry partnerships
- Funding the Plan
- Other feedback?

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4. Current Status of Australian Space Science

Australians with internationally recognised expertise in many areas:

- Solar and interplanetary physics,
- Space plasma physics,
- Coupling Sun → magnetosphere ↔ ionosphere ↔ atmosphere,
- Space weather services,
- Cosmochemistry and dating of the solar system,
- Comparative planetology,
- Remote sensing planetary atmospheres & surfaces (Earth, Venus, Mars),
- Geodesy,
- Astrobiology,
- Hypersonics and Plasma Thrusters,
- Advanced timing & communication electronics, &
- Education and Outreach, including testing efficacy

Ionosphere, atmosphere & space weather

Quiet Ionosphere UT = 12h 00m

Ionospheric Storm UT = 12h 00m

Electron Column Density 100km to 4000km (m⁻²)
UT = 12h 00m

Electron Column Density 100km to 4000km (m⁻²)
UT = 12h 00m

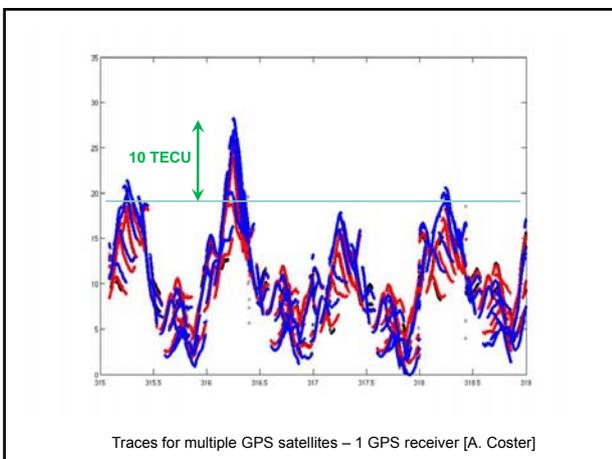
Strong coupling between Sun, solar wind, ionosphere and the atmosphere:

- sunlight → ionization during day
- space weather → ionization via auroral / solar wind particles

Ionospheric Irregularities

- Antennas look through different patches of ionosphere
- Beyond several km, more complex than simple gradients
- This sets maximum useful physical separation between antennas and distorts images

Virgo A at 74 MHz with VLA



i. Space physics & space weather

- Sun ↔ solar wind ↔ planet surfaces ↔ interstellar medium
- Plasma physics vital
- Big questions include
 - What heats the solar corona?
 - Solar activity?
 - Can we model and predict space weather?
 - What processes produce radiation & particle acceleration?

Coronal Mass Ejection

Coronal Mass Ejection with relativistic proton production