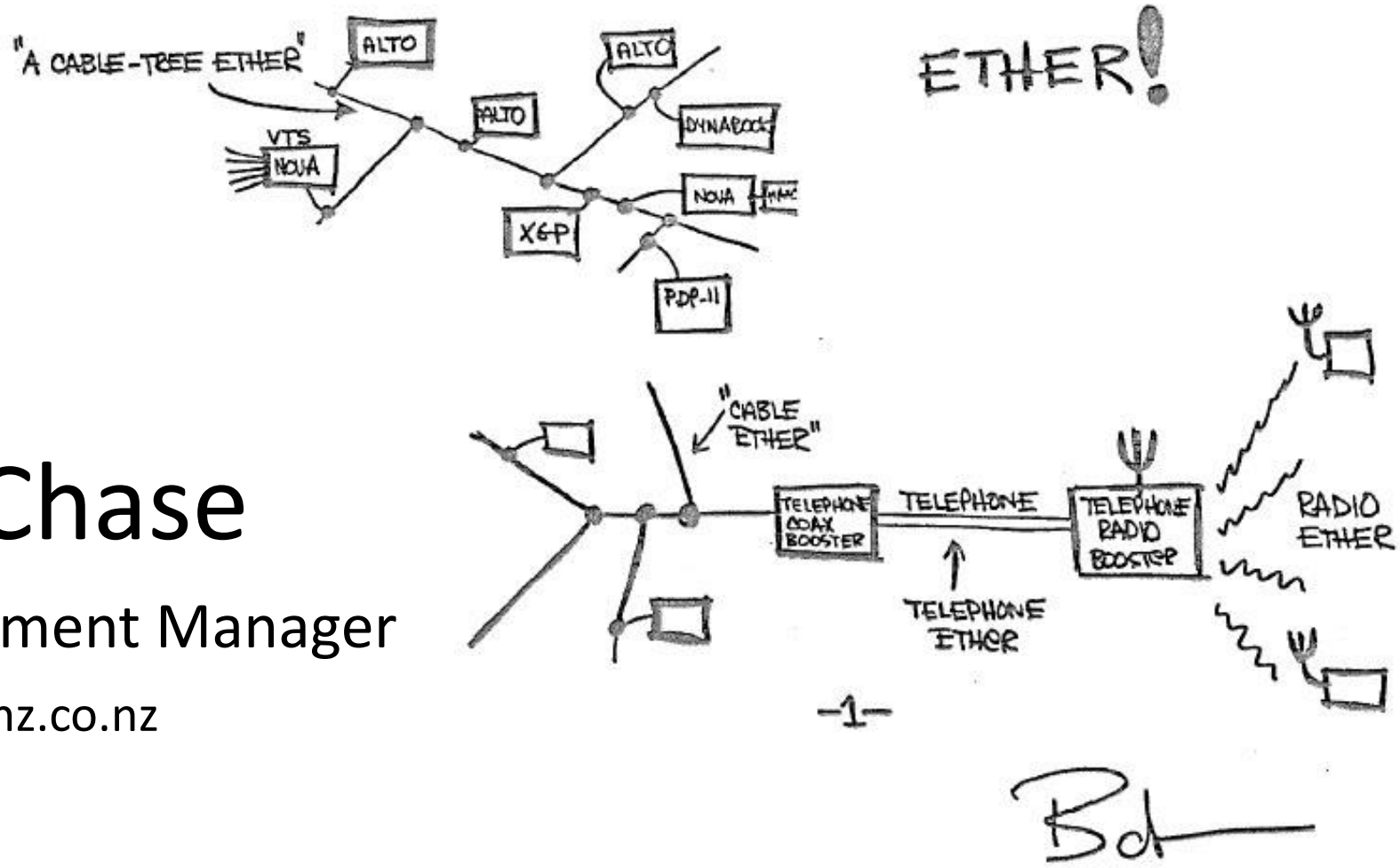
REAANZ



Wallace A. Chase

Technical/Science Engagement Manager

wallace.chase@reannz.co.nz

@bmtfr

REANNZ

The Current Reality of Internet in McMurdo

State-side Household
Single Internet Connection

- **2.5: Average US Household Size**
- **18.75 Mbps: Average US Internet Bandwidth**
- **7.4 Mbps: Average Per Person, Per Household Bandwidth**
- **104 Mbps: Average Peak US Internet Bandwidth**
- **40 Mbps: Average Per Person, Per Household Peak Bandwidth**

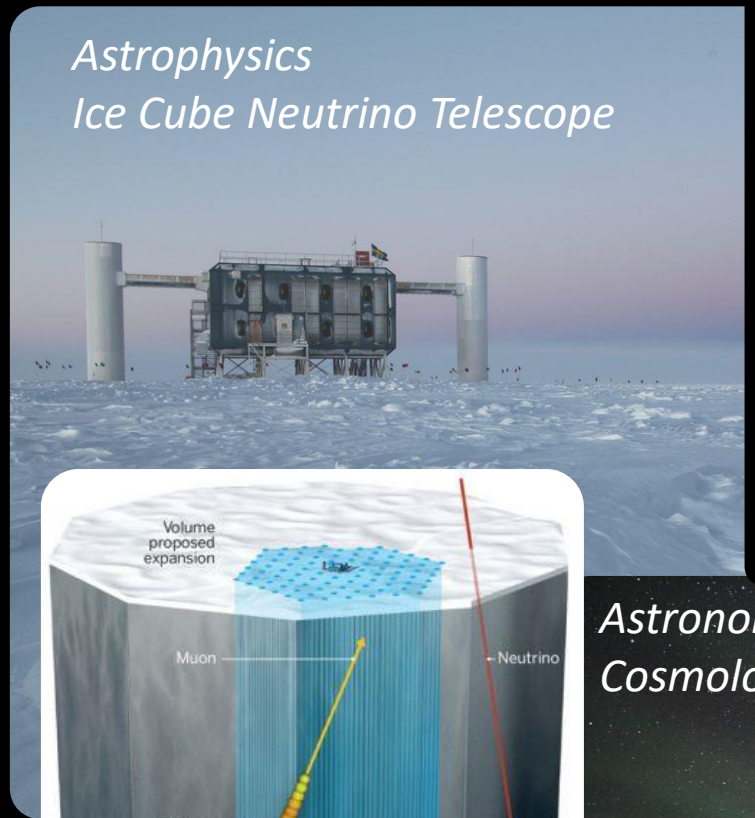
McMurdo - a Small Town
Sharing a Single Internet Connection

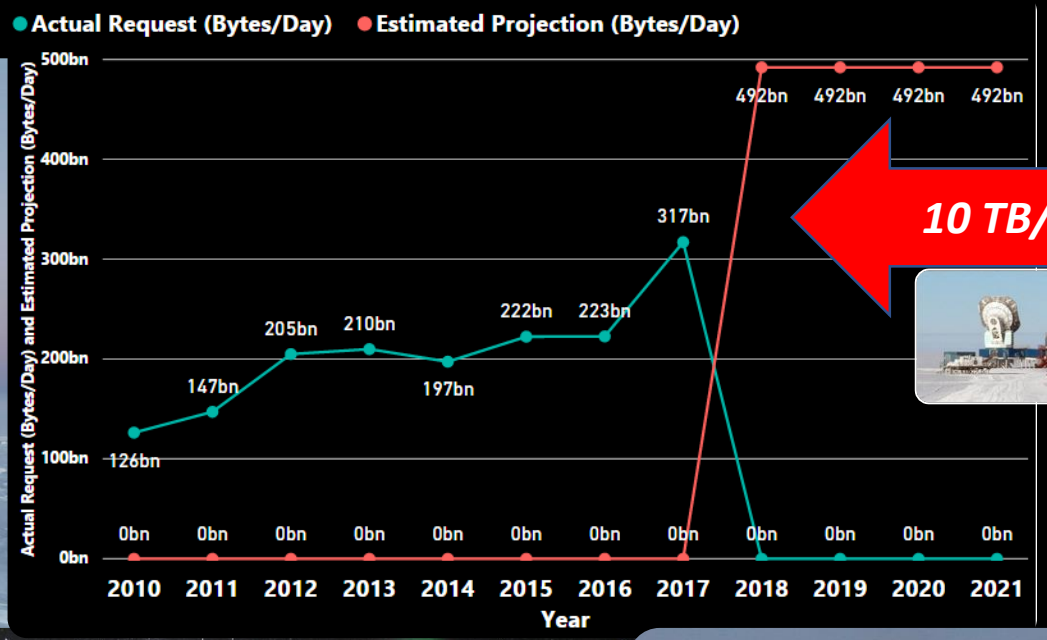
- **~900: Average Peak Summer Population**
- **18/10 Mbps Network Bandwidth**
- **0.025/0.014 Mbps (25/14 kbps): Average Per Person Bandwidth**

McMurdo services ~1000 people for base operations, science, medical services, educational outreach, phone service and personal use/morale, 24x7x365, with just a single network connection the size of an average household in middle-America…

South Pole Challenge – Big Science – Big Data

Astrophysics
Ice Cube Neutrino Telescope





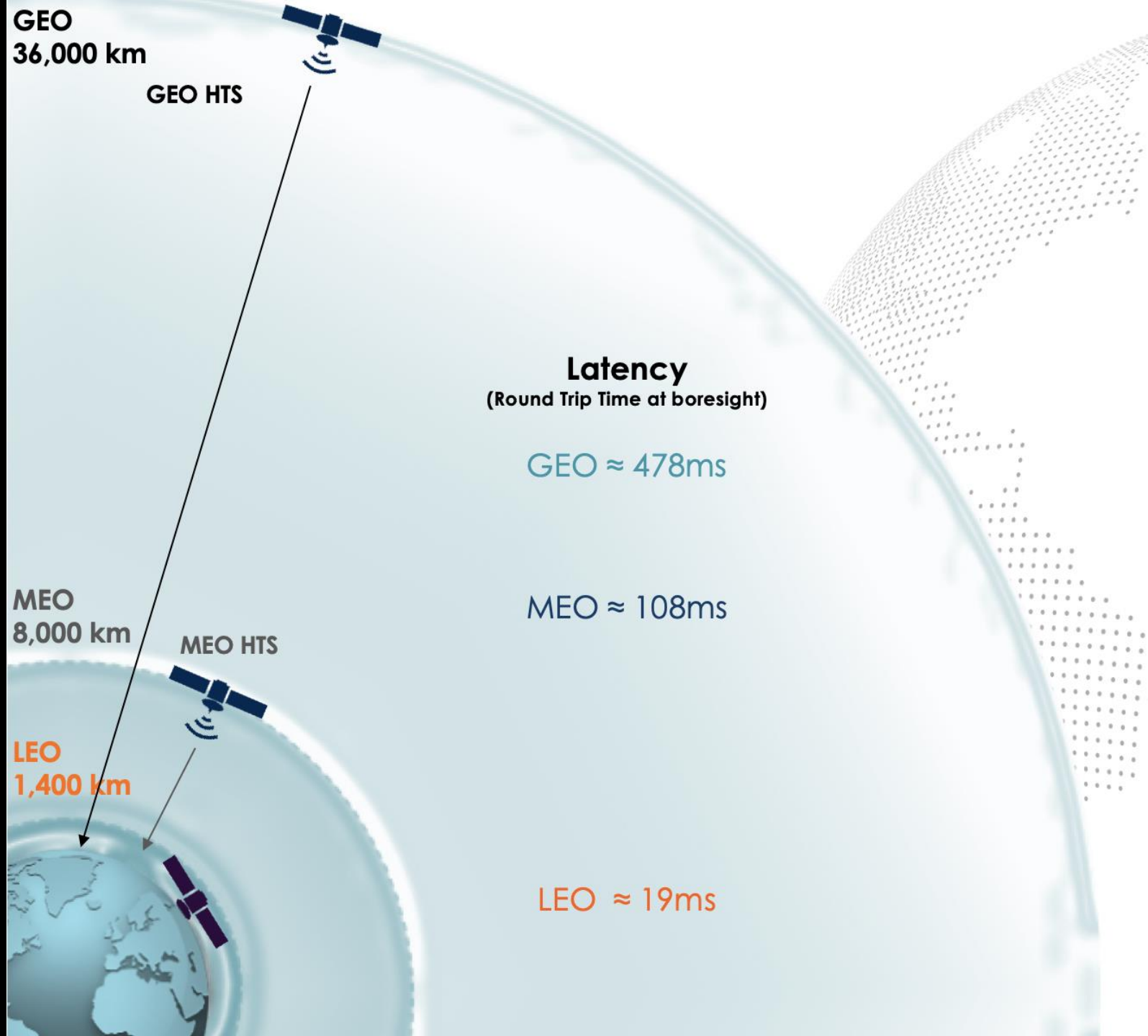
10 TB/day by 2027-ish

Astronomy
Cosmology – Echoes of the Big Bang

South Pole Telescope

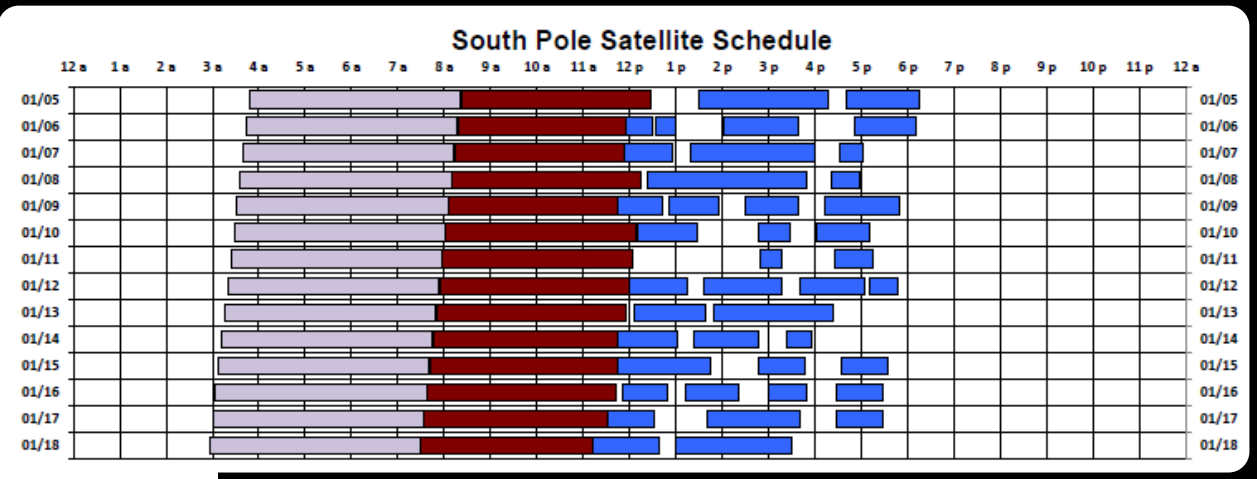
Satellite 101

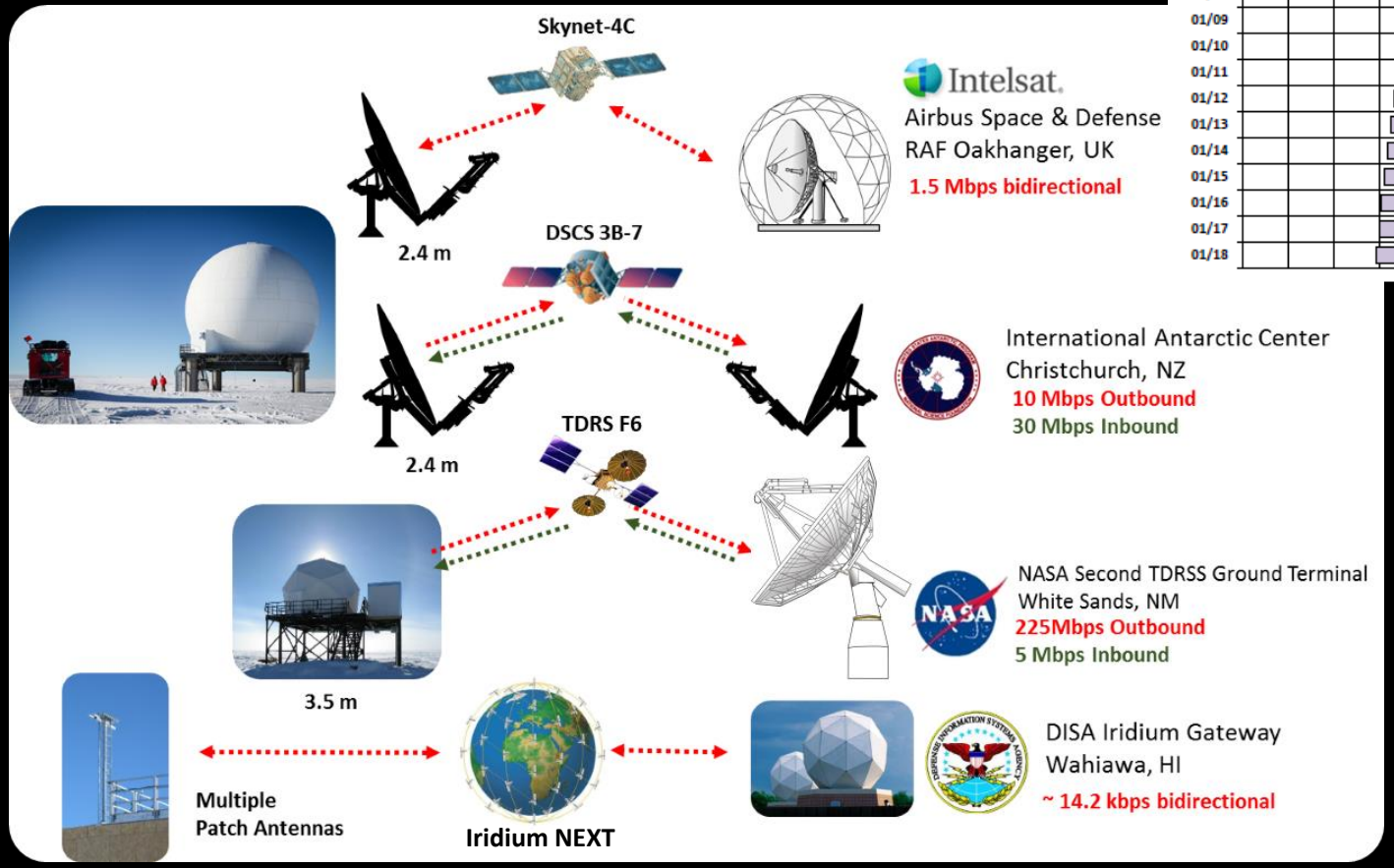
- Geostationary (GEO) satellites:
  - have been around since the 60s of last century
  - mainly for telephony (early days) and TV broadcast
  - not useful (long latencies and slow) for Internet usage
- Medium Earth Orbiting (MEO) tried to be the fix for the Internet, did not happen
- New development: **Low** Earth Orbiting (LEO) satellites



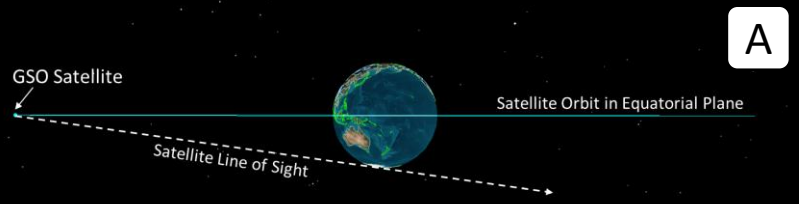
Present-Day South Pole Satellite Network

SPTR
Skynet
DSCS

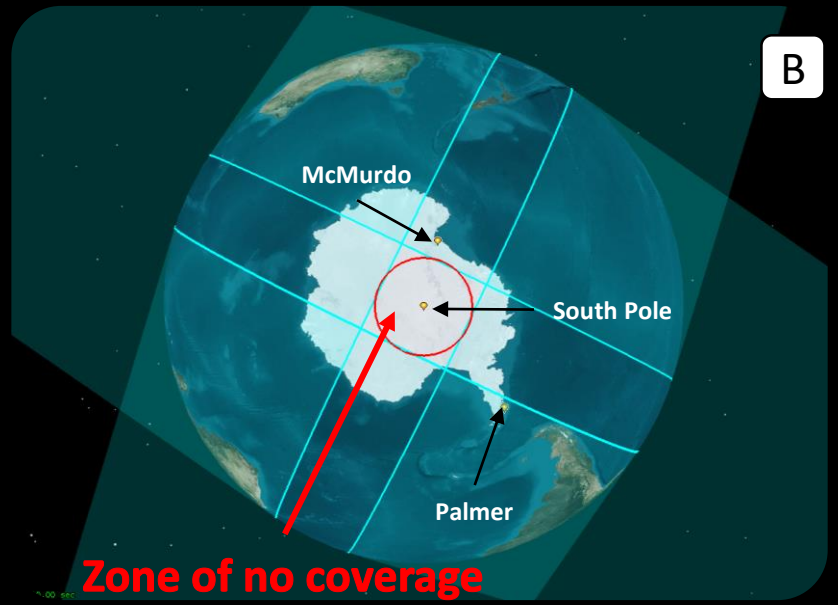




Antarctic Geometry Affects Satellite Availability



The limit of visibility of the satellite for a ground observer is denoted by the red line. The satellite appears at the horizon. Beyond this line to the right, the satellite is below the horizon and not visible.

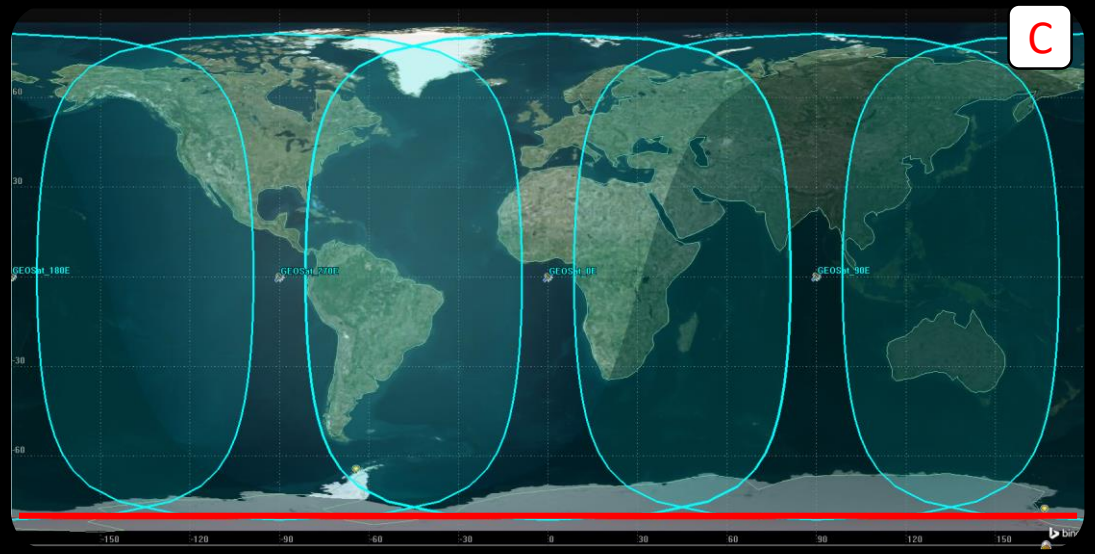


Views of standard GSO satellite visibility footprints

- A – From the Equator
- B – From the southern pole
- **C – The red line shows the limit of visibility in the Antarctic,** representing 0° local elevation (at the horizon) at longitude 81°S

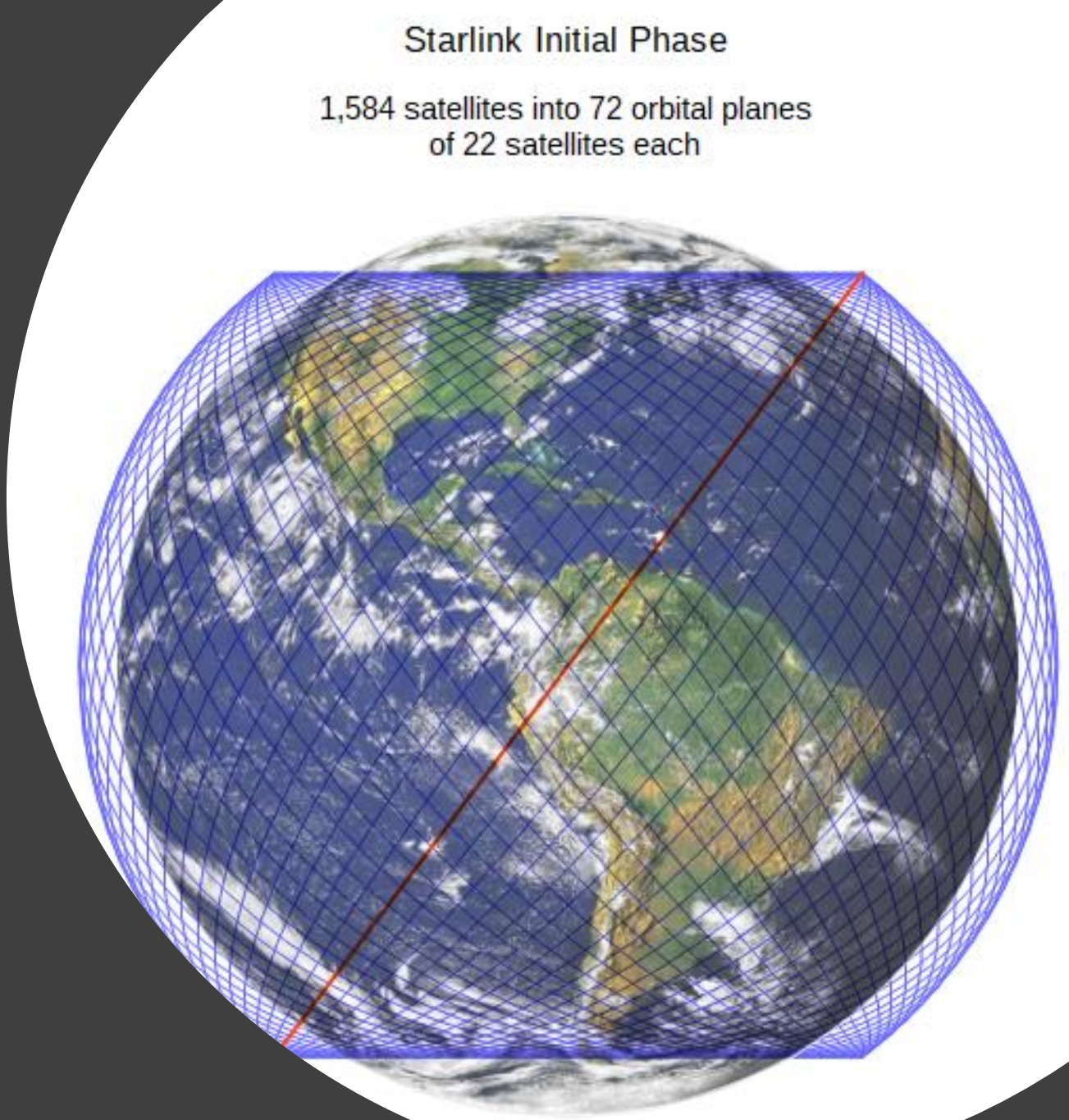
❖ Longitudes closer to the South Pole (90°S) cannot see the satellites due to blockage by the Earth

❖ At McMurdo the satellites are only 3.5° above the horizon



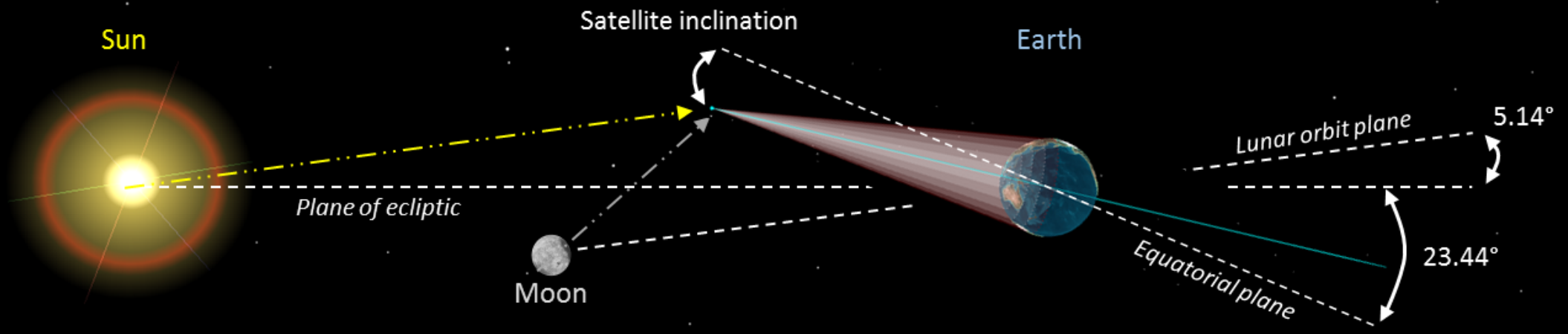
- Big focus and lots of investments:
  - Starlink (by SpaceX)
  - OneWeb
  - Iridium Next
  - Telesat
  - Others

- Purpose:
  - Ubiquitous “high-speed” low-latency for the entire planet



How Once-GEO Satellites Can Support South Pole

Changing Solar and Lunar gravitational forces, along with the Earth's gravity field, over time cause a GSO satellite inclination to drift from 0° to roughly 14.5° and then returning to 0° with a period of approximately 52 years. Drift rates vary from 0.7°/year to 0.95°/year.



Lunar inclination relative to the equator varies from a minimum of 18.32° to a maximum of 28.58° with a period of 18.6 years. This causes variability in Lunar gravitational forces on the satellite over time.

Sun Inertial Axes
6 Feb 2016 06:07:00.000 Time Step: 10.00 sec

Figure 5 Solar-Lunar Gravitational Forces Affecting GSO Orbital Inclination Over Time

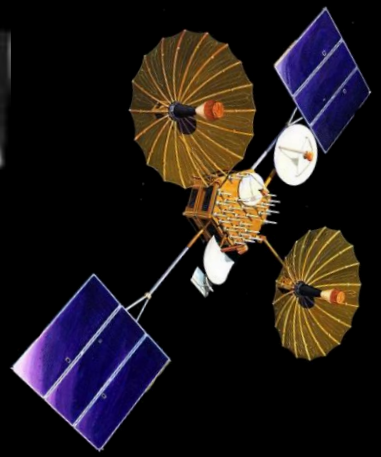
South Pole: Dumpster Diving Architecture

Old inclined GEO satellites only current options for South Pole Station

Guess who?

DoD DSCS-3 Fleet

NASA First Gen TDRS Fleet



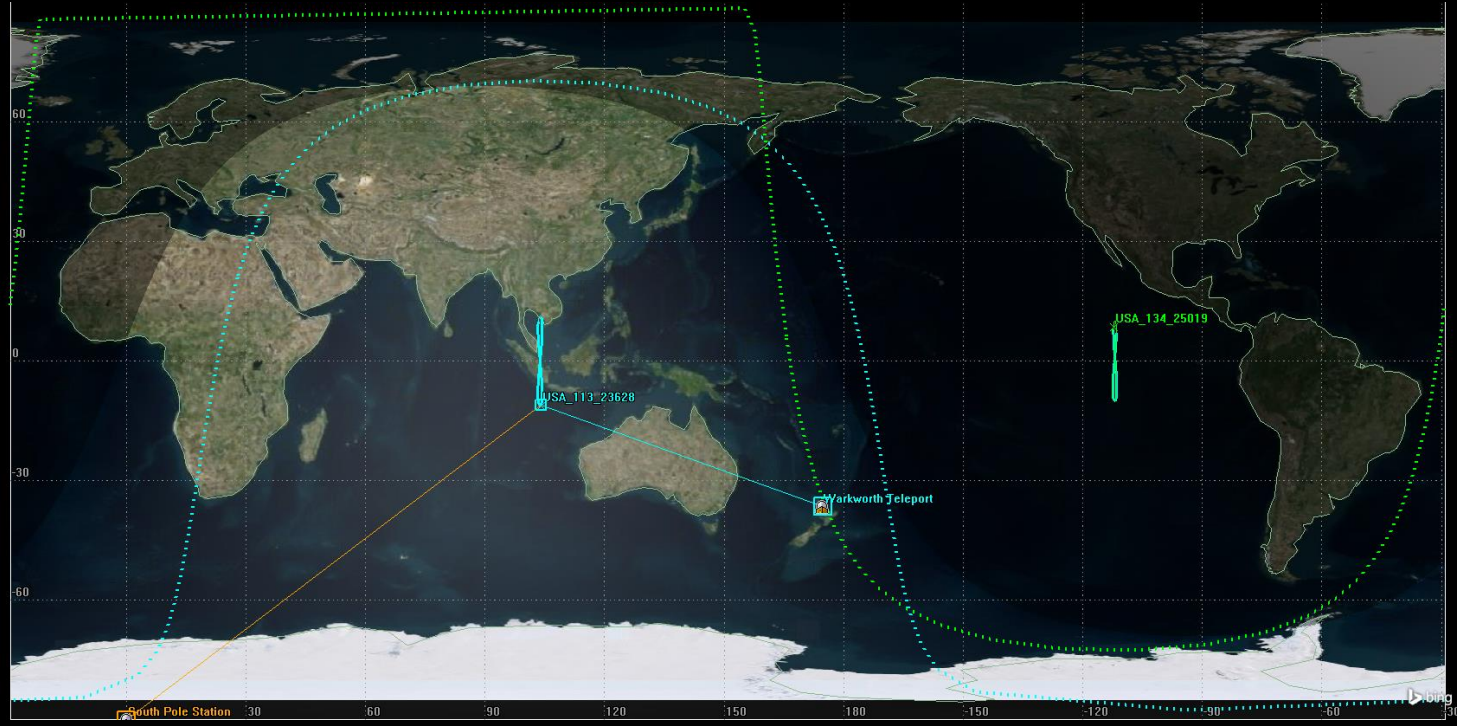
- There are not very many of these and are hard to come by (requires searching a lot of dumpsters for a long time…)
- Limited capacity (these were built when dial-up networking was king - have to live with what one finds…)
- Questionable longevity (these things are old & tired by the time one finds them…)

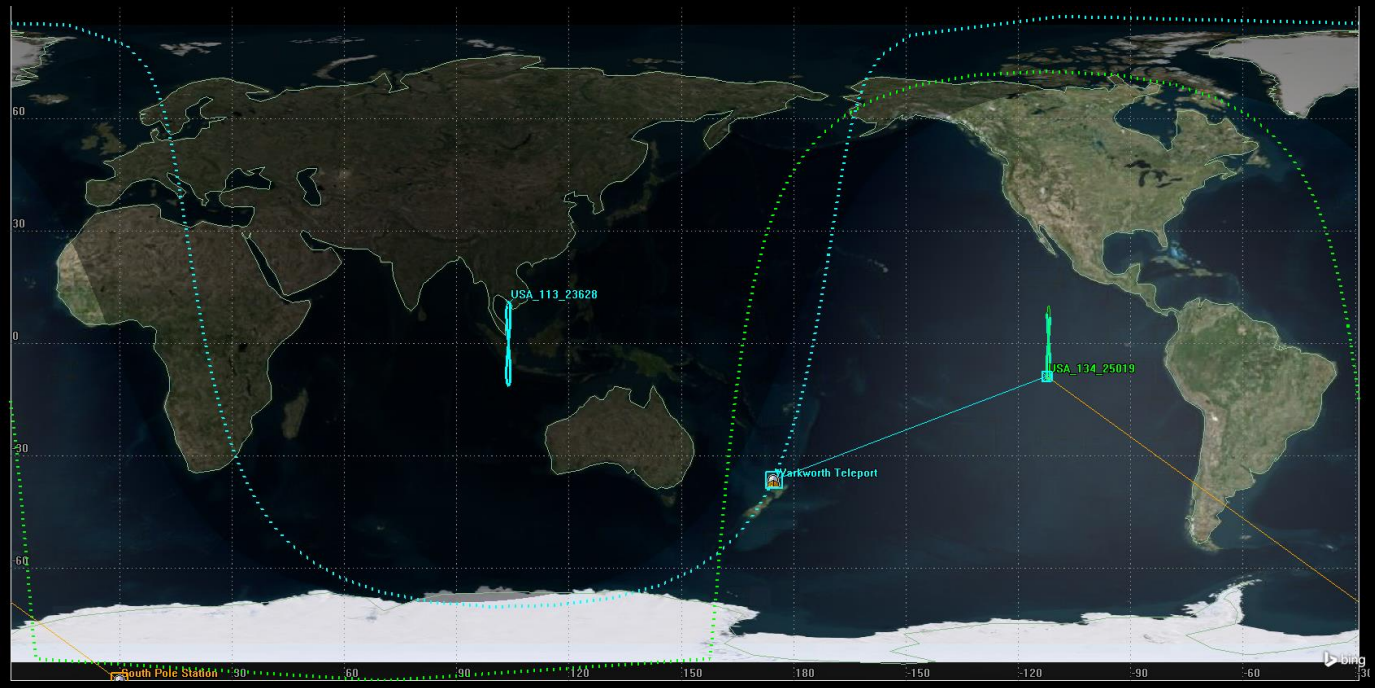
Today…

- Big Data science of astronomy/astrophysics at South Pole Station currently generates up to 470 GB/day of data flow to home institutions
- Legacy NASA satellites are used to provide the data link, and these satellites are few in number and aging to the point of end-of-life
- NSF/OPP and its support contractor Leidos/ASC have been working to establish alternate satellite resources as a risk reduction to failure of the NASA satellite now supporting South Pole
- Two different satellites identified will provide landing points in either NZ or Guam, and this opens the opportunity for Trans-Pac NREN to provide backhaul

DSCS

Warkworth Teleport
North Island



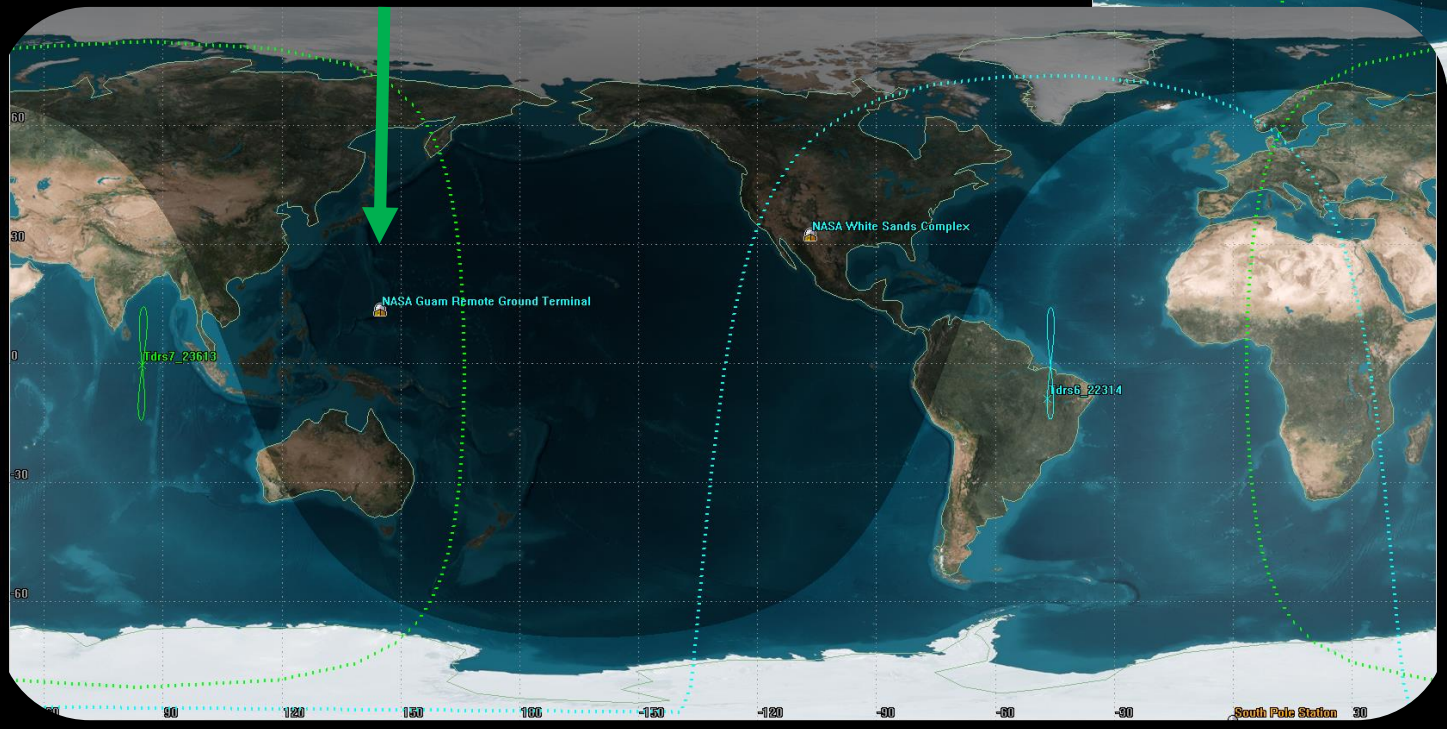


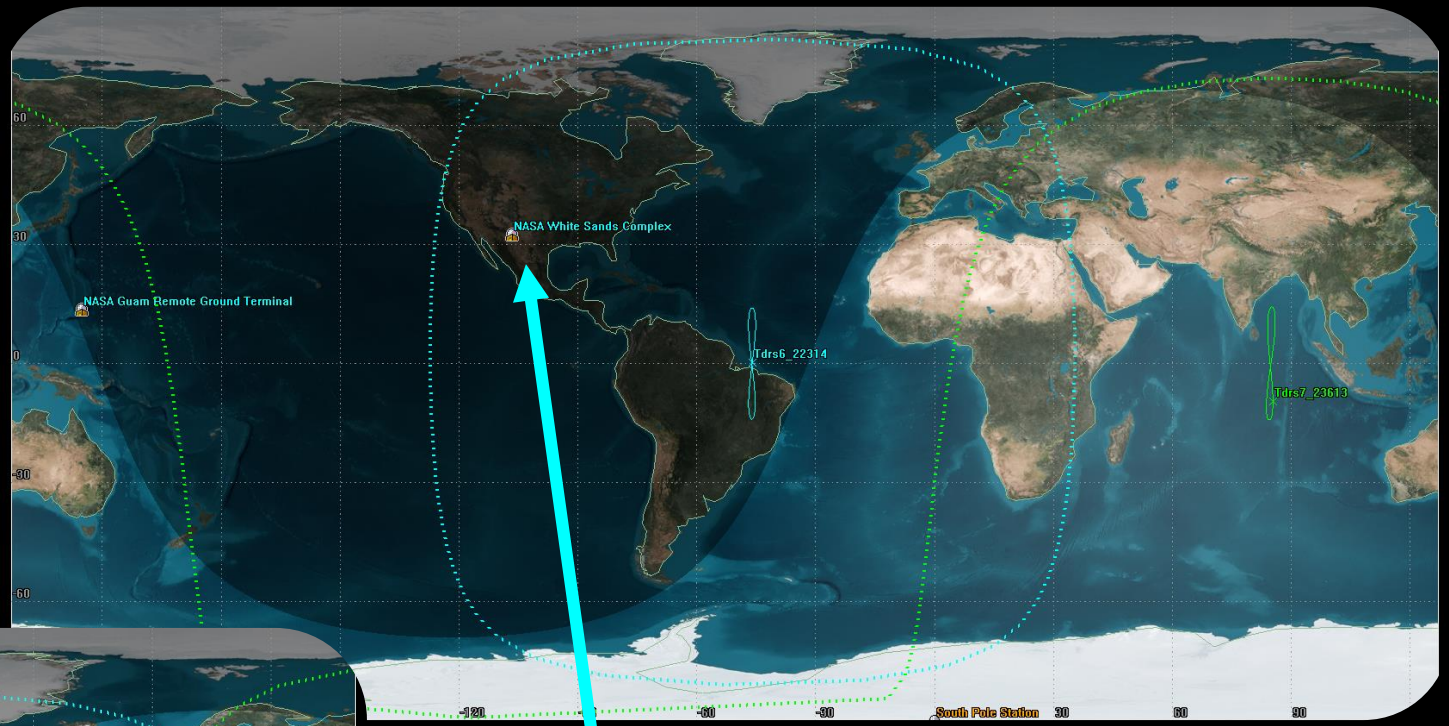
The Spark NZ Warkworth commercial teleport can establish a viable link with two DSCS-3 satellites available to NSF: one at 104°E and one at 112°W

NASA Guam Remote Ground Terminal – Needed for Contact with TDRS F7 Satellite

Nominal TDRS F7 Footprint at Equator Crossing

- White Sands is not covered
- Guam is covered

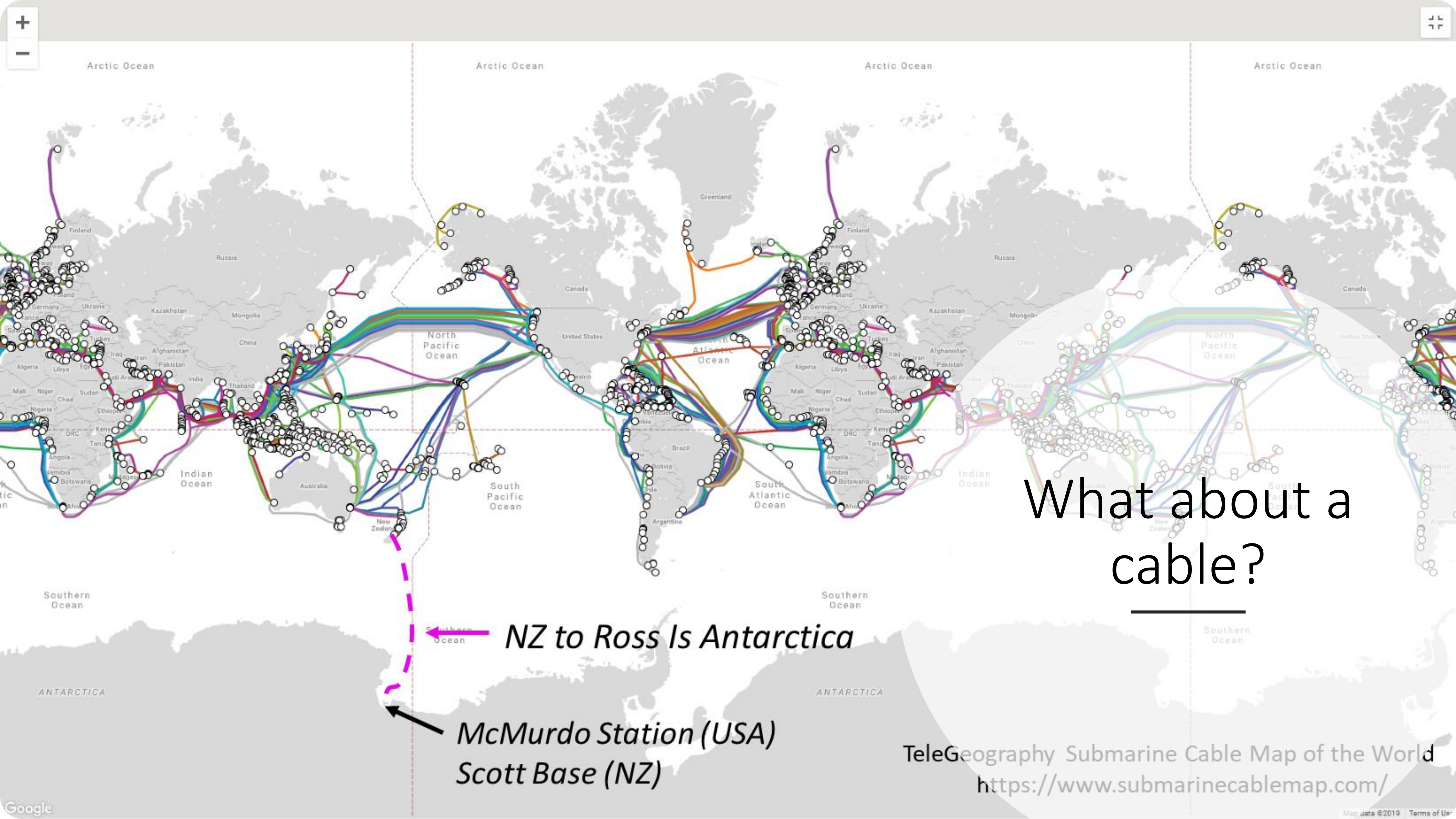




Nominal TDRS F6 Footprint at Equator Crossing

- White Sands is covered
- Guam is not covered

What about a cable?



TeleGeography Submarine Cable Map of the World
https://www.submarinecablemap.com/

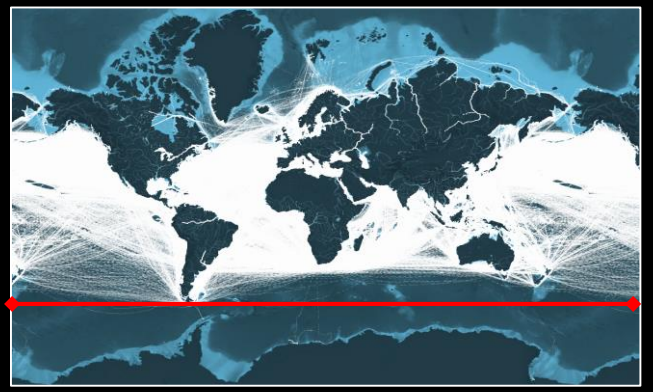
Why a Cable?: *Conventional satellite operators are not incentivized to target service for Antarctica*

Construction and launch costs for modern geosynchronous communications satellites are between $200M to $600M. Service lifetimes are nominally 15 years. Satellite operators place satellites in global regions and target service where revenue will be generated to produce a positive return on investment for shareholders:

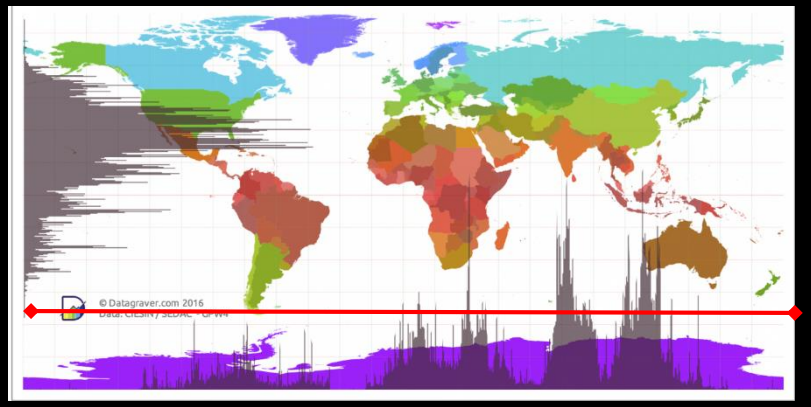
- Land masses with high population densities
- Global shipping and airline routes
- FCC only requires operators to provide service between 70°N to 55°S

- *Latitude > 54°S (Tierra del Fuego)*
  - → *Not many people*
  - → *Not many ships*
  - → *Not many aircraft*
  - → ***NO SUBSTANTIVE REVENUE***

Global shipping route maritime traffic density



World population distribution by latitude and longitude - 2015

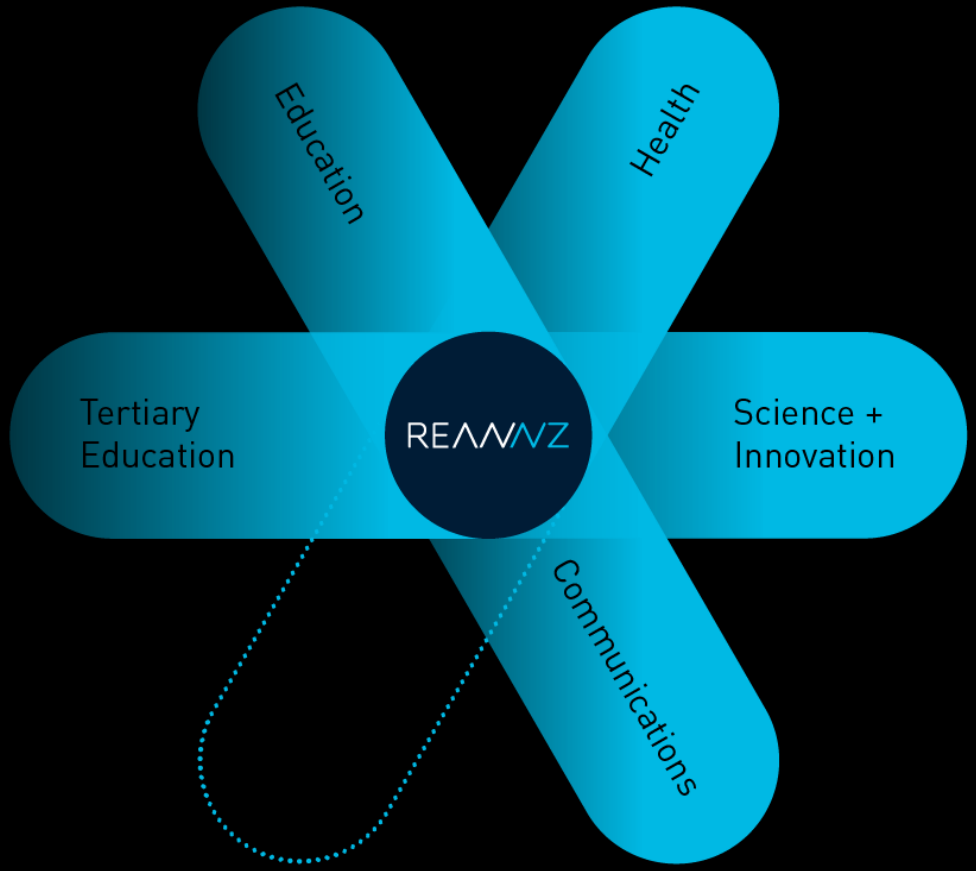


Global air route airline traffic density

McMurdo Neighborhood

What other international Antarctic operators have an interest?

Thank you!



wallace.chase@reannz.co.nz
@bmtfr