



Data transfer from ALMA to North America

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ALMA telescope

- Largest mm/submm telescope ever built.
- Interferometer – combines signals from multiple antennas to form an image.
- Inauguration occurred at the OSF on March 13th 2013
- All 66 antennas delivered, all but one now at high site.
- Multinational project with many partners, three ALMA Regional Centers (ARCs): US, EU and EA
- Operated “space mission” style, with pipeline data processing and a science archive at each ARC allowing data reuse.
- First PI projects released to public from the ARCs January 2013
- Cycle 2 observations will begin in June 2014.

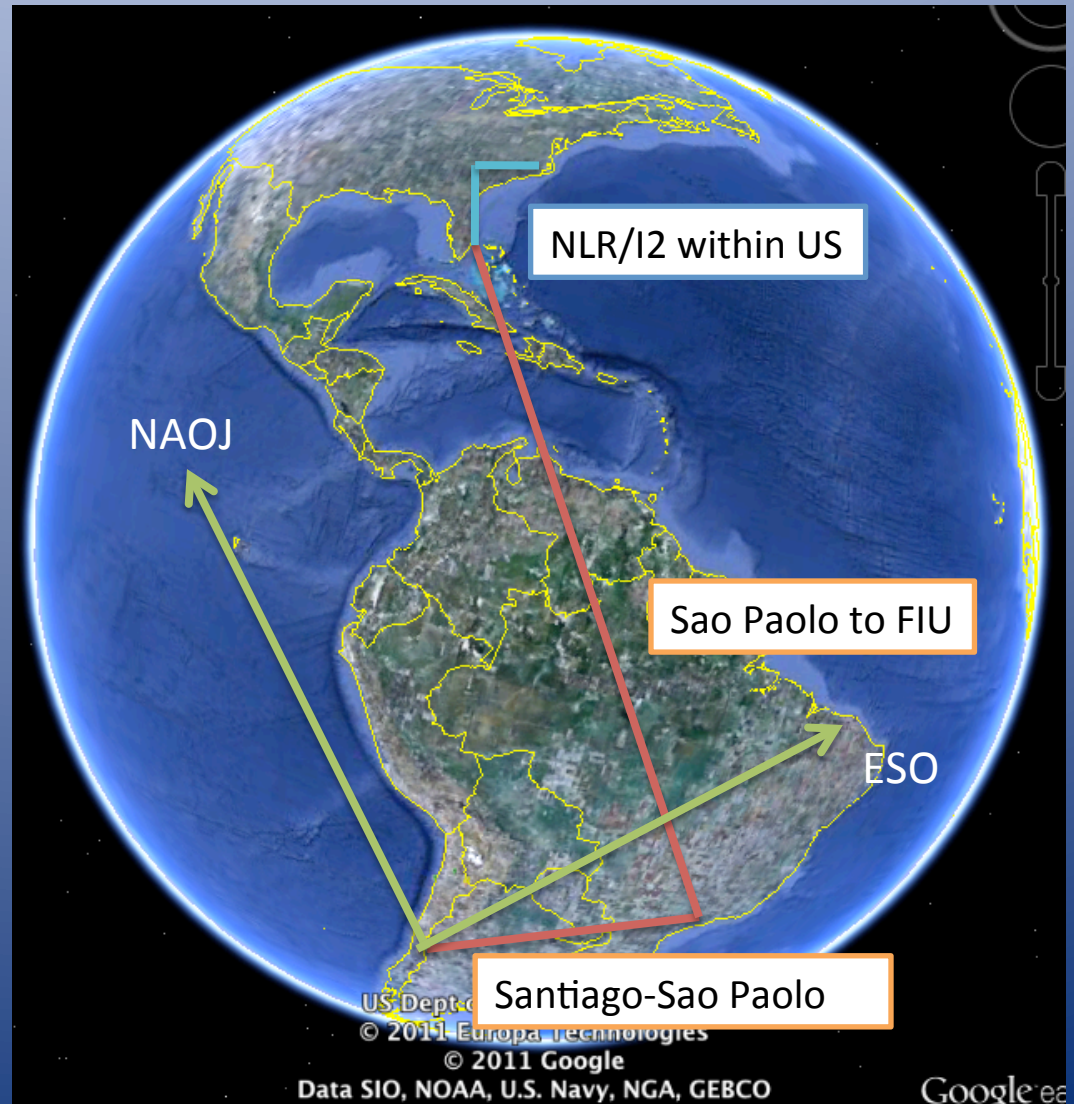
Data Transfer within Chile

- AOS to OSF: 48 dedicated fibers
 - (1Gbp/s upgradable to 10Gb/s)
- OSF to Santiago currently 100Mb/s (part microwave)
- Upgrade project from ALMA development:
 - OSF to Calama fiber build early 2014
 - Calama to Antofagasta provided by Telefonica
 - 2.5Gb/s from Antofagasta to SCO from EVALSO/REUNA
 - Redundant fiber loop via Argentina planned
- Pipeline run in Santiago to produce L2/L3 data products, increases data size by 10-30%.
- Primary ALMA archive in Santiago (SCO)
- Santiago to ARCs: individual ARC contracts with REUNA and NRENs

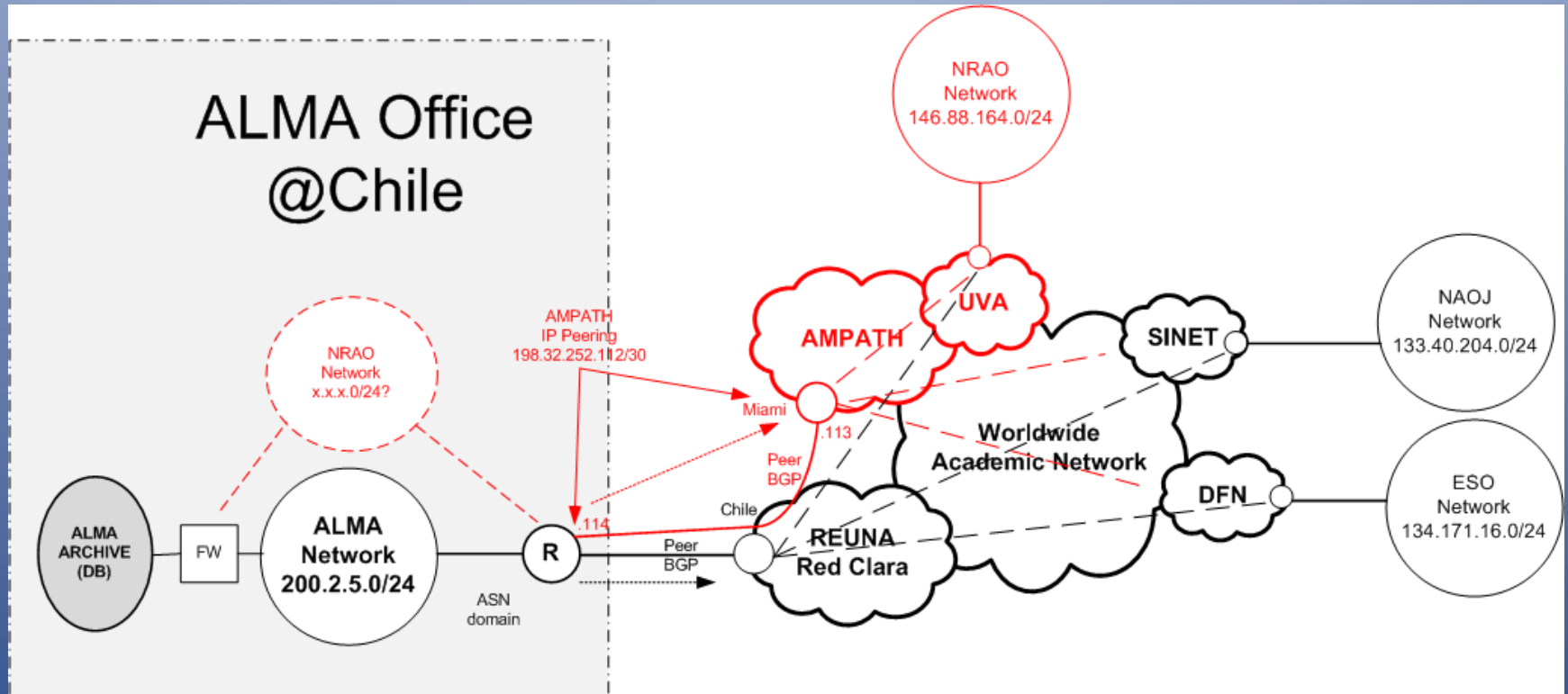


Data transfer – Chile to NA

- Joint AURA-AUI agreement for NRAO to have 100Mb/s committed (burstable to capacity) of AURA's 622Mb/s link to Chile through Sao Paolo and Miami (FIU/AmLight) to the US research network backbone (NREN).
- MOU signed between AUI/REUNA
 - local link to SCO.
 - implementing international links.
- Will likely need ~1Gb/s to the ARCS by ~2016.
 - 90% is bulk data with low QoS.
 - Remainder is database sync and telepresence
- **100Mbps from SCO to REUNA for NRAO**
 - Requested upgrade to 1Gb/s with JAO/REUNA
- MOUs in place between AURA/AUI and AUI/REUNA
- Opportunities for improving Chilean astronomer access under consideration



Paths from ALMA



Note: NRAO will be abandoning 146.88.x.x IP space in the next month

ALMA Science data rate evolution

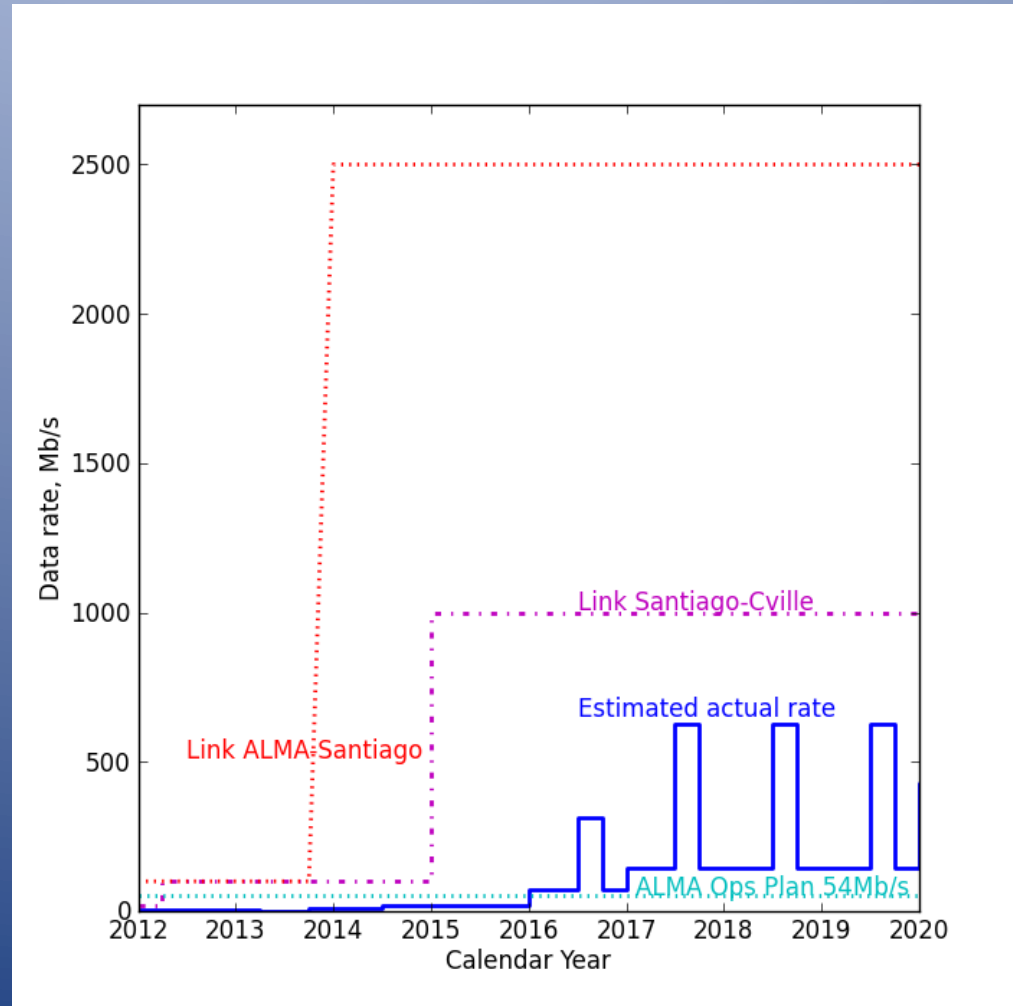
- ALMA Cycle 0 completed (Oct 2011-Jan2013)
 - 16-24/50 antennas used (data rate proportional to square of antenna number)
 - ~5-10% of array time for science
 - Data inflated to supply users with intermediate products
 - Total data volume was about 20TB
- ALMA Cycle 1 in progress (~Aug 2013-Jun2014)
 - 32-40/50 antennas, plus 7/12 compact array
 - ~10% of array time for science
 - Users will not get intermediate products, better software means unnecessary data not taken.
 - Best guess is about 40TB over 1yr (ALMA archive hit 50TB in March 2014)
- ALMA Cycle 2 starts in June 2014, ends November 2015
 - ~34 main array antennas, all 12 compact array
 - ~15% of array time for science (but some carryover from Cycle 1)
 - Best guess data volume is around 100TB in a 17 month Cycle.

Future Cycles

- Data rates will increase as we transition into full operations, unclear how fast the ramp-up will be, and whether data rates will be throttled by the project.
- Unthrottled, we expect data rates driven by a typical mix of science use cases to be $\sim 100\text{Mb/s}$, with seasonal peaks $\sim 600\text{Mb/s}$ in the Austral winter/spring.

Current data rate projections

- Assumes no imposed limit on data rate (cyan line is current Operations Plan rate).
- Blue line is for data generation
- Data transmission is per ARC



Summary

- In March this year the ALMA archive in North America reached 50TB, all transferred from Chile – our thanks to the SAACC and our colleagues at AmLight, REUNA and JAO!
- Ramp-up of ALMA data rate has been slower than anticipated, allowing us to stay ahead of the curve.