# The challenges of remotely operating an astronomical observatory

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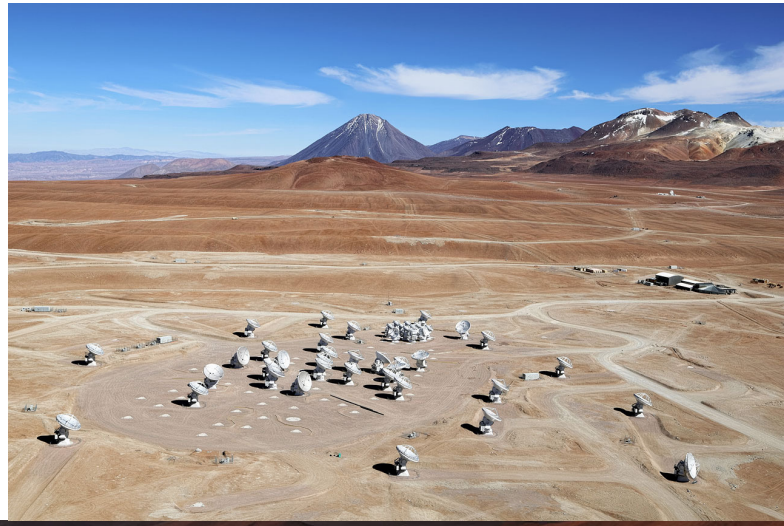
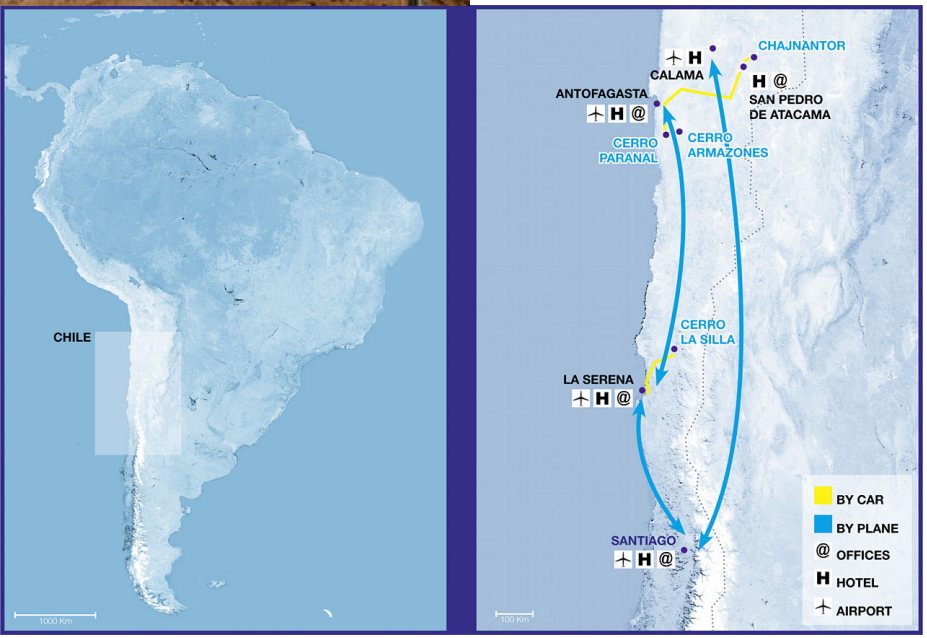
# ESO's observatory sites in Chile

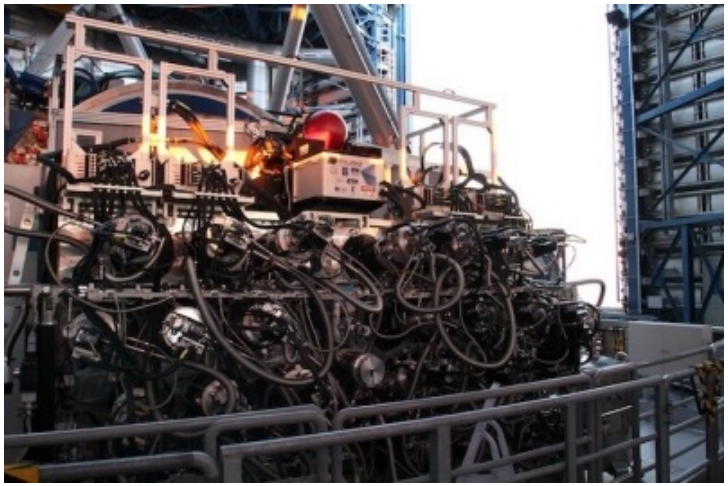
- Paranal/Armazones Observatory (VLT/ELT)
- Chajnantor Observatory (ALMA/APEX)
- La Silla Observatory

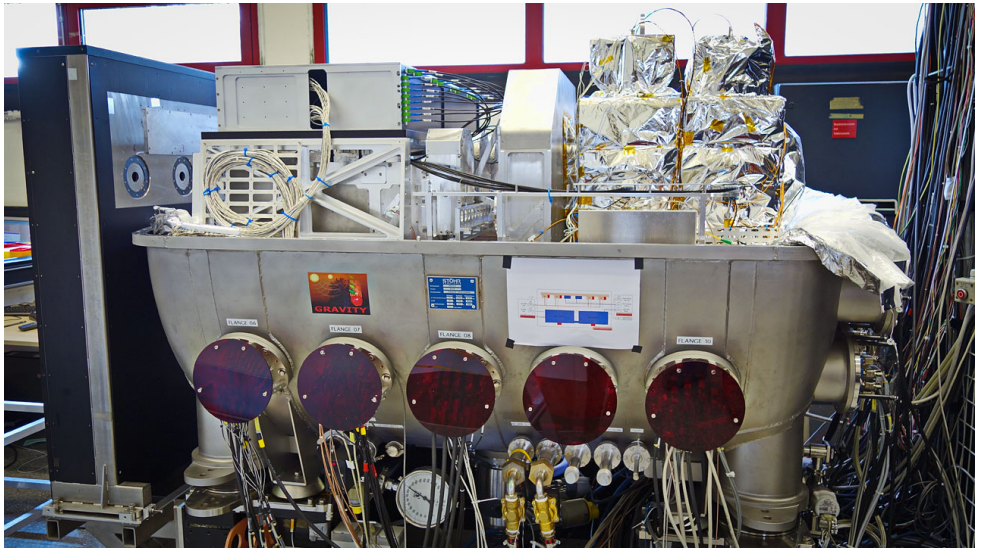


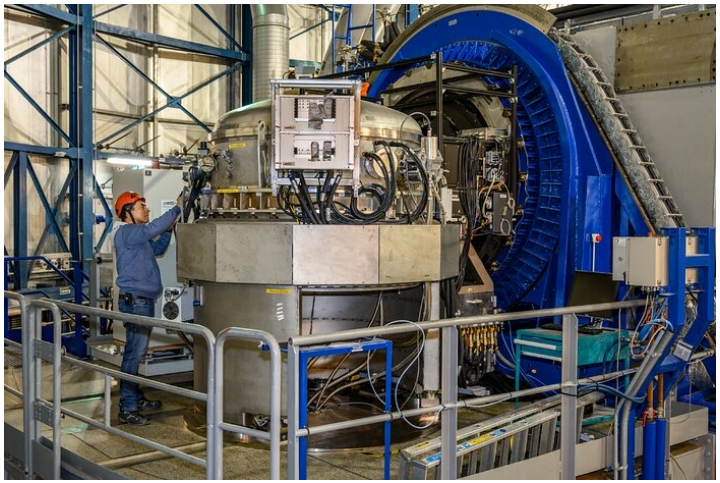



# ESO's Very Large Telescope

- 4 telescopes of 8m with 3 instruments each = 12
- Telescopes can also be combined as interferometer





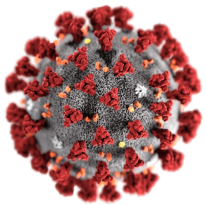



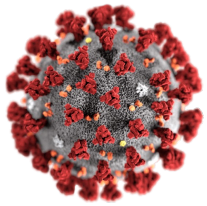
# Instrument commissioning

- Instruments are built in Europe, mostly by consortia in ESO member state institutes
- After extensive testing, instruments are shipped to Chile, then installed by the instrument teams
- Commissioning activities take up to 1 year, requiring multiple travels of instrument team to Chile
- Instrument team trains local engineers in Chile in use and maintenance of the instruments
- To help with short commissioning activities, in 2015 ESO set up the Garching Remote Access Facility (G-RAF)

# Garching Remote Access Facility

- During the pandemic, G-RAF was the *only* possibility for Europe-based staff to perform commissioning activities
- We run into logistical and panedemic safety limits to use the room more extensively with external visits
- See Stéphane Brillant's presentation for the view from Chile





# Operations of the APEX telescope

- Operational since 2005, 100% in service mode to make optimal use of appropriate weather conditions
- Telescope at 5100m elevation to obtain best atmospheric transperency, but lack of oxygen for observers
- Stays at 5100m limited to max 8 hours, overnight stays are at Sequitor base camp at 2400m in San Pedro de Atacama

# Operations of the APEX telescope

- Observations done by Telescope & Instruments Operator (TIO) together with visiting astronomer (VA)
- TIO is responsible for safe operations of the telescope and instruments, logging downtime, overall performance monitoring
- VA selects observing projects as a function of observing conditions, scientific priorities, instrument availability
- VA checks data quality, decides when goals are reached
- TIO & VA jointly responsible for calibrations (pointing, focus, flux calibration, atmospheric transparency)
- Observing up to 24h/day, split in 3 shifts of 8 hours
- Strong teamwork, with handover meetings between shifts
- Daily morning meeting to coordinate activities between operators, astronomers and engineers

# Local → remote APEX operations

From 2005 till 2015:

- Night shift from base camp Sequitor
- Morning & afternoon shift: 69km commute to telescope @5100m in order to intervene in case of problems.
- Continuous observing between shifts at different locations thanks to VNC's running critical processes.

From 2016:

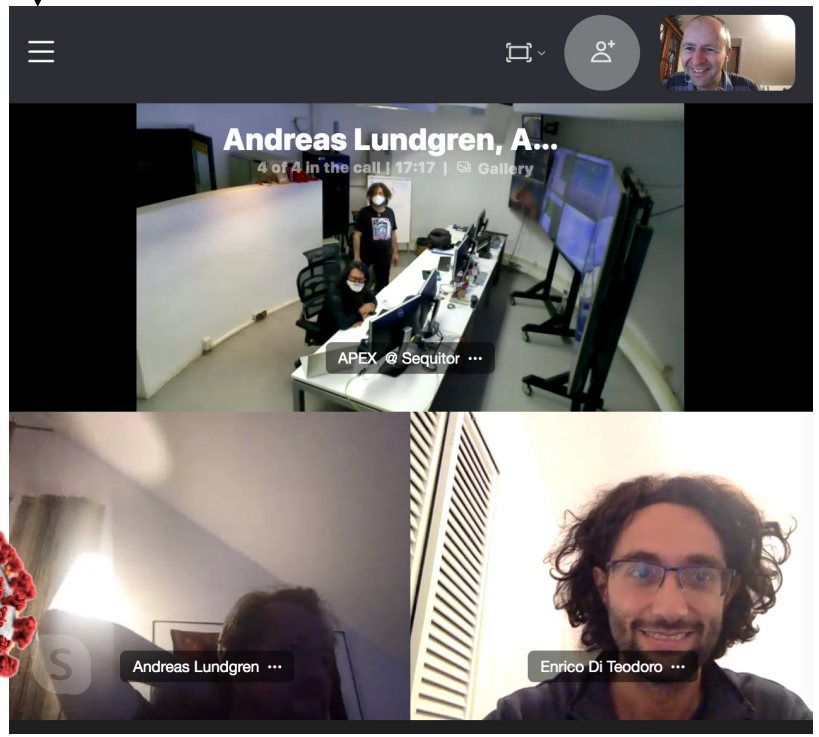
- Installation of Sun Avoidance System allows daytime (remote) operations from Sequitor.
- Requires detailed & reliable monitoring of critical systems in control room.

# (dis/)advantages of Sequitor observing

- Saving 2 round trips (69 km / 1h one-way) for 2+2 observers per day → Time + safety + cost savings!
- Improved interaction between different observing shifts, local astronomers & engineers: more time for handover.
- More flexible schedule offers the possibility for better training of newcomers (e.g. visiting students).
- Visits to the telescope are still possible, and can be done more relaxed/safer (no time limit for shift change).
- Missing the feeling to be at the telescope.
- More work for engineers, some small maintenance tasks at the telescope (e.g. cryogenic refills) done by the observers now need a 3h+ trip.

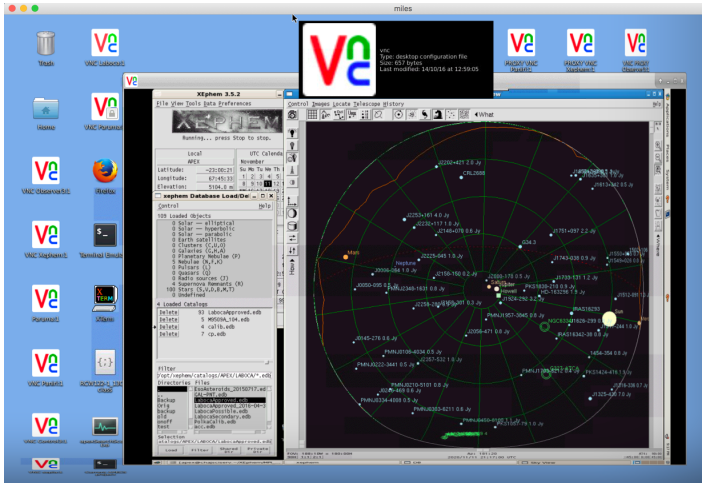
# Remote² APEX Operations

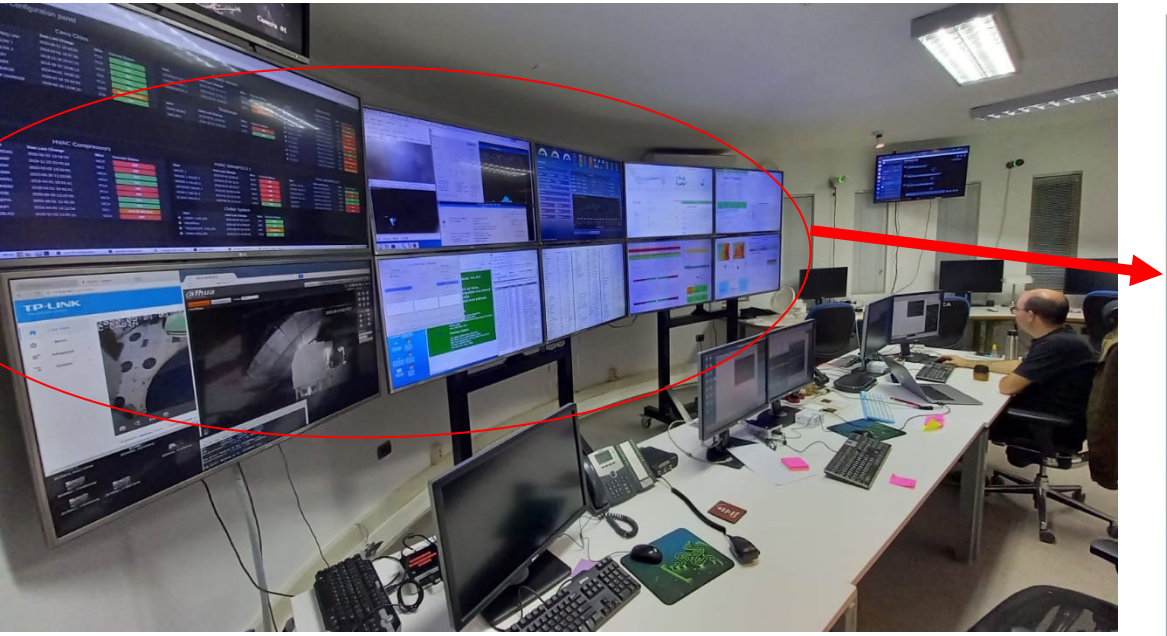
- Emergency solution using existing hardware and software tools.
  - Observing from 5100m
  - Observing from 2400m
  - Observing from 500m

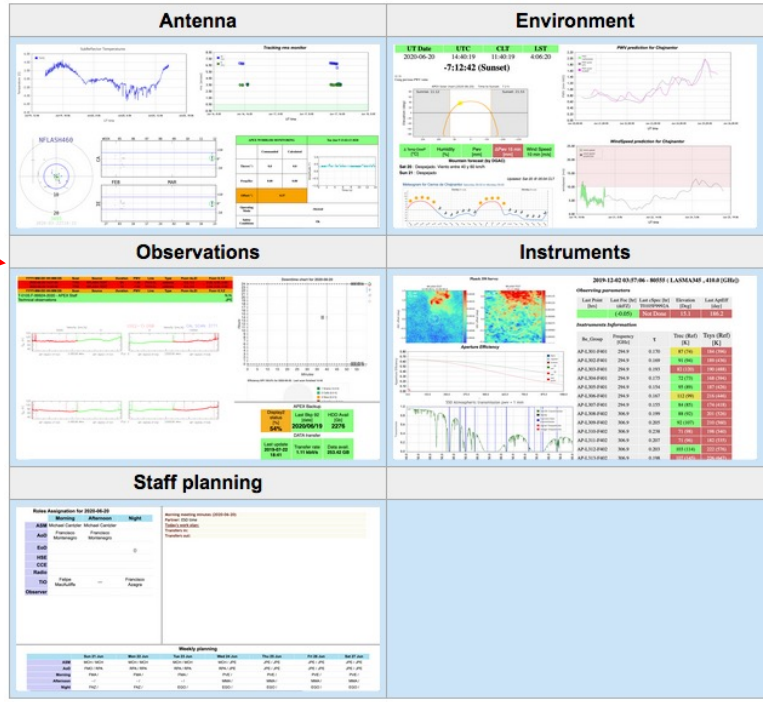


# COVID → remote² operations

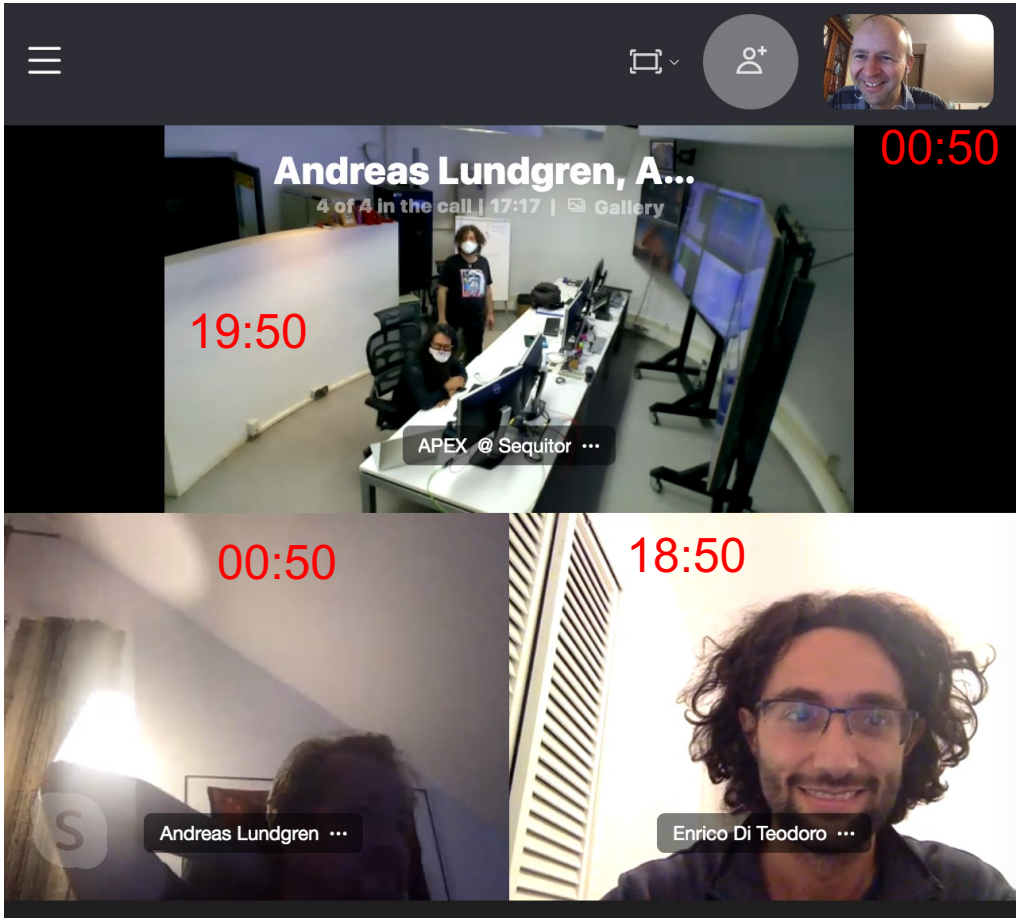
- Remote observer using classical VNC tools inside single VNC (to save bandwidth) → cluttered windows.
- 10 Control room monitoring screens on single intranet page using (unstable) VPN connection.







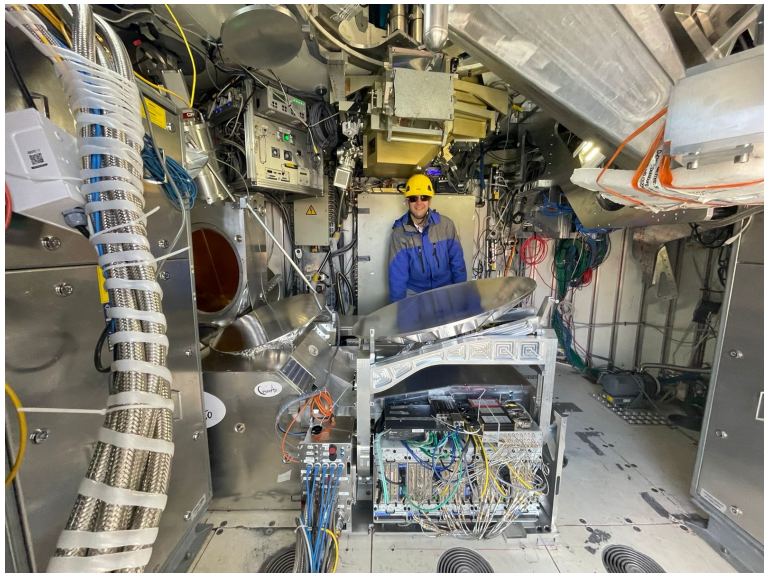
# COVID → remote$^2$ operations




- During entire observing night, operator and observer(s) keep an Skype video+audio session open → essential for interaction!
- Occasionally also involve PIs to solve setup questions.
- Observing plan & data analysis remains responsibility of remote observer → problem when connection is lost!
- New data *only* remotely accessible → remote data reduction & quality control.

# Remote instrument commissioning

- CONCERTO instrument installed in March-April 2020, *just* before Chilean borders were closing
- Only 6 of the instrument team members could travel to Chile
- Instrument was deliberately designed for remote operations, allowing remote commissioning → working on slow connection
- All critical systems on powernuts, many monitoring systems, all on VNC/x2go to enable handover between teams



# Advantages of remote$^2$ observing

- No international travels: lower carbon footprint, cost savings
- Saving long travel time for the observers
- Less logistical organization at the observatory
- More flexibility to replace observers, split observing shifts
- Allow to solicit short-time help from experts to solve problems

# Disadvantages of remote$^2$ observing

- Less interaction between astronomers & operators
- More work/responsibility for telescope operators.
- Not for the unitiated, need expert observers
- Knowledge transfer is more complicated
- Diminished feeling of involvement by the remote observer.
- Slow and/or unreliable network connection will affect observing efficiency → *de facto* shift of responsibilty
- Observing infrastructure needs to be replicated at each remote observing site (e.g. # of monitor screens)
- Night-time observing from Europe not easy (access to building restricted during night-time, difficulties to observe from home while others are sleeping, …)
- Observers keep other work during remote observing shifts

# Conclusions/recommendations

- Observing from the APEX base camp rather than from the telescope at 5100m has increased efficiency & safety
- Remote observing from Europe can make ESO a “greener” observatory by reducing travel → largest benefit for short trips.
- Generalizing transcontinental observing will need careful planning to train the users → send observers to Chile *at least* once per year to keep the experience & contact with the local staff.
- Remote observing requires a lot more work/responsibility of the local operators & astronomers → shift of experience to Chile.

- An extensive remote operations plan from Europe would require a substantial investment in logistics: a full-scale control room with a stable internet connection, daytime sleeping rooms, food, cleaning
- Recommend to have a single remote control room in Europe with critical mass of experts around