

IceCube M&O and Upgrade Population and Cargo Needs during the FY25 Field Season

Change Log

Revision	Description	Date
1.1	Original document	2/12/2024
1.2	Rearranged information; updated population/cargo	2/15/2024
1.3	updated cargo text, information; added priorities to rotations; updated rotation scenarios and text	4/25/2024
1.4	Added text to discuss flexibility of 5 strings of D-Eggs moving by vessel from CHC-McMurdo instead of ComSur.	4/25/2024

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2. Executive Summary

This document is a preliminary summary of plans and needs for the FY25 Field Season personnel and cargo logistics for the IceCube program. The full program (IceCube Upgrade and IceCube M&O) has been optimized to both complete needed maintenance for the current detector and to complete the plan of work for the Upgrade to prepare for the final drilling and installation season in FY26. The critical path for the Upgrade project schedule runs through the South Pole Field Seasons. These seasons are short and must be meticulously planned to be successful.

In terms of personnel deployments, we present two scenarios and discuss the differences and risks:

- 1.) a baseline scenario with personnel rotations; and
- 2.) a scenario with rotations before the C-17 air gap but not during.

The scenario with reduced rotations results in loss of productivity, and results in a higher risk of not completing all the season's goals. The FY26 Field Season is the first time that the reconfigured drill will be in full operation, and a delay of even two or three weeks in this season compared to the planned schedule will result in a reduction of the number of strings installed. Thus, any tasks incomplete in FY25 will increase the risks for full project completion.

In the baseline scenario, based on our original planning assumptions, we request a rotation of 12 personnel on January 6, covering both Upgrade and M&O. This rotation would allow the relevant Subject Matter Experts to be on ice at the appropriate time to perform their work. It would be the most efficient use of personnel. Additionally, the FY25 Field Season is when we need to build expertise in drilling and installation tasks in preparation for the main FY26 drilling and installation season. The drill will be focused on doing a full system wet test with the main hot water drill, which will require full shift coverage. The installation and M&O teams will be installing surface cables, junction boxes, and electronics to support the new strings, receiving all of the D-Eggs (292 optical modules built in Japan), acceptance testing, and storing, as well as two strings worth of mDOMs (128 modules built in Germany) and other special devices that will be used for calibrations. Electronics and data acquisition support is critical to ensure the module testing can be done efficiently.

3. Overview and Background

This document is a preliminary analysis of population and cargo needs for both the Upgrade and M&O portions of the IceCube Neutrino Observatory program during the FY25 Field Season. We are assuming the C-17 "gap" during which deployment South is strongly curtailed similar to the gap for the FY24 Field Season, December 12–January 31. We are working hard to minimize the number of rotations needed during the FY25 season, as we did during the previous season. Personnel movement north during the air gap, when possible, is helpful.

Figure 1 shows the planning capacities for the IceCube Upgrade as communicated to us from NSF before the IceCube Upgrade rebaselining exercise, which was completed at the end of September, 2022.

ICU Planning Capacities
OPP-AIL, 1/31/2022

Year	FY23	FY24	FY25	FY26	FY27
Vessel South (TEUs)	18*	as needed	as needed	n/a	n/a
Vessel North (TEUs)	n/a	17	50	17	50
LC-130: Hours/Flights^	12/2	114/19	60/10	42/7	36/6
SPoT-1 (Sleds/Weight, lbs)	3/180,000	3/180,000	3/180,000	3/180,000	3/180,000
SPoT-2 (Sleds/Weight, lbs)	3/180,000	3/180,000	3/180,000	3/180,000	3/180,000
SPoT-3 (Sleds/Weight, lbs)	3/180,000	3/180,000	3/180,000	3/180,000	3/180,000
Pole Population (Nov-Jan)	0	11	21	46~	4

*If ICU needs more space to move things ahead, we will find a way to make more TEUs available.

^This does not fully meet the goal to have all fuel required on site prior to the FY26 main drilling season. AIL will continue to look at ways to mitigate that risk as planning moves forward.

~This is a hard maximum and needs to be reviewed again for ways to bring it down if at all possible.

In general:

1. Our supportability is dependent on moving as much cargo to Pole as possible in FY24. This means getting as much cargo on the FY23 vessel or, if needed, getting it to MCM via commercial surface shipment/C17 no later than Nov. 2024.
 2. FY27 info is provided in advance of IPT discussion/clarification on retro requirements.
 3. Temperature controlled storage (at MCM and Pole) is likely still an issue that needs to be resolved with this capacity.
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Figure 1 Planning capacities for the IceCube Upgrade as communicated from NSF in January 2022. These capacities formed the basis of the IceCube Upgrade Rebaseline in September 2022.

For background, the final deployment schedule for the FY24 season for Upgrade is shown in Table 1. The requested number of beds (deployments) in the Upgrade SIP for FY24 was 11 (16) total with 5 mid-season rotations. (This did not count the additional two outfall drill members who were supported by the Upgrade). Because of constraints in rotations during the C-17 air gap, several people arrived at Pole early, and others were extended beyond their nominal deployment dates, leading to a total max bed space of 14 for about four weeks in the middle of the season. This allowed the team to reduce the impact of schedule delays due to late arriving cargo. For example, SPoT1, which brought one of our generators to Pole, did not arrive until December 8, and our generator technician was initially scheduled to leave a few days later; extending his stay allowed us to get all three generators running and synchronized. This extra bedspace, coupled with the additional two outfall drillers, enabled service drilling of a dry hole for the station and allowed our team to gain valuable experience in the operations of the independent firm drill and the rodwell hot water drill, both of which are needed during the FY25 FS.

		C17 air gap Dec 12 - Feb 2																							
		Start				End				Week of:		Nov		Dec		Jan		Feb							
ICU TEAM:	Role	McM Arrival	Pole Departure								5	12	19	26	3	10	17	24	31	7	14	21	28	4	11
											BEDS:														
Kurt Studt	Drill manager	11/16/2023	2/9/2024																						
Sarah Johnson	Electrical, controls/PLC/HW/sensors	11/16/2023	2/9/2024																						
Åse Torgilsson	Mechanical, heaters/pumps	11/28/2023	2/9/2024																						
Erik Ejdepalm	Mechanical, pumps/reels	11/20/2023	2/9/2024																						
Skyler Grulke	Mechanical, PHS/MHP/TOS	11/16/2023	2/9/2024																						
Chris Nielsen	Mechanical	11/20/2023	2/9/2024																						
Tony Carleton	Generator tech	11/20/2023	1/4/2023																						
Terry Benson	Systems Engr, L2, Gen-1 HW drill	11/16/2023	12/6/2023																						
Jeanne Edwards	Electrical, power/drives	11/20/2023	1/12/2023																						
Brent Folmer	Electrician, gensets/PDM/driveIntg	11/16/2023	1/26/2024																						
Xu Zhai	Electrical, estop/motion	11/16/2023	1/12/2024																						
Chana Sinsabvarodom	Mechanical	12/12/2023	2/9/2024																						
Paul Wisniewski	Electrical, controls/PLC/HW/SW	12/12/2023	2/9/2024																						
Tom Nordin	Electrical, power/systems	12/12/2023	2/9/2024																						
Jake Nesbit	Mechanical	12/12/2023	2/9/2024																						
OUTFALL TEAM:																									
Sam Wolcott	Outfall	12/12/2023	2/9/2024																						
Dave Pernic	Outfall	12/12/2023	2/9/2024																						

Table 1 Deployments during the FY24 Field Season for the Upgrade. Hashed lines represent extensions or early arrivals at Pole.

The FY24 season was very successful, and the team completed nearly all work planned by the end of the season, setting us up for a strong start in the FY25 Field Season. The field team left the South Pole on February 9 and is on the way back at the time of this writing. We have not yet had the opportunity to debrief.

The IceCube M&O FY24 field season population (shown in Table 2) was reduced compared to the original plan and relative to support levels in the operational notice. The program had requested to deploy 12 people total with a maximum bed space of 7. Instead, 5 people deployed, including two winterovers. All surface array and Askaryan Radio Array maintenance was deferred to FY25, due to the lack of expertise and personnel. All graduate student deployment slots were also canceled, eliminating this important training opportunity.

In terms of cargo, in FY24 the IceCube Upgrade shipped 10,483 lbs via ComSur (not listed in the capacity table in Figure 1) and 1 Twenty-foot Equivalent Unit (TEU) on the FY24 USAP vessel southbound. A total of 76,683 pounds of cargo was delivered to the South Pole: 22,883 lbs cargo via ~8 LC-130 flights (we aren't sure of the exact number of LC-130 flights used), and 53,800 lbs cargo via overland (SPOT-1), compared to the planned capacity of 19 flights and 540,000 total SPoT capacity allowed for the Upgrade. These numbers do not include fuel or the 4 empty fuel tanks (34,065 pounds) purchased by IceCube Upgrade for fuel transportation. We do not get reports on fuel movement for IceCube Upgrade so cannot include it in this analysis.

The requested 9,570 lbs of FY24 M&O ComSur cargo was all delivered to the South Pole, but was delayed relative to the Required On Site (ROS) dates, ranging from 11 to 77 days. The life-cycle UPS replacement planned for the summer is now being performed by the winterovers and will stretch into the winter. Related retrograde and battery disposal is deferred until FY25. The IceACT maintenance is also now deferred until FY25.

- Receive, test, and store all the D-Eggs, 2 strings worth of mDOMs, and 2 strings worth of calibration and special devices.
- Develop and streamline the sensor handling process of FS3
- Receive and store installation equipment

Additionally, the M&O team plans to request support for:

- Computing / IT
 - Complete FY24 UPS upgrade / retro
 - Life-cycle replacement of networking firewalls
 - Life-cycle replacement of computer workstations
 - Rack power cabling and PDU upgrades
 - Infrastructure software maintenance and upgrades
- IceCube Upgrade integration
 - Support installation of Upgrade electronics in ICL
 - Commission Upgrade electronics in ICL
 - Support testing of Upgrade DOMs
 - Installation of Upgrade rack UPSes
- Detector maintenance and upgrades
 - DOM readout computer maintenance
 - Surface array upgrades / maintenance
 - IceAct upgrades / maintenance
 - Askaryan Radio Array repair / maintenance
 - Support Upgrade SES solar installation

4.2 Deployment plan for FY25 Field Season

In the sections below, we describe three scenarios: 1) the scenario with no rotations. 2) a scenario with rotations before the air gap, and Deployment plan with no rotations, and 3) our baseline deployment plan with one mid-season rotation during the C-17 air gap,

4.2.1 Deployment plan with rotations before the air gap

Scenario 1: Beds: Upgrade 21, M&O: 9; Deployments total: 40

Figure 2 shows the deployment plan with no rotations during the C-17 air gap for both the IceCube Upgrade project and the IceCube M&O program. It is assumed in this scenario that rotating before the air gap is possible. This plan calls for 14 (10) arriving at Pole (leaving Pole) just before the air gap. We have kept the Upgrade team request to 21 as in the planning capacities listed in Figure 1. The total maximum bed space request is 30, 21 for the IceCube Upgrade project and 9 for the IceCube M&O program. We have added an additional column with rotation priorities: those with priority 0 are deploying for the full season, priority 1 is our top priority across ICNO (both Upgrade and M&O), priority 2 is the next priority, etc.

					C17 air gap Dec 12 - Feb 2																							
					Nov				Dec				Jan				Feb											
					Week of:	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10								
Plan with rotations outside of flight gap					Rotation Priority																							
Drill Team - 14 beds, 5 positions rotate					Role	Pole Arrival	Pole Departure	Rotation Priority																				
Kurt Studet	drill manager	11/7/2024	2/12/2025	0																								
Tony Carleton	gen tech/elec	11/7/2024	2/12/2025	0																								
Åse Torgilsson	sr mech	11/7/2024	2/12/2025	0																								
Erik Ejdepalm	sr mech	11/7/2024	2/12/2025	0																								
Chris Nielsen	sr mech/elec	11/7/2024	2/12/2025	0																								
Chana Sinsabvarodom	sr mech	11/7/2024	2/12/2025	0																								
Dave Pernic	sr mech	11/7/2024	2/12/2025	0																								
Sky Grulke	sr mech	11/7/2024	2/12/2025	0																								
Sarah Johnson	sr elec	11/7/2024	2/12/2025	0																								
Brent Folmer	sr electrician	11/7/2024	12/12/2024	1																								
TBA 1 - electrician	electrician	12/12/2024	2/12/2025	1																								
Jeanne Edwards	sr elec	11/7/2024	12/12/2024	3																								
Lexi Oxborough	sr mech	12/12/2024	2/12/2025	3																								
Jeff Lemery	systems engr	11/7/2024	12/12/2024	1																								
Terry Benson	sr systems engr	12/12/2024	2/12/2025	1																								
Tom Nordin	sr elec or new	11/7/2024	12/12/2024	2																								
Xu Zhai	sr elec	12/12/2024	2/12/2025	2																								
Jake Nesbit	sr mech or new	11/7/2024	12/12/2024	2																								
Paul Wisniewski	sr elec	12/12/2024	2/12/2025	2																								
ICU tech team (installation/other) NR - 7 beds					Role	Pole Arrival	Pole Departure	Rotation Priority																				
Safety Lead (1)	Quality / Safety	11/7/2024	12/12/2025	2																								
Safety Lead (2)	Quality / Safety	12/12/2025	2/12/2025	2																								
Project Director	Oversight / deputy safety / support	11/7/2024	12/12/2025	1																								
Principal Investigator	Oversight/installation expert	12/12/2024	2/12/2025	1																								
Jason Chan	technical support	12/2/2024	2/12/2025	0																								
Karlheinz Sulanke	CPT SME electronics	12/9/2024	2/12/2025	0																								
Chris Ng	CPT SME cables	12/2/2024	2/12/2025	0																								
Jeff Weber	SPAT (DOM testing) lead	12/9/2024	1/20/2025	0																								
Delia Tosi	String Install lead	12/2/2024	2/12/2025	0																								
M&O - 9 beds					Role	Pole Arrival	Pole Departure	Rotation Priority	Prio																			
TBD	Winterover 1	11/4/2024	11/11/2025	0																								
TBD	Winterover 2	11/4/2024	11/11/2025	0																								
Ralf Auer	Computing / IT SME	11/4/2024	12/9/2024	1																								
Mirko Kugelmeier	DAQ SME	11/4/2024	12/9/2024	1																								
TBD	Computing / IT	11/4/2024	12/9/2024	1																								
John Kelley	Upgrade ICL integration SME	12/9/2024	1/13/2025	1																								
TBD	Upgrade ICL integration	12/9/2024	1/13/2025	1																								
Sarah Mechbal	DOM testing SME	12/9/2024	2/7/2025	1																								
TBD	Surface array maintenance	12/9/2024	1/27/2025	2																								
Abby Bishop	Radio array maintenance	12/9/2024	1/13/2025	2																								
TBD	Surface array installation	12/9/2024	1/27/2025	3																								
TBD	IceACT maintenance	12/9/2024	1/13/2025	3																								

Figure 2 IceCube program deployment plan with rotations before the air gap. This plan calls for 14 (10) arriving at Pole (leaving Pole) just before the air gap. The rotation priority column rates our priorities with respect to rotations, with priority 1 being the top priority. A priority of 0 indicates the person is staying for the full season.

Drill Team:

The plan without air-gap rotations introduces the following risks:

- Not all the experience gained in FY24 field season is retained, some loss of season-to-season continuity of trained drill crew members
- SME coverage for key activities is not well aligned
- Enhanced risk of unavailability of important team members
- Opportunity to bring in new team members remains at 3

For the Drill and Installation teams, priority 0 indicates a full season deployment, and priority 1 indicates the highest priority for rotations. The highest priority for rotations are for SME for the electrical work and SME for drill engineering. For the installation team, the highest priority is for the Project Director / Principal Investigator who are not available for a full season deployment. The next highest priority is for safety lead – if that rotation cannot be supported, we would identify a safety lead able to deploy for the entire season.

M&O Team

Version 1.4

For the M&O team, rotations before the air gap allow key SMEs to deploy that would not be available otherwise and restores the opportunity to fill other roles needed for detector maintenance later in the season. In a logistics scenario where the operational notice bed space of 9 cannot be realized, we have prioritized the M&O team member deployments / rotations as follows, as shown in the above figure:

- Priority 0 (winterovers): non-deployment poses risk of major data and/or hardware loss, including permanent detector damage. Total bed space: 2
- Priority 1: non-deployment poses risks that the highest-priority detector maintenance tasks will not be achieved, and that Upgrade integration and DOM testing tasks will be delayed into FS3. Total bed space: 5
- Priority 2: non-deployment poses risks to hardware already deployed and loss of the associated science. This includes the existing surface array radio antennas that must be raised above the snow, and servicing of failed radio (ARA) DAQ electronics. Total bed space: 7
- Priority 3: non-deployment risks continued degradation of the IceTop array due to snow accumulation from deferred installation of the surface array enhancement, and deferred maintenance of the IceACT air Cherenkov field telescope. Total bed space: 9

4.2.2 Baseline Scenario: Deployment plan with rotations

Scenario 2: Beds: Upgrade 21, M&O: 9; Deployments total: 42

Figure 3 shows the deployment plan with one mid-season rotation for both the IceCube Upgrade project and the IceCube M&O program. In this plan the total maximum bed space request is 30, 21 for IceCube Upgrade (as allocated in the ICU planning capacities shown in Figure 1) and 9 for the IceCube M&O program which is the number in the M&O Operations Notice. A total of 11 (8) rotations to South Pole (leaving South Pole) during the C-17 air gap is requested, and an additional 5 (6) to South Pole (leaving South Pole) rotations before the flightgap. Again, the table details rotation priorities across the Upgrade and M&O program.

Plan with rotations					C17 air gap Dec 12 - Feb 2															
					Nov				Dec				Jan				Feb			
Drill Team - 14 beds, 5 positions rotate					Week of:	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10
Role	Pole Arrival	Pole Departure	Rotation Priority	BEDS:																
Kurt Studt	drill manager	11/7/2024	2/12/2025	0																
Tony Carleton	gen tech/elec	11/7/2024	2/12/2025	0																
Åse Torgilsson	sr mech	11/7/2024	2/12/2025	0																
Erik Ejdepalm	sr mech	11/7/2024	2/12/2025	0																
Chris Nielsen	sr mech/elec	11/7/2024	2/12/2025	0																
Chana Sinsabvarodom	sr mech	11/7/2024	2/12/2025	0																
Dave Pernic	sr mech	11/7/2024	2/12/2025	0																
Sky Grulke	sr mech	11/7/2024	2/12/2025	0																
Sarah Johnson	sr elec	11/7/2024	2/12/2025	0																
Brent Folmer	sr electrician	11/7/2024	12/12/2024	1																
TBA 1 - electrician	electrician	12/12/2024	2/12/2025	1																
Jeanne Edwards	sr elec	11/7/2024	12/12/2024	3																
Lexi Oxborough	sr mech	12/12/2024	2/12/2025	3																
Terry Benson	sr systems engr	11/7/2024	1/6/2025	1																
Jeff Lemery	systems engr	1/6/2025	2/12/2025	1																
Xu Zhai	sr elec	11/7/2024	1/6/2025	2																
Tom Nordin	sr elec or new	1/6/2025	2/12/2025	2																
Paul Wisniewski	sr elec	11/7/2024	1/6/2025	2																
Jake Nesbit	sr mech or new	1/6/2025	2/12/2025	2																
ICU tech team (installation/other) - 7 beds																				
Safety Lead (1)	Quality / Safety	11/7/2024	12/12/2025	2																
Safety Lead (2)	Quality / Safety	12/12/2025	2/12/2025	2																
Project Director	Oversight / deputy safety / support	11/7/2024	1/6/2025	1																
Principal Investigator	Oversight/installation expert	1/6/2025	2/3/2025	1																
TBD	technical support	12/2/2024	2/12/2025																	
Karlheinz Sulanke	CPT SME electronics	12/2/2024	1/6/2025	3																
TBD	CPT SME electronics	1/6/2025	2/12/2025	3																
Chris Ng	CPT SME cables	12/2/2024	1/6/2025	3																
TBD	CPT SME cables	1/6/2025	2/12/2025	3																
Jeff Weber	SPAT (DOM testing) lead	12/9/2024	1/20/2025																	
Delia Tosi	String Install lead	12/2/2024	2/12/2025																	
M&O - 7 beds																				
TBD	Winterover 1	11/4/2024	11/11/2025	0																
TBD	Winterover 2	11/4/2024	11/11/2025	0																
Ralf Auer	Computing / IT SME	11/4/2024	12/12/2024	1																
Mirko Kugelmeier	DAQ SME	11/4/2024	12/12/2024	1																
TBD	Computing / IT	11/4/2024	12/12/2024	1																
John Kelley	Upgrade ICL integration SME	12/9/2024	1/13/2025	1																
TBD	Upgrade ICL integration	12/9/2024	1/13/2025	1																
Sarah Mechbal	DOM testing	12/9/2024	2/7/2025	1																
TBD	Surface array maintenance SME	1/13/2025	2/7/2025	2																
TBD	Surface array maintenance	1/13/2025	2/7/2025	2																
Abby Bishop	Radio Array maintenance SME	1/13/2025	2/7/2025	3																
TBD	IceACT maintenance SME	1/13/2025	2/7/2025	3																

Figure 3 Deployment plan with one mid-season rotation for IceCube Upgrade and IceCube M&O. The total maximum bed space request is 30, 21 for IceCube Upgrade and 9 for the IceCube M&O program. A total of 11 (8) rotations to South Pole (leaving South Pole) during the C-17 air gap is requested, and an additional 5 (6) to South Pole (leaving South Pole) rotations before the airgap.

Drill Team:

The plan with rotations takes the following into mind:

- Retain and build upon core experience gained in the FY24 field season
- Build field experience for SMEs who could not deploy in FY24 field season
- Ensure SMEs are on-site for and aligned with key activities
- Bring in up to 3 new team members to continue building experience required for the FY26 drill season

Installation / M&O team

The M&O deployment plan follows the existing operational notice, requesting a maximum of 9 beds and a total of 12 deployers, including two winterovers. A small number of population rotations into the South Pole in early January will ensure that SMEs, especially for activities in January, are on site

at the appropriate time. As discussed above, the M&O population works closely with the Upgrade team in FY25, performing critical non-drilling activities on surface cable installation, IceCube Laboratory electronics installation, and DOM testing. For the Upgrade installation team, mid-season rotations ensure we have a full complement of electronics and cabling SMEs for installing FieldHubs, junction boxes, and surface cable installation and testing. The project leaders (PI/PD) also split the season with a mid-season rotation to ensure strong communication between the drill, installation, M&O, and ASC teams, as well as NSF and station management. Population movement north out of South Pole during the air gap, as supported during FY24, is critical to ensure that experts can fulfill other duties in the North (for example, on Upgrade data acquisition software development) in a timely manner before the FY26 installation season.

5. FY25 Cargo

Table 3 shows the remaining cargo to ship for the IceCube Upgrade. While the total project cargo weight has not changed since the operations notice, the profile has.

Intercontinental leg: ORIGIN - MCM	volume [cu ft]	weight [lbs]	Contents (roughly)
At South Pole	22,092	224,522	
In McMurdo	6,762	81,903	Drill hose surface cables, installation kits and crane, surface cables, spare drill cables.
FY25 ComSur	1,594	28,306	Special devices, drill controls/refit/resupply, ICL patch panels, timing, and power electronics
FY25 USAP Vessel (PTH - MCM)	3,584	111,125	Main (downhole) cable assemblies
FY25 USAP Vessel (CHC - MCM)	266	3,710	Breakout cables
FY25 OCONUS ComSur	4,863	35,538	Field Hubs, D-Eggs (7 strings), mDOMs, special and calibration devices (strings 87-88)
FY26 USAP Vessel (PTH - MCM)	0	0	
FY26 ComSur	2,558	36,591	mDOMs(MSU), special &, calibration devices (strings 89-93), dust logger and electronics, winch
FY26 OCONUS ComSur	950	9,795	mDOMs (DESY), special & calibration devices (strings 89-93)
Total project cargo (*)	42,402	527,780	

Table 3 Intercontinental cargo (off continent to McMurdo) for IceCube Upgrade for FY25 and FY26. OCONUS stands for Outside Continental U.S. This represents equipment shipped by colleagues in Europe and Japan directly to New Zealand.

Figure 4 shows the major changes in cargo profile between the Operations Notice plan and the current plan. The Main Cable Assemblies are shipping on the FY25 USAP resupply vessel instead of the FY24 vessel. Originally 2 strings worth of optical modules (D-Eggs and mDOMs) were shipping FY25 ComSur and the rest in FY26 ComSur; in order to mitigate risk, we have moved up

shipping all of the D-Eggs in the FY25 ComSur shipment. Thus in FY26, only 5 strings worth of mDOMs will be shipped ComSur.

Cargo Table from Operations Notice

Intercontinental leg:	volume	weight
ORIGIN - MCM	[cu ft]	[lbs]
At South Pole	733	12,241
In McMurdo	20,513	205,787
FY23 Vessel	10,866	103,546
FY23 ComSur	1	5
FY24 Vessel	4,704	121,302
FY24 ComSur	370	4,892
FY25 Vessel	1,022	12,362
FY25 ComSur	2,842	38,030
FY26 Vessel	0	0
FY26 ComSur	4,600	61,722
Total project cargo (*)	45,651	559,887

Cargo Table as of 4/25/2024

Intercontinental leg:	volume	weight
ORIGIN - MCM	[cu ft]	[lbs]
At South Pole	22,092	224,522
In McMurdo	6,762	81,903
FY25 ComSur	1,594	28,306
FY25 USAP Vessel (PTH - MCM)	3,584	111,125
FY25 USAP Vessel (CHC - MCM)	266	3,710
FY25 OCONUS ComSur	4,863	35,538
FY26 USAP Vessel (PTH - MCM)	0	0
FY26 ComSur	2,558	36,591
FY26 OCONUS ComSur	950	9,795
Total project cargo (*)	42,403	527,780

MCA's

D-Eggs

Figure 4 Upgrade cargo showing the difference between the cargo plan in the Upgrade Operations Notice and the current plan. Overall, the total cargo weight and volume has decreased. The major changes are the Main Cable Assemblies (MCAs) moving from FY24 Vessel to FY25 Vessel. Originally two strings of optical modules were shipping ComSur in FY25 and the remaining 5 strings in FY26; to reduce risk, we plan to ship all 7 strings of D-Eggs in FY25. This increases the FY25 ComSur to 63,844 lbs (sum of the two green boxes on the right) and decreases to FY26 ComSur request.

Table 4 shows the cargo movement needs between McMurdo and South Pole for both FY25 and FY26 Field Seasons and Table 5 shows the cargo delivery needs by the Required-On-Site (ROS) dates. In our April face-to-face with ASC, we learned that half a sled (1 TEU) is needed for shipping helium for the weather balloons; we therefore have reduced the number of drill hose spools to 8 (leaving 2 at McMurdo) and propose to fly the surface cables (currently in McMurdo) on LC-130 to Pole. to free up space on SPoT1. Table 4 shows the proposed route for cargo from McMurdo to South Pole for both the FY25 and FY26 seasons.

Upgrade Cargo

Intracontinental leg: MCM - NPX	volume [cu ft]	weight [lbs]	# SPOT TEUs (**)	# 263 Pallets (**)	Contents (roughly)
FY25 LC-130	7,707	80,956	0.0	19.3	Spare drill cable, controls, resupply, ICL power, timing, patch cables, Field Hubs, mDOMS (strings 87-88), D-Eggs, special/calibration devices (strings 87-88), breakout cables, surface cable assemblies
FY25 SPOT 1	4,820	56,258	5.1	0.0	Drill hose (10 spools), installation kits, crane
FY25 SPOT 2	0	0	0.0	0.0	
FY25 SPOT 3	692	8,533	0.7	0.0	2 spare spools of drill hose (if needed)
FY26 LC-130	3,508	46,386	0.0	8.8	mDOMs (strings 89-93), special/calibration devices (strings 89-93), dust logger and winch, drill components
FY26 SPOT 1	3,584	111,125	3.8	0.0	Main (downhole) cable assemblies
FY26 SPOT 2	0	0	0.0	0.0	
FY26 SPOT 3	0	0	0.0	0.0	

(*): fuel tanks & fuel not included

(**) assumes 80% filling capacity

Table 4 Intracontinental Leg (McMurdo to South Pole) for IceCube Upgrade for FY25 and FY26.

Table 5 shows a breakdown of cargo by ROS date. We note that it is possible to delay delivery of 5 strings of D-Eggs to the South Pole as long as they get there before the Upgrade team leaves so that they can be properly unloaded and stored in the designated DNF space for the sensors. This flexibility could be used to send the sensors for 5 strings of D-Eggs from CHC to McMurdo by vessel, for example, before flying onward to Pole in an LC-130. The D-Eggs cannot overwinter in McMurdo as there is no DNF space for them there.

Upgrade Cargo delivery schedule by ROS date

Fiscal Year	Calendar Date	ROS date	volume [cu ft]	weight [lbs]	Contents (roughly)
FY25	11/09/2024	4314	1,099	21,500	Drill controls, resupply
FY25	11/30/2024	4335	6,811	80,118	Drill hose, spare cable, surface cables, installation equipment, ICL power, timing, patch cables, surface cables, field hubs
FY25	12/07/2024	4342	4,696	32,659	Optical sensors (*), special devices
FY25	12/14/2024	4349	0	0	
FY25	12/28/2024	4363	0	0	
FY25	1/11/2025	5011	347	7,760	Spare drill hose
FY25	2/1/2025	5032	0	0	
FY25	2/8/2025	5039	266	3,710	Breakout cables
FY26	11/8/2025	5312	64	1,500	Installation equipment
FY26	11/15/2025	5319	737	12,400	Drill refit, resupply
FY26	11/22/2025	5326	2,707	32,486	Calibration, special devices, optical sensors, dust logger and winch
FY26	11/29/2025	5333	3,584	111,125	Downhole cable assemblies

Table 5 Delivery needs for the IceCube Upgrade Project by Required-On-Site (ROS) dates for both the FY25 and FY26 Field Seasons. (*) 13,670 lbs (2,310 cuft) representing 5 strings of D-Egg cargo can be moved to the end of the season but must arrive at Pole before the ICU team leaves in order to ensure they are inventoried and stored in the designated DNF area. They *cannot* overwinter at McMurdo.

Table 6 shows the preliminary cargo plan for FY25 for M&O along with approximate ROS date. This request is under the 10,000-lb operational notice level. The ROS dates shown support either population plan with rotations. In the case of no rotations, all cargo ROS dates will be in November.

item	lbs	N		O				V				D				E				C				J				A				N				F				E			
		4	11	18	25	2	9	16	23	30	6	13	20	27	3	10																											
ICL networking and workstations	1500																																										
Askaryan Radio Array DAQ, IceACT	500																																										
SES solar installation	1500																																										
Surface array cabling & FieldHubs	2000																																										
Surface array instrumentation (2 stations)	4000																																										
Total	9500																																										

Table 6 Cargo needs for the IceCube M&O Project by Required-On-Site (ROS) dates for FY25