



Australian Government

Department of Defence

Science and Technology

# Wide field-of-view sensing for surveillance-of-space

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Science and Technology for Safeguarding Australia

# Introduction

- Why space situational awareness?
- A quick look at SSA today
- Experience with a low-cost wide field-of-view sensor





# Why Space Situational Awareness?

# Why Space Situational Awareness?

- Understanding what is above us
  - What are other people doing?
  - Recognised Aerospace Picture (RAP)
- Managing our space assets
  - Mission management/operations
  - Good international citizen
  - Fragile resource – Kessler Effect
- Launch services
  - Orbital + sub-orbital launch
  - Collision avoidance
  - Debris management
  - End-of-mission (incl. de-orbit)
- Scientific exploration



# Historical Context

- Satellites
  - Comms, ISR, Remote Sensing, Nav/Time, Science
- Open Skies
  - Satellites vs. Aircraft
  - Sputnik (1957) vs. Gary Power's U2 (1960)
  - Treaty on Open Skies (Aircraft) (1992/2002)
  - National Technical Means (NTM) – verification as part of Deterrence
- Strategic Defence
  - ABM systems (ABM Treaty 1972)
    - Nuclear interceptors
  - Phased Array Radar
    - Massive attack tracking
  - Surveillance of space (as well)
- Weaponisation
  - Outer Space Treaty (1967)
    - Fractional Orbital Bombardment System (1960's)
  - Don't mess with verification (NTM)
  - ASAT (on-again off-again)
  - Strategic Defence Initiative (SDI) (1983)
    - X-ray Laser, Brilliant Pebbles, etc
  - Cancellation of ABM Treaty (2002)
    - Mobile (ship-based SM-3)
    - Interceptor velocity (>3km/s)
    - Radar Power Aperture
  - **Inhibited by treaty not technology**

# Future Perspective

- More of the same
  - ISR, Comms, Remote Sensing, Nav/time, Broadcast, Emergency
- Integrated Aerospace and Missile Defence
  - IAMD >100km alt
- Small-sats
  - “You think drones are annoying!”
- Australia
  - Space asset management
  - Increasing launch services
  - Low-cost applications
- Counter ISR
- CyberEW against space elements
  - ISR, Nav, Comms, etc
- Counter co-orbital
  - Satellites with defence
- Weapons
  - Treaty failure (e.g. ABM-1972/2002)
  - ABM (Hit-to-Kill, Direct Energy)
  - ASAT (incl. soft-kill)
  - Ballistic Missiles + Manoeuvre
  - Hypersonic Missiles
  - In-situ/Pop-up

Future space more complex environment than today

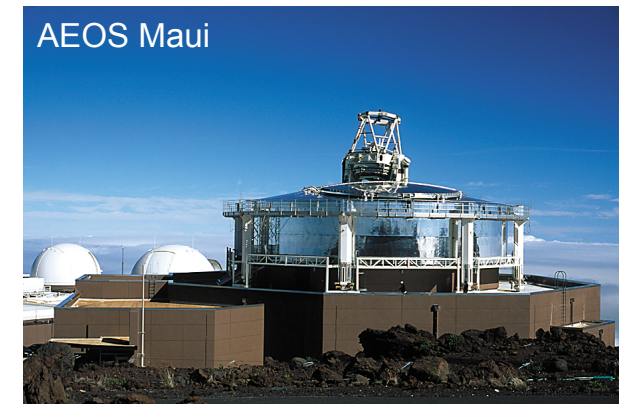
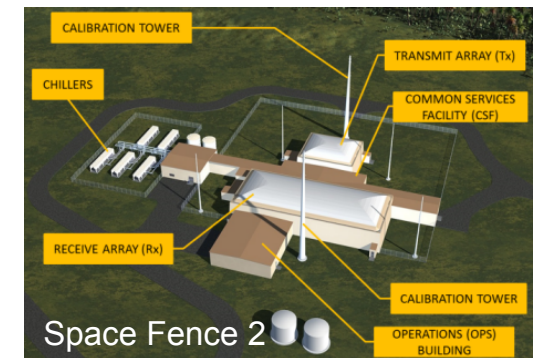


## Existing SSA Systems



# Existing SSA Systems

- Orbit determination
  - New launch - new object
  - Catalogue maintenance
- Imaging of space object
  - Identification
  - Inspection
- Optical
  - Passive (Sun illumination)
  - Active (laser illumination)
- Radar
  - Active
    - Search, Orbit-D, ISAR
  - Passive
    - Incoherent (MWA)
    - Coherent (demonstrated)





# SSA Archaeology



Missile Site Radar (S-band) (from late 1960s) Nike-X/Sentinel/Safeguard ABM System. Meck Is, RMI.



## A Wide Field-of-View Sensor for SSA

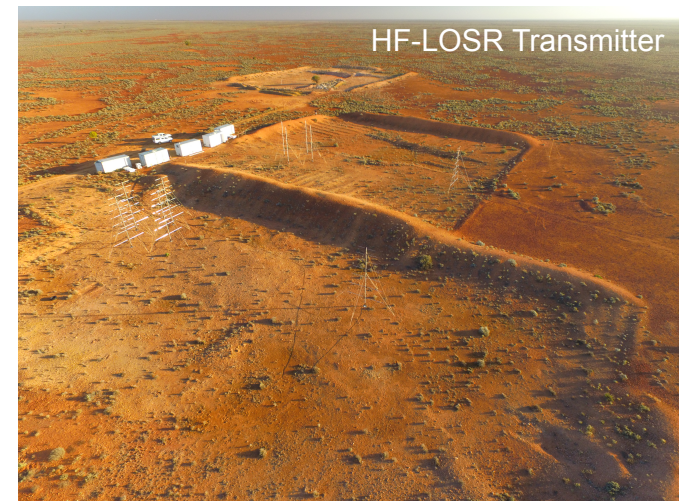


# SSA Sensor Taxonomy

- Field-of-View
  - Narrow
  - Scanning
  - **Wide**
- Modality
  - Optical
  - **Radar**
- Location
  - **Ground-based**
  - Space-based
- Illumination
  - Passive incoherent
  - Passive coherent
  - **Active**
- Object size
  - **“Useful” objects**
  - Debris (small)
- Accuracy
  - **Cueing**
  - Orbit determination
- Utility
  - **Cueing**
  - **Orbit determination**
  - Imaging/classification
- Application
  - **New launch**
  - **Catalogue maintenance**

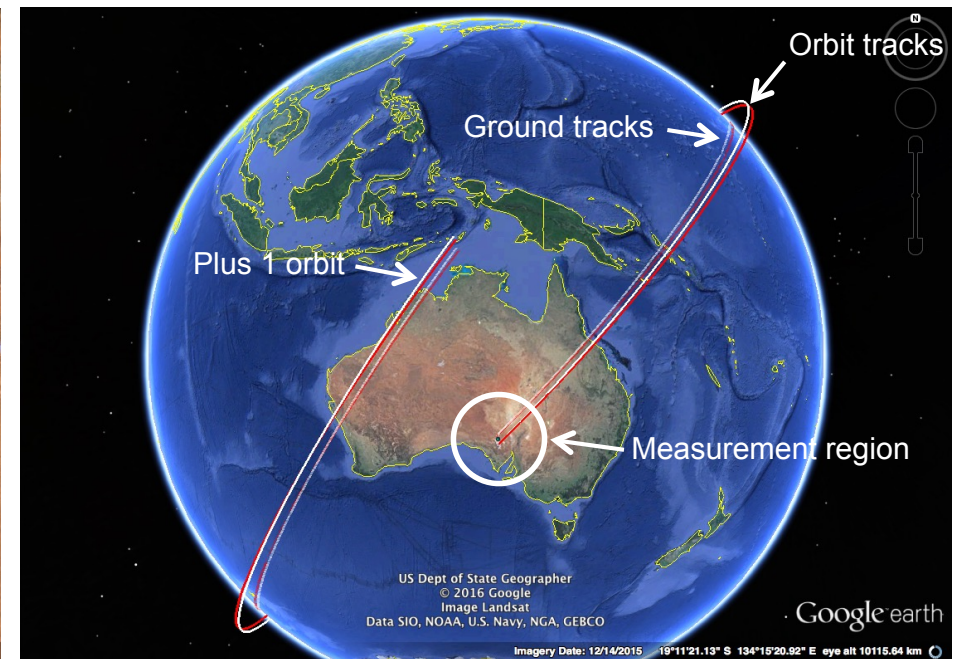
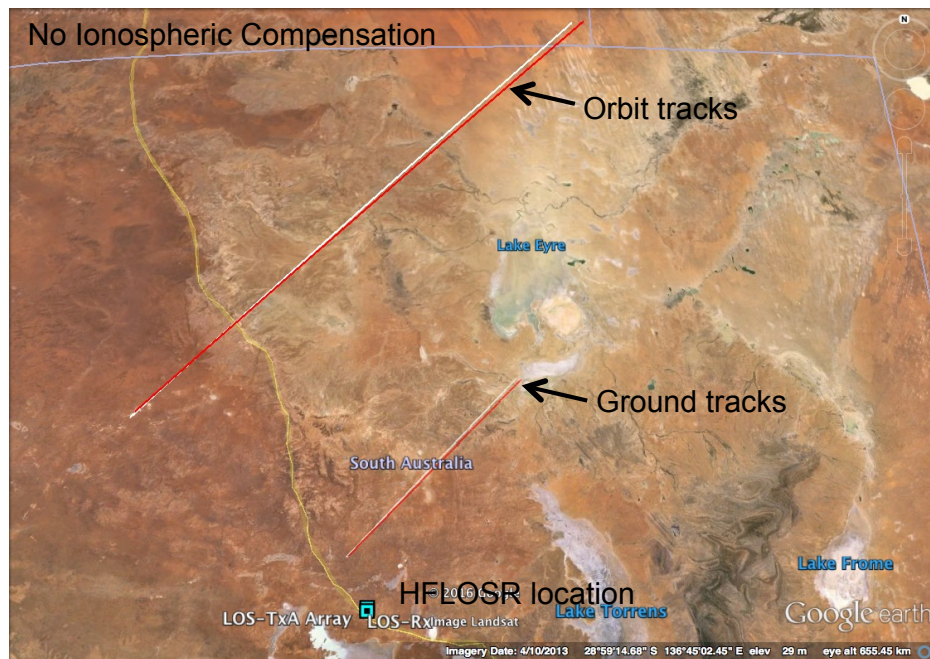
# A Wide Field-of-View Sensor for SSA

- Wide FoV cueing sensor
- Asymmetric TX-RX antenna gain
- Floodlight TX incl. free-space combining
- Bistatic for maximum energy
- Full coverage multiple simultaneous RX beams
- Limit data flow rate by limiting angle/range resolution
- High-accuracy Doppler (incl. motion comp.)
- Multi-frequency operation using common aperture
- Ionospheric compensation – dual freq., sounder, Galactic noise field
- Co-sited with upward-looking ISAR uW radar





# Example Wide-Field Cueing SSA Application



- ISS orbit path –  $TLE_{WWW}$  (white)
- ISS orbit path –  $TLE_{HFLOS}$  (red)

Orbit projected forward 90mins

## International Space Station



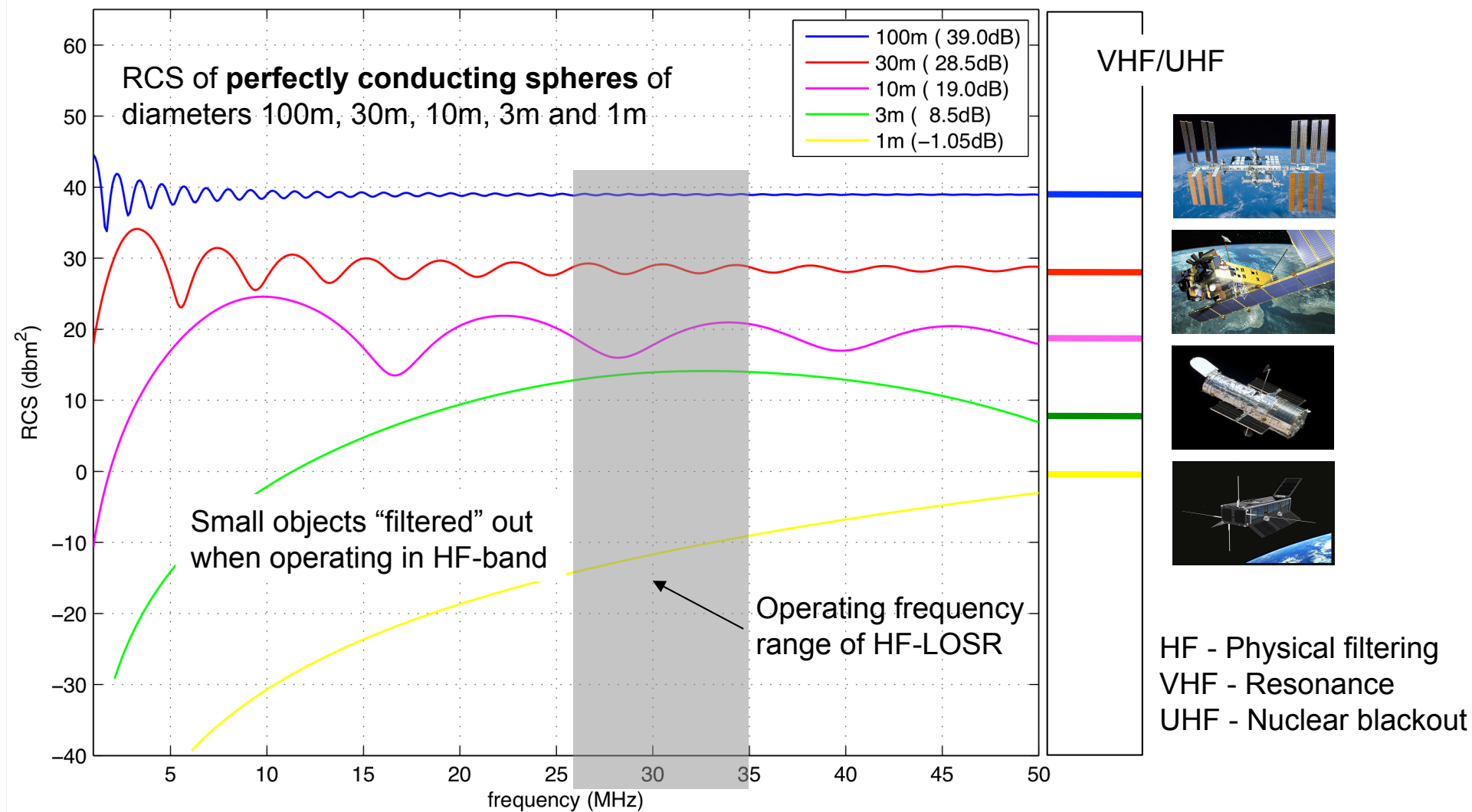
# Comments

- *“Look everywhere all the time”*
  - No scanning – long CITs (incl. accel processing)
  - Good for fleeting and unknown objects
- Example uses HF-band (26-35 MHz) although VHF or UHF also suited for SSA
  - Retain same philosophy/architecture
  - Exploit commercial broadcast power amplifiers
  - Freq. allocation (incl. dual freq.) more complex
  - Antennas, PA, different, but remainder same as HF case
- Accurate to cue other sensors
  - Optical, ISAR uW radar, etc
- Low-cost and scalable
  - +12dB sensitivity increase system ~A\$10-20M
  - Range >1500km for operationally relevant objects





# Frequency Selection – Radar-Cross Section



# Conclusions

- Prepare for future uses of space
- Not everyone has the same SSA need
- Wide-FoV architecture demonstrated (HF or VHF, UHF)
- Cue Narrow-FoV orbit determination and imaging sensors (ISAR radar)
- System-of-systems – multi-phenomenology – radar/optical
- Location and cost – many systems in diverse locations
- Indigenous experience and opportunities (Optical, radar, etc)



