Sites Plenary: Chile Infrastructure and I&C

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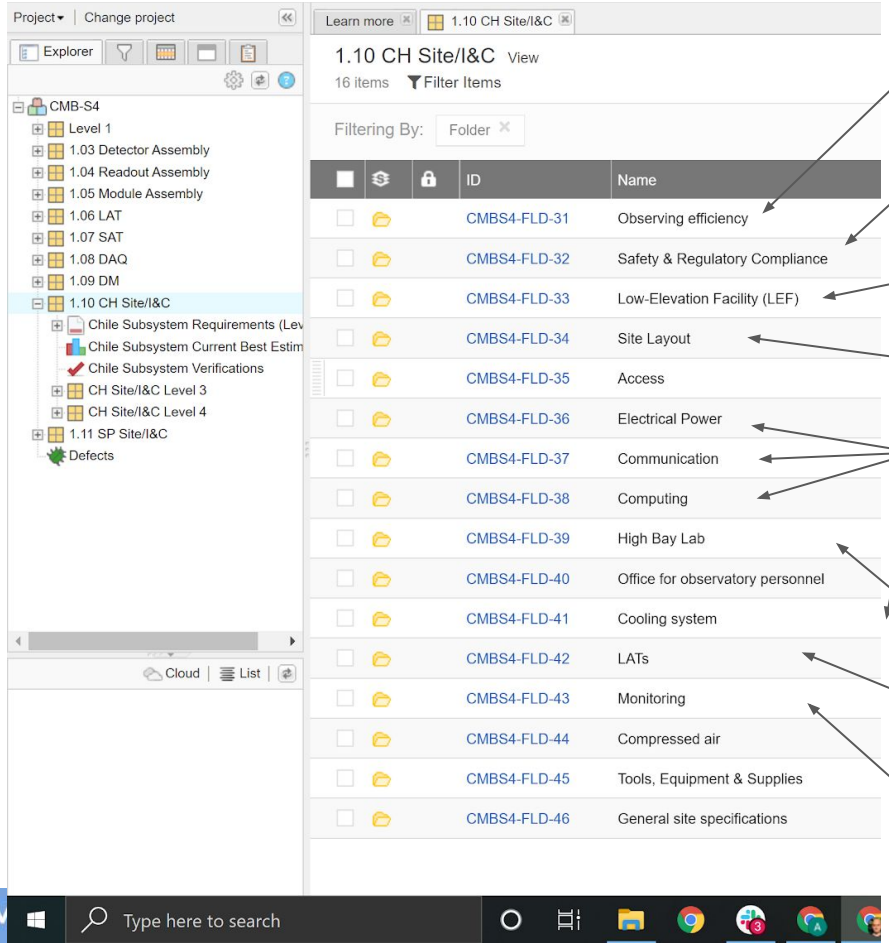
CMB-S4

Outline

- Site Infrastructure
  - Requirements
  - Facility Overview
  - Long-lead infrastructure & logistics items
- Integration & Commissioning
  - Requirements status and needs
  - PBDR assumptions compared to the South Pole
- Chilean Project Office roles & responsibilities

Site Infrastructure Requirement categories



Observing efficiency requirements are a metric during observations for our success, an important input to the sensitivity of the instrument.

Safety and regulatory Compliance drives a lot of the work right now on legal and bureaucratic items, and a lot of what will be done by the Chilean project office.

Project personnel stay at a low-elevation facility in or around San Pedro when they visit. This will be a contract with an existing facility.

Input to the site layout is based primarily on optical clearances and natural geographic features

Utilities provided by the site for the working of the instrument: electrical power, communication for data transfer, control, and situational awareness, On-site computing for limited data storage and observatory control, Cooling to exhaust heat from the compressors, and Compressed air for dilution refrigerators

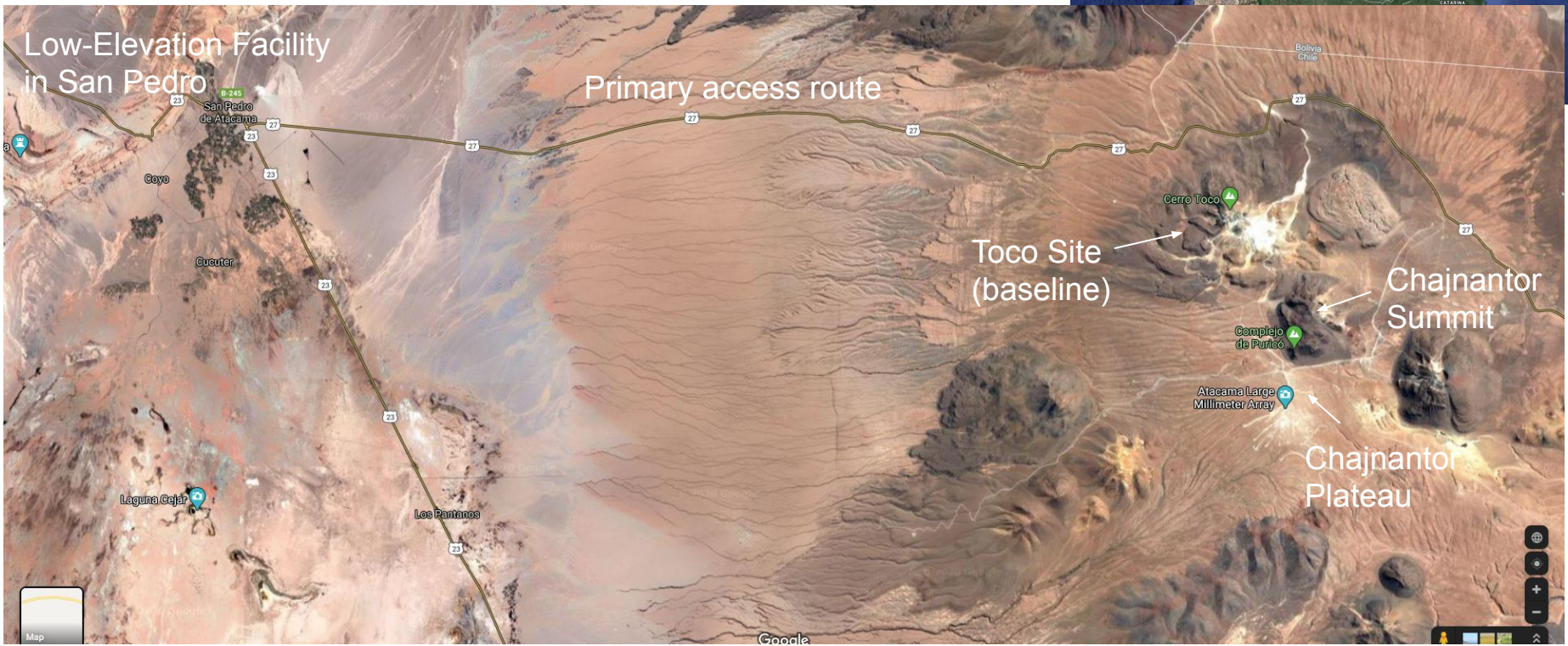
The High Bay Lab must allow for assembly and cooling of the LATR

Getting the LAT foundation requirements from the LAT telescope vendor could be a schedule-driving point, and we need to make sure the schedule requirements for this are clear.

Routine full remote operation is required, which leads to monitoring requirements.

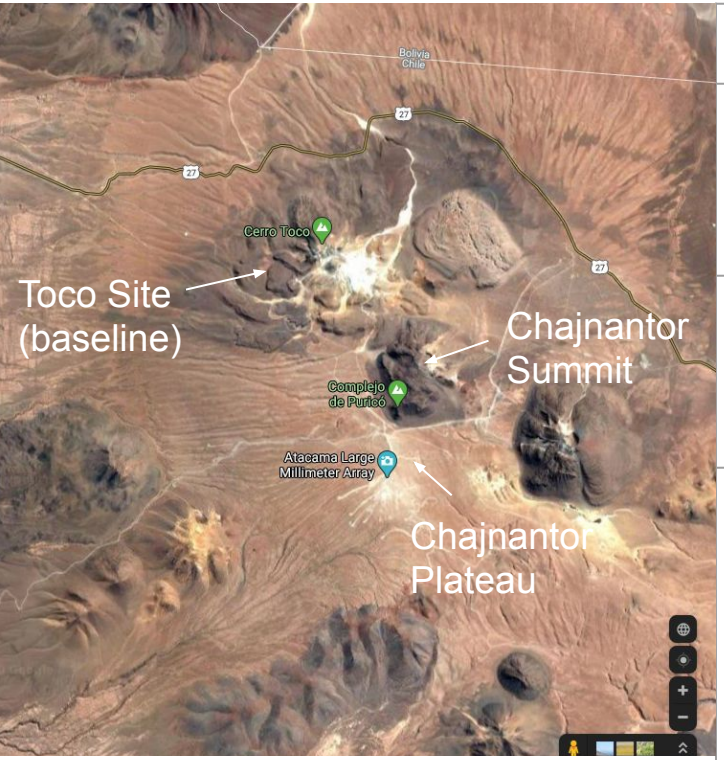
No requirements yet written down for integration and commissioning, assumptions that go into the plan will be discussed later in the talk

Site Aerial View



Site Location Trade Study

A trade study is underway across three possible sites in the Atacama:



Site	Pros	Cons
Toco Plateau (reference design, and current basis for PBDR)	Easiest access, promotes coordination with all existing CMB work. Slightly higher than Chajnantor Plateau.	Somewhat limited space, horizon blockage in the northeast from Toco at 15 degrees.
Chajnantor Plateau (near or on the ALMA Concession)	Places with horizon blockage peaks at ~10 degrees rather than the ~15 degrees on Toco.	Worse atmosphere, more difficult agreements to be made with all of the ALMA stakeholders.
Chajnantor Summit (near CCAT-p)	Better atmosphere (quantization to be documented). Horizon blockage limited only by positioning with respect to existing infrastructure.	Significantly more difficult to work because of more difficult access and much stricter labor and regulatory framework due to being above 5,500 meters. Limited space available.

View of the reference site, with existing CMB experiments highlighted

Under study for PBDR: photovoltaic array addition to the power generation plan

We are currently evaluating a photovoltaic (PV) array to be a second source of power working as a hybrid system with diesel power generation.

We are in discussion with multiple Chilean energy companies about implementing such a PV array. A few have created pre-feasibility studies.

In a study lead by AUI prior to this, the circled location was identified as the best location for such a power generation facility

Along with any PV system, we will have full diesel generation on-site that is synchronized and redundant with the PV system.

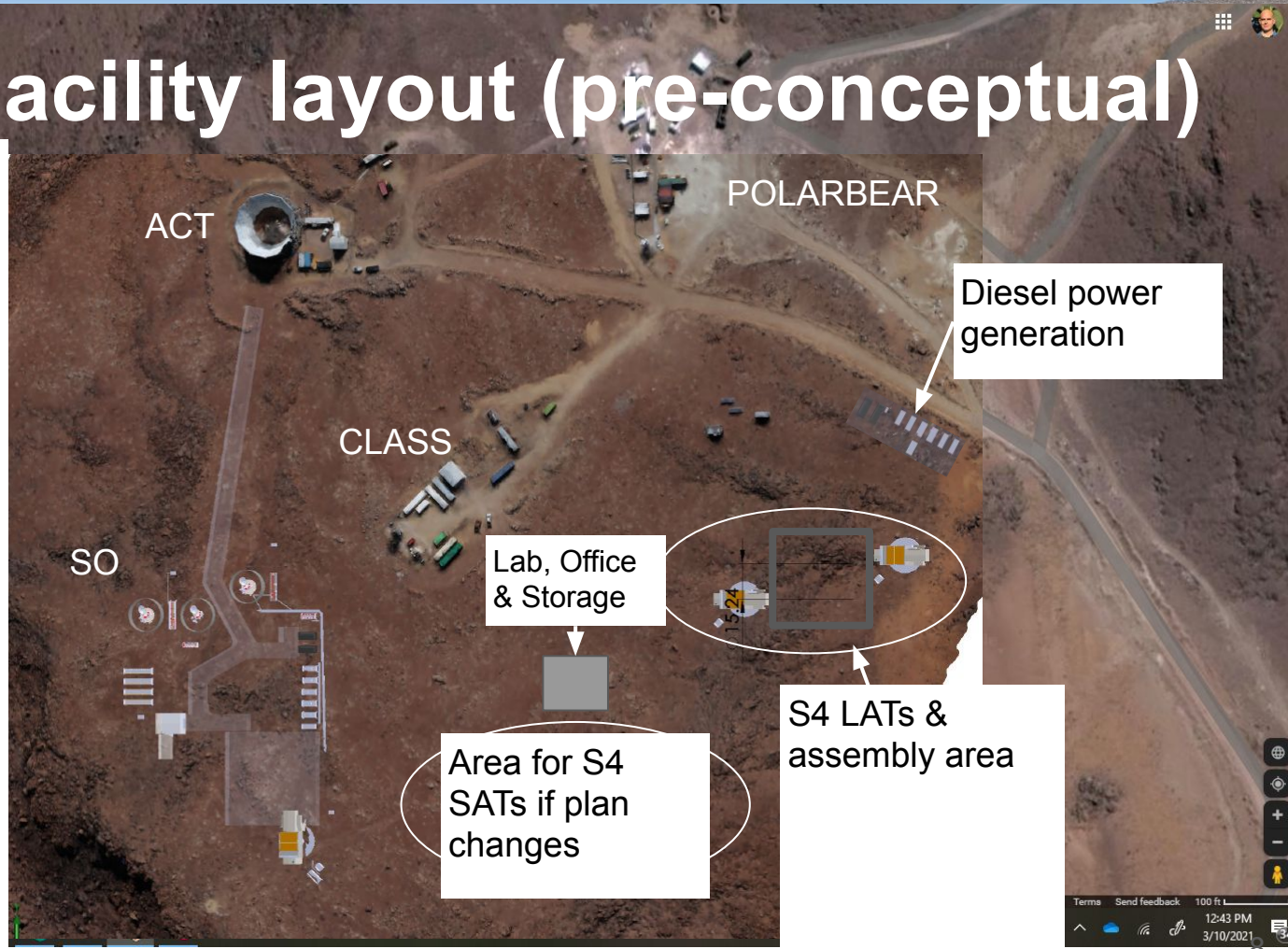
Facility layout (pre-conceptual)

Contract with Chilean architect firm to produce the conceptual design is executed, kick-off meeting on Monday.

This layout satisfies the requirements listed on the next slide.

Space to reserve for possible SATs and their beam clearance will be discussed in the parallel.

As stated in the past slide, we are currently evaluating the possibility of power from a PV array coming up from the south (bottom) of this image



Site Layout Requirements (from Jama)

External ID	Description	Basis / Rationale
Chile-0100	Other facilities/instruments at the site will not block LAT observations above 10 degrees elevation, as measured from the elevation axis of the LAT (currently 10 meters high)	Ground pick-up mitigation during LAT scans
Chile-0105	There will be no LAT groundscreen	
Chile-0110	All facilities/instruments at the site will present blockage below 5 degrees elevation to existing instruments at the site	
Chile-0115	Geotechnical surveys will be completed for all candidate telescope sites and used as input to the foundation design and the excavation contract	
Chile-0120	A graded area 40 meters by 40 meters will be provided adjacent to each LAT to stage assembly of the LAT	Requirement from Vertex for SO-LAT
Chile-0125	Heavy vehicle access, assembly area, and other graded areas will be graded such that there are no 10 cm height variations on 2-meter baselines	Smooth movement of trucks and forklifts

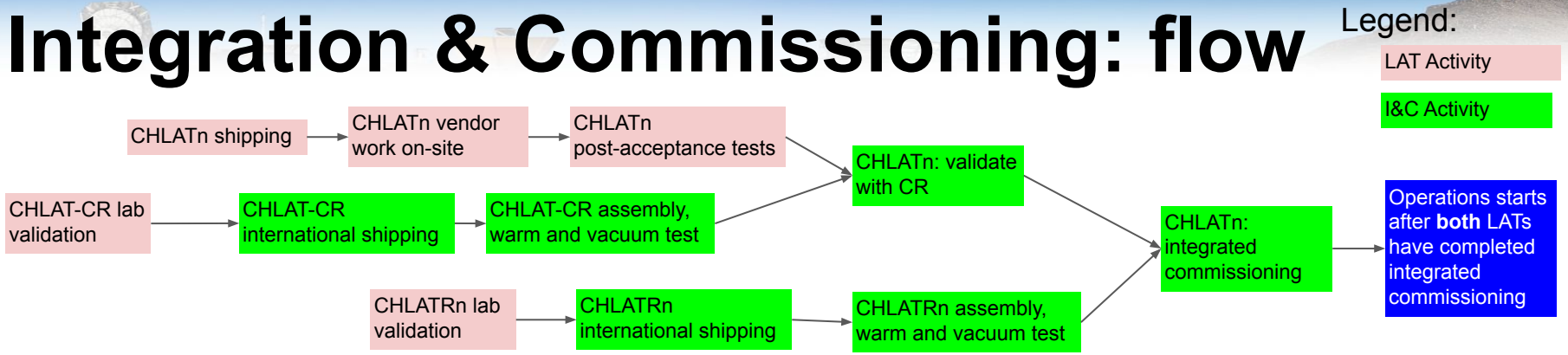
Chile Site: Technical Design Overview

- **Foundations:** PBDR is with poured-in-place slab foundations.
  - During foundation design, we will conduct a trade study based on SO (poured-in-place) and CCAT-p (partially prefabricated) experience.
- **Buildings and utilities:** prefabricated buildings installed on-site. Similar or same as SO, which is already on-site and soon to be assembled.
- **Power generation:**
  - Diesel generators. Same as SO, which has a 5-generator 380-kW load plan.
  - Opportunity: a photovoltaic array that would likely decrease operational cost by more than the required investment over the lifetime of the project, while reducing environmental impact and reducing the need for investment in a road for diesel trucks.
- **Cooling:** dry coolers that exhaust heat to the atmosphere. Similar to SO LAT, ACT, and PB systems.
- **Communication**
  - High-bandwidth (10 Gbit) fiber connection to the Chilean science & education network administered by REUNA. Contract to install underway.
  - Redundant connection for control and monitoring through a radiolink to a commercial connection.
- **Local Logistics**:
  - Safety management with dedicated Chilean safety manager working with L1
  - Low-Elevation facilities provide logistics base, housing, food and services for Chilean staff and visiting collaboration members / integration team

Long-lead infrastructure & logistics

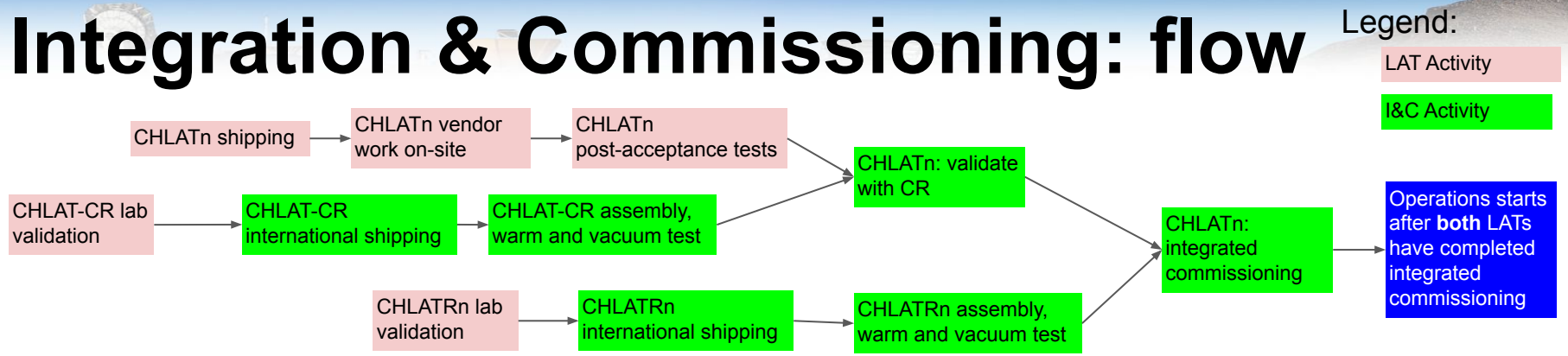
- Power generation:
  - Diesel generation is straightforward and not a long-lead issue. Design can be launched in 2023
    - Diesel generation will be designed to allow synchronization with incoming power from another source
  - A PV array in addition to the diesel generation could provide a more robust power system overall while reducing the environmental impact and reducing cost over the lifetime of the experiment. Planning for this is underway, and maturing of the plan is required before 2023.
- Communication:
  - Fiber initially capable of 1 Gbit and easily expandable to 10 Gbit planned for connection to central location on Cerro Toco by 2022. This is happening as part of existing funding.
- Road improvement
  - Construction traffic can go through ALMA roads, as is done with current experiments
  - Supply of diesel to generators **cannot** be regularly transmitted through ALMA roads. With the current road and full diesel generation, SO + CMB-S4 would require **370 diesel trucks per year** (5,000 liters each) to come to the site.
  - An engineering study on modification of the road to allow 20,000-liter trucks of diesel If Toco is fully powered by
- Legal & Bureaucratic:
  - Environmental studies
  - Agreement between U. Chicago and U. Chile, taking into account the Chilean astronomical community
  - Decree signed by the Chilean president
  - Agreement between U. Chicago and government entity with authority over land use
  - The framework for all of this is being worked on currently as part of the MSRI-DP1 scope, with final land use agreement signed after the award of an MREFC.

Integration & Commissioning: flow



- Difference from the SPLAT: The CHLAT is delivered to the site and installed by the Vendor.
  - It is assembled on-site by the vendor, with oversight/help by LAT personnel. This is managed by LAT, with the site only supplying generic logistics support.
  - Acceptance of the LAT from the Vendor is run by LAT on-site
  - Any further tests of the LAT that do not involve the commissioning receiver are run by the LAT group. The LAT is then “delivered” for integration & commissioning
- A single CHLAT commissioning receiver is integrated and validated in the lab by the LAT team. It is then given I&C to run the international shipping onward
  - The commissioning receiver is then re-used for commissioning tests of both LATs
- The CHLATRs are each integrated and validated in the lab by the LAT team, then delivered to I&C for international shipping and beyond

Integration & Commissioning: flow



Activity	Working days	Size of team
CHLAT Commissioning Receiver: assembly, warm and vacuum test	20	5-10
CHLATn: validate with Commissioning Receiver	50	3-8
CHLATRn: assembly, warm and vacuum test	17	10-18
CHLATn: integrated commissioning	43	3-8

Need to define full list of tasks for the commissioning receiver and the integrated commissioning, and then adjust the durations and teams.

Some vocabulary about I&C

"Test" = Usually refers to basic functionality

- telescope motion, cryogenic performance, detector signals ~ nominal

"Commission" = Verify readiness for moving to operations phase

- On-sky gain and noise properties nominal
- Beams & sidelobes within specifications
- Polarization properties nominal
- May use some calibration equipment, or may use specialize equipment

"Calibration" (not part of I&C)

- Ongoing activity throughout observations (in operations phase)
- I&C needs to deliver required calibration equipment

I&C Requirements

- We do not yet have requirements for:
  - The types of validations that need to take place during commissioning with either the commissioning receiver or the integrated instruments
  - The precision with which these validations will be required to declare ready or operations
- We need these requirements to create a well-referenced commissioning plan
  - The plan and schedule for developing these requirements will be discussed in our breakout
- The PBDR is based on assumptions and experience from S3 experiments

I&C Assumptions for the PBDR

- I&C assumptions for Chile are currently the same as for Pole
- I&C durations are based on extrapolations from Stage 3 experience

- As we refine the working hours and calendar day assumptions, we will take into account:
  - The on-site working hours assumptions, which are different in Chile because of transportation time to the site each day
  - The potential for weather-related access problems causing delays
- Note that calendar constraints in Chile are not as strong as in the South Pole
  - Year-round access
  - Snowiest times of the year are February-March and June-July

Chilean Project Office Responsibilities

The legal entity in Chile will establish a project office in Santiago that has the following responsibilities. It will report to the L1 project office as required on all of these responsibilities.

Note that this is in addition to the general project control requirements within the WBS element.

- Regulatory compliance (US and Chile)
- Legal administration & support
- Representation in Chile
- Chile human resources
- Support of international staff
- Chile safety & health management
- Local budget management and control
- Travel administration
- Accounting, including payroll and taxes
- Language support
- Insurance services
- Physical security
- Chile contracts & procurement
- Logistics: import/export, receiving, shipping, storage
- Property management
- Inventory management
- Physical plant non-technical operations and maintenance
- Manage low-elevation facility contract
- Site access management
- Transition from project to operations
- Education & public outreach
- IT support