Questions for Day 2 of the Review

Answers are *italicized text in line* plus in the following files also in this (answers to questions) directory:

Field Seasons 1-3 Gantt Charts

Shipping Float Table

Master Shipping Spreadsheet

(1) Please explain who (by name and position) does risk assessment for each of the WBS elements at level 2 (or low levels if appropriate).

Our Level Two managers do this, often in consultation with Level Three managers.

Ian McEwen for 1.2
Timo Karg for 1.3
Tyce DeYoung for 1.4
Dawn Williams for 1.5
Erik Blaufuss for 1.6

Show how the risk planning connects to cargo planning (spares, shipping damage, etc.) and risk mitigation generally.

The top level risk registry for the IceCube Upgrade is focused on NSF costs and draws against contingency. The level of technical detail in that project-wide risk registry is low. However, the project risks include risks that are related to cargo planning. Spares, shipping damage, personnel delays, safety incidents, and similar. All of these are part of overall risk planning. That risk planning has more detailed elements than the project risk registry, and one of those planning tools is the cargo/shipping list and the associated tasks and scheduling.

Risks are mitigated at a number of different levels. At the lowest levels this includes spares and repair capability (see next part of the answer also), adequate personnel training (including safety training and cross training), and the design of subsystems for ease of testing, manufacturability, and built-in-self-test. At the WBS Level Two this includes scheduling adequate resources for activities, monitoring deviations from the cost and schedule, and wrangling the in-kind contributions. At the project level, the risks and the FMEA (Failure Modes

and Effect Analysis) and the mitigations are discussed on Tech Board Calls and in system and subsystem reviews.

Are the individuals responsible for risk assessment also they the individuals responsible for assessing spares needs? For example, if someone is responsible for drilling, do they also do the risk planning and determine the need for spares associated with that activity?

Yes, in general, however, pares needs are even more likely than risk assessments to come from the deeper levels of the WBS structure. There is no project-wide, general spares policy, but rather spares were specified at the subsystem level by the subsystem leads and reviewed at the L2 and project levels. Within the drill systems, most subsystems have full spares (e.g., online spare heaters, extra high-pressure pump, extra motor controllers in a box) and the parts and tools for repairs to most items with repairs being the backup the spares. For modules, there are some spares shipped to South Pole but testing and rework represents the dominant strategy for module risk mitigation before they reach the ice. In Gen1 IceCube there were only a handful of modules which failed final testing at Pole, these were replaced with spares, and the non-conforming materials were shipped back North for evaluation and rework.

The panel assumed that this is probably the case, but it is not clearly stated in the documentation.

(2) In the cargo planning document, there is mention of various positions such as SME, logistics POC, etc. It would be helpful to the panel to see a concise org chart with names of these individuals.

This was shown in Ian/Delia's talk this afternoon.

(3) Safety in Antarctica seems like a big job during the IceCube upgrade, with all of the activities that will be going on. Explain how the IceCube team determined that the level of safety support planned is sufficient for each of the field seasons.

We have a full-time safety manager for the IceCube Upgrade. Mike Zernick directs a Summer safety training program for all drillers and installation folks. This program is directed at a culture and environment of safety rather than a rules-based system. All drillers and installation workers

can stop unsafe processes at any time, and unanimous concept is required for operations to be started.

The project team feels safety was sufficient during Gen1, this was demonstrated. We are adhering to the same safety program as we did then and making improvements wherever possible. For example, we are working more closely with the Antarctic Support Contractor (ASC) safety team to establish common safety practices and ensuring Upgrade/ASC are on the same page on a more regular basis. The key people who developed the safety program in Gen1 are still a part of the Upgrade project.

(4) The review panel would like to see a Gantt chart that is a schedule of on-ice activities by field season: with task priorities, durations, and dependencies. How confident is IceCube of planned task durations? Is there a potential knock-on effect from delay of a particular task whose risk could be minimized by prioritizing the task order?

These Gantt Charts, for Field Seasons 1-3, are included in this directory but are too large to sensibly be attached to this single document.

(5) Are requirements for support labor from NSF's Antarctic Support Contractor sufficiently well identified to allow confident planning (amount of effort and when it will be needed) to assure availability?

We discussed today the Support Information Package (SIP) annual planning process that takes place between the Upgrade project staff, the NSF, and the Antarctic Support Contractor. We have had a SIP in draft form for the FY22 season that has been shared with ASC.

We accept the suggestion received today to draft the SIPs for field seasons 2 and 3 as soon as possible to help facilitate the planning for future field seasons.

(6) Explain plans for managing activities in the north to assure that materials are going to be available in time to get into USAP system. Do you track the dates material will be available to ship from the fabrication sites vs. the dates it will be needed at the trans-shipment sites to enter the USAP system? Which items have the shortest float for getting into system?

A table of the floats between production/procurement/repair completion and shipping dates is included in this directory.

(7) What happens after the IC/U project is complete? According to the definition we heard today, this is after the seventh hole is finished. But what is in the plans for getting the site cleaned up and material shipped north? There should be a plausible closeout plan that defines this effort at the end of the project.

The preparation for the disposition of the drill is part of the project. At the end of the drilling, the drill systems will be left in a state which allows for storage or shipment away from the South Pole. We hope that these drill systems will be useful at the start of the IceCube Gen2 effort and will remain properly stored at the Pole, but the final state of the drill at the end of Field Season 3 will be commensurate with either shipping or storage at the discretion f the NSF. This was also done at the end of the Gen1 effort in a coordination between the project and the ASC under the guidance of the NSF directive.

(8) Discuss the impacts of Field Season 2 being cancelled, so that there is a gap between Field Season 1 and Season 2, and then Season 3 follows Season 2 consequently as planned.

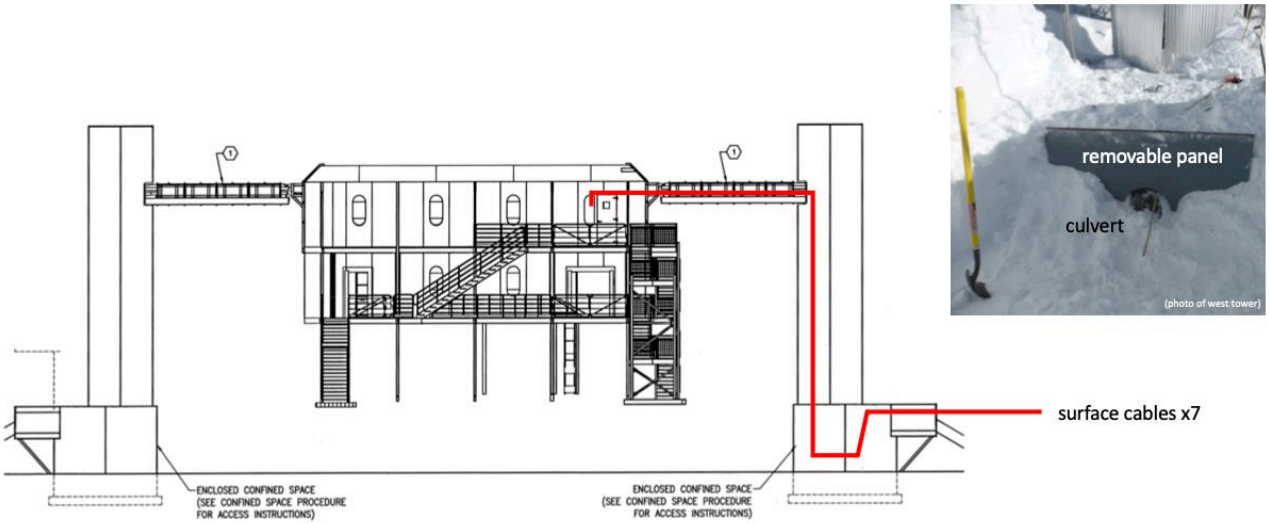
As mentioned in today alternate scenario presentation, a cancellation of Field Season 2 adds to contractor snow mitigation efforts and increases the Upgrade labor required for reestablishing the Seasonal Equipment Site (SES) when Field Seasons resume (primarily in dealing with the additional snow accumulation. As seasonal drillers would not have continuous employment for a years time, there would likely be attrition of talent. Adding project years also, of course, adds to the Total Project Cost.

(9) The panel is concerned about the effort that may be needed to pull the IC/U cables into the ICNO counting house. This could be harder to do now that the snow level is higher. It would be

good to know how the IceCube team estimated the time and effort. What is the impact of snow level change since this was last done for Gen 1?

Slides from John Kelley which were used in the final technical design review of the surface cables. All of the work was based on reconnaissance of the ICL cable towers and cable entry a couple of seasons back.

Cable Entry



I would first note that we have a proof of principle from 2017–18 when we successfully pulled new cables into the grid west tower for the scintillator station using the original cable culverts, after some excavation to form a ramp. When assessing the grid east cable tower situation in 2019–20 , we were able to access the base of the tower and the "door" without excavation because wind scouring has kept the area immediately around towers relatively clear of snow. There is a "cliff" of snow accumulation that would need to be excavated to form a ramp, but fundamentally we did not see any issue with accessing the existing cable culverts from Gen1, as we did in 2017–18 on the other tower.

(10) Does IceCube qualify components for shipping – is there a specification that assures materials transported will survive handling via the various transport methods planned? What was Gen 1 experience with shipping damage?

Yes, there is a master guide for IceCube shipping and storage requirements which is shown below. The D-Eggs and mDOMs (with their custom packaging) undergo full vibration and shock

testing to the specifications shown (MIL-STD-810F and ASTM D-4169). D-Egg packaging is fully qualified and we expect mDOM packaging to be so qualified in the next six months or so.

Harmonized with ERDs: January 2021

	US Domestic Shipping	Air Cargo (Pacific)	Sea Cargo (Pacific)	Sea Cargo (Southern Ocean)	MCM storage	NPX outdoor storage	NPX "not deep freeze"	Value to quote in general	Comments
Low temp	0 C	0 C	0 C	-30 C	-45 C	-70 C	-35 C	-40 C storage	Air shipments can be DNF. DNF storage needs to be arranged at NPX.
High temp	40 C	40 C	50 C	40 C	30 C	-20 C	25 C	50 C storage	Highest ever container temp recorded was +57 C.
Low humid	20 %	20 %	20 %	20 %	20 %	0 %	0 %	0 %	Actual South Pole relative humidity is high, but the air is 0 % RH when raised to room temperature (as it is normally specified).
High humid	70 %	60 %	70 %	75 %	80 %	30 %	30 %	80 %	Can remediate with dessicant in some cases.
Shock testing	YES	YES	YES	YES	NO	NO	NO	---------->	MIL-STD-810F method 516.5 procedure II 10G 6 axis. Testing is in full packaging.
Vibration testing	YES	YES	NO	NO	NO	NO	NO	---------->	ASTM D-4169 section 12.4 z-axis, truck & air assurance. Testing is in full packaging.
Water	NO	NO	YES	YES	NO	NO	NO	IP54	IP54 = protected from limited dust and splashes, packaging could protect
Salt	NO	NO	YES	YES	YES	NO	NO	IP54	IP54 = protected from limited dust and splashes, packaging could protect
Max dimensions	92.5" x 92.5" (container)	61"H for PAX flights	92.5" x 92.5" (container)	92.5" x 92.5" (container)	UNKNOWN	102" x 102" x 440"L	102" x 102" x 440"L	92.5" x 92.5" to fit in container, except items not containerized (MCAs)	LC-130 maximum dimensions 102" x 102"; shipping container 92.5" x 92.5" (high cube gets you another 12.5" vertically)
Notes	Probably similar to domestic shipping elsewhere.				May not be much if any MCM storage available. (DNF or not)		Some of this storage could be genuinely DNF.	No peanuts. ESD wrap required on electronics.	

All IceCube shipments ship from a short list of locations with the shipping manager at each shipping site reporting to the logistics coordinator (Ian M.) here at UW-Madison. Many of the drill components and spares are packed in shipping containers with excellent past experience in that shipping approach.

Overall IceCube experience with cargo damaged in transit has been excellent. The IceCube Gen1 DOM packaging informed the Upgrade module packaging quite strongly. One shipping damage item in the last few years (post Gen1 construction) was a pallet of UPS batteries which had a cardboard overwrap and was delivered to Pole with standing water inside and forklift holes in the sides. Hard-sided overcartons have been used since then whenever feasible and additional waterproofing layers have been added to shipments.

The first two strings worth of components will arrive a year early at South Pole and at a minimum a visual inspection will be carried out to assess potential shipping damage. Our experiences have been good with very few cases of visible damage (main one that comes to mind is above) and no cases of hidden damage which we ultimately thought had to do with shipping. SPoT shipping experience on our end is limited and we had proposed putting accelerometers onto a SPoT a couple of years ago. This activity was not supported on the contractor's end. The first IceCube SPoT shipments are quite robust units, and we will have some asset tracking devices (with accelerations and temperatures logged) attached.

(11) Are there “stretch opportunities” identified in each of the field seasons, in the event that things go better than expected, to reduce risk for the following season?

The 3 consecutive season work plan leaves lots of room for stretch goals, though in all cases the associated cargo would be required. In season 1, furthering SES set-up beyond basic layout is our stretch goal. This reduces risk as more is known about SES interconnections by seasons end. It also front-loads season 2 activities which, in turn, free up additional time for system integration and testing. In season 2, a full, rather than a partial system wet-test is our stretch goal. With a full system-wet test drill system functionality is known well before the drill season allowing ample time to tweak and adjust off-ice. Assuming materials and fuel are on hand, drilling could potentially begin earlier than planned in this scenario.

(12) Has the IceCube team done a failure analysis on the R&D devices to determine that any malfunction of one of the devices would be isolated? Discuss potential mechanical failure as well as electrical.

In Gen1 there was an extensive review process for R&D devices. For the Upgrade, with a limited number of people available for this oversight, we instituted an early requirement that all modules "speak DOM" and are 100% controlled by the normal IceCube DAQ. Every module has the same, IceCube Upgrade produced, communications module internally in the device. This allows for proper communications addressing, command "off" capability, and control over "light in the detector" or other emissions. We will still have a final review on the deployability of each item prior to shipment and the R&D devices are included in the Upgrade FMEA (Failure Mode & Effect Analysis).

Mechanical failures of rigging components are very unlikely. Everything will be specified with a safety factor of 5 or higher (to yield) and each item will be proof tested. A single failure of a pressure vessel will result in failure of the item but not string failure.

Electrically, in most DOM failure modes, if one device fails, all other devices on the pair are still usable. We have plenty of examples of this in Gen1, where we just remove the DOM from the configuration and continue with the partner. The exception to this is an electrical short on the wire pair — that will take down the pair (corresponding to 3 devices in Upgrade)