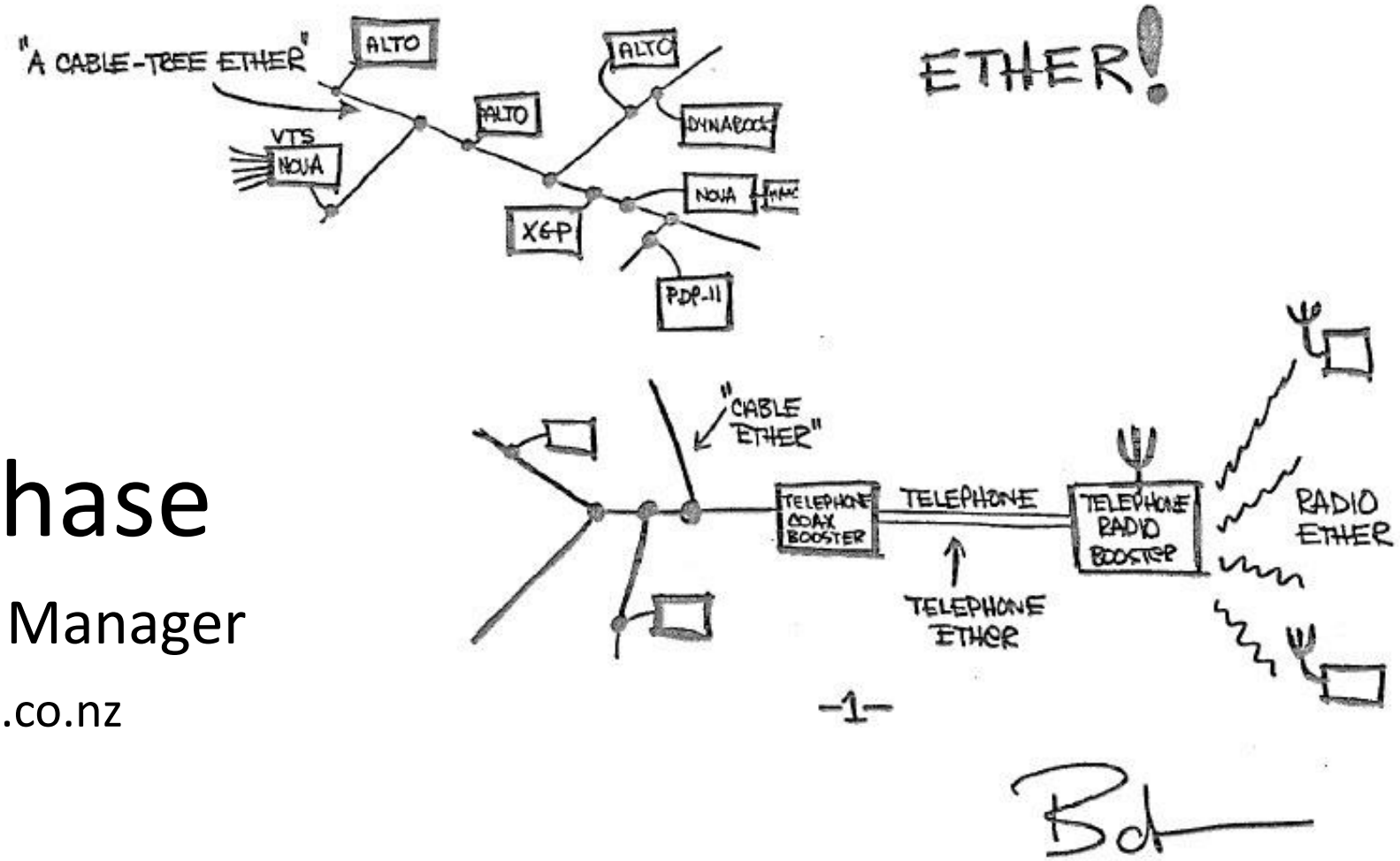
REAANZ



Wallace A. Chase

Technical Engagement Manager

wallace.chase@reannz.co.nz

@bmtfr

REANNZ

RESEARCH & EDUCATION ADVANCED NETWORK NZ LTD (REANNZ)

A business owned by Government, we report to:

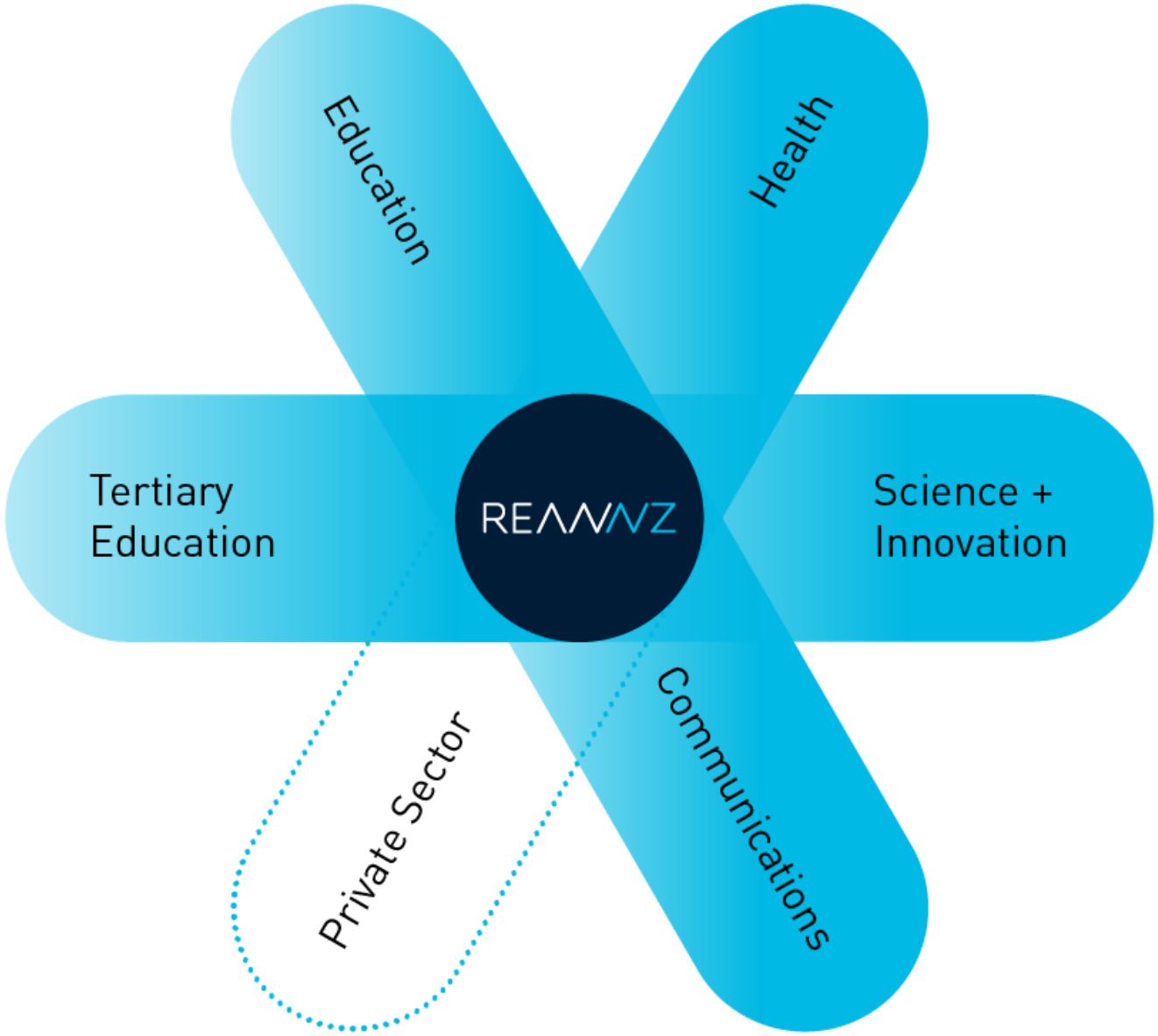
- Minister of Science and Innovation
- Minister of Finance

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

REANNZ

- not for profit entity
- Board of Directors appointed by the Govt
- Govt funding of USD$2M p.a (note = that's only 16% of our total revenues)
- The other 84% comes from our members and services
- 27 highly skilled staff

REANNZ's target sectors



REANNZ members

8 Universities

AUT University

Lincoln University
Te Whare Wānaka o Aoraki
AOTEAROA • NEW ZEALAND
New Zealand's specialist land-based university

Massey University
Te Kunenga ki Pūrehuroa
University of New Zealand

The University of Auckland
Te Whare Wānanga o Tāmaki Makaurau
New Zealand

UC University of Canterbury
Te Whare Wānanga o Waitaha
Christchurch New Zealand

University of Otago
Te Whare Wānanga o Otāgo
New Zealand

Victoria University of Wellington
Te Whare Wānanga o te Ūpoko o te Ika a Māui

The University of Waikato
Te Whare Wānanga o Waikato

7 Crown Research Institutes

agresearch

ESR

GNS Science
Te Pū Ao

Landcare Research
Manaaki Whenua

NIWA
Taihoro Nukurangi

Plant & Food Research
Rangahau Ahumāra Kai

Scion
Forests • Products • Innovation

8 Polytechnics/Wānanga

EIT
EASTERN INSTITUTE OF TECHNOLOGY

OTAGO POLYTECHNIC
Te Kura Matatini ki Otago

SOUTHERN INSTITUTE OF TECHNOLOGY
TE WHARE WĀNANGA O MURIHIKU

TE WHARE WĀNANGA O AWANUIĀRANGI

Unitec Institute of Technology
TE WHARE WĀNANGA O WAIRAKA

WelTec
Wellington Institute of Technology
Te Whare Wānanga o te Awakairangi

WITT
WESTERN INSTITUTE OF TECHNOLOGY AT TARANAKI
Te Kura Matatini o Taranaki

Whitireia
NEW ZEALAND

Independent research organisations/govt depts etc

Tertiary Education Commission
Te Amorangi Mātauranga Matua

CallaghanInnovation

BRANZ

NZCER
Rangahau Mātauranga o Aotearoa

MINISTRY OF EDUCATION
TE TĀHUHU O TE MĀTAURANGA

NZQA
NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

CAWTHRON INSTITUTE

AM
TĀMAKI PAENGA HIRA
AUCKLAND WAR MEMORIAL MUSEUM

WHITECLIFFE
COLLEGE OF ARTS & DESIGN
TE WHARE TAKIURA O WIKIRIWHI

LINCOLN AGRITECH LTD

Techion Group Ltd

MALAGHAN INSTITUTE
OF MEDICAL RESEARCH

compac

EDUCATION PAYROLL LIMITED

PACIFIC EDGE LTD
CANCER DIAGNOSTICS COMPANY

DIOCESAN SCHOOL FOR GIRLS

Kristin
KINDERGARTEN - SENIOR SCHOOL
BUILDING GREATNESS

Why do we exist

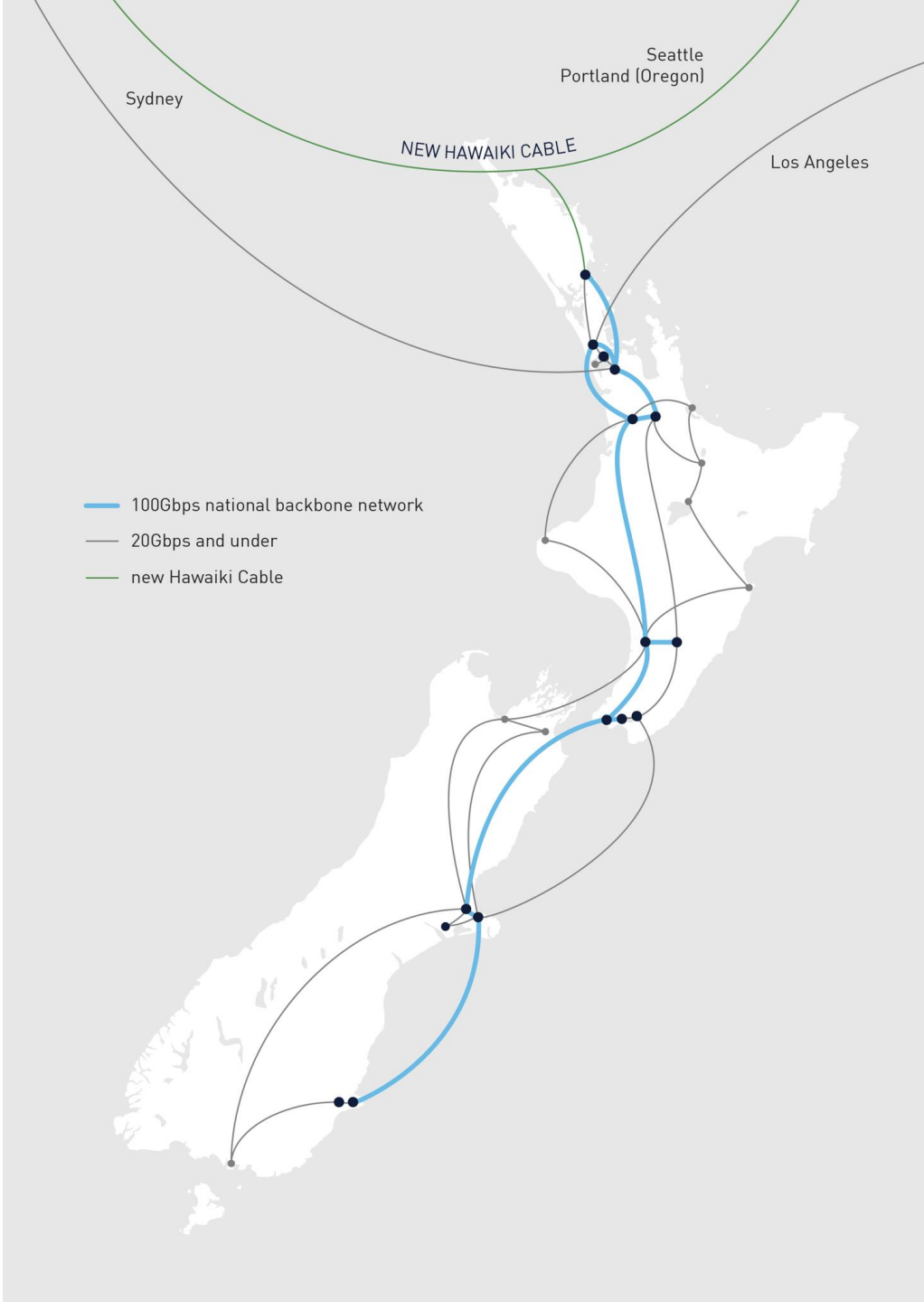
- Increases in productivity for IT teams
- Increases in capability
  (types of work simply not otherwise able to be done)
- International competitiveness for science
- Attraction of global talent to NZ

A file transfer that took 72 hours on commercial ISP → 55 mins on REANNZ network

Domestic network

- Network spans the country with extremely high speed links
- Members connect to REANNZ with over 300 links
- Creates the ability for researchers and educators to share data/resources across the country

Achieved zero packet loss across our network, ie, <0.0000001% loss over 58 trillion packets.



Ok, great.

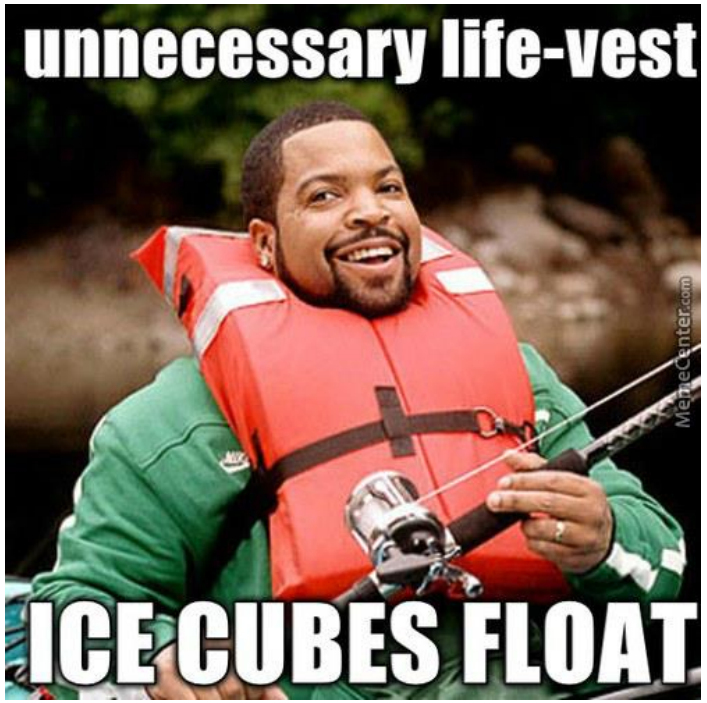
That’s nice.

So what you are saying is that you provide the internet…

“Commodity” Networks

“Commodity” Networks

Works great for traffic such as

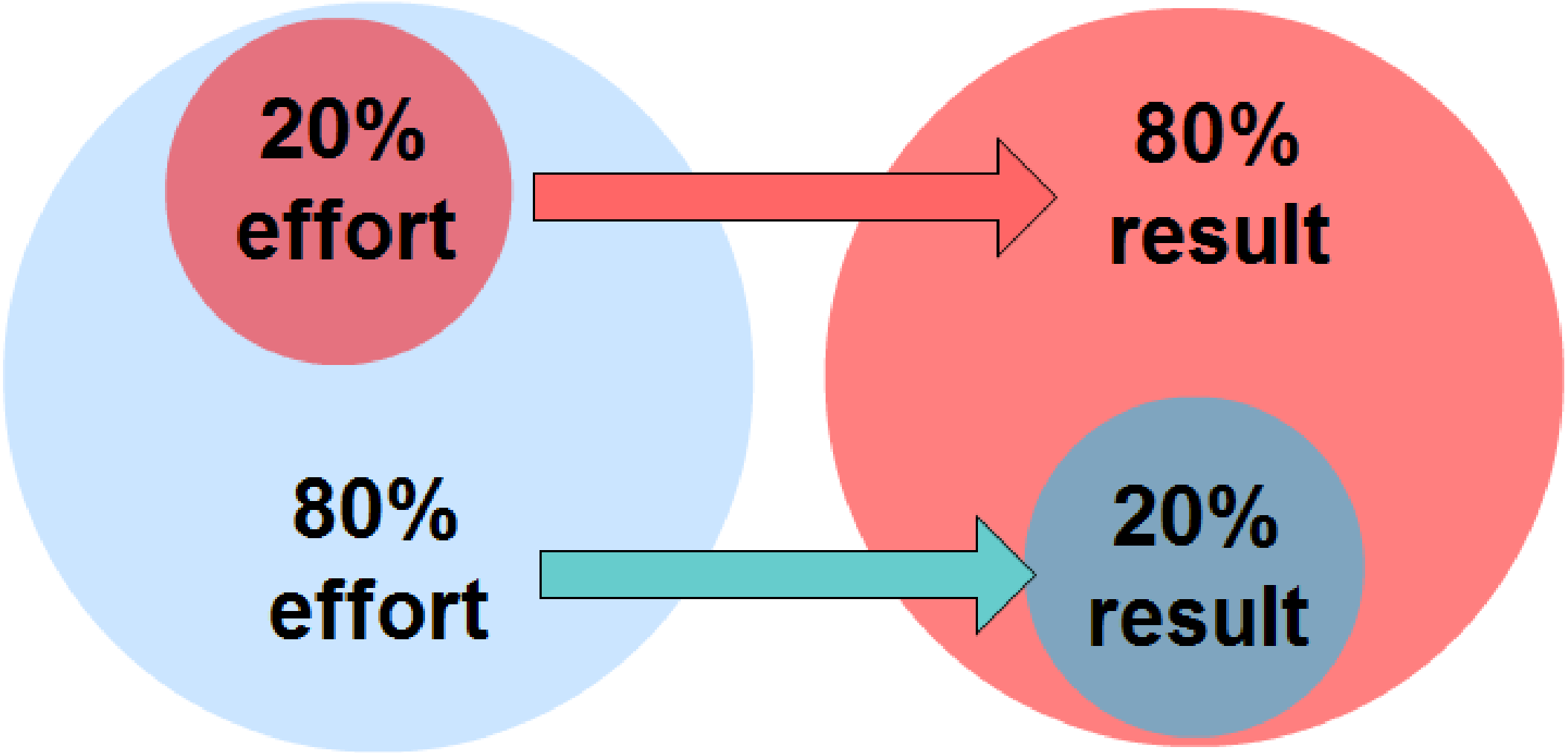


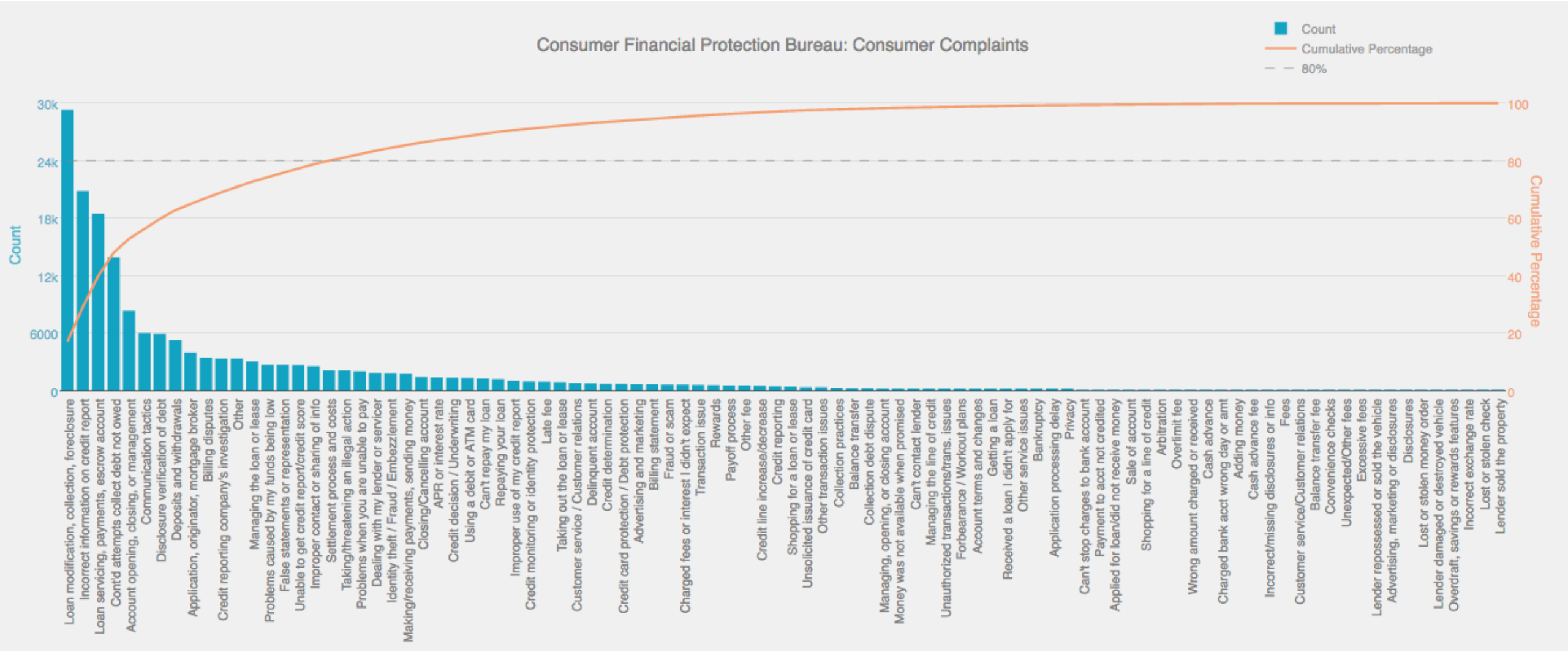
“Commodity” Networks

tastefullyoffensive

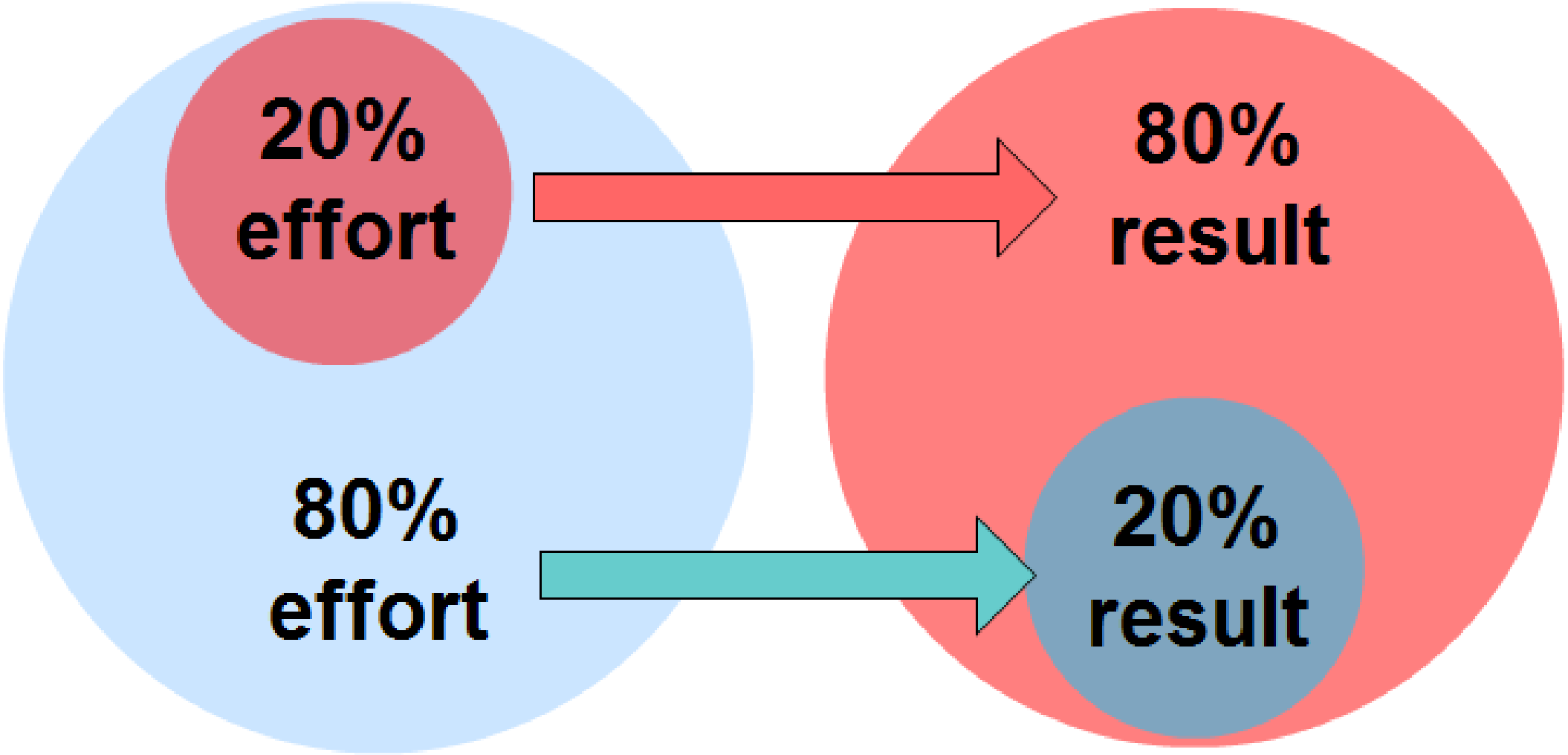
Further proof that cats are liquid. (via jabbathechav)


DEPTH
GAUGE
FROM: DISNEY


20%
effort
80%
result
80%
effort
20%
result

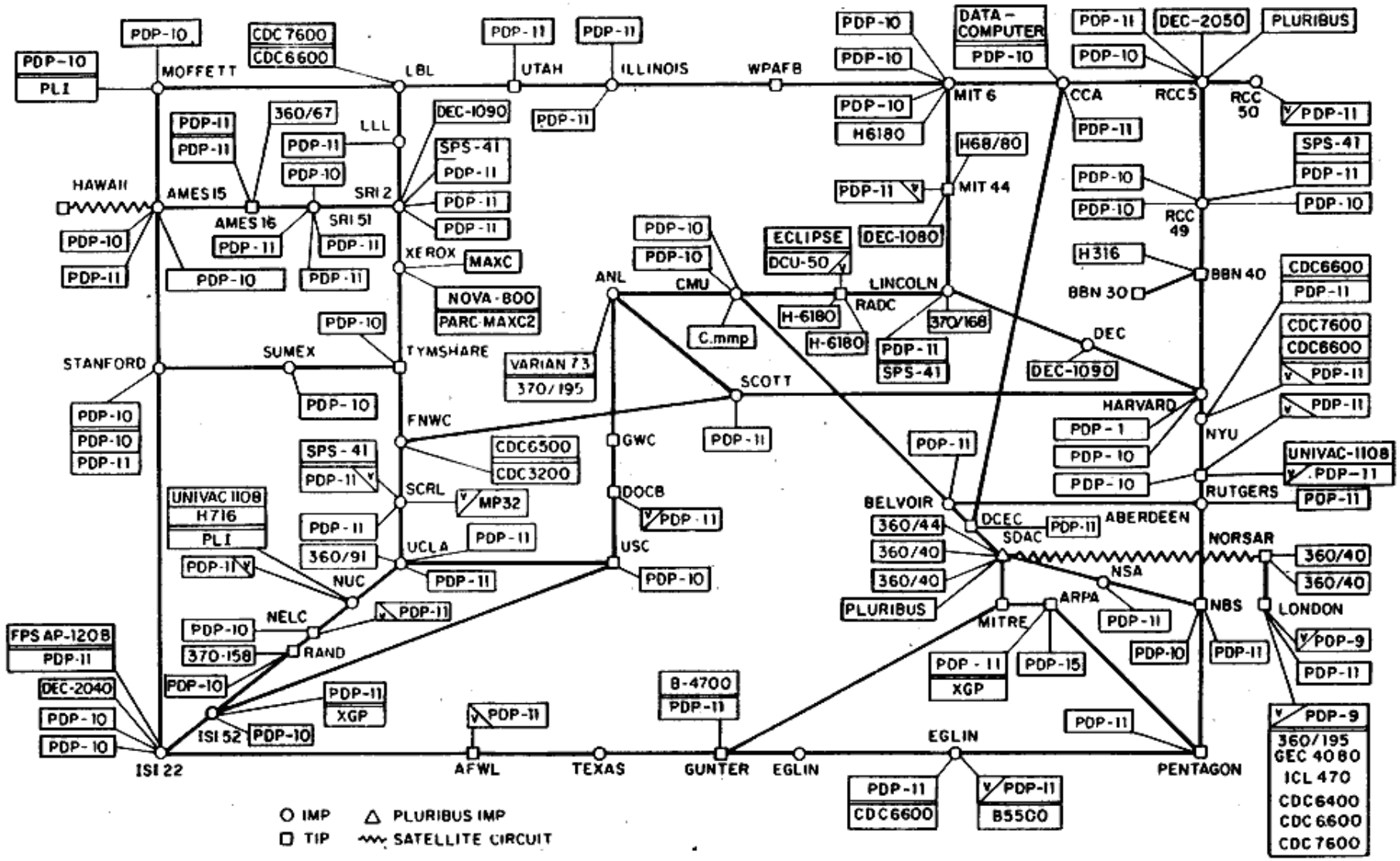

Consumer Financial Protection Bureau: Consumer Complaints
Count
Cumulative Percentage
80%
30k
24k
18k
12k
6000
0
100
80
60
40
20
0
Count
Cumulative Percentage
Loan modification, collection, foreclosure
Incorrect information on credit report
Loan servicing, payments, escrow account
Cont'd attempts collect debt not owed
Account opening, closing, or management
Communication tactics
Disclosure verification of debt
Deposits and withdrawals
Application, originator, mortgage broker
Billing disputes
Credit reporting company's investigation
Other
Managing the loan or lease
Problems caused by my funds being low
False statements or representation
Unable to get credit report/credit score
Improper contact or sharing of info
Settlement process and costs
Taking/threatening an illegal action
Problems when you are unable to pay
Dealing with my lender or servicer
Identity theft / Fraud / Embezzlement
Making/receiving payments, sending money
Closing/Cancelling account
APR or interest rate
Credit decision / Underwriting
Using a debit or ATM card
Can't repay my loan
Repaying your loan
Improper use of my credit report
Credit monitoring or identity protection
Late fee
Taking out the loan or lease
Customer service / Customer relations
Delinquent account
Credit determination
Credit card protection / Debt protection
Advertising and marketing
Billing statement
Fraud or scam
Charged fees or interest I didn't expect
Transaction issue
Rewards
Payoff process
Other fee
Credit line increase/decrease
Credit reporting
Shopping for a loan or lease
Unsolicited issuance of credit card
Other transaction issues
Collection practices
Balance transfer
Collection debt dispute
Managing, opening, or closing account
Money was not available when promised
Can't contact lender
Managing the line of credit
Unauthorized transactions/trans. issues
Forbearance / Workout plans
Account terms and changes
Getting a loan
Received a loan I didn't apply for
Other service issues
Bankruptcy
Application processing delay
Privacy
Can't stop charges to bank account
Payment to acct not credited
Applied for loan/did not receive money
Sale of account
Shopping for a line of credit
Arbitration
Overlimit fee
Wrong amount charged or received
Cash advance
Charged bank acct wrong day or amt
Adding money
Cash advance fee
Incorrect/missing disclosures or info
Fees
Customer service/Customer relations
Balance transfer fee
Convenience checks
Unexpected/Other fees
Excessive fees
Lender repossessed or sold the vehicle
Advertising, marketing or disclosures
Disclosures
Lost or stolen money order
Lender damaged or destroyed vehicle
Overdraft, savings or rewards features
Incorrect exchange rate
Lost or stolen check
Lender sold the property

“Commodity” Networks



REANNZ

ARPANET LOGICAL MAP, MARCH 1977



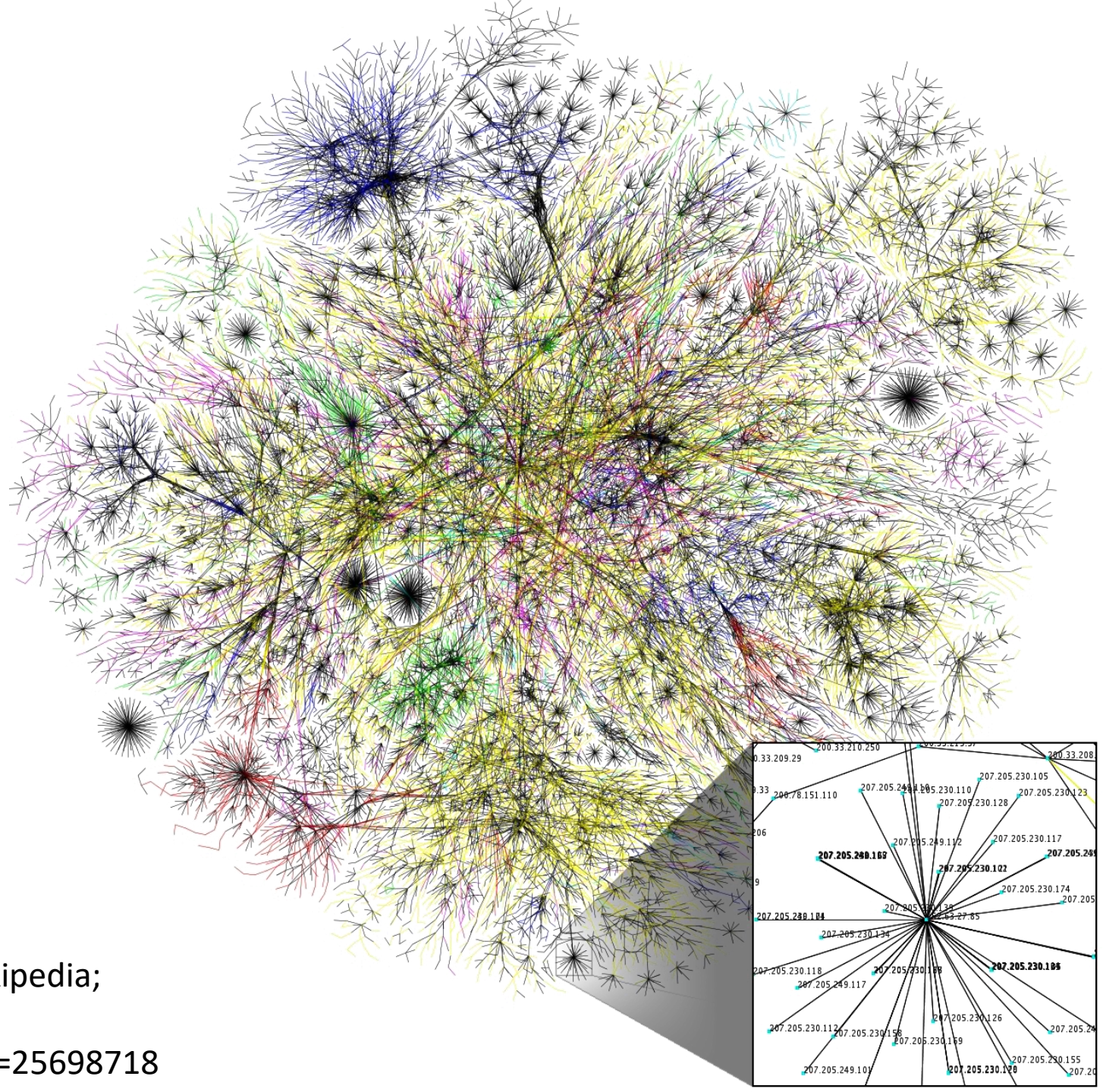
(PLEASE NOTE THAT WHILE THIS MAP SHOWS THE HOST POPULATION OF THE NETWORK ACCORDING TO THE BEST INFORMATION OBTAINABLE, NO CLAIM CAN BE MADE FOR ITS ACCURACY)

NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

The goal was to exploit new computer technologies to meet the needs of military command and control against nuclear threats, achieve survivable control of US nuclear forces, and improve military tactical and management decision making.

Stephen J. Lukasik

Lukasik, Stephen J. (2011). "Why the Arpanet Was Built". *IEEE Annals of the History of Computing*. **33** (3): 4–20. doi:10.1109/MAHC.2010.11



By The Opte Project - Originally from the English Wikipedia; description page is/was here., CC BY 2.5, https://commons.wikimedia.org/w/index.php?curid=25698718

Commodity networks

The good

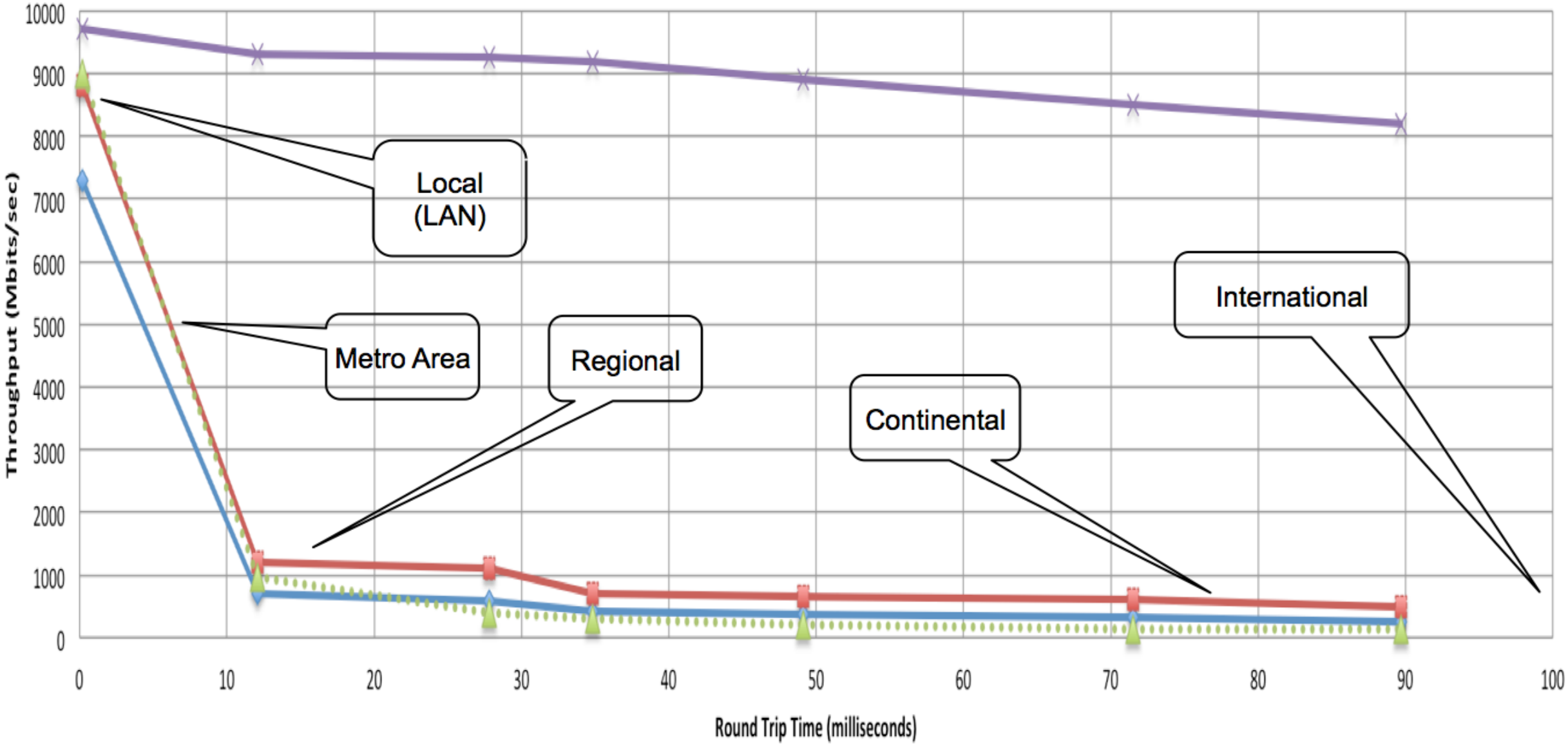
- Great for “normal” traffic
- Resilient by design
- Can move lots of “small” things moving around
- Great if what you are doing is accessing/and on a CDN (Content Delivery Network)
- Available almost everywhere

The not so good

- Not at all optimized for large flows
- Can be very expensive at scale
- **Often sub optimal routing and peering for point to point research traffic**
- Throttling , queuing, traffic shaping destroy throughput (and “they” don’t care)
- Commodity networks assume, and are designed for, “lots of small stuff”
- High speeds are not always available, or cost effective (10G, 40G, 100G)
- **If you have issues, good luck getting help**

Photo by averie woodard on Unsplash

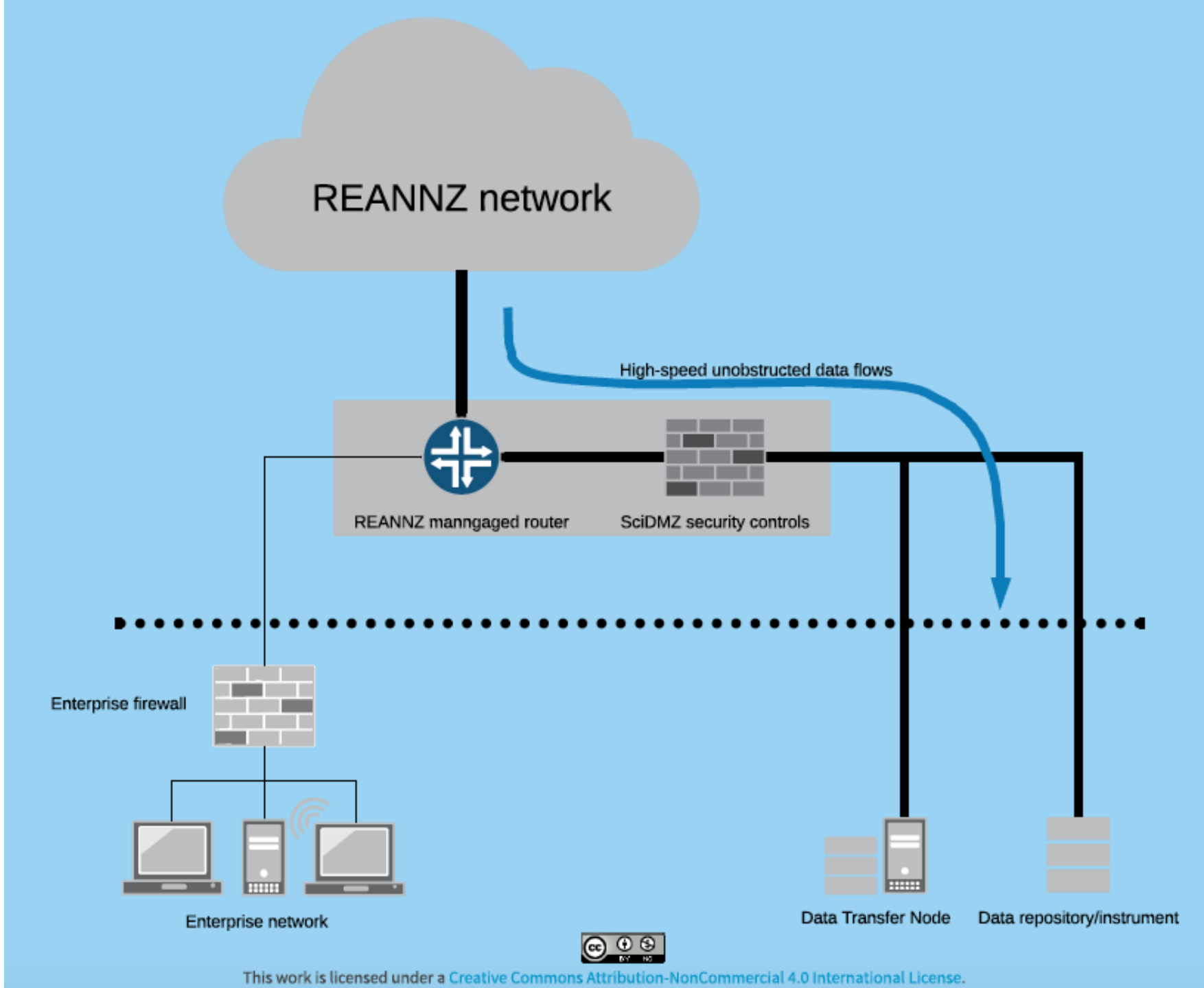
Throughput vs. increasing latency on a 10Gb/s link with *0.0046%* packet loss



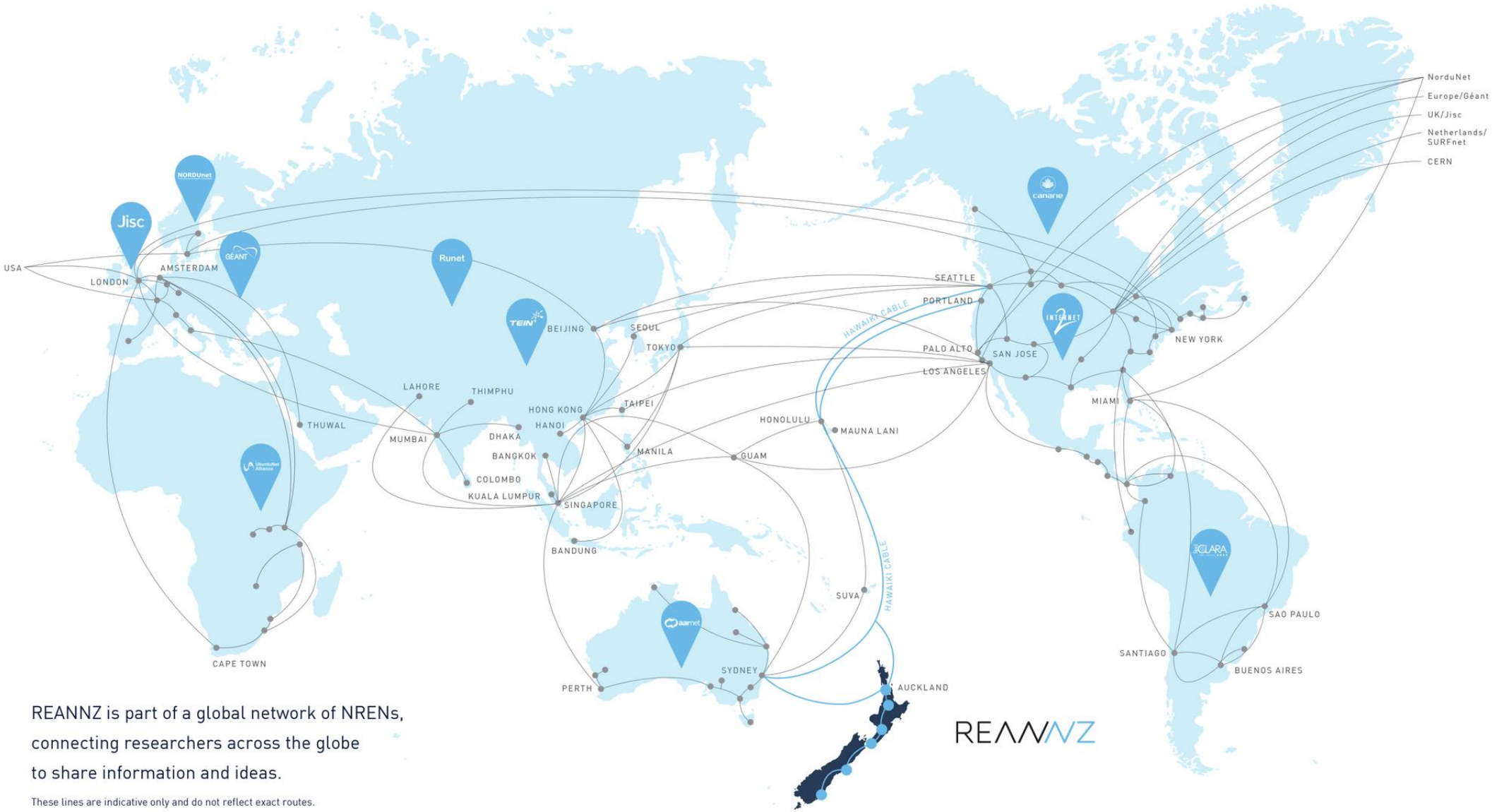
Measured (TCP Reno) **Measured (HTCP)** **Theoretical (TCP Reno)** **Measured (no loss)**

Photo by Ante Hamersmit on Unsplash

Science DMZ



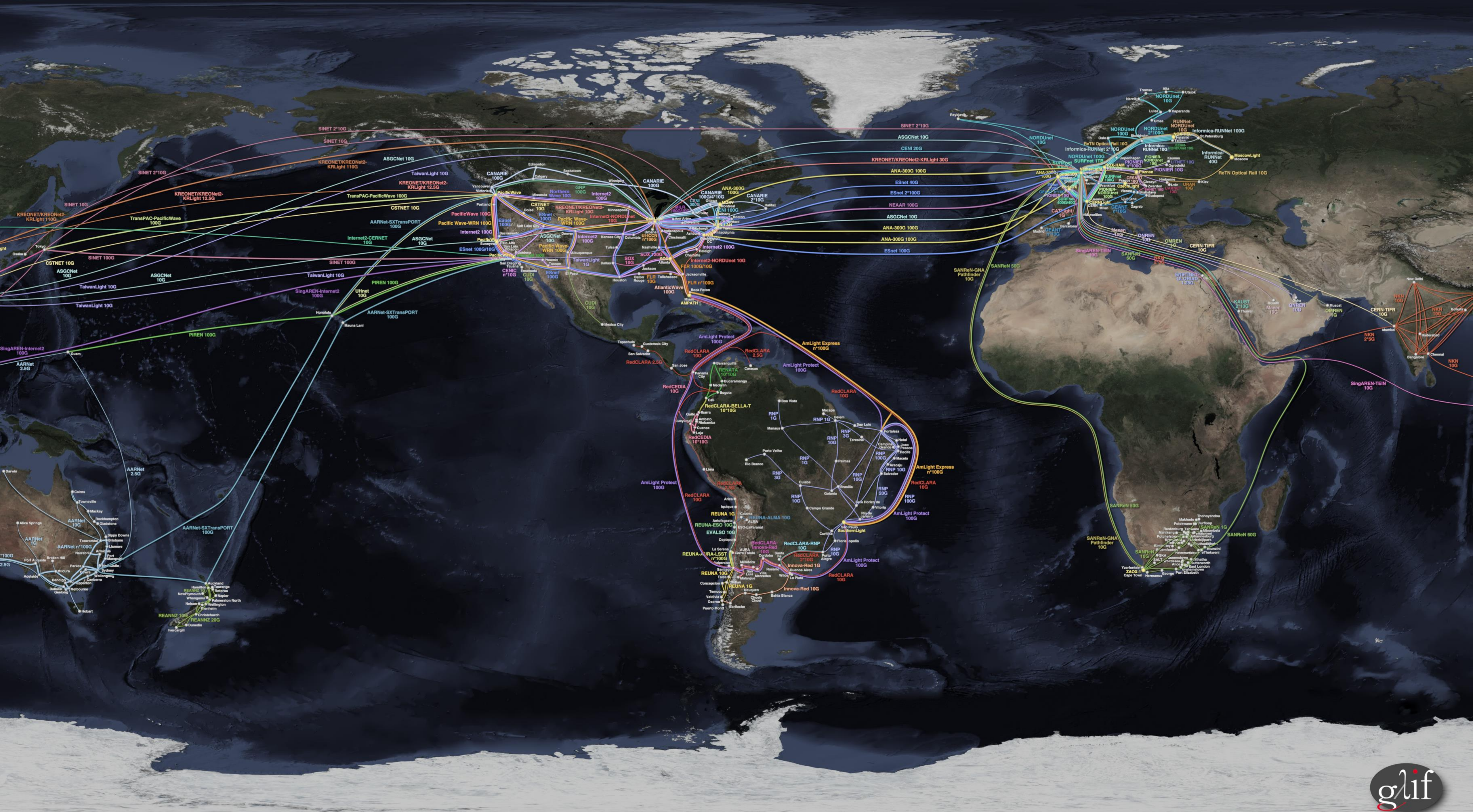
GLOBAL RESEARCH AND EDUCATION COMMUNITY /



REANNZ is part of a global network of NRENs, connecting researchers across the globe to share information and ideas.

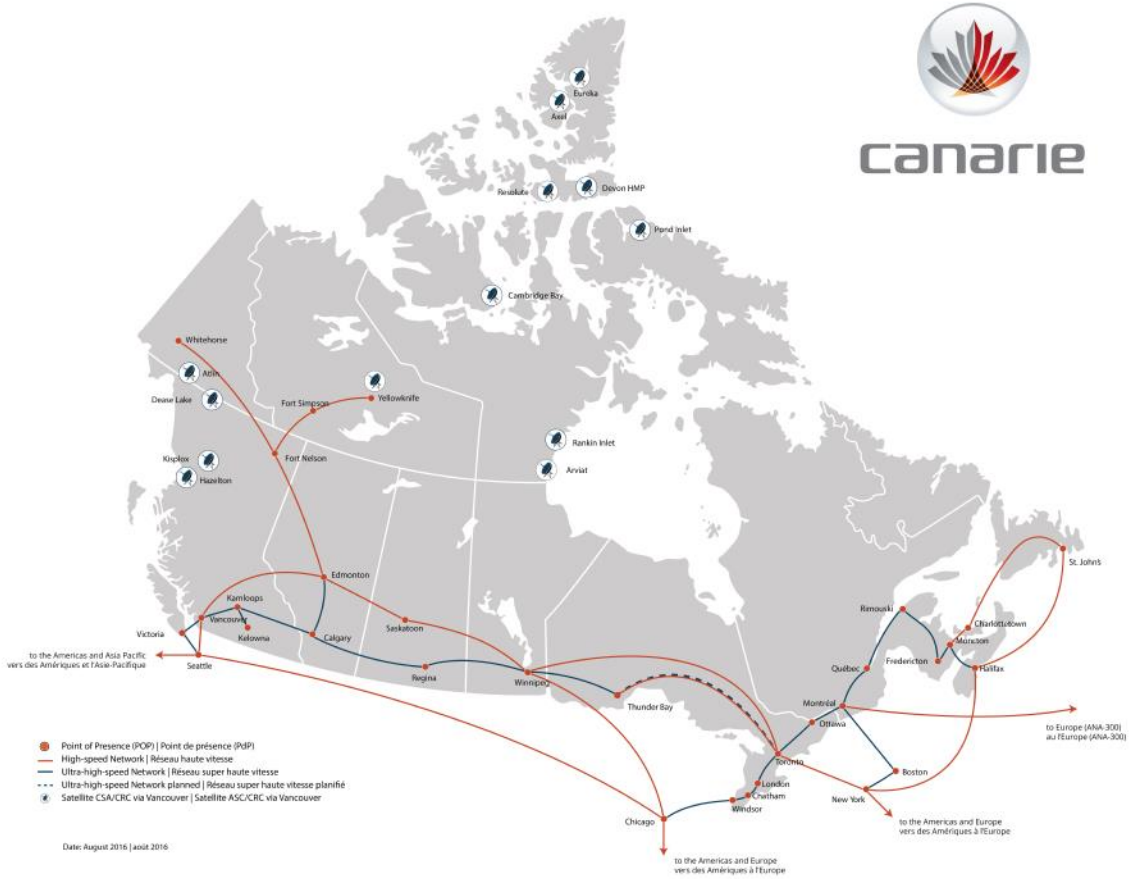
These lines are indicative only and do not reflect exact routes.

REANNZ

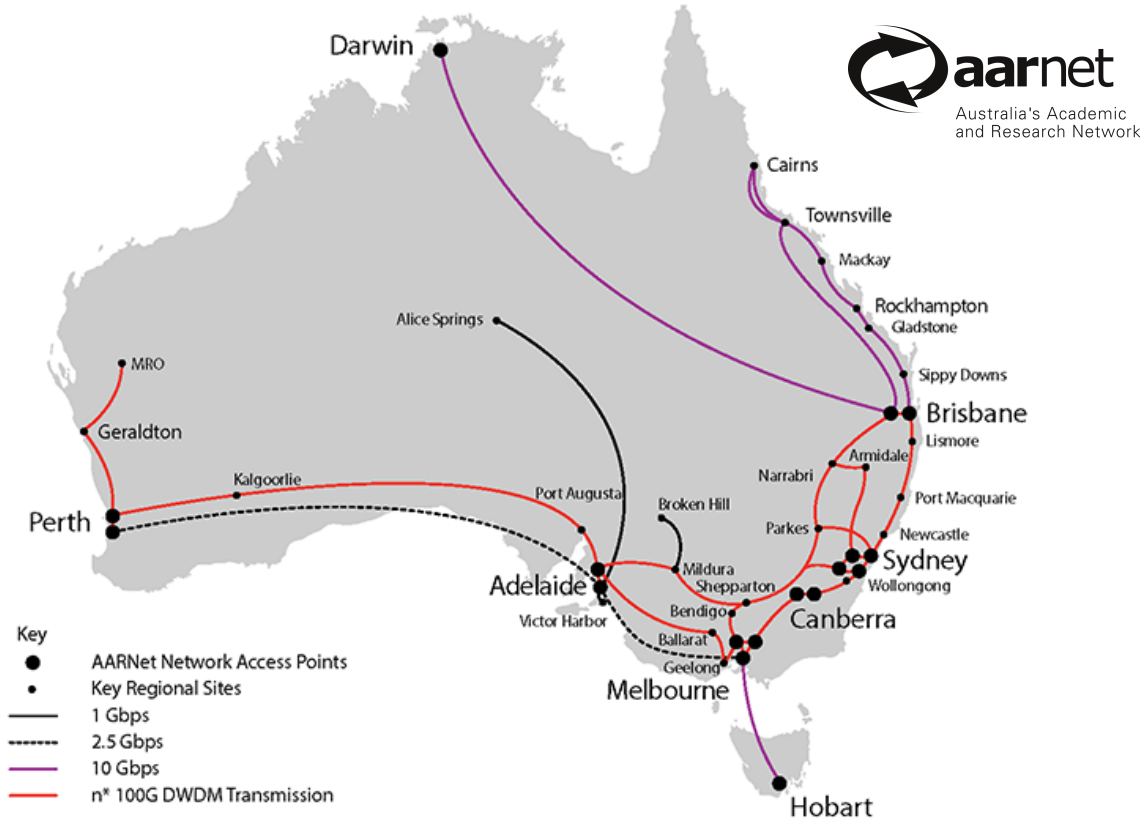


Integrated Facility   Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign   Data Compilation by Maxine Brown, University of Illinois at Chicago   Texture Retouch by Jeff Carpenter, NCSA   Earth Texture, visibleearth.nasa.gov   www.glif.is

canarie



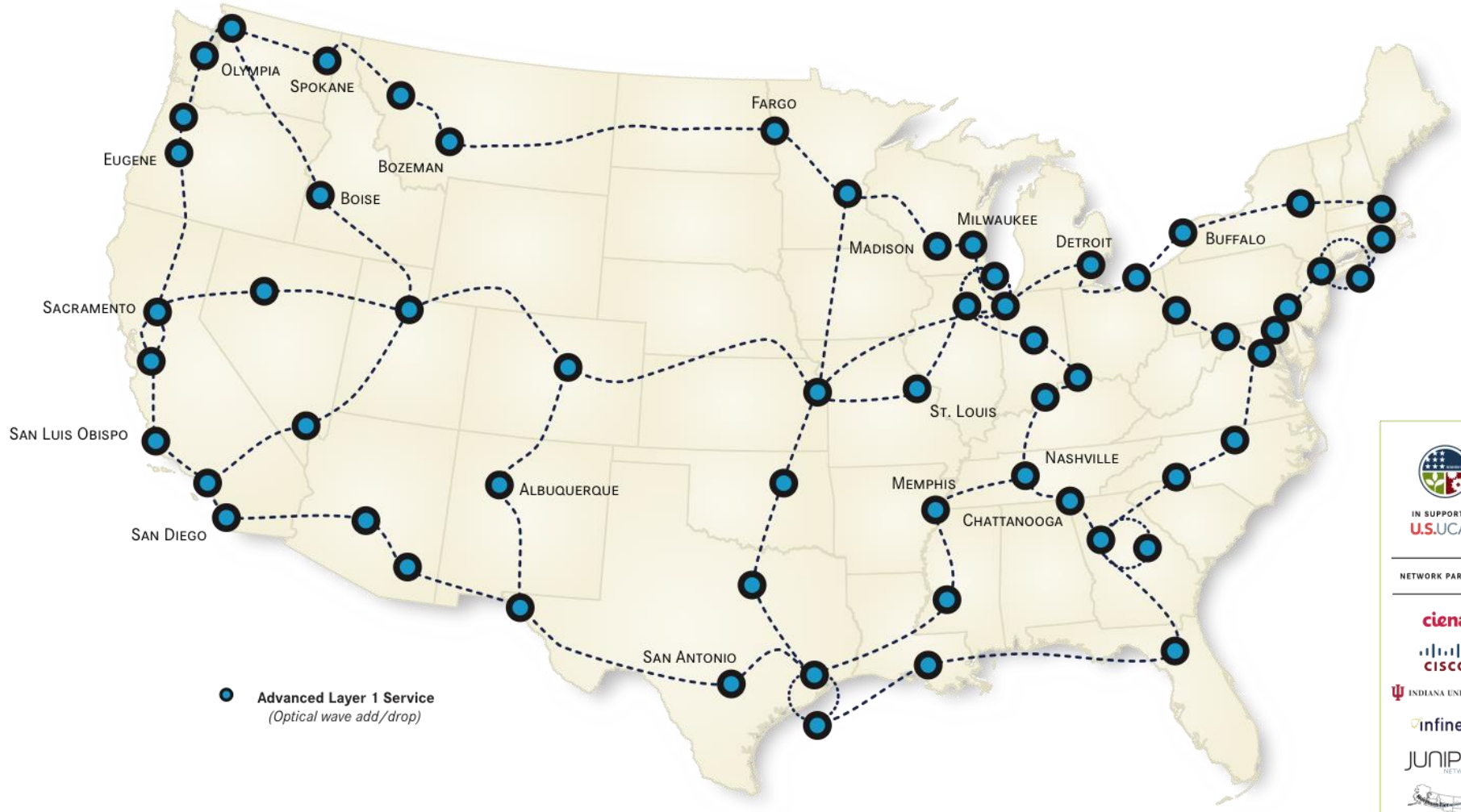
aarnet
Australia's Academic and Research Network



INTERNET2®

INTERNET2 NETWORK ADVANCED LAYER 1 SERVICE

MAY 2017



IN SUPPORT OF U.S.UCAN

NETWORK PARTNERS

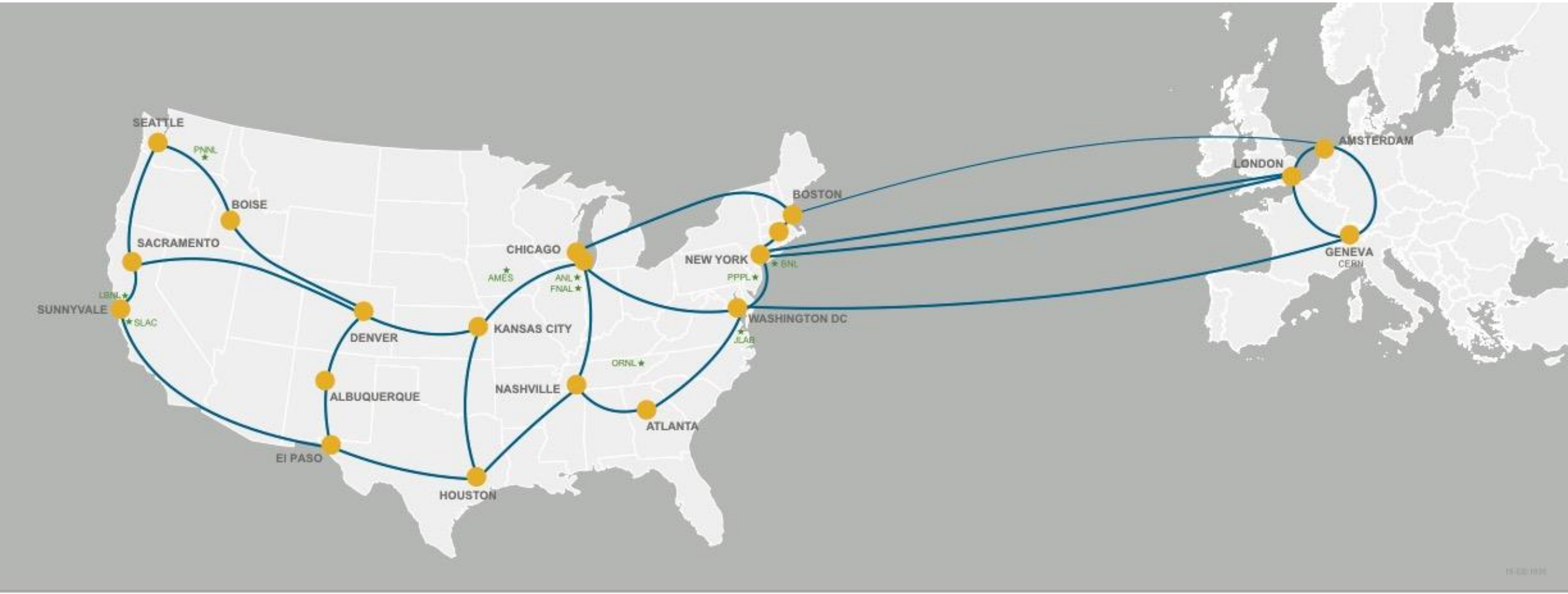
ciena

cisco

INDIANA UNIVERSITY

infinera

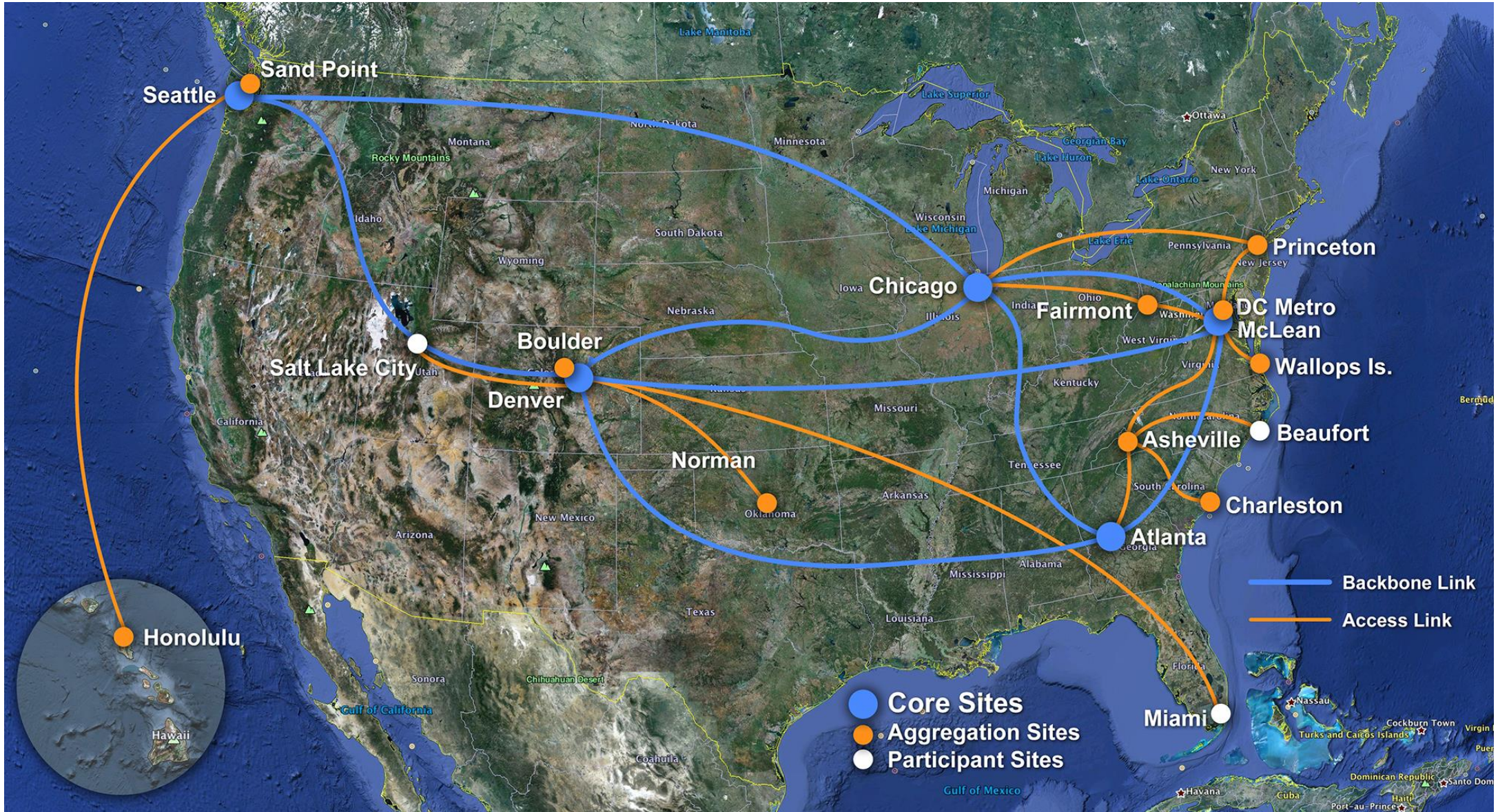
JUNIPER NETWORKS



ESnet
ENERGY SCIENCES NETWORK

★ Department of Energy Office of Science National Labs

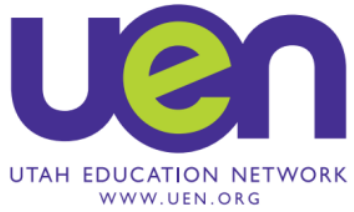
Ames	Ames Laboratory (Ames, IA)
ANL	Argonne National Laboratory (Argonne, IL)
BNL	Brookhaven National Laboratory (Upton, NY)
FNAL	Fermi National Accelerator Laboratory (Batavia, IL)
JLAB	Thomas Jefferson National Accelerator Facility (Newport News, VA)
LBNL	Lawrence Berkeley National Laboratory (Berkeley, CA)
ORNL	Oak Ridge National Laboratory (Oak Ridge, TN)
PNNL	Pacific Northwest National Laboratory (Richland, WA)
PPPL	Princeton Plasma Physics Laboratory (Princeton, NJ)
SLAC	SLAC National Accelerator Laboratory (Menlo Park, CA)

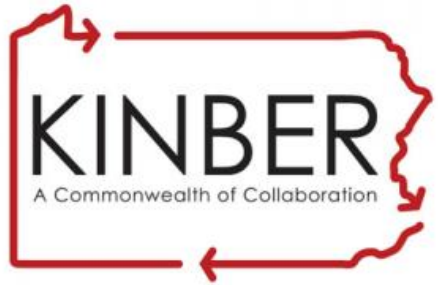


n-wave

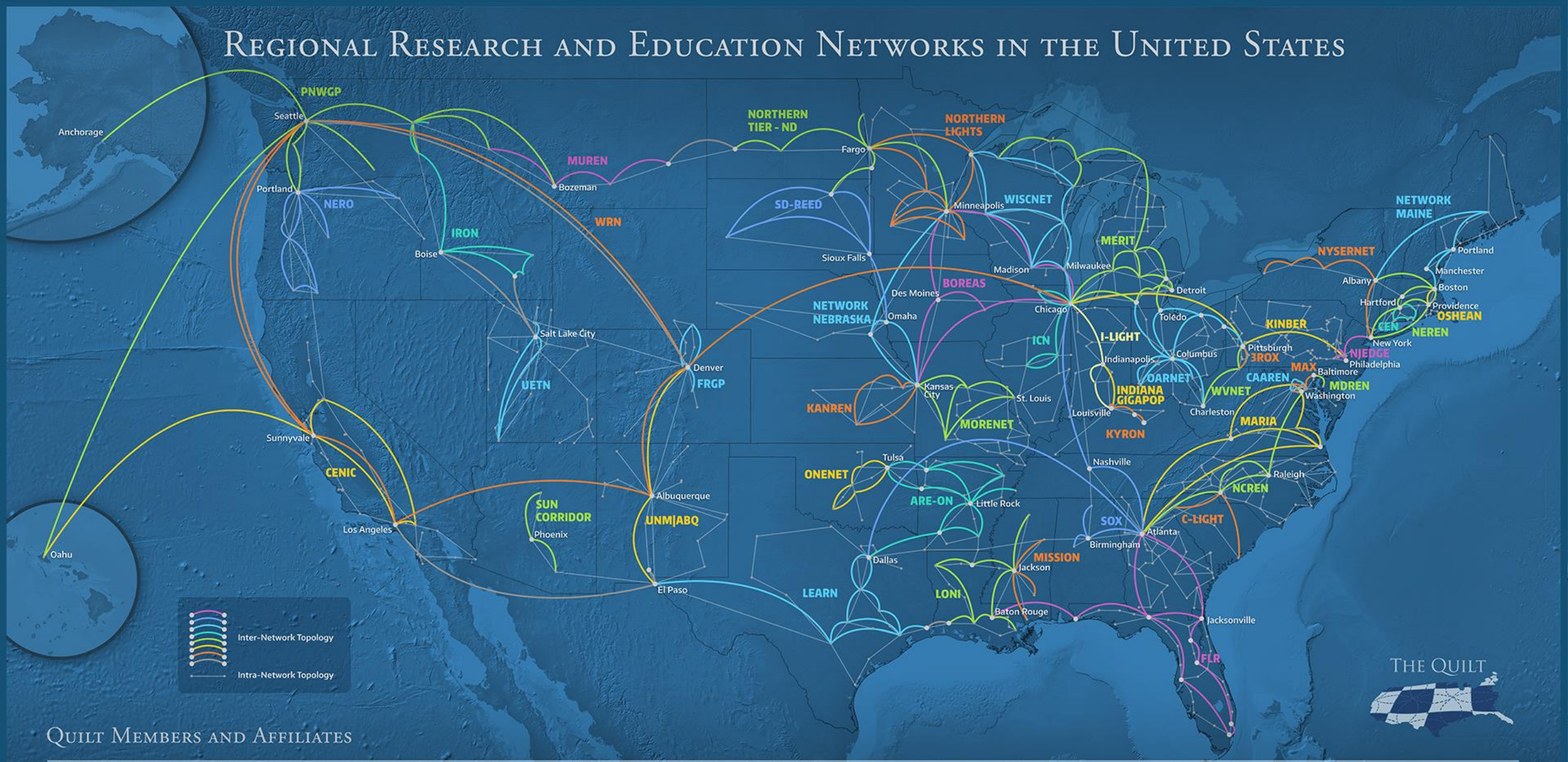
NOAA ENTERPRISE NETWORK

State/regional networks





Regional Research and Education Networks in the United States



Quilt Members and Affiliates

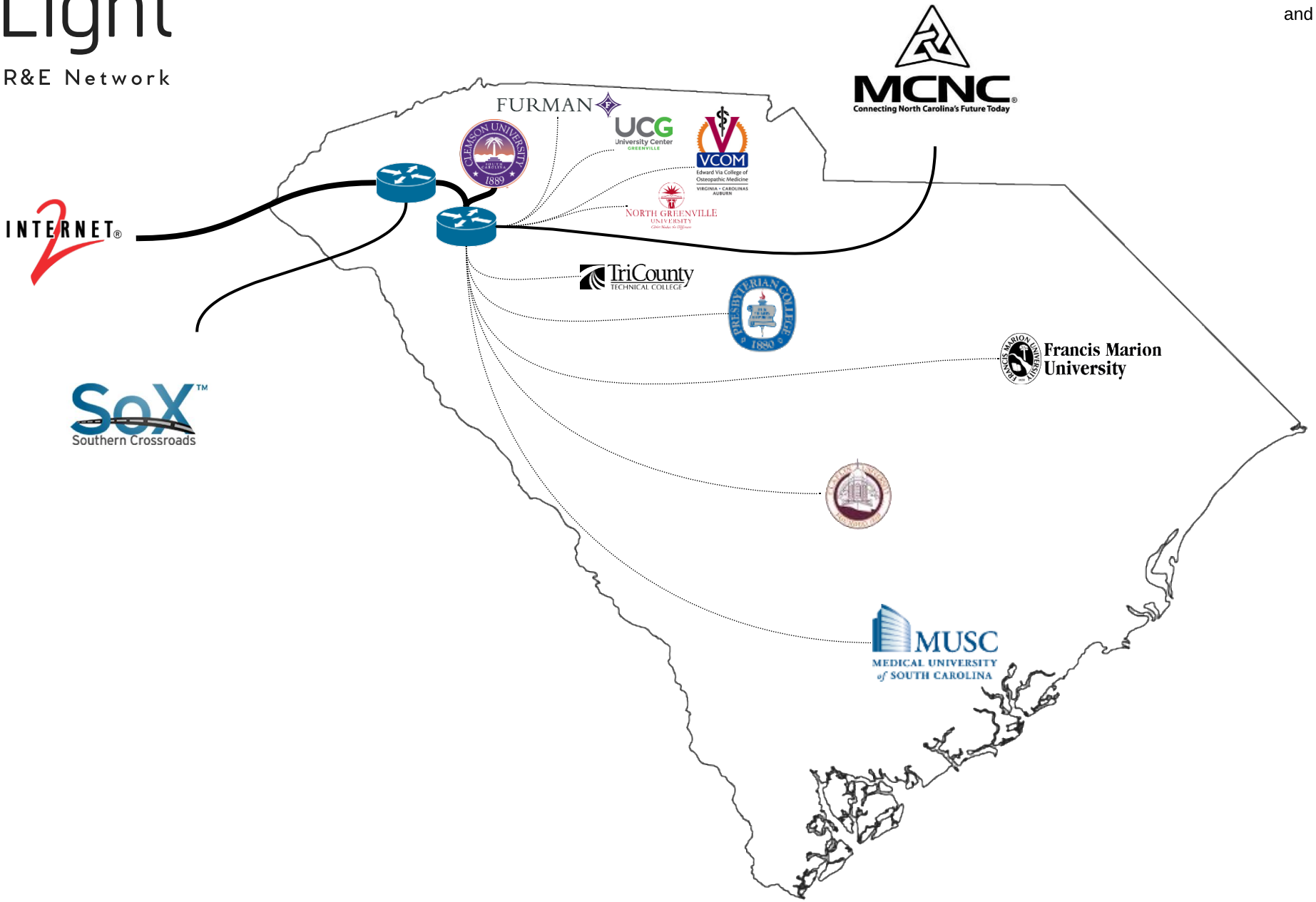
3ROX · UNM|ABQ · ARE-ON · Light R&E Network · CAAREN · CENIC · FLR · Front Range GigaPop · GPN · I-Light · Indiana GigaPOP · Illinois Century Network · KanREN · KINBER · KyRON · LEARN · LONI · MCRIA · MAX · MDREN · merit · MOREnet · MREN · NCREN · NERO · Network Nebraska · NetworkMaine · NJEdge · Northern Lights · NOX · nysernet · OARnet · OneNet · OSHEAN · Pacific Northwest GigaPOP · SoX · Sun Corridor Network · UEN · WiscNet · WV NET

12-6-2017

C-Light

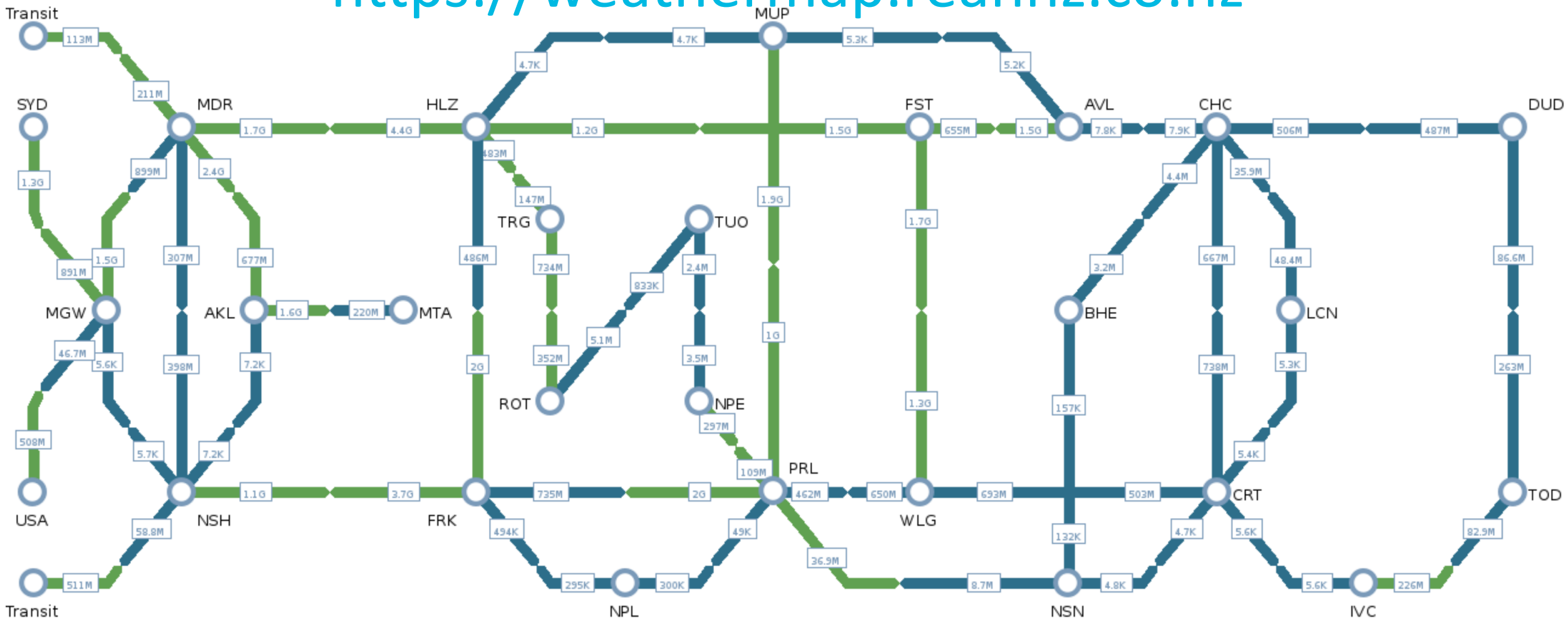
South Carolina Research
and Education Network
05/29/17

C Light
R&E Network

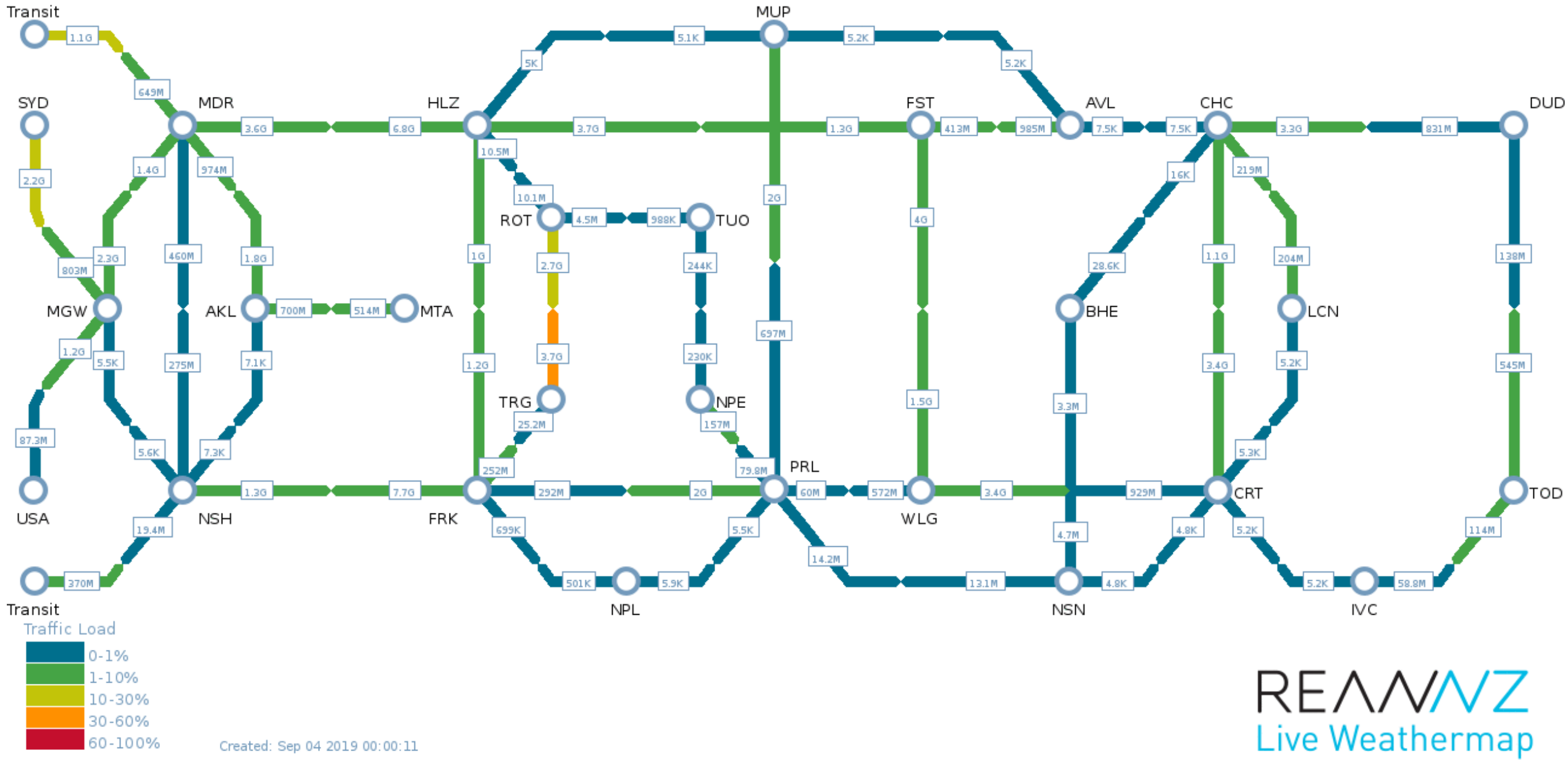


International Networks

https://weathermap.reannz.co.nz



https://weathermap.reannz.co.nz

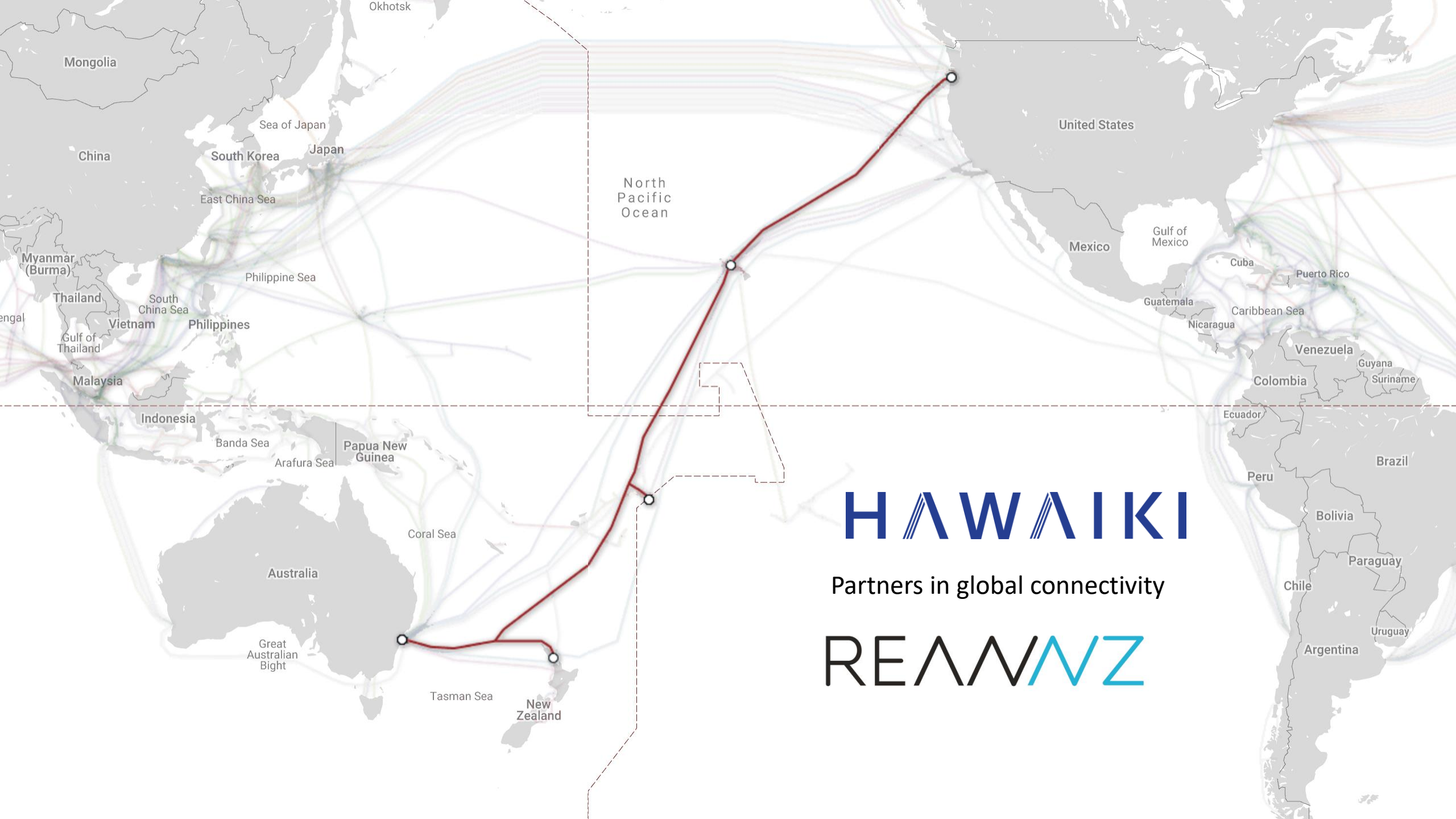


Traffic Load

- 0-1%
- 1-10%
- 10-30%
- 30-60%
- 60-100%

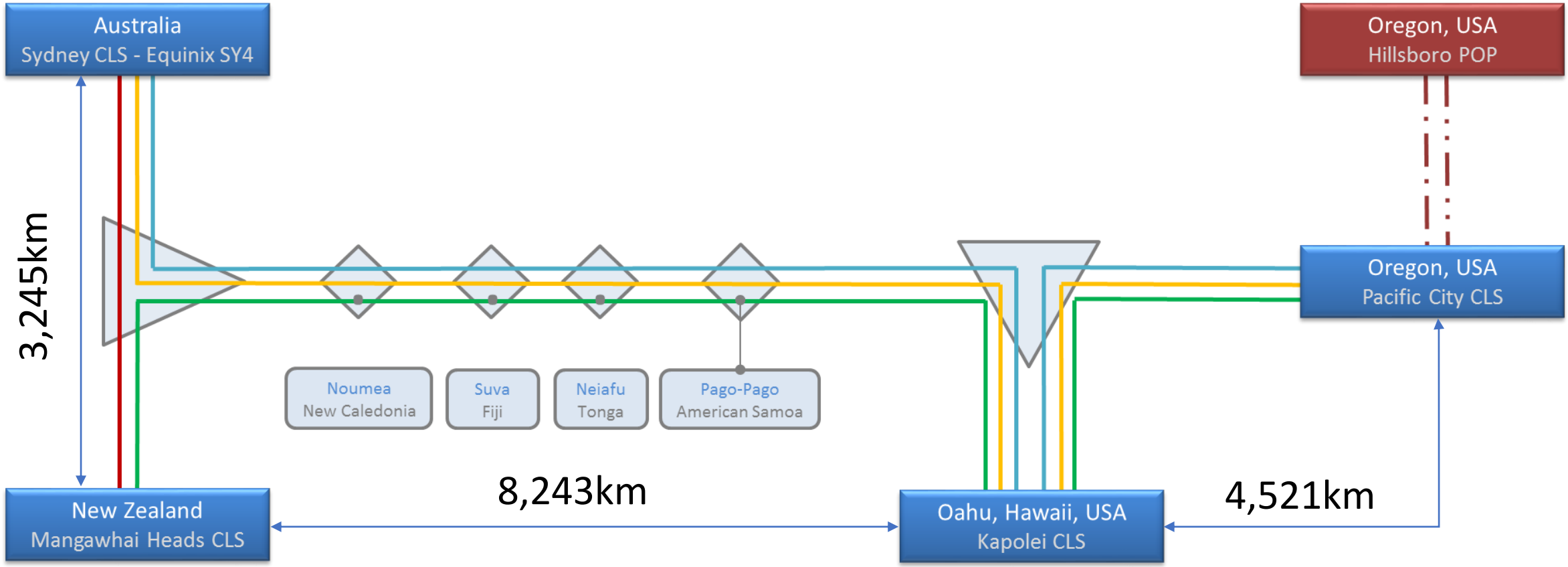
Created: Sep 04 2019 00:00:11

REANNZ
Live Weathermap


Okhotsk
Mongolia
Sea of Japan
China
South Korea
Japan
East China Sea
North
Pacific
Ocean
United States
Gulf of
Mexico
Mexico
Cuba
Puerto Rico
Guatemala
Caribbean Sea
Nicaragua
Venezuela
Guyana
Suriname
Colombia
Ecuador
Brazil
Peru
Bolivia
Paraguay
Chile
Uruguay
Argentina
Myanmar
(Burma)
Thailand
Vietnam
Philippines
Philippine Sea
South
China Sea
Gulf of
Thailand
Malaysia
Indonesia
Banda Sea
Arafura Sea
Papua New
Guinea
Coral Sea
Australia
Great
Australian
Bight
Tasman Sea
New
Zealand
HAWAIKI
Partners in global connectivity
REANNZ

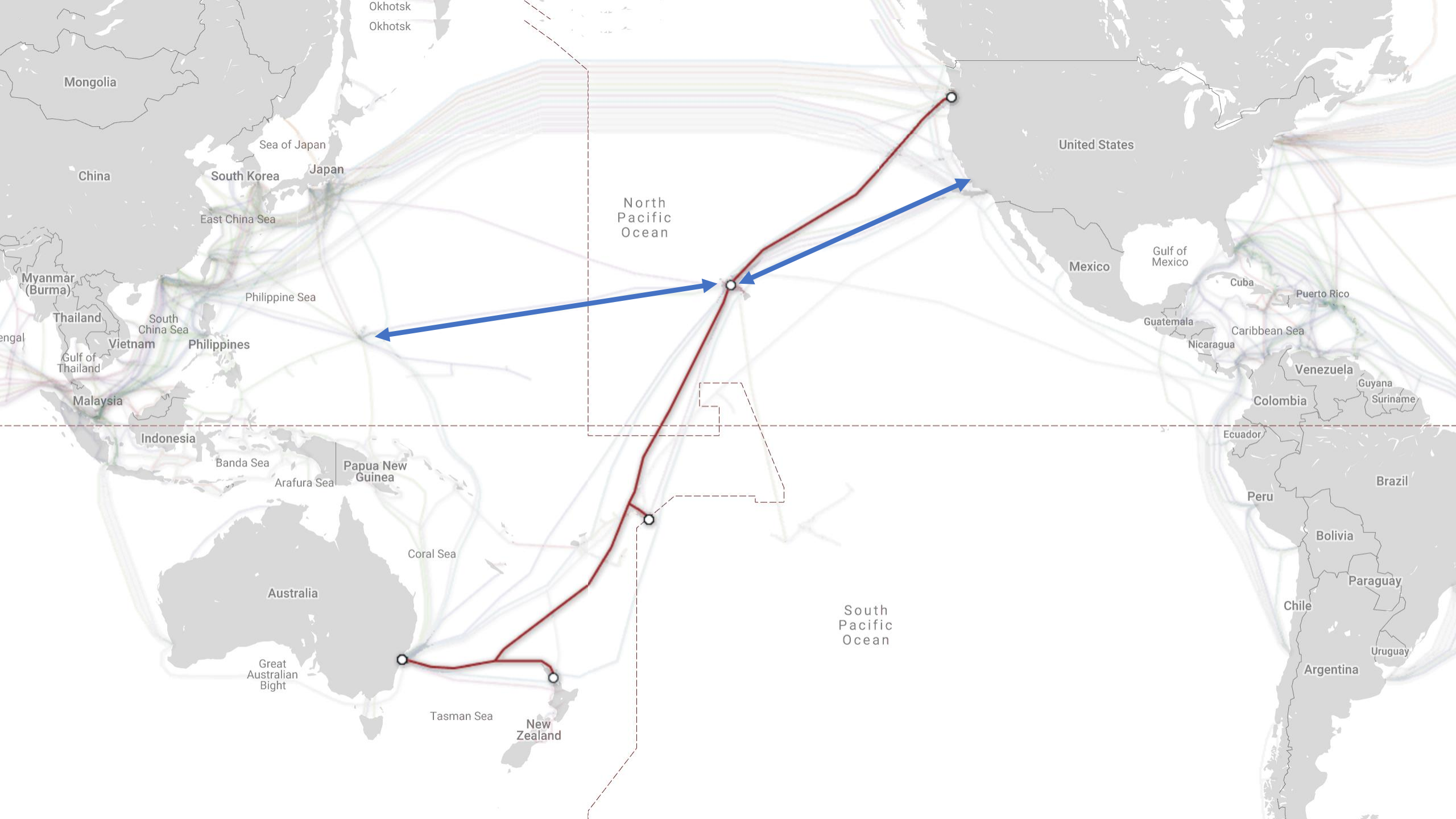
HAWAIKI

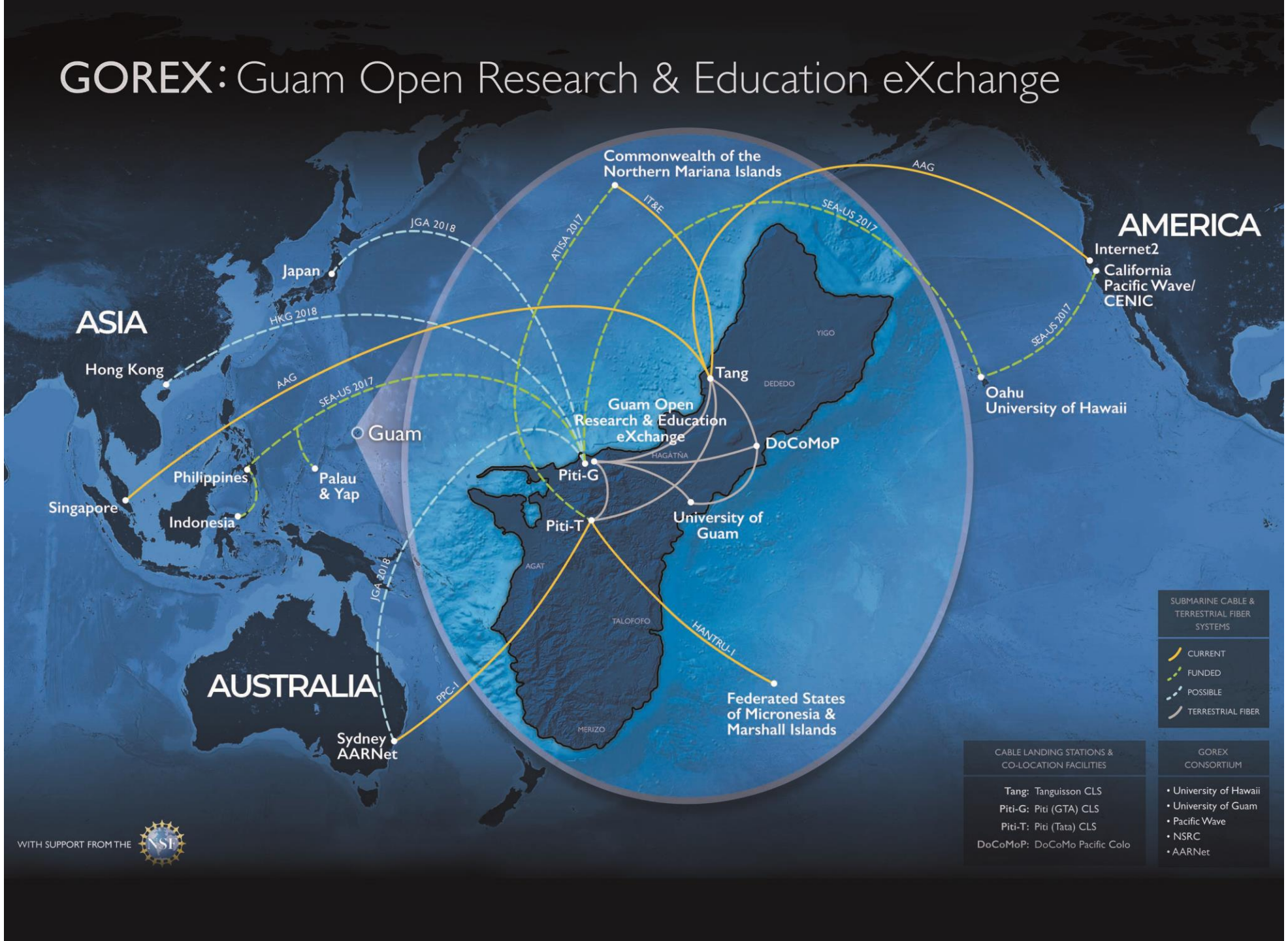
NETWORK DESIGN



PIREN Pacific Islands Research and Education Network

The memorandum outlines assistance UH will provide in connecting REANNZ to Asian research and education networks via Hawai‘i and Guam. It also articulates a shared interest in bringing research and education networks to the Pacific islands, which have been historically unserved and unconnected.


Okhotsk
Okhotsk
Mongolia
China
Sea of Japan
South Korea
Japan
East China Sea
North
Pacific
Ocean
United States
Mexico
Gulf of
Mexico
Cuba
Puerto Rico
Guatemala
Caribbean Sea
Nicaragua
Myanmar
(Burma)
Philippine Sea
Thailand
South
China Sea
Vietnam
Philippines
Gulf of
Thailand
Malaysia
Venezuela
Guyana
Colombia
Suriname
Ecuador
Indonesia
Banda Sea
Papua New
Guinea
Arafura Sea
Brazil
Peru
Coral Sea
Bolivia
Australia
Paraguay
Chile
South
Pacific
Ocean
Uruguay
Argentina
Great
Australian
Bight
Tasman Sea
New
Zealand

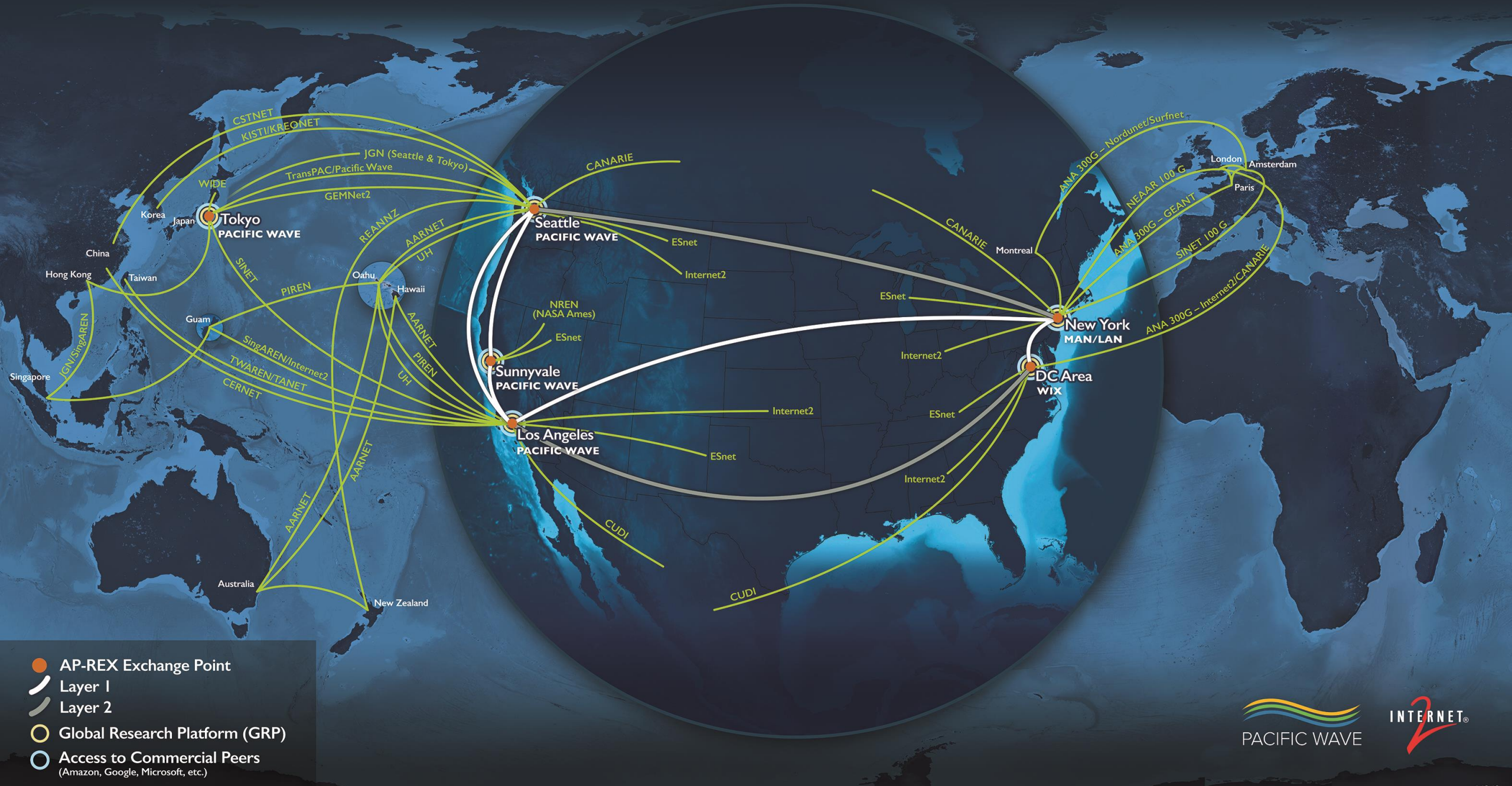

GOREX: Guam Open Research & Education eXchange
Commonwealth of the Northern Mariana Islands
AAG
IT&E
ATISA 2017
SEA-US 2017
JGA 2018
HKG 2018
AMERICA
Internet2
California
Pacific Wave/
CENIC
ASIA
Japan
Hong Kong
YIGO
Tang
DEDEDO
Oahu
University of Hawaii
Guam Open
Research & Education
eXchange
Guam
DoCoMoP
HAGÅTÑA
Philippines
Palau
& Yap
Piti-G
Singapore
Indonesia
University of
Guam
Piti-T
AGAT
TALOFOFO
HANTRU-1
AUSTRALIA
PPC-1
Federated States
of Micronesia &
Marshall Islands
MERIZO
Sydney
AARNet
SUBMARINE CABLE & TERRESTRIAL FIBER SYSTEMS
CURRENT
FUNDED
POSSIBLE
TERRESTRIAL FIBER
CABLE LANDING STATIONS & CO-LOCATION FACILITIES
Tang: Tanguisson CLS
Piti-G: Piti (GTA) CLS
Piti-T: Piti (Tata) CLS
DoCoMoP: DoCoMo Pacific Colo
GOREX CONSORTIUM
• University of Hawaii
• University of Guam
• Pacific Wave
• NSRC
• AARNet
WITH SUPPORT FROM THE NSF

https://pacificwave.net/participants-affiliations


PACIFIC WAVE
NATIONAL & INTERNATIONAL PEERING EXCHANGE
Pacific Wave is a project of CENIC & PNWGP
CSTNET
KIST/KREONET
JGN (Seattle & Tokyo)
TransPAC/Pacific Wave
GEMNet2
WIDE
Korea
Japan
China
Taiwan
Hong Kong
SINET
IGN/SingAREN
Singapore
Guam
SingAREN/Internet2
PIREN
CERNET
TWAREN/TANET
PIREN
Oahu
UH
Hawaii
AARNET
AARNET
Australia
REANNZ
New Zealand
AARNET
UH
REANNZ
PACIFIC WAVE BACKBONE
CANARIE
PNWGP
Vancouver
Seattle
ESnet
Internet2
DREN
CENIC
NREN (NASA Ames)
ESnet
San Francisco Bay Area
Los Nettos
CENIC
DREN
Los Angeles
Tijuana
Albuquerque
ABQG
El Paso
Transtelco
CUDI
Mexico
FRGP
Denver
UltraLight (Caltech)
Kansas City
Tulsa
Internet2
Dallas
Houston
StarLight
Chicago
NORDUNet
Nordic Countries
JANET
United Kingdom
SURFnet
GEANT
ESnet
Europe
SPEEDS/POPS
10 Gbps
100 Gbps
CURRENT
FUTURE
Pacific Wave POPs
Pacific Research Platform (PRP)
PRP Science DMZ Fabric
Software Defined Network
Commercial Peering Points
(Amazon, Google, & Microsoft)
WESTERN REGIONAL NETWORK
States served by WRN members:
- ABQG: New Mexico GigaPoP
- CENIC: California
- FRGP: Colorado and Wyoming
- PNWGP: Washington, Montana, Alaska, Oregon & Idaho
- UH: Hawaii
With support from the National Science Foundation
NSF

Atlantic Pacific Research and Education Exchange (AP-REX)

A Pilot Project of Internet2 and Pacific Wave (CENIC and PNWGP)



aarnet
Australia's Academic and Research Network

EQUINIX

SciDMZ in New Zealand

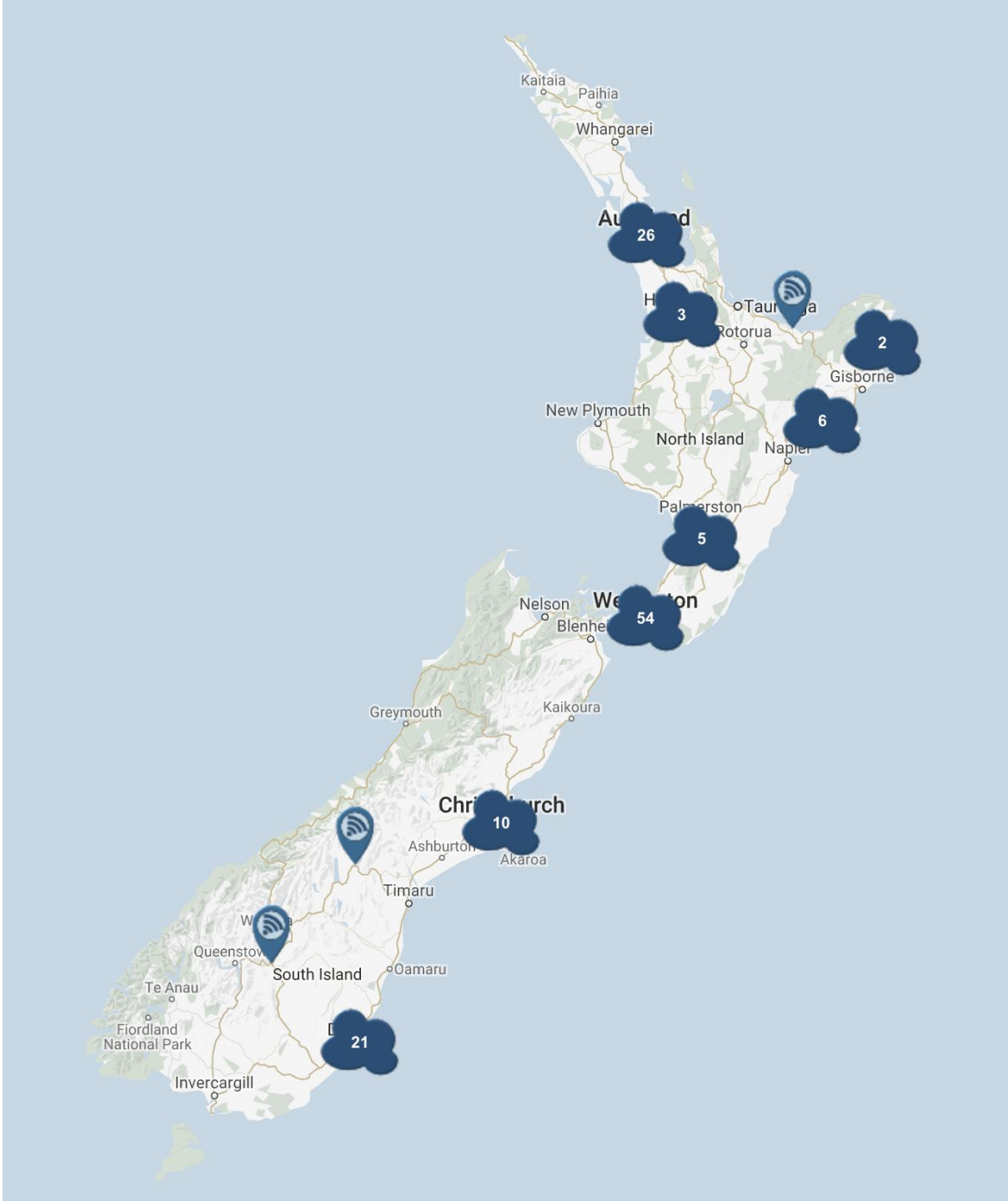
NeSI
New Zealand eScience Infrastructure

globus

Data transfer nodes

Eduroam

- 86 countries
- Tens of thousands of hotspots around the world



REANNZ
TUAKIRI

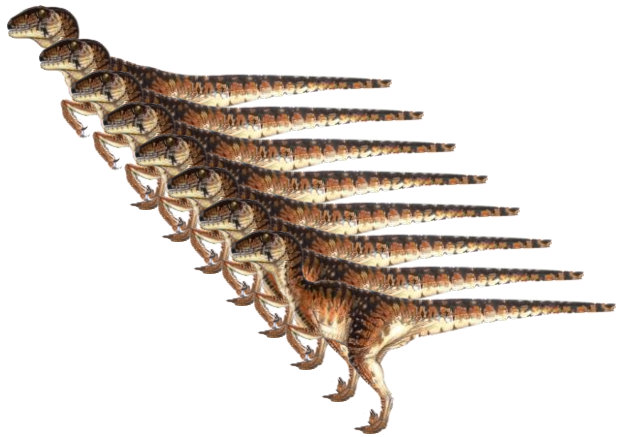
New Zealand's national identity federation

REANNZ

TUAKIRI

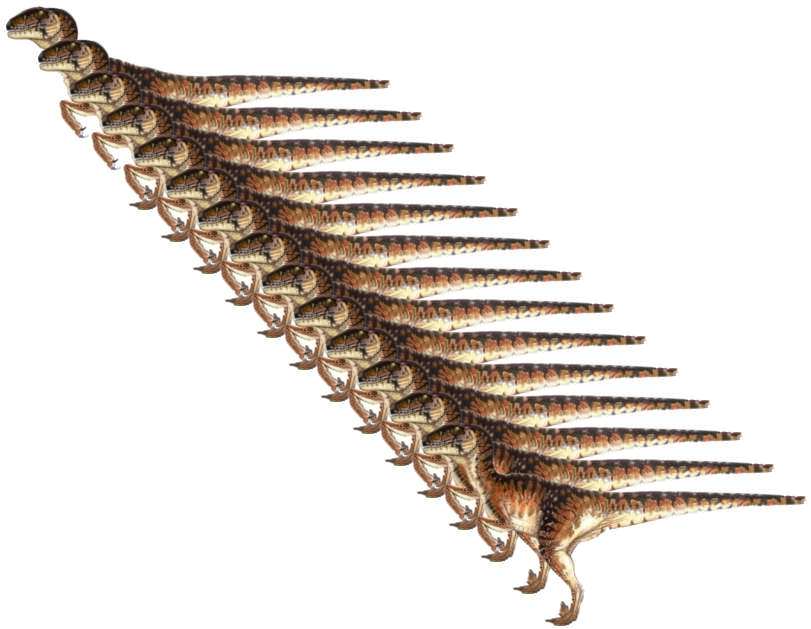
REANNZ

TUAKIRI



REANNZ

TUAKIRI



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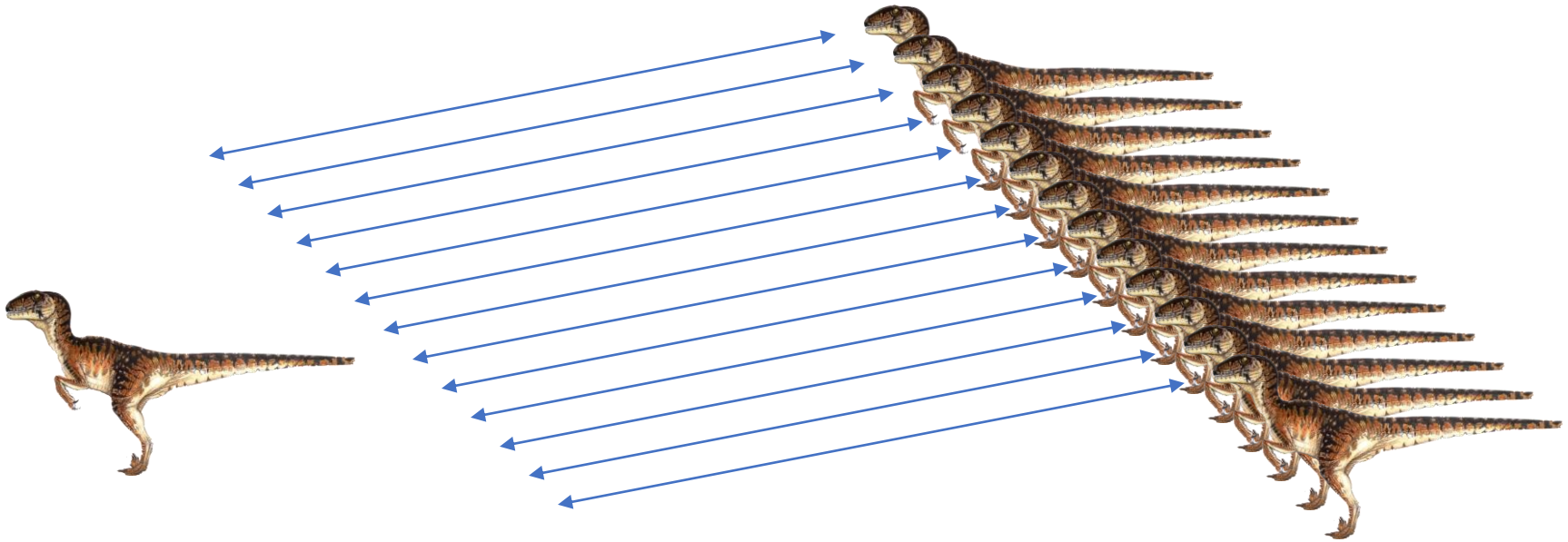
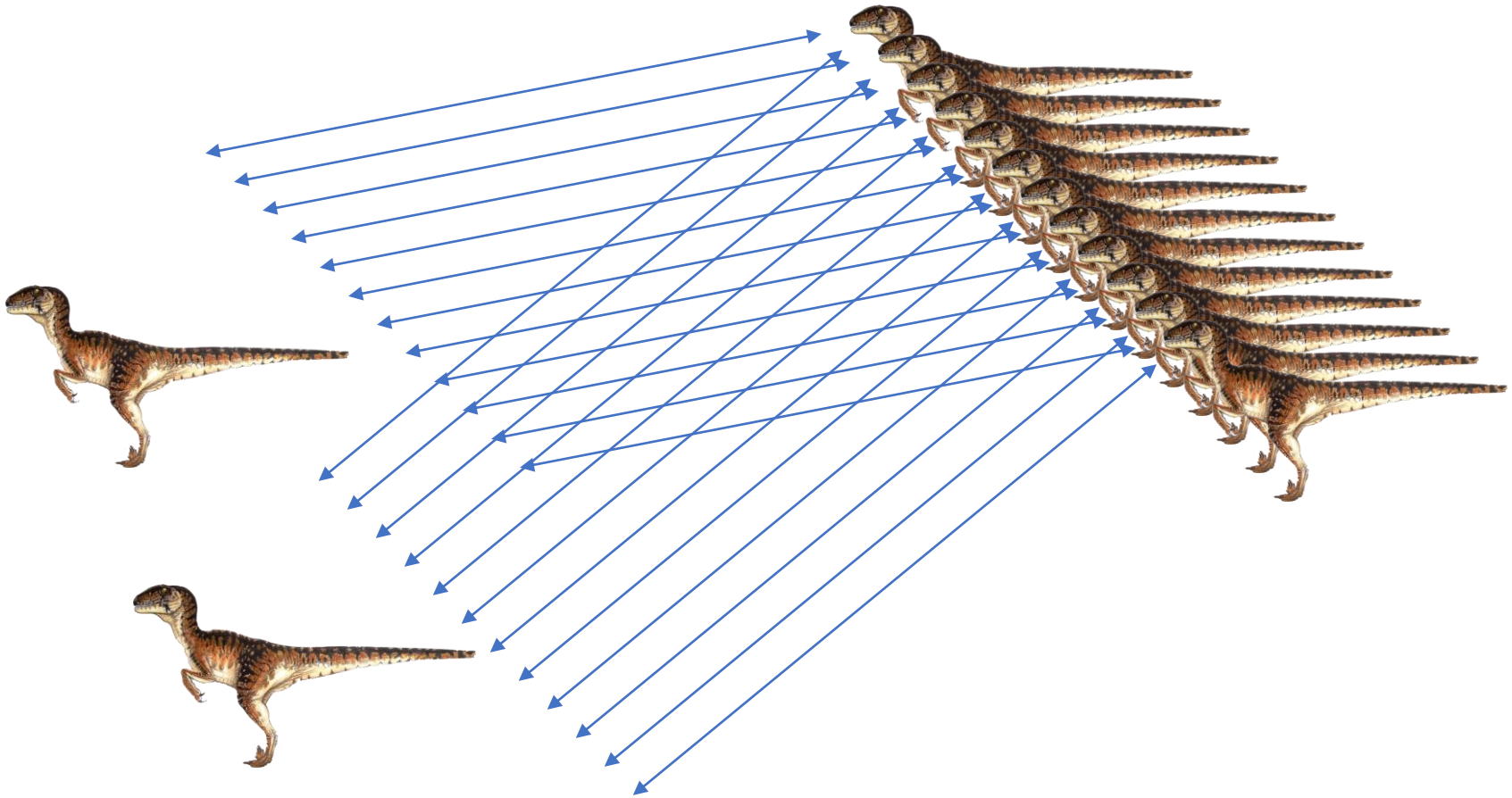
TUAKIRI



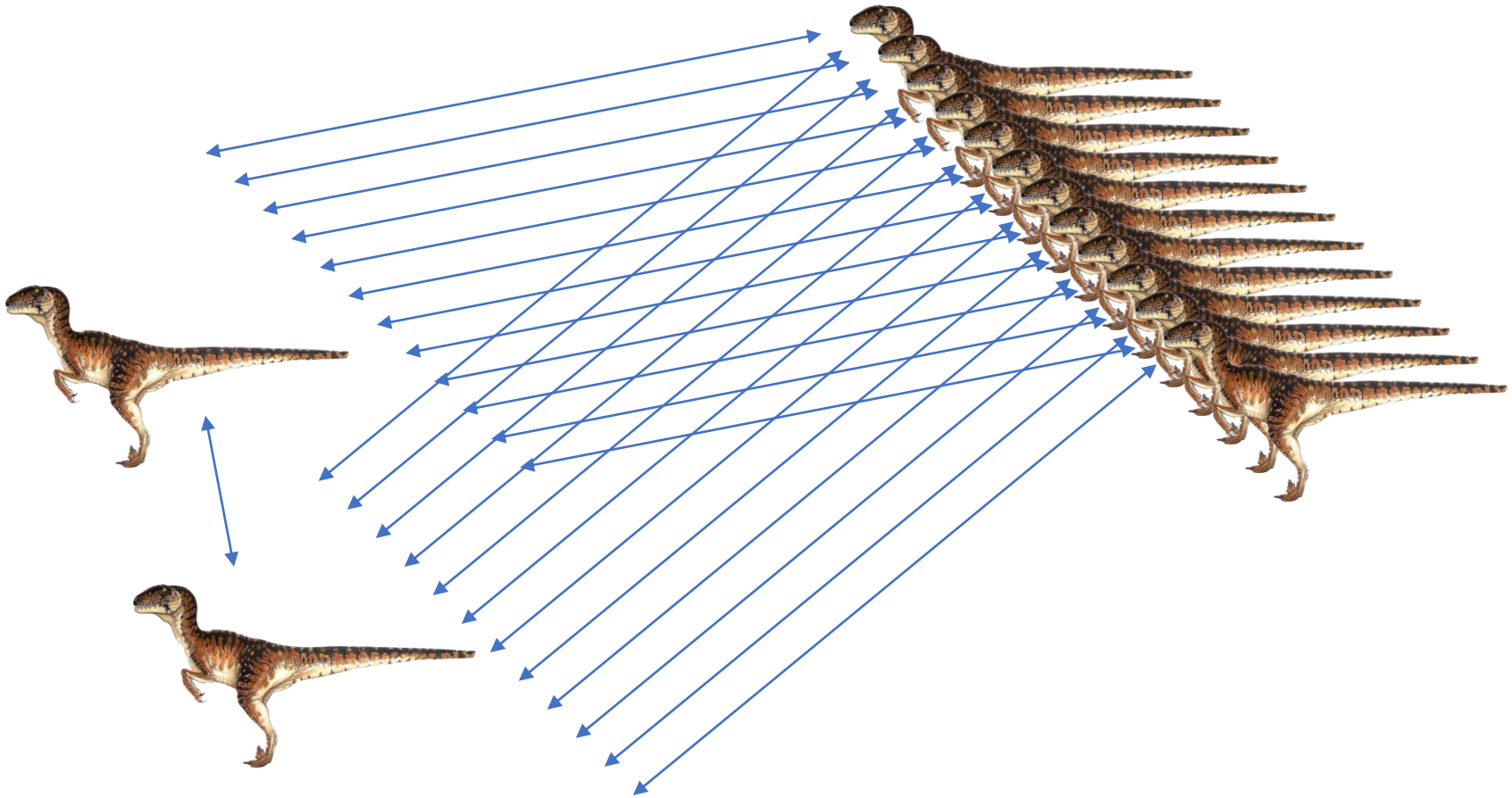
REANZ

TUAKIRI



REANNZ

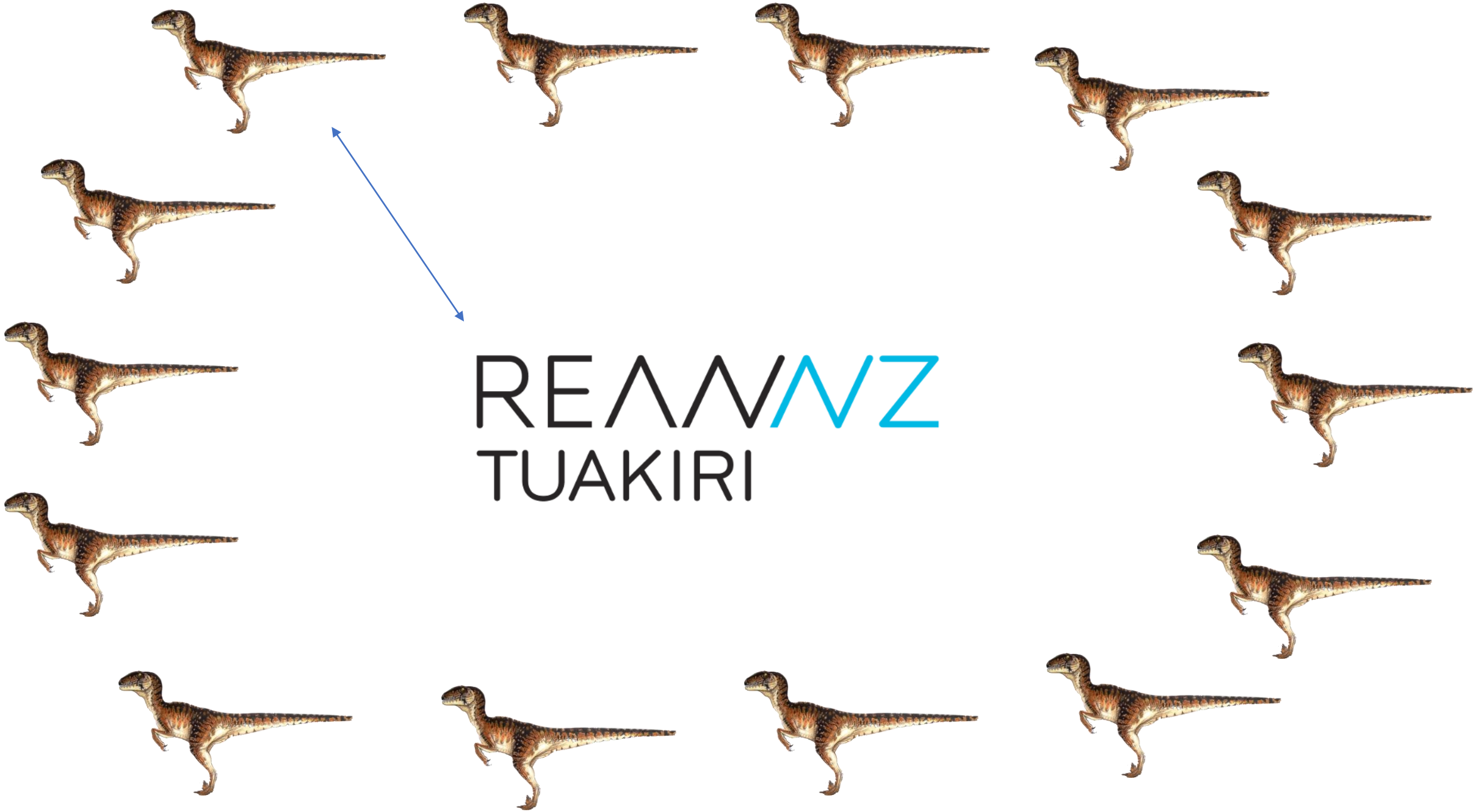
TUAKIRI

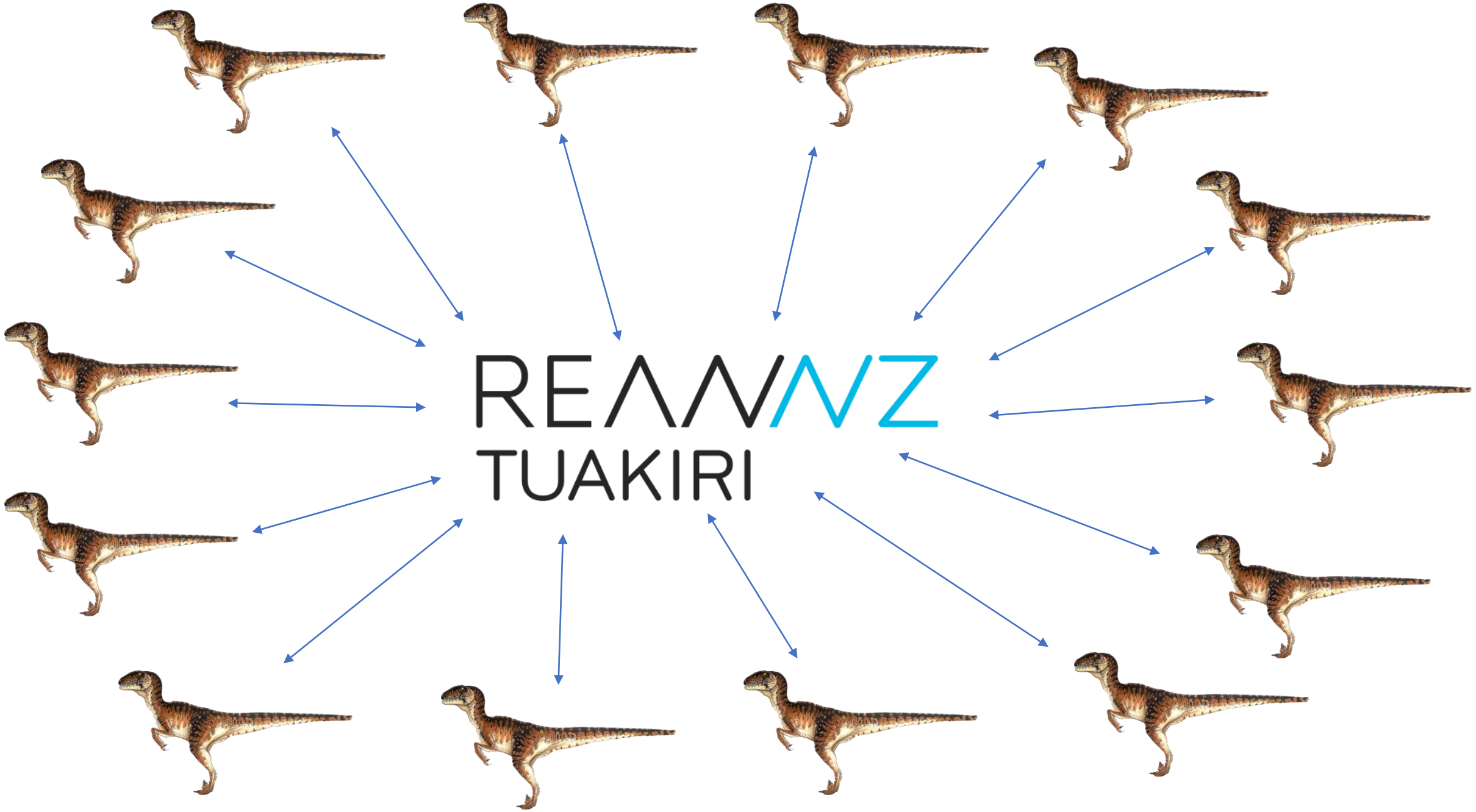


REANNZ
TUAKIRI

REANNZ
TUAKIRI

Good thing collaborative IT projects across institutions are so easy, am I right?!


REANNZ
TUAKIRI


REANNZ
TUAKIRI


REANNZ
TUAKIRI
eduGAIN
InCommon

eduGAIN WORLDWIDE

eduGAIN GÉANT

55+
FEDERATIONS

>2.600
IDENTITY PROVIDERS

>1.900
SERVICE PROVIDERS

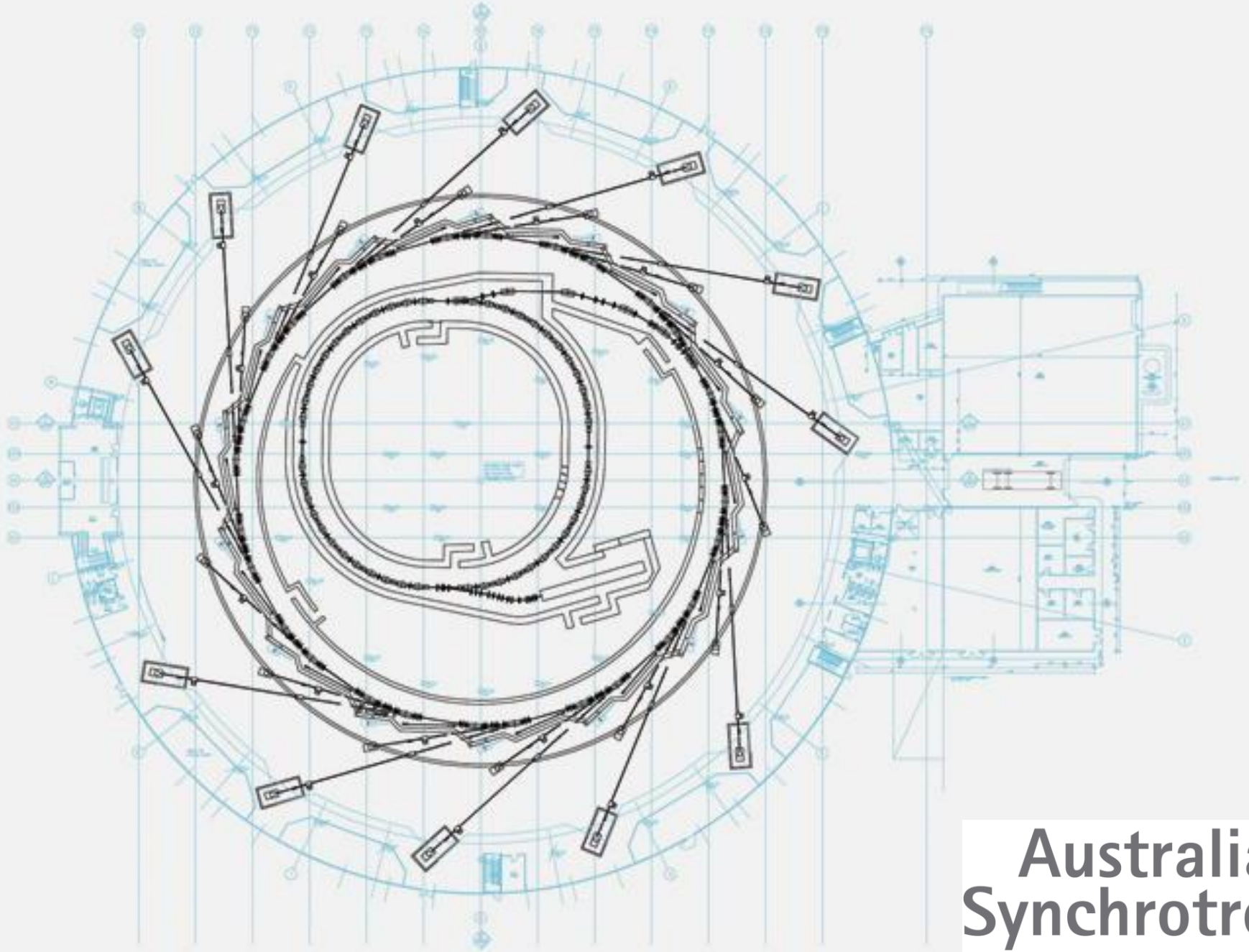
33M
AUTHENTICATIONS PER WEEK (est)

27M
USERS (est)

eduGAIN is part of the GÉANT Project (GN4-2), which is funded by the European Union's Horizon 2020 research & innovation programme under grant agreement 731122 as part of the GEANT 2020 Framework Partnership Agreement no. 653998

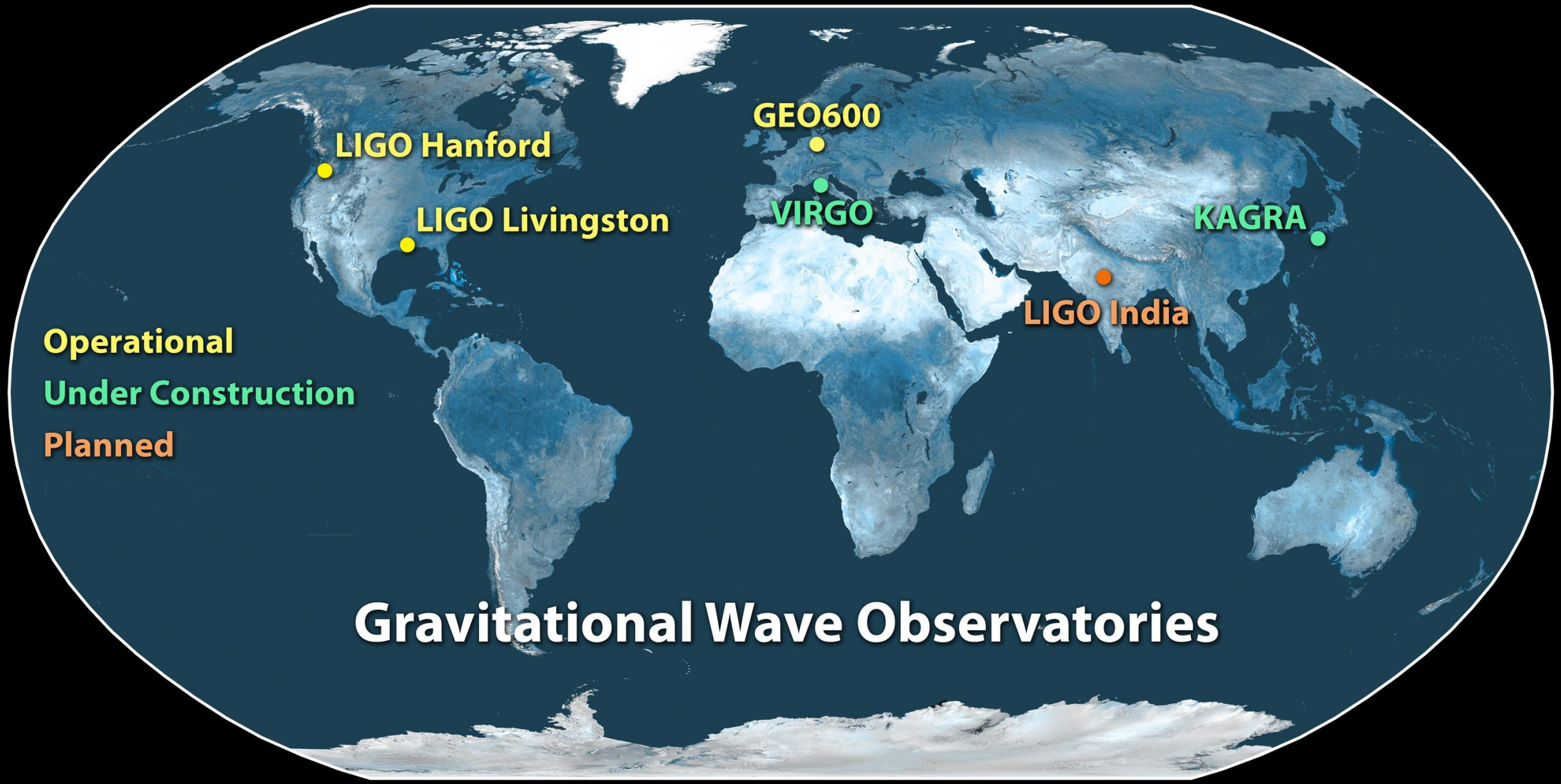
June 2018

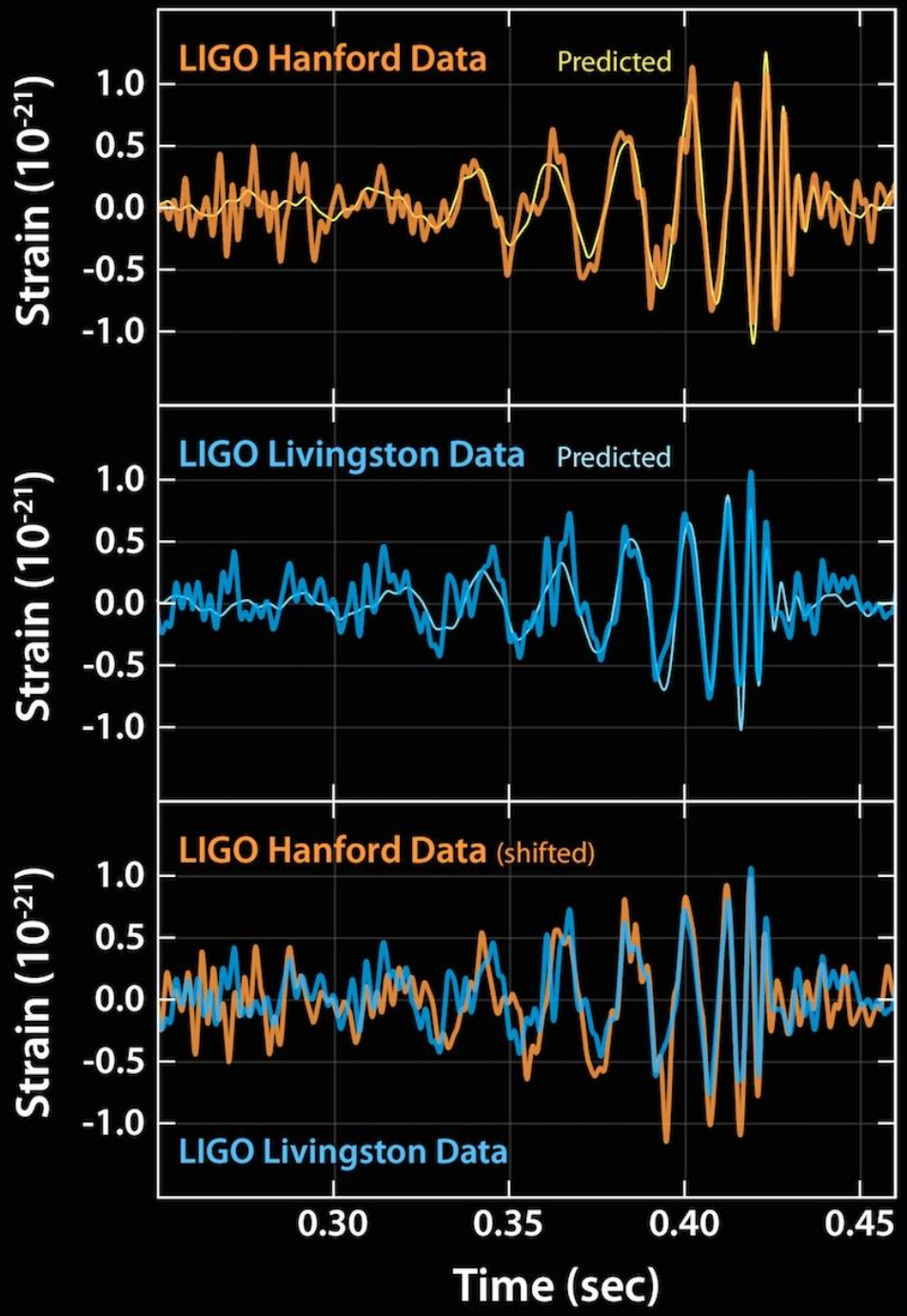
edugain.org



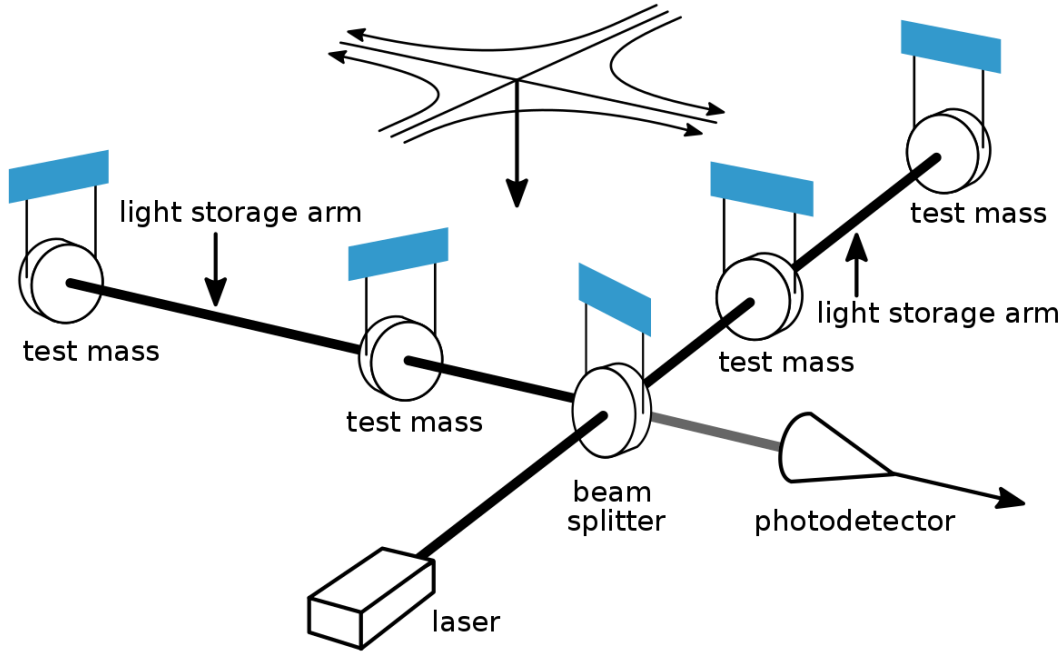
Australian Synchrotron

Turning bright ideas into brilliant outcomes


LIGO Hanford
LIGO Livingston
GEO600
VIRGO
KAGRA
LIGO India
Operational
Under Construction
Planned
Gravitational Wave Observatories

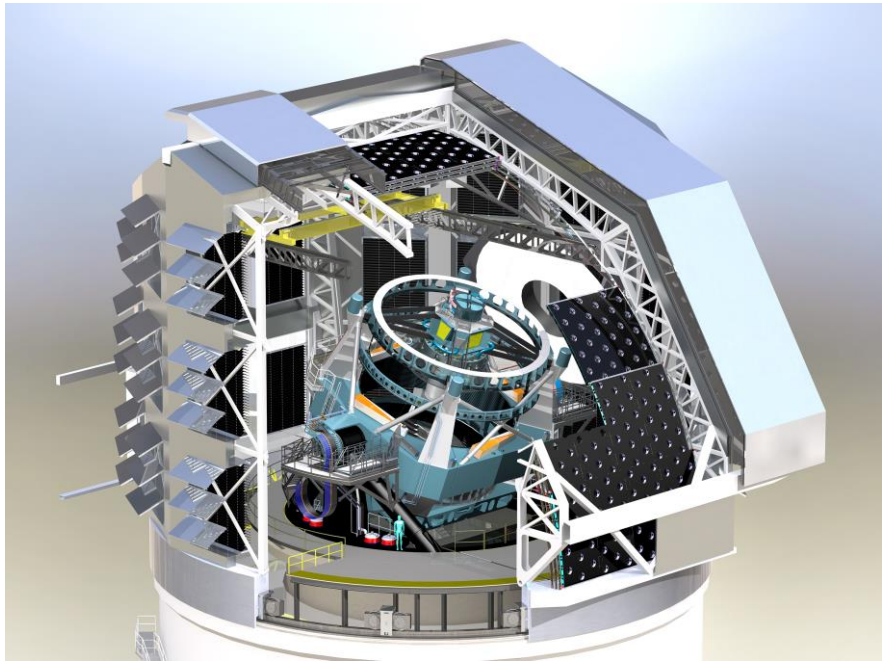

LIGO Hanford Data
Predicted
LIGO Livingston Data
Predicted
LIGO Hanford Data (shifted)
LIGO Livingston Data
Strain (10-21)
1.0
0.5
0.0
-0.5
-1.0
0.30
0.35
0.40
0.45
Time (sec)

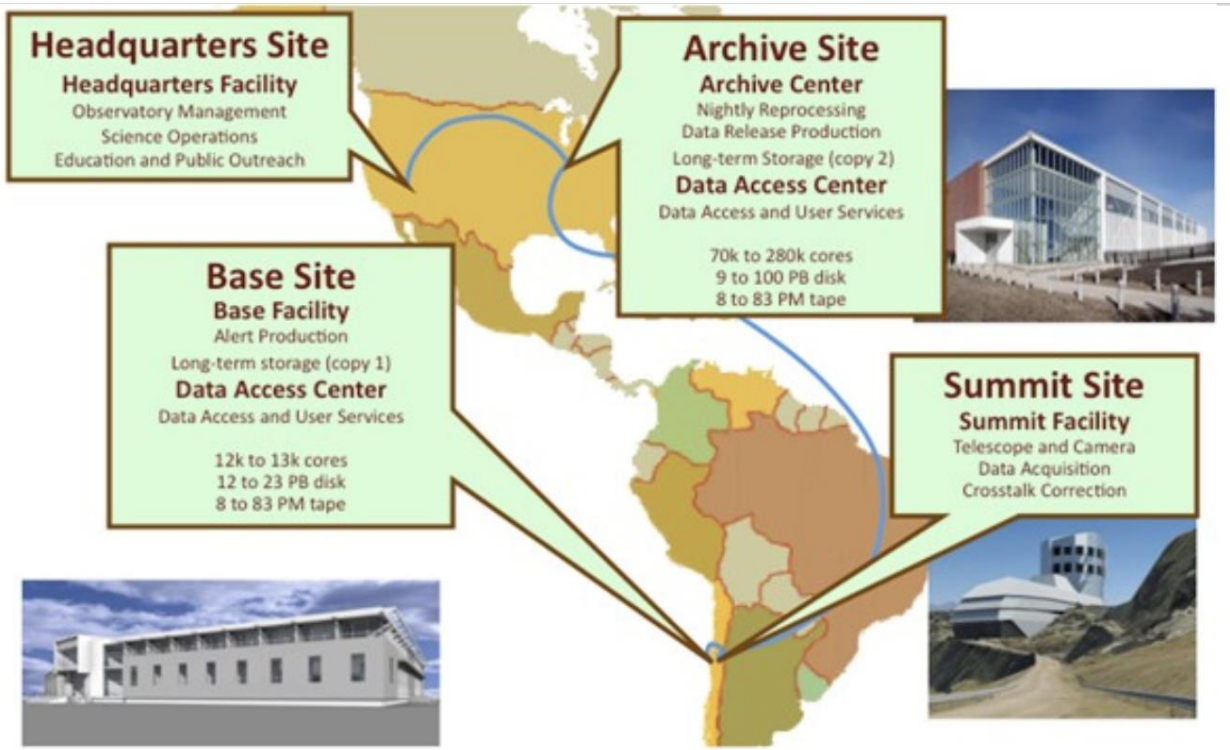
LIGO


light storage arm
test mass
test mass
test mass
test mass
light storage arm
beam
splitter
photodetector
laser

LSST

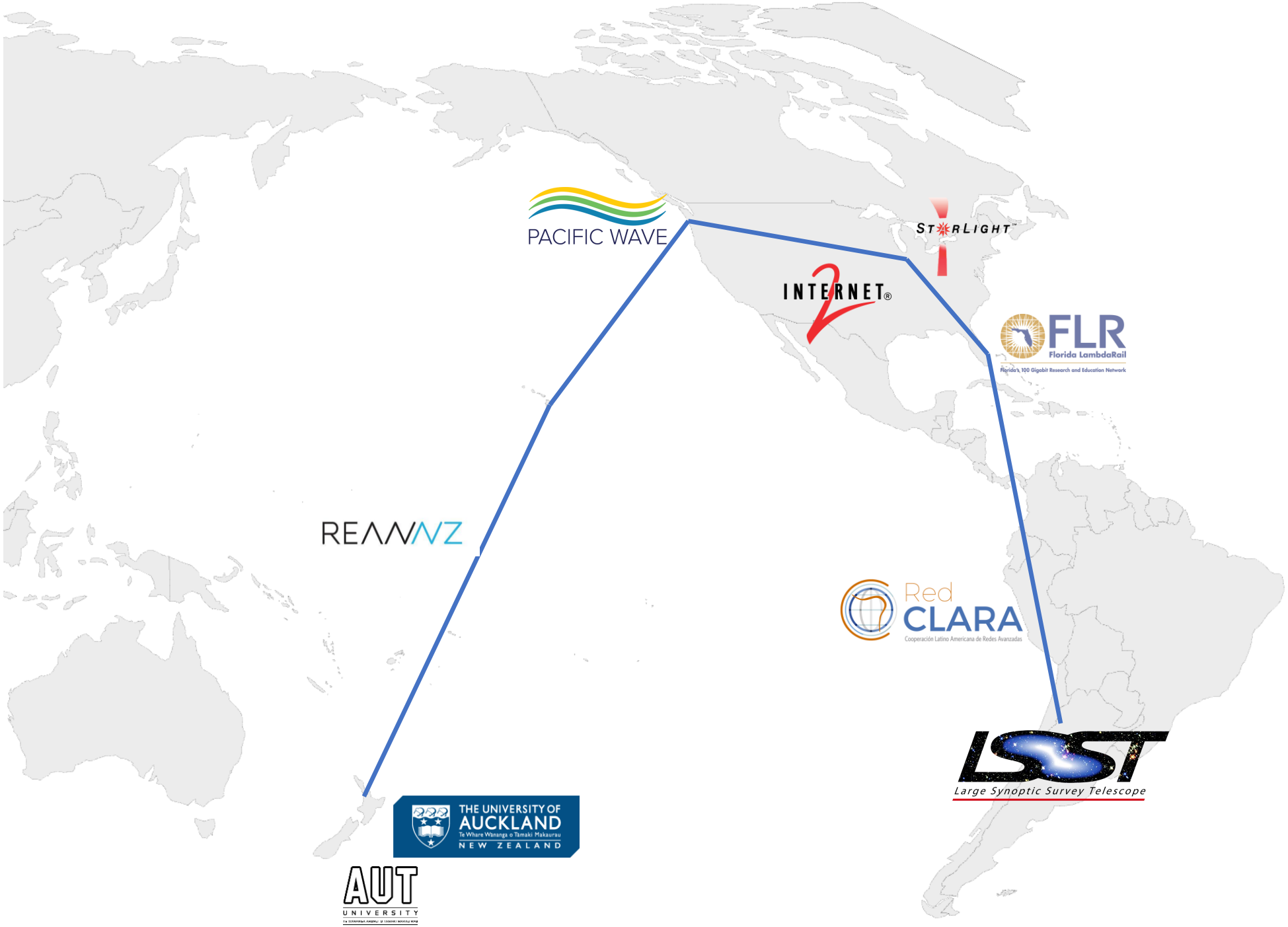
Large Synoptic Survey Telescope

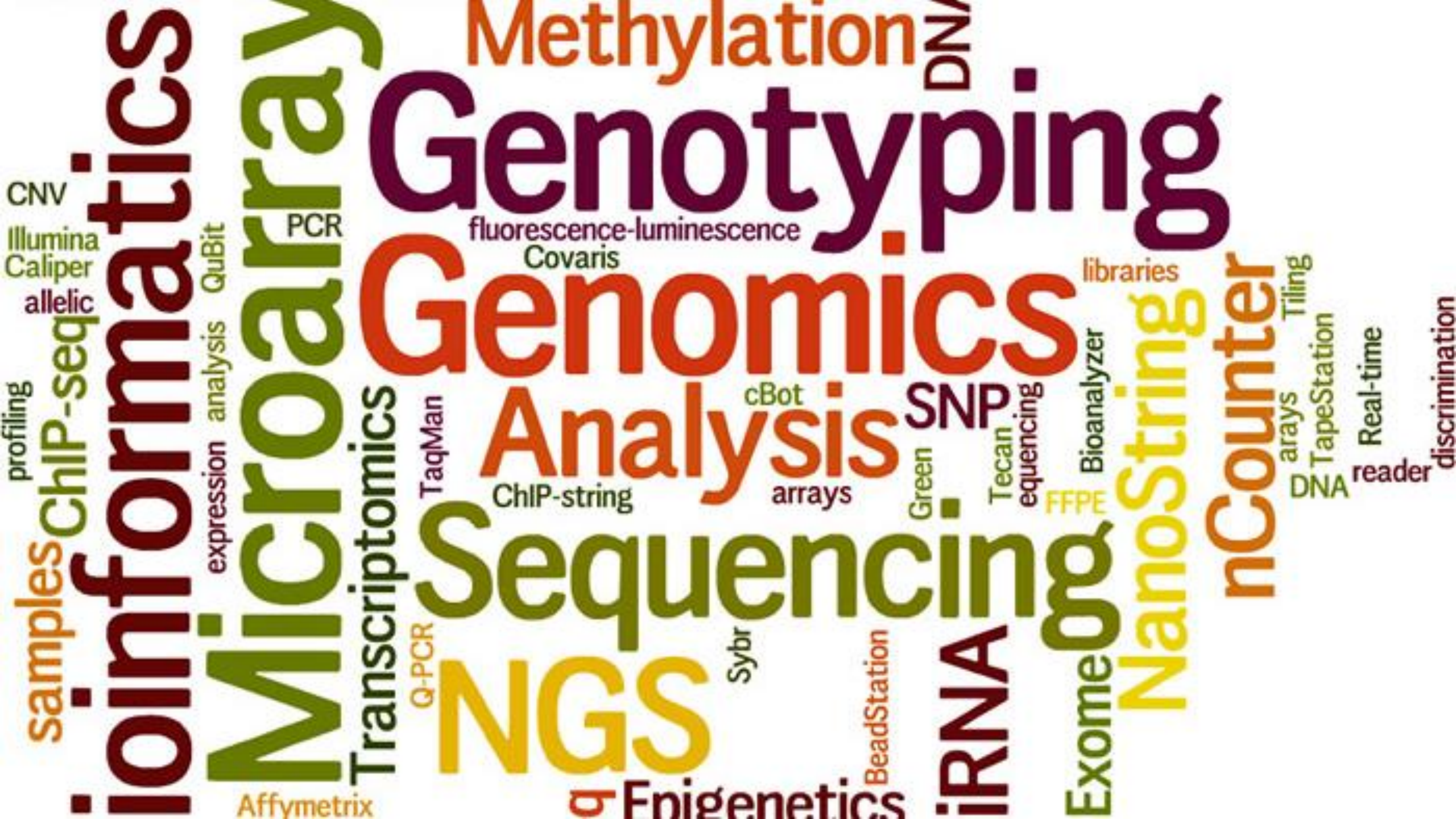




LSST Data Management system must deal with an unprecedented data volume.

- one 6-gigabyte image every 17 seconds
- 15 terabytes of raw scientific image data / night
- 100-petabyte final image data archive
- 20-petabyte final database catalog
- 2 million real time events per night every night for 10 years


PACIFIC WAVE
STARLIGHT
INTERNET2
FLR
Florida LambdaRail
Florida's 100 Gigabit Research and Education Network
REANNZ
Red CLARA
Cooperación Latino Americana de Redes Avanzadas
LSST
Large Synoptic Survey Telescope
THE UNIVERSITY OF AUCKLAND
Te Whare Wananga o Tamaki Makaurau
NEW ZEALAND
AUT
UNIVERSITY


Methylation
DNA
Genotyping
CNV
PCR
fluorescence-luminescence
Illumina
Caliper
QuBit
Covaris
libraries
allelic
Genomics
Tiling
profiling
ChIP-seq
expression analysis
TaqMan
cBot
SNP
Bioanalyzer
TapeStation
Real-time
discrimination
Analysis
arays
reader
DNA
Tecan
equencing
FFPE
ChIP-string
arrays
Green
Sequencing
samples
Transcriptomics
Sybr
Q-PCR
NGS
BeadStation
Affymetrix
Epigenetics
Exome
NanoString
nCounter
Microarray
Bioinformatics


CERN

THE LARGE HADRON COLLIDER BY THE NUMBERS

27KM
(16 MILES)
IN CIRCUMFERENCE

1 PETABYTE-PER-SECOND
IN RAW DATA GENERATED BY LHC EXPERIMENTS

1 BILLION COLLISIONS
OCCUR PER SECOND

100K
TIMES HOTTER THAN THE SUN'S CORE,
HEAT GENERATED BY COLLISIONS

99.99999999%
SPEED OF LIGHT
ACHIEVED BY PARTICLES

1.9 KELVIN
(-271.3 DEGREES CELSIUS)
INTERNAL OPERATING TEMPERATURE

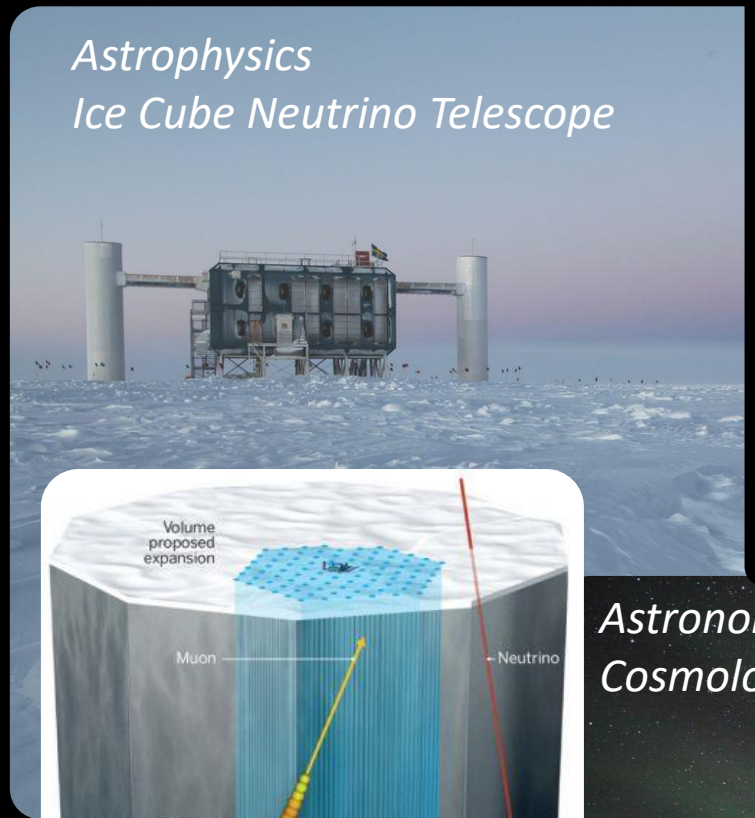
120,000
CORES RUNNING
CERN'S OPENSTACK CLOUD ACROSS TWO DATA CENTERS

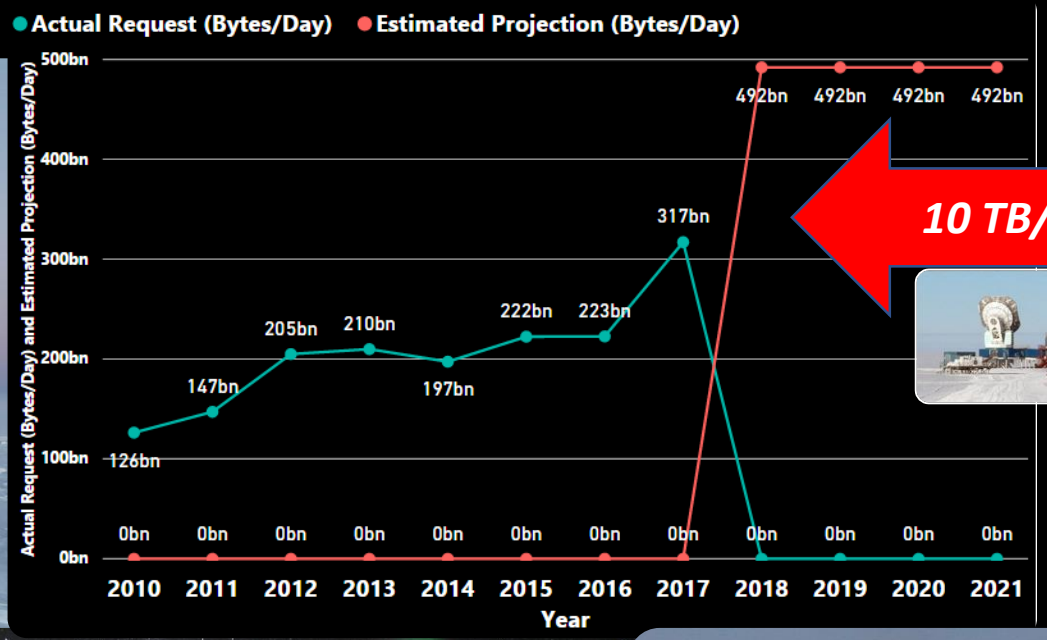
FABRIC

https://fabric-testbed.net/

South Pole Challenge – Big Science – Big Data

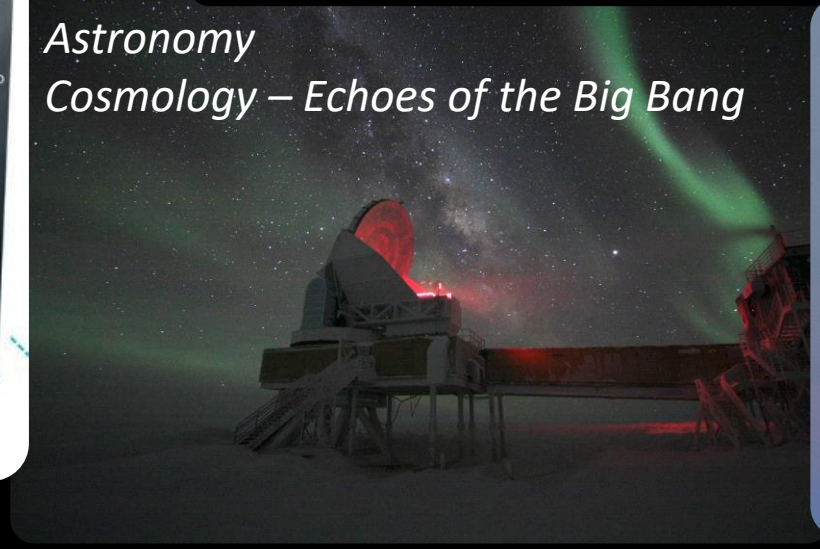
Astrophysics
Ice Cube Neutrino Telescope





10 TB/day by 2027-ish

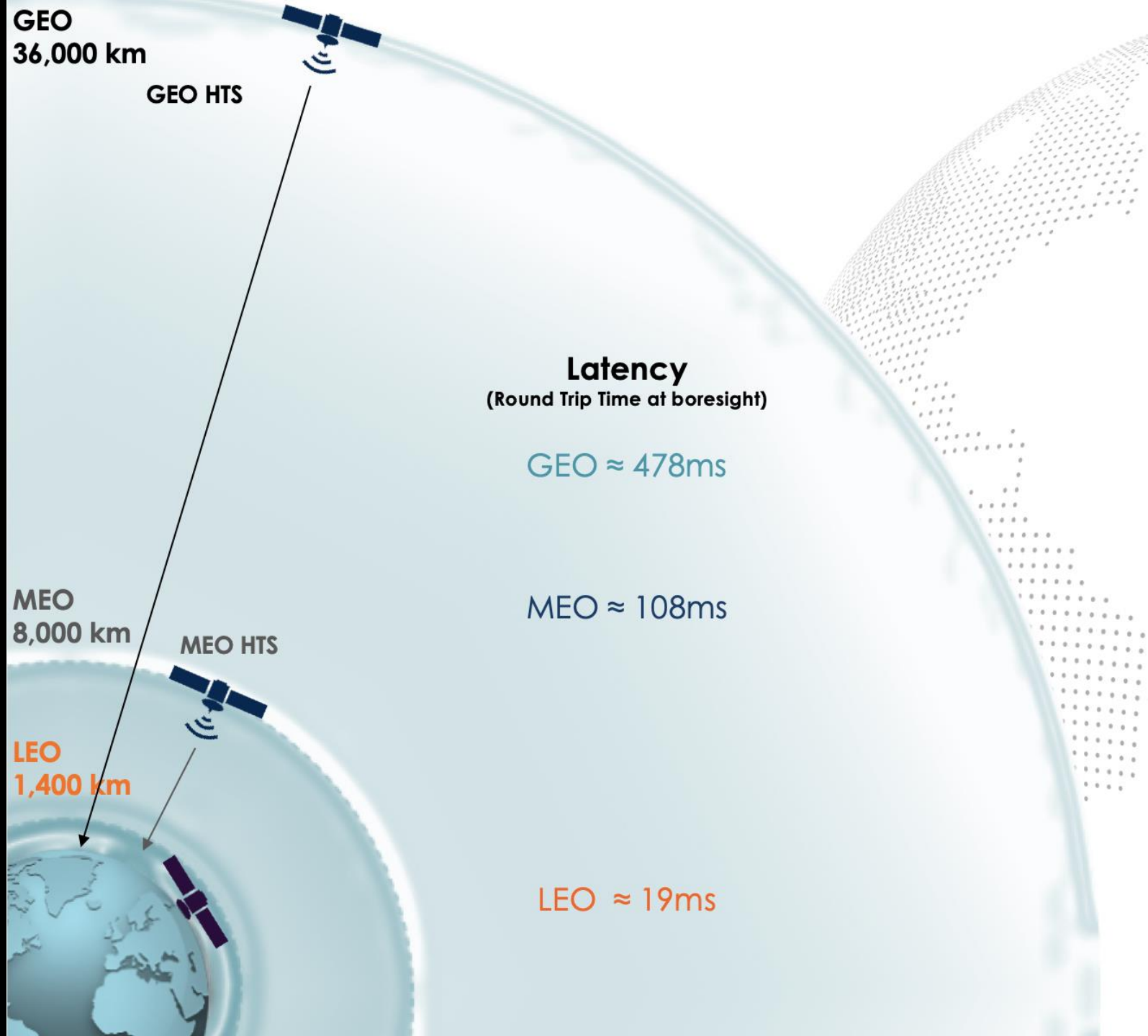
Astronomy
Cosmology – Echoes of the Big Bang



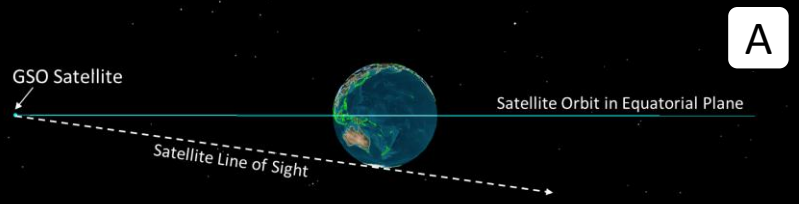
South Pole Telescope

Satellite 101

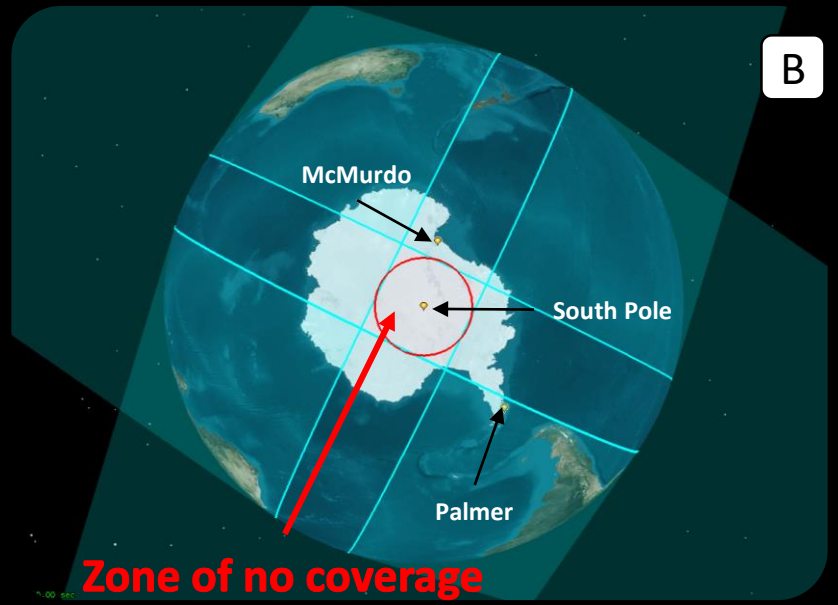
- Geostationary (GEO) satellites:
  - have been around since the 60s of last century
  - mainly for telephony (early days) and TV broadcast
  - not useful (long latencies and slow) for Internet usage
- Medium Earth Orbiting (MEO) tried to be the fix for the Internet, did not happen
- New development: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



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.

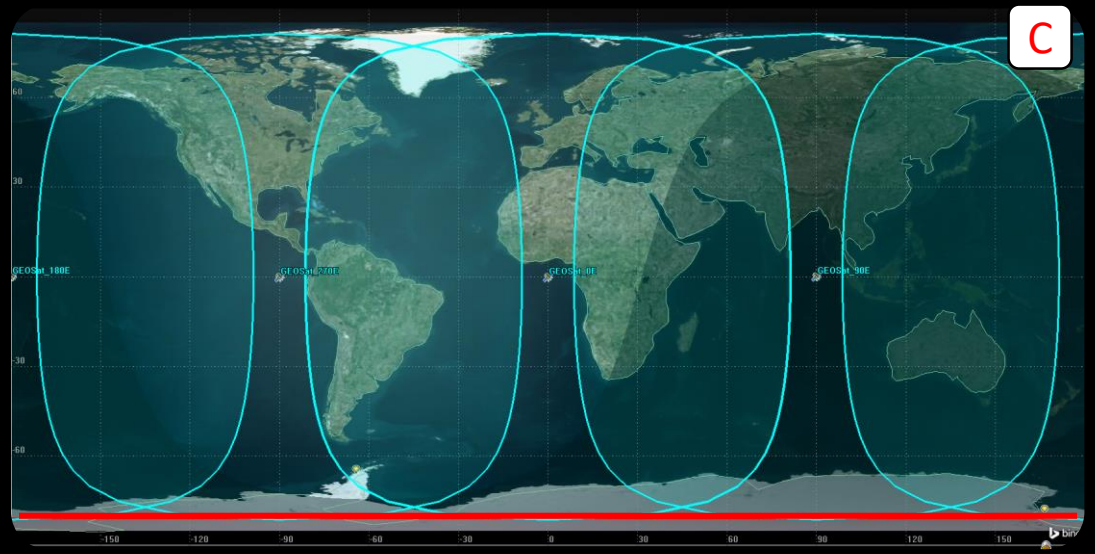


Views of standard GSO satellite visibility footprints

- 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

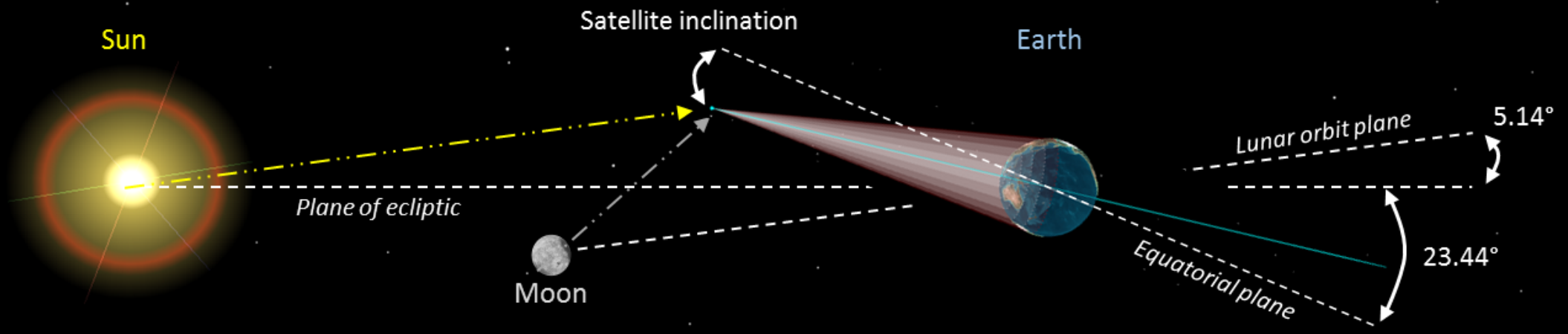
❖ Longitudes closer to the South Pole (90°S) cannot see the satellites due to blockage by the Earth

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



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

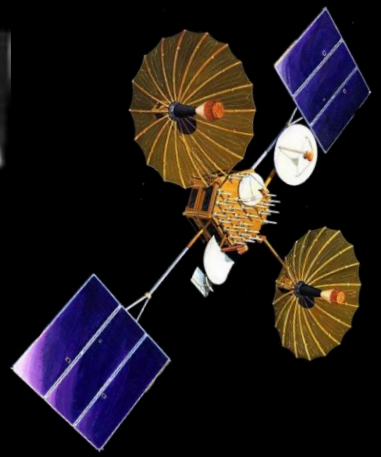
South Pole: Dumpster Diving Architecture

Old inclined GEO satellites only current options for South Pole Station

Guess who?

DoD DSCS-3 Fleet

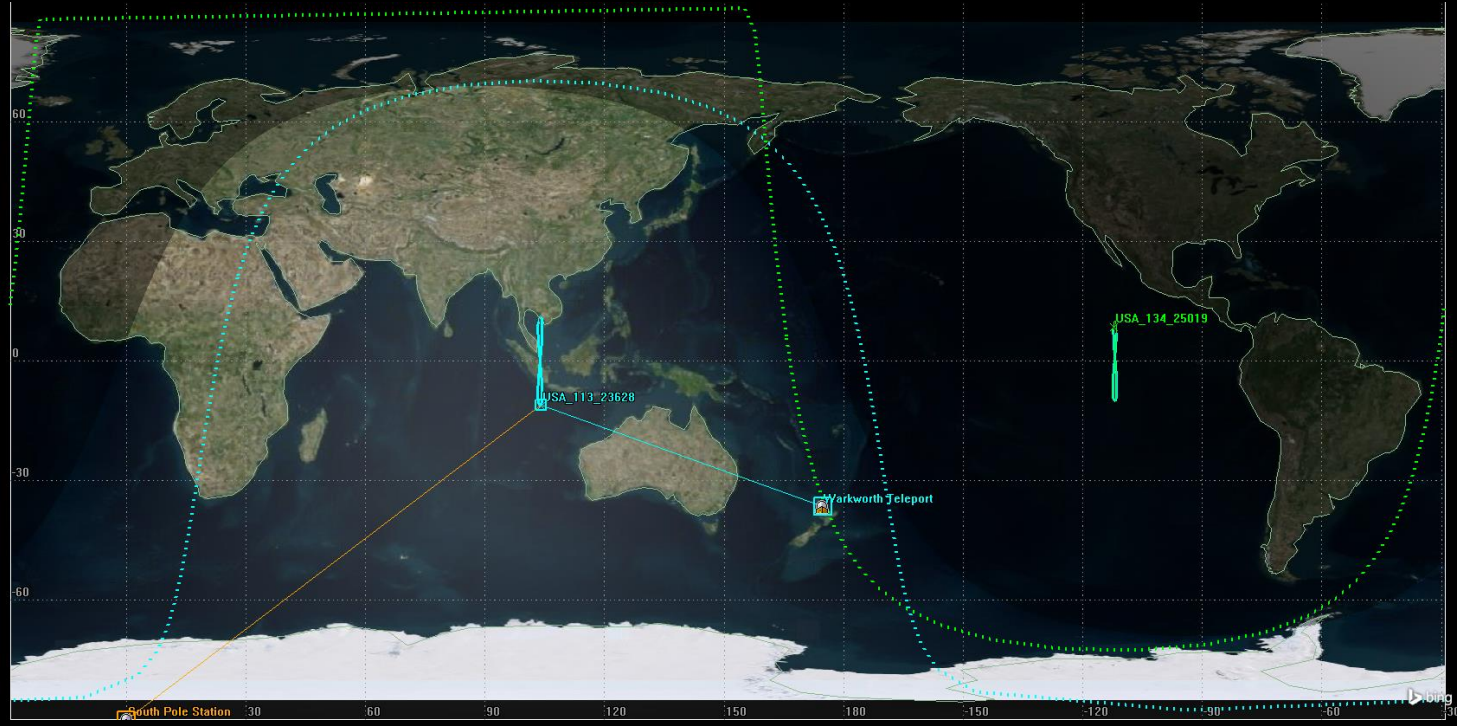
NASA First Gen TDRS Fleet

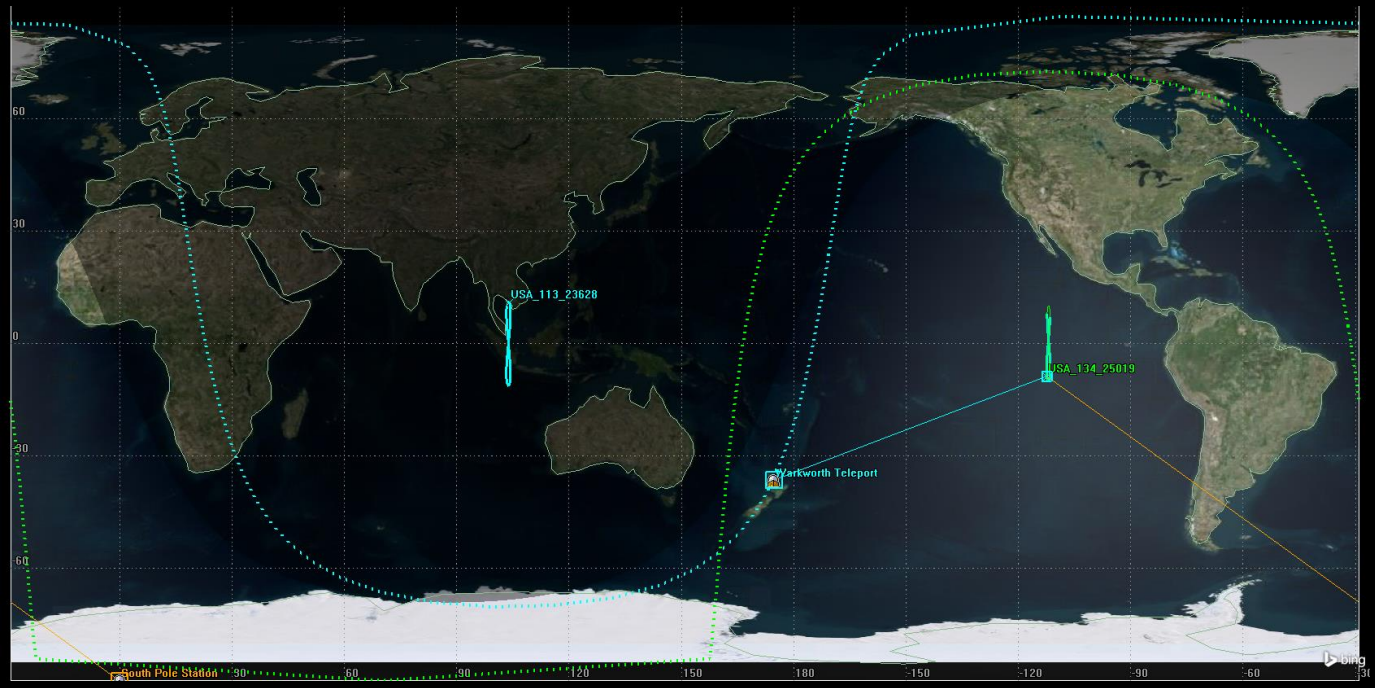


- There are not very many of these and are hard to come by (requires searching a lot of dumpsters for a long time…)
- Limited capacity (these were built when dial-up networking was king - have to live with what one finds…)
- Questionable longevity (these things are old & tired by the time one finds them…)

DSCS

Warkworth Teleport
North Island



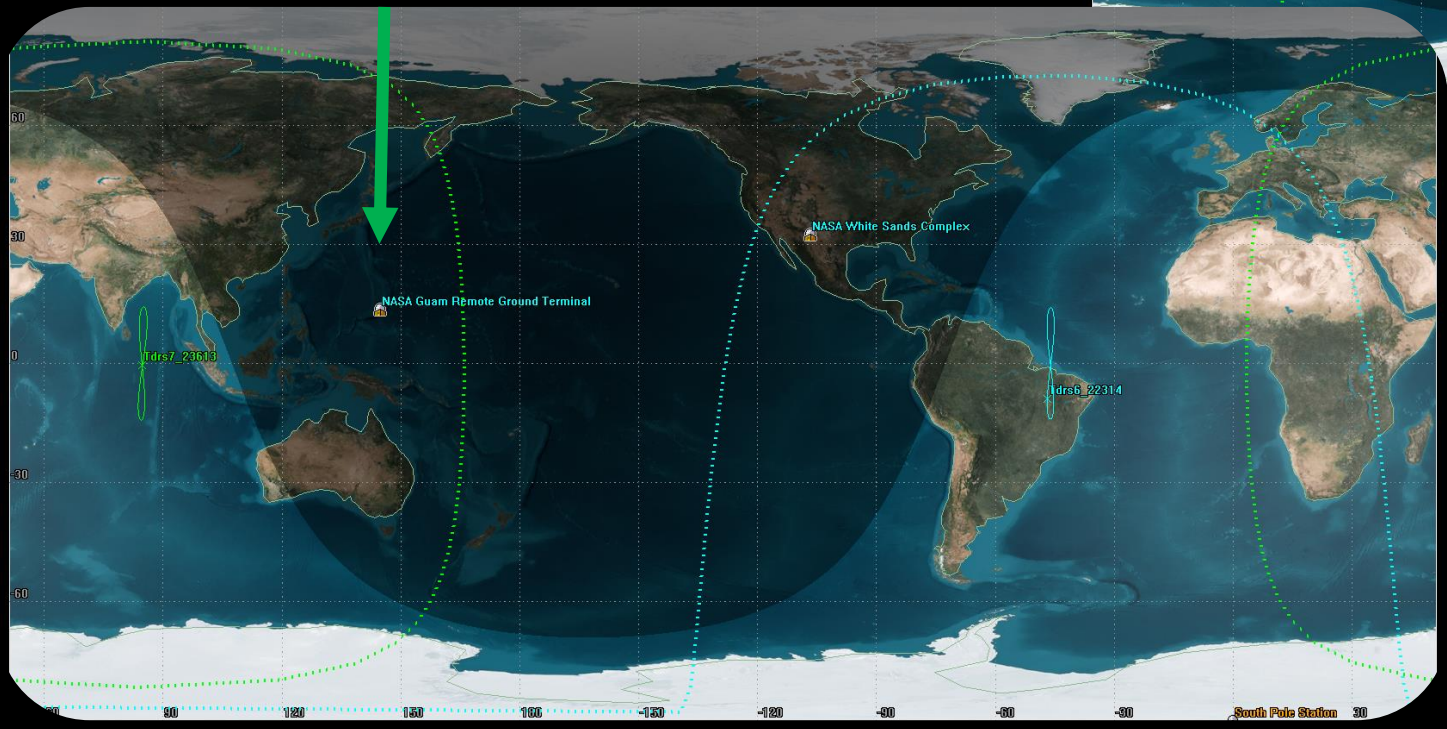


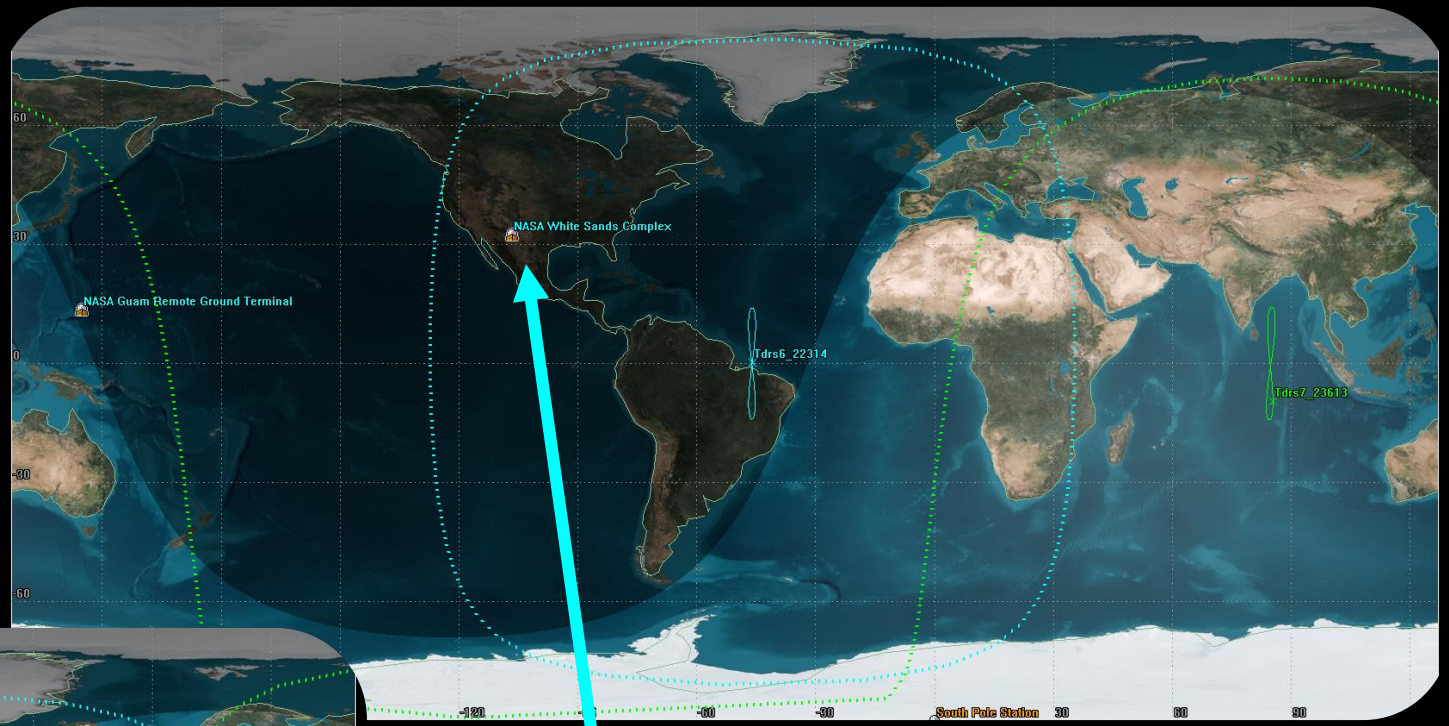
The Spark NZ Warkworth commercial teleport can establish a viable link with two DSCS-3 satellites available to NSF: one at 104°E and one at 112°W

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

Nominal TDRS F7 Footprint at Equator Crossing

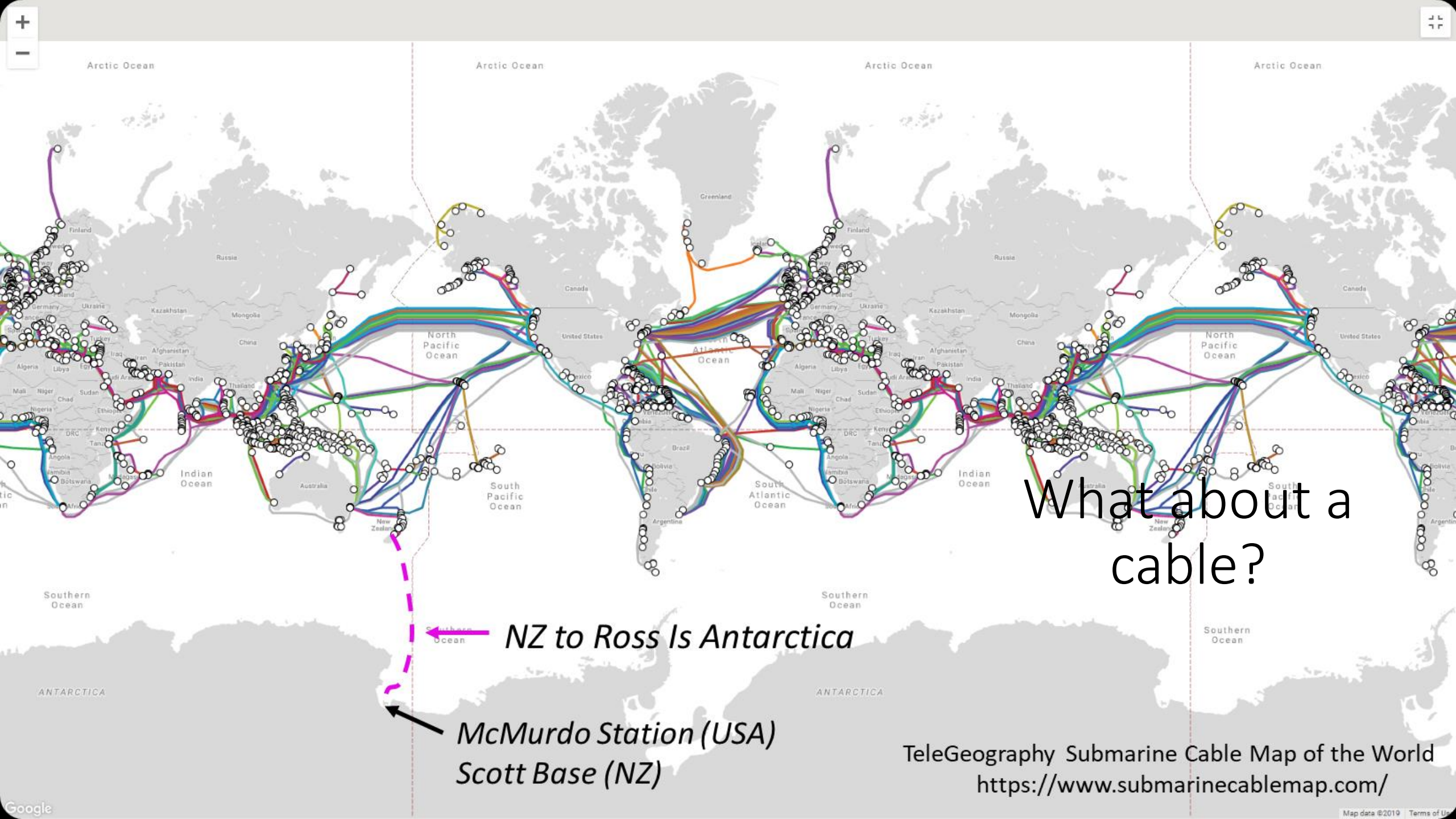
- White Sands is not covered
- Guam is covered





Nominal TDRS F6 Footprint at Equator Crossing

- White Sands is covered
- Guam is not covered


Arctic Ocean
Arctic Ocean
Arctic Ocean
Arctic Ocean
North Pacific Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Indian Ocean
Southern Ocean
Southern Ocean
Southern Ocean
ANTARCTICA
ANTARCTICA
What about a cable?
NZ to Ross Is Antarctica
McMurdo Station (USA)
Scott Base (NZ)
TeleGeography Submarine Cable Map of the World
https://www.submarinecablemap.com/

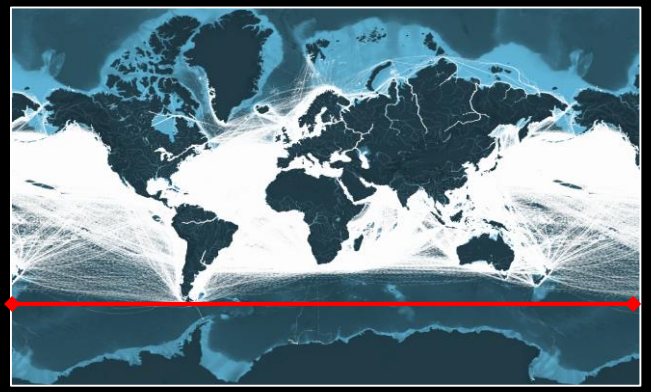
Why a Cable?: *Conventional satellite operators are not incentivized to target service for Antarctica*

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:

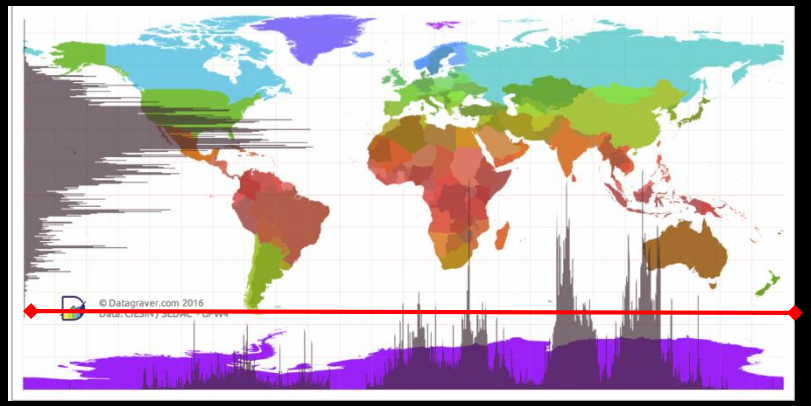
- Land masses with high population densities
- Global shipping and airline routes
- FCC only requires operators to provide service between 70°N to 55°S

- *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

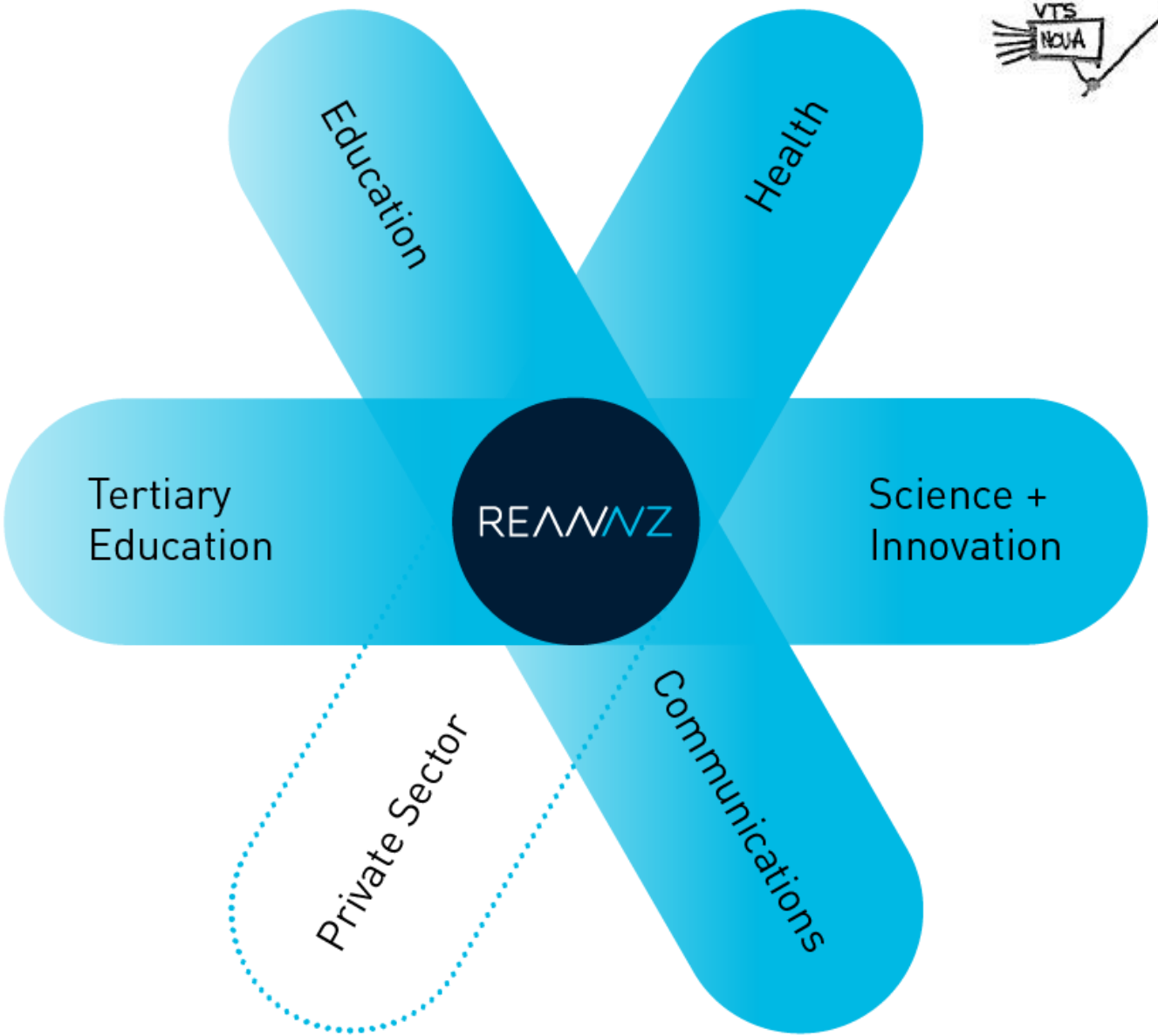
McMurdo Neighborhood

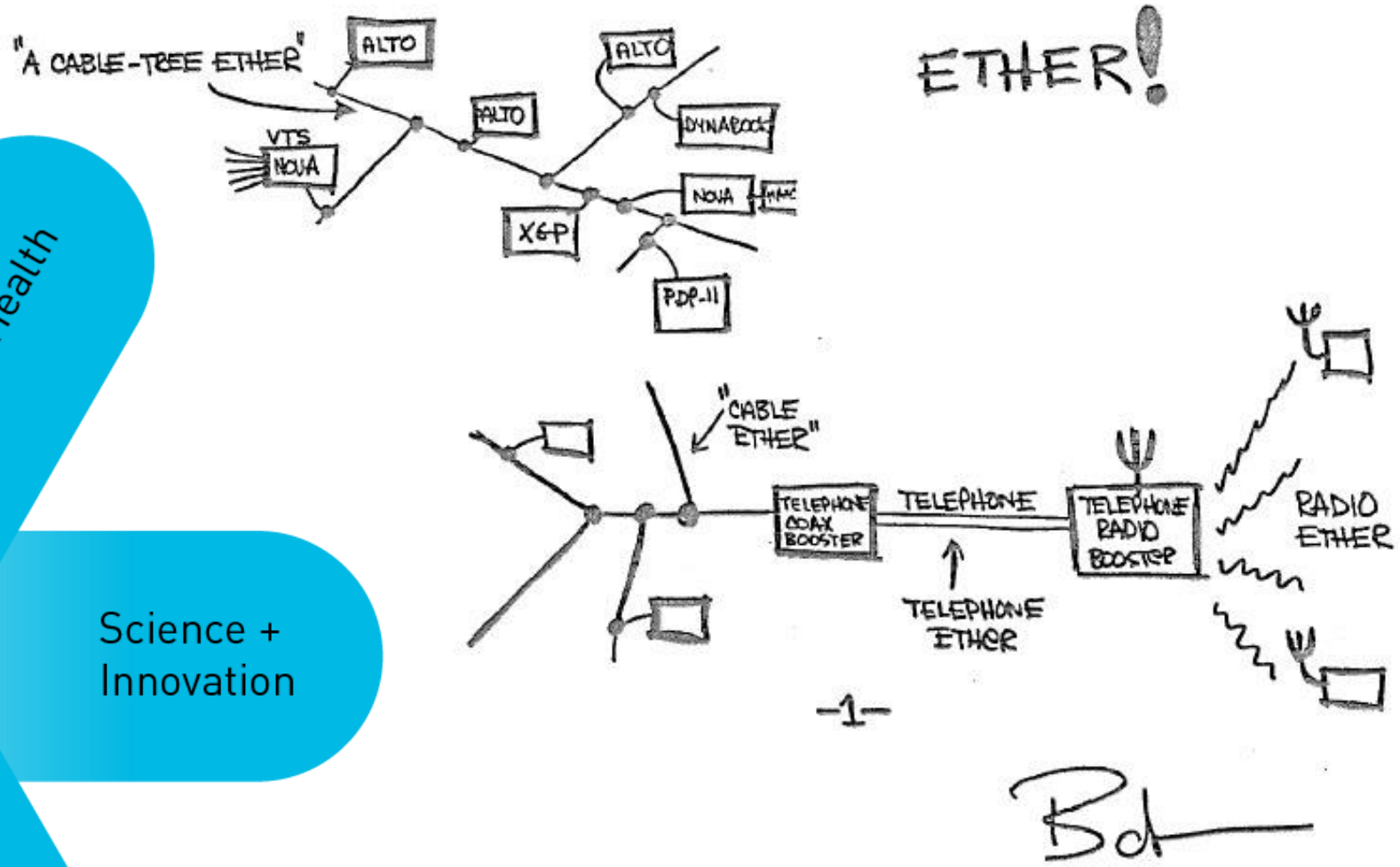
What other international Antarctic operators have an interest?

We are here to help you.

REANNZ

Thank you!





Please ask me anything!

wallace.chase@reannz.co.nz
@bmtfr