Telecon 2 – Panel Questions:

Oct. 25, 2021

IceCube Upgrade Answers
Oct. 28, 2021

1. Where is the float in the cargo transportation schedule and how was it estimated?

No float has been added to the South Pole delivery or Required On-Site (ROS) date. We have included a discussion on this in the *IceCube Upgrade Cargo Estimation and Shipment Planning #2021-003.2* on page 9.

"Do not pad Required On-Site (ROS) dates, when the cargo must be at the South Pole, with float. USAP logistics planners need to see unbuffered required by dates to make good logistical decisions. The USAP logistics system is heavily burdened. Adding a buffer of two weeks could preclude a USAP shipment option (overland vs air) that would otherwise be considered. Assign reasonable arrival dates based on the schedule and communicate to ASC that the (ROS) date is when the item is needed. They will weigh the options based on all Antarctic cargo needs and build in the buffer. "

Float has been added between the shipments point of origin and the USAP cargo system port (Pt Hueneme or Christchurch) in the shipping schedule. We have included guidelines for adding float in the *IceCube Upgrade Cargo Estimation and Shipment Planning #2021-003.2* on page 8 of the document.

"For ICU shipments to USAP cargo system entry sites (Christchurch & Port Hueneme) adding float, two to four weeks or more, is appropriate. This buffer provides for commercial shipment delays and allows the USAP site ample time to receive, inspect, and prepare the shipment."

Above principles are applied to the planning for all shipments. The result is best demonstrated in the case study for one of the optical module types, mDOMS as shown in appendix 5 of 2021-003_IceCube Upgrade Logistics - Cargo Estimation and Planning. Sections relevant to float are included below.

"In order to maximize the potential for this shipment to transport on a SAAM flight we want to be able to deliver our cargo to the Christchurch Air Cargo Yard at the beginning of the Heavy Airlift period. […]
We then set our target date for shipping to be Aug 1 (2023) which is shown in our master shipping spreadsheet. […]
Floats on our side are kept large on purpose to reduce risk that in 3-4 years the dates may change so significantly to impact our sensor delivery schedule.
As time gets closer (usually within the same calendar year) dates are confirmed with ASC to ensure our cargo does not burden the program by arriving to PTH or CHC too early. "

2. On the estimating methodology -Steve will send some detailed questions today for forwarding to UW.

Have list of detailed questions, will answer separately.

3. Re: Charge Question 2A – where is the prioritization of cargo and substantiation for why it is high priority?

Cargo is prioritized in terms of delivery or ROS date. The South Pole ROS dates are the on-site required date for associated tasking to begin. We recognize that some shipments such as the main down-hole cable assembly and the string sensors could be in principle broken down with a higher granularity, as strings will be installed one after another. However due to existence of the heavy airlift gap, spreading delivery dates out over the one month period planned for deep drilling would increase risk to the project.

It must be noted that a 7-year project timeline is not the approved project timeline. It is used for date entry only to show the relative priorities of shipments. The project requires three consecutive field season for completion. The earliest possible first year is FY23 field season which is November 2022 to January 2023.

4. Could UW please provide a zip file of the supporting materials to assist reviews downloading them?

Done

5. How much contingency do they carry with unknowns created by pandemic and related logistics concerns? (global and US supply chain links are a concern.) How much contingency is being carried on schedule and cost? (Note from Mark – we will look at budget issues at the rebaseline review in March 2022.)

Prior to the onset of the pandemic, the project carried a risk in cost and schedule for one additional season of deployment in case all holes could not be drilled, and instrumentation installed, in the intended final field season.

The pandemic was not known at the time of project baselining and started in year two of the five-year project. It has resulted in a minimum of a two-year delay in project completion due to the cancellation of two consecutive field seasons when on-ice work for drill refurbishment, drill testing, firn drilling, and surface cable installation were planned. It has also resulted in delays in completion of off-ice work in production and testing of components to a lesser extent than two years.

The result of the delays due to the pandemic are greater than the original risk of one additional year of deployment. As a result the project will be reviewed for rebaselining in March 2022. Cost and schedule contingency, and risks going forward, will be reviewed at that time.

6. What is the UW strategy for hiring Season 2 and Season 3 staff? These criteria are TBD right now. Especially in season 3 where there are 7 people per shift – so lots of staff to hire and this could be a challenge to train and hire for one year. (George says about 80% of USAP is polar mercenaries, so this is not an uncommon challenge to deal with in Antarctica.)

The project maintains a list of potentially interested people, many of whom have experience with IceCube or other drilling projects in Antarctica. The project takes advantage of hot water drilling at the South Pole for IceCube being very exciting and rewarding to many, and a proof of that is that a driller job

posted in Sweden in 2019 got nearly 200 applications. We are often asked if we are hiring drillers. Due to the uncertainty on the schedule, it is not currently possible to solidify the interest into contracts, but it is our plan to do so as soon as we have an outyear field season plan in place. We also plan to re-hire several people between season 2 and season 3, to guarantee continuity.

The project has a core group of full-time and part-time engineers and technicians that have been engaged with the drill refurbishment and installation work since the project start. They will participate and be an integral part of the on-ice crew. We will supplement this core group with more seasonal hires starting in FS1. We will also solicit participation from our international collaboration in recruiting seasonal drillers and installers. This strategy was proven to be very effective for recruiting during Gen1.

Off ice and on-ice training for all drillers and installers is essential. The project has the experience and facilities for training from Gen1. Many of the core staff remain and are key members the Upgrade team. Training of new staff and retraining of retuning staff is conducted yearly and will be conducted for every field season.

7. Does UW fully realize the uncertainty in the project timeline?

The project fully realizes that the on-ice seasons are unscheduled at this time and may be delayed further than the 2 years already delayed.

Developing the cargo schedule required assuming some certainty in a project timeline in order to answer questions on critical path items. It also provided an opportunity to evaluate the feasibility of logistics support on this timeline. For simplicity, in the ICU cargo master shipping spreadsheet we have used dates based on the seven-year plan to compute ROS dates and shipping dates. These dates are based on the FY22 available acquisition calendar only as an example and point of reference, as this calendar is released yearly. These dates need to be adjusted based on the schedule. Outside of the Master Cargo Tracker we refer to the field seasons as FS1, FS2, & FS3.

The project fully understands the large degree of uncertainty in the project timeline. Cancellations of seasons or cargo shipments per season have a one-to-one impact on project completion schedule.

8. Schedule appears to be as compressed as possible. UW should confirm if this is a technically limited schedule and what their confidence level is to be able to meet this schedule? (Mark asks: Is this a sensible approach? NSF wants a robust schedule that is resilient to foreseeable risks and uncertainties.)

Completion of the Upgrade detector requires three consecutive on-ice seasons. From project side this is a realistic schedule both for the off-ice tasking and on-ice tasking. The production of the 693 optical sensors is under way. Production of D-Eggs in Chiba is nearing completion, the seven surface cables are ready to ship, the main down-hole cables will be in production soon. Three consecutive on-ice seasons are necessary for the installation of the detector in the field and carefully sequenced with each season building upon the last.

We have provided the cargo and population profiles that supports the three-season implementation as it is the most effective solution for total project cost. The project recognizes risks due to logistics which

are outside project control. Plans based on more than three consecutive field season would allow for the cargo delivery for the first seasons to be spread out. However, such plans must take into account that some of the cargo (e.g. drill hose and optical sensors) cannot be delivered to the South Pole years ahead of time unless plans are made to guarantee a storage temperature that meets the requirements.

9. Population planning references a detailed task description and labor hours estimate document, but this information wasn't included.

File below added to population folder:
Population Profile Formatted Hourly per Season Data v1.xlsx
It lists detail drill tasks by WBS and field season with estimated labor hours and labor category. It will be explained during population discussion session.

10. The Risk Matrix seemed to be all about risk of late delivery at South Pole and the projected cost impact. The panel had expected to see analysis of activities on station and mitigation strategies – for example if a component fails, what is the likelihood of failure and what is the plan for mitigation? The only risk seemed to be labor cost due to cargo delay.

Per project plans, all components of the drill and instrumentation have been designed for use in the extreme environment at the South Pole with the understanding that repairs will be challenging and access to parts limited. Components and instruments will be fully tested and verified prior to shipment to the South Pole. All instrumentation will be tested again at the South Pole after arrival and prior to installation. System spares will be stocked based on experience acquired in IceCube-Gen1. All drill components will go through a full test prior to commencement of drilling. In the unlikely event that a component of drill or instrumentation fails, effects will be mitigated or spares will be used. Labor time for component testing and on-site mitigation and spares are included in the project plans. Risks outside of cargo delivery and population limitations will be evaluated as part of project rebaselining.

11. Hot water drill system - HWDS – has it gone through a shakedown or will it before they really get started with it for drilling?

Drill repair and refit activities will be accomplished in field season 1. A full system wet-test is planned for field season 2 after the Seasonal Equipment Site (SES) has been established and drill subsystems integrated. As a result the drill will go through a complete test and verification prior to drilling in field season 3.

12. Data from prior Ice Cube installation showed a fair bit of idle time for generator and HW heater operation. Any thoughts on reducing idle time?

During IceCube-Gen1 the term "idle time" was used to refer to the time when generator supported the base camp needs but deep drilling was not occurring. During seasons prior to drilling, once the SES is setup, all operations require power that is supplied by generators. Idle time is unavoidable once operations are switched to SES.

Once deep drilling commences during the drill season, the pacing item is drilling. A fundamental enhancement of the Gen1 Enhanced Hot Water Drill was two drill tower/TOS structures, allowing us to leapfrog from hole to hole, and to set up and begin drilling the next hole while the last hole was still being instrumented. This optimized approach will of course be used during the Upgrade as well, and our estimates of turnover time are informed from those experiences. During this idle period between holes, there is a minimum amount of energy usage to keep the system powered up and to keep warm water flowing. This is also a time that we assess the health of our Rodwell and make adjustments if necessary.

13. The efficiency of drilling increased over time with the initial IceCube effort. Which year of that program was used to estimate progress for this upgrade? Are they starting out at the same efficiency as at the end of the prior program? Or somewhere in middle?

The project used the midpoint of the drill efficiency as a starting point for planning the drilling for the upgrade. Efficiency of drilling, in a broad sense, improved over time during Gen1 because of equipment reliability and, most importantly, drill crew experience. We have no expectations of achieving the performance we did at the end of Gen1. The last season of Gen1, 2010-11, we drilled 7 holes in 15 days. We also know, however, that we drilled 8 holes in the second (2005-06) season of Gen1, and can reasonably expect that we will be in a better state of readiness for the Upgrade than we were in that season. For example, that 8-hole season predated the Independent Firn Drill, which substantially increased efficiency in the field by decoupling the firn drilling process from deep drilling.

It is important to point out that the holes for the Upgrade are different than in Gen1. Overall they are larger in diameter, deeper, must stay open longer, and a subset of holes have a new degassing phase built into the drill strategy. This impacts the rate of hole production and the fuel consumed. On average we will be spending 50% more time and 40% more fuel drilling these holes over a typical Gen1 hole. These estimates are provided by our thermal drill model, which we demonstrated to be a reliable tool during Gen1.

14. What is the power required for winter heating?

Our winter heating power requirements are estimated to be 7 kW average steady-state, with peak loads of 39.6 kW of 480V 3 phase power, and 10.5 kW of 208V 3 phase power. See PSL Document "*IceCube Upgrade Winter Power/Monitoring Requirements*" for additional information.

15. They estimate 100K gal of fuel to complete project, is this a project cost or AIL provided?

Fuel is provided by AIL.

16. There is some buried cabling from prior construction - how well known are the positions? Is this a problem – what happens if they hit one? Maggie Knuth mentions they will have ground penetrating radar to mitigate risk.

An overall ground penetrating radar (GPR) scan was run in 2019/2020 in the Upgrade area to search for

obstructions. The resolution of the scan was insufficient in determining that the cable trench routes and hole locations are fully clear of debris. An additional focused CRREL supported GPR scan of cable trench and hole locations has been requested and it will greatly reduce risk of trench or hole relocation.

Each string has its own surface junction box (SJB). The SJB is the interface between the surface cable assembly (SCA) and the main in-ice cable assembly (MCA). The 7 junction boxes are distributed between two areas, called Pits. The length of the SCA has been adjusted to include 15 m contingency to accommodate possible rerouting. See slide 7 of "Surface Cable Assembly (SCA).pptx" document in "cargo/supporting documentation/cables" for detailed calculation of the various contingencies considered.

Should the GPR analysis not be conclusive, the highest likelihood depth for debris is the top 50 m of the snow. We therefore expect that any obstruction will be discovered during firn drilling in field season 2. We have added contingency on fuel for 4 re-tries on firn drilled holes. Additionally, the maximum distance between hole and junction box (page 3 of the surface map) is 42 m. We budget an extra length on cable length of at least 15 m to allow a hole shift. Given the tight geometry of hole, PIT and cable locations, a successful GPR scan would without any doubt remove risk associated with trenching or drilling.

17. Re: NSF (AIL) allocation of resources. Has AIL given targets to UW for capabilities? In season 3, when they need 46 beds (3/4 of sci pop) is this a looming surprise? Maggie: this is something that they are working on and looking at. If they are expecting third party support for a particular activity but it is not listed, then the description of that activity is additional information that will be useful for NSF to have.

The population discussion was held early in the project planning phase with ASC and the NSF. We understand that a peak population of 46 consumes roughly 1/3 of available bedspace during an Austral Summer. The drilling/installation season is labor intensive and around the clock (3 shifts of drillers).

18. Re: the charge question: The panel had questions about the method used to estimate cargo – the only reference for estimating method that has been provided is for fuel. There should be a project summarizing what was learned from Gen 1 cargo logistics management – this seems to be a missing. How was the concise cargo list for Gen 2 generated?

The IceCube Upgrade cargo estimating plan is explained in the IceCube Upgrade Cargo Estimation and *Shipment Planning #2021-003.2*. A list of items is generated based on the equipment (drilling equipment mainly) and deliverables to South Pole (sensors, cables, computing). Each item of the list has a guardian/custodian institution (typically the point of origin of the item). A subject matter expert (SME) at the institution provides an estimate for all the items coming from the same institution. The basis of estimate (indicated in the cargo master spreadsheet) is designated "actual" (when the item final weight is known), "preliminary" (based on a design, a partial as-built, or vendor specifications), "estimated" (based on an expert estimate). Communication between the SME and a logistics expert ensures that

shipping weight and cubes include appropriate packaging (shipping container, or crate). The list of items is cross checked by WBS L2 for completeness. The cross check is often independent as items related to a WBS are spread over different institutions. For the Upgrade, the acting logistics expert is the L2 Implementation Manager.

During the IceCube Gen1 project, the support contractor was an integrated part of the organizational structure and was a L2 entry in the WBS. The project manager from RPSC was the direct interface between the support contractor and the IceCube project office. The project office included a full-time logistics manager who developed logistics plans in close coordination with the RPSC PM. This close relationship between RPSC and the IceCube logistics manager was instrumental to the success of the project. The ICU project is aware of the importance of this relationship and a similar relationship exists between ASC, NSF, and the ICU L2 Implementation manager.

In Gen1 the logistics manager developed a cargo list with each of the L2 managers, then worked with RPSC PM on the transport needs and availability. The cargo (and population) information were regularly communicated to RPSC and evolved each year as seasonal plans solidified into the SIP and as off-season work was executed.

The estimating techniques for Upgrade cargo draw upon the Gen1 experience. Logistics for the Upgrade are less complex than Gen1 because there is a single drilling season and much of the drill equipment is already on site. ICU is however navigating a significantly different logistics environment, including a big shift from planes to vessel and traverse, stronger competition for cargo space, and tighter constraints on population.

19. Should there be an allowance for expediting shipping (i.e. air transport to Christchurch is something is running late?)

There is a possibility for air transport. Air transport is not preferred by the USAP due to its high cost. If absolutely needed, a formal request must be made with justification to the USAP contractor to use commercial air shipping.

20. The cargo planning says there is a role of subject matter experts SMEs for cargo at each site, but each site is left alone to pack materials to meet requirements and meet schedules. It seems like there should be some sort of QA step and an overall organization structure to make sure that this is coordinated so that there is a single POC to assure adherence to packing requirements and schedule across the project.

Communication between SMEs at points of departure and logistics expert is well developed and we have exercised it to review shipping cubes and weights, and to make sure that packing respects the USAP guidelines for shipping. See *IceCube Upgrade Cargo Estimation and Shipment Planning #2021-003.2* on page 14 of the document (reported below) and, for a step-by-step tutorial, refer to the example detailed in the appendix of the same document.

“The ICU logistics managers oversee the movement of all the cargo items. They collect the information on the ICU Cargo Master Spreadsheet and provide instructions for consolidation based on volumes, similar shipping schedule, port of origin and special handling considerations. A designated point of contact at each departure point with a deep knowledge of the shipping process ensures that packaging is appropriate and shipping dates are observed. The Point of Departures (POD) and corresponding Point of Contacts (POC) designated for the IceCube Upgrade are shown in Table 2.”