IceCube Upgrade
1.2.8 Field Seasons

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Field Season Planning

Upgrade Drill Team will resume work in Antarctica beginning with **2023-2024** season

Scheduling field season work on-Ice is complex. South Pole is a unique and very remote work environment

- 6-day workweek / 9 hour days / 54 hour week
- Field Season 1 – Team will work in (1) shift
- Field Season 2 – Team will split into (2) shifts – Distribute work load & manage water circulation
- Field Season 3 – Team will operate (3) shifts – Drilling & instrumentation installation

Season Designations / Timeline

FS0 2022-2023 (Non-Deploying)
FS1 2023-2024
FS2 2024-2025
FS3 2025-2026

FS4 2026-2027 (Retro)
Retrograde of Upgrade EHWD equipment – This season is off-project / season plan still to be determined

Field Season Sequence

First season is a **non-deploying** season

Followed by 3 deploying field seasons

Each season builds on the progress made in prior season

Field Season 0

- Move Cargo
- Groom/Pack Drill Pad
- Generator #2 Repairs
- Install W/O Electric Heating Infrastructure

Field Season 1

- Subsystem Repairs and Refit
- Commission ARA Drill
- Commission Firn Drill
- SES Setup

Field Season 2

- Systems Integration and Testing
- Control System Ready
- Generators Ready
- Firn Drill 9 Holes
- Full System Wet Test

Field Season 3

- Drill and Install 7 Holes

Field Season 0 - 2022/2023

This is a **non-deploying** season but cargo movement and coordination with ASC (Antarctic Support Contractor) for work on-continent will continue

- Cargo movement to Antarctica
  - Vessel Shipment - November 2022
  - DNF Equipment Shipment (Do Not Freeze) ~ June 2023
- Major movement of Upgrade cargo from McMurdo to South Pole via Traverse
- Drill pad preparation at South Pole (hard-pack/groom snow at site)
- Generator#2 move off-site for repairs and service
  - TerraCat - Caterpillar equipment dealer located in New Zealand
- Overwinter Storage heating electrical infrastructure installed by ASC
  - Storage for DNF Equipment

Field Season 1 - 2023/2024

Drill Team resumes work in Antarctica

- Projected Drill Team Personnel at South Pole – 11
- Team will work (1) shift

- Season Start
  - Excavate drill components from storage berms
  - Set up worksite at the Cryo Facility
  - Groom Seasonal Equipment Site pad
  - Generators / Power distribution

- Subsystems repair and refit
  - MHPs, PHS, HPP, Water Tanks
  - TOS/Tower, Hose Reels and Cable Reels
- Commission Independent Firn Drill (IFD)
- Commission Antarctic Rodwell Apparatus (ARA Drill)
- Build up Seasonal Equipment Site

- Season End
  - Winterize and stow modules, equipment and cargo

Field Season 1 - 2023/2024

Subsystems Repair and Refit

- Begin with primary Seasonal Equipment Site (SES) components
  - MHPs and PHS, HPP, Water Tanks
- Follow with Tower Operations Site (TOS) components and ancillary equipment
  - TOS/Tower, Hose Reels and Cable Reels, ARA Drill, Independent Firn Drill

- Examples of Mechanical tasking at Cryo Facility include:
  - MHP and PHS heater flushing, pressure and operational testing
  - Condensate collection and disposal system replacement
  - Install Water Tank pumps, plumbing and protective housing
- Primary Electrical/Controls work to be completed at Cryo Facility includes:
  - Install DGH modules and new Gateway hardware
  - Mount new motor drives and softstart hardware
  - Install Estop boxes
  - Install Sensor hardware and I/O boxes
  - Validate repaired subsystems with Mobile Test System
  - Test Individual devices at time of install **and** test subsystems prior to moving to SES

- Independent Firn Drill (IFD) – final repairs, upgrades, testing and commissioning
- Antarctic Rodwell Apparatus (ARA Drill) – modifications, upgrades, testing and commissioning
- Hose heating system – install and test

- Build out the SES, mount cable trays, connect and evaluate all interconnects

Field Season 1 - 2023/2024

Detailed schedule for on-ice activities

- Itemized list of all tasks to be completed
  - Broken out by Mechanical & Electrical tasking
- Sets the order for subsystem upgrade & repairs
- Sets the order for the Seasonal Equipment Site build up

C	D	E	N	O
L2	**WBS**	**Task Name**	**Duration**	**Start Date**
1.2	1.2.8.5.6.3	Main Heating Plants (MHP)	23d	11/14/23
1.2	1.2.8.5.6.3.1	MHP Relocation Support (USAP)	1d	11/14/23
1.2	1.2.8.5.6.3.2	Install MHP Fall Restraint Towers (USAP)	1d	11/15/23
1.2	1.2.8.5.6.3.3	MHP1	9d	11/15/23
1.2	1.2.8.5.6.3.3.1	Mechanical Refit & Repairs (MHP1)	9d	11/15/23
1.2	1.2.8.5.6.3.3.1.1	Heater Flush and Pressure Test	4d	11/16/23
1.2	1.2.8.5.6.3.3.1.2	Plumbing Upgrades & Repairs	3d	11/22/23
1.2	1.2.8.5.6.3.3.1.3	Fuel System Upgrades and Repairs	1d	11/15/23
1.2	1.2.8.5.6.3.3.1.4	Exhaust System Upgrades and Repairs	1d	11/16/23
1.2	1.2.8.5.6.3.3.1.5	MHP Subsystem Evaluation	1d	11/28/23
1.2	1.2.8.5.6.3.3.1.6	MHP1 Mechanical Complete	0	11/28/23
1.2	1.2.8.5.6.3.3.2	Electrical/Controls Refit & Repairs (MHP1)	6d	11/16/23
1.2	1.2.8.5.6.3.3.2.1	Install PLC-to-DGH Gateway in Network Box, Install M-DGHs, & Test	1d	11/16/23
1.2	1.2.8.5.6.3.3.2.2	Install Refurbished Heater Control Assemblies on All Heaters (M-DGHs	3d	11/16/23
1.2	1.2.8.5.6.3.3.2.3	Replace Thermostats in Heaters & Test	2d	11/21/23
1.2	1.2.8.5.6.3.3.2.4	Reconfigure MHP E-stop Panel to Function with N.C. Slap Switch	1d	11/17/23
1.2	1.2.8.5.6.3.3.2.5	Test E-stop and Heater Controls with No Water	2d	11/20/23
1.2	1.2.8.5.6.3.3.2.6	Test Flow Sensor Operation with No Water	1d	11/22/23
1.2	1.2.8.5.6.3.3.2.7	Install Ethernet Switch, Connect to Network Box, Route Cable to DCC &	1d	11/24/23
1.2	1.2.8.5.6.3.3.2.8	MHP1 Controls Complete	0	11/24/23
1.2	1.2.8.5.6.3.4	MHP2	11d	11/16/23
1.2	1.2.8.5.6.3.4.1	Mechanical Refit & Repairs (MHP2)	11d	11/16/23
1.2	1.2.8.5.6.3.4.1.1	Heater Flush and Pressure Test	3d	11/22/23
1.2	1.2.8.5.6.3.4.1.2	Plumbing Upgrades & Repairs	3d	11/28/23
1.2	1.2.8.5.6.3.4.1.3	Fuel System Upgrades and Repairs	1d	11/16/23

Rebaseline Schedule PY4-PY8 20220310.xlsx

Field Season 2 – 2024/2025

Systems Integration and Test

- Projected Drill Team Personnel at South Pole – 14
- Team will split in (2) shifts for part of the season
- Season Start
  - Excavate and establish SES as primary worksite
  - Maintain Cryo Facility as secondary worksite
  - Finish all remaining subsystem upgrades from FS1
- Integrate subsystems
  - Drill Control Center (DCC) – computer and network components install and connected
  - Install remaining system interconnects
  - Integrate all subsystems into fully functioning Enhanced Hot Water Drill (EHWD)
- System Operation
  - Energize entire system – begin water circulation and system testing
  - Complete and demonstrate full controls system capability
  - Cable/Hose Reels load share tuning
- Firn Drill (9) holes – 7 for Deep, 1 Condensate, 1 Rodwell
- Final generator integration and commissioning
- Perform Full System Wet Test
- Install drill hose on Main Hose Reel, prepare for winter-over heating with TOS1, TOS2 and DCC
- Season End – Winterize and stow modules, equipment and cargo

Field Season 3 – 2025/2026

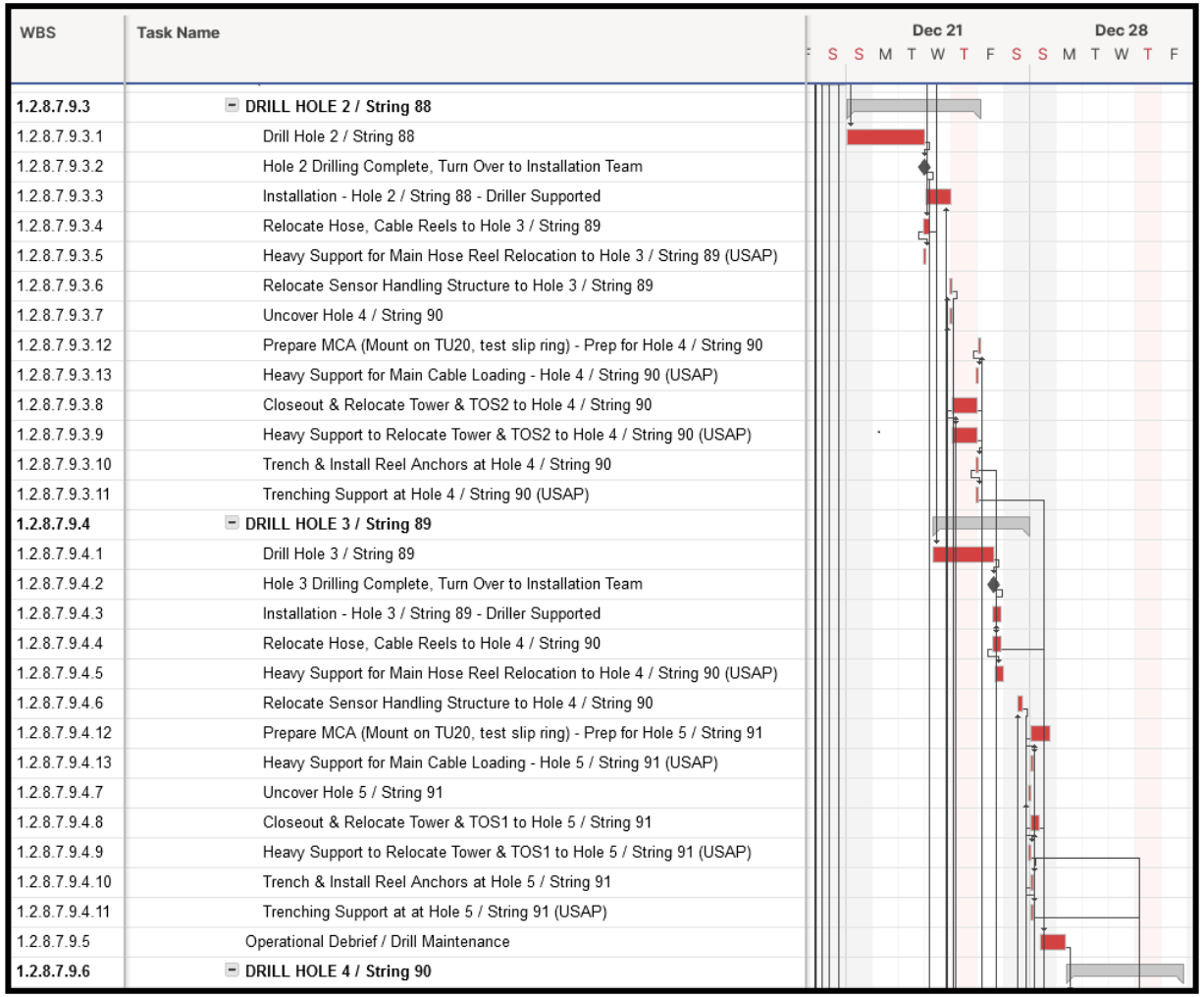
Drill and Install 7 Holes

- Projected Drill Team Personnel at South Pole – 29
- 3 Shifts of 9 Drillers + Drill Manager + Safety Officer
- Team will work (3) shifts

- Season Start
  - Excavate, power-up, initiate Rodwell and circulate water
  - Prepare Seasonal Equipment Site and Tower Operations Site for drilling
  - Complete systems safety testing and readiness review

- Drill (7) deep holes
- Install instrumentation – (7) strings

- Season End
  - Decommission, winterize and disassemble EHWD for storage and retrograde

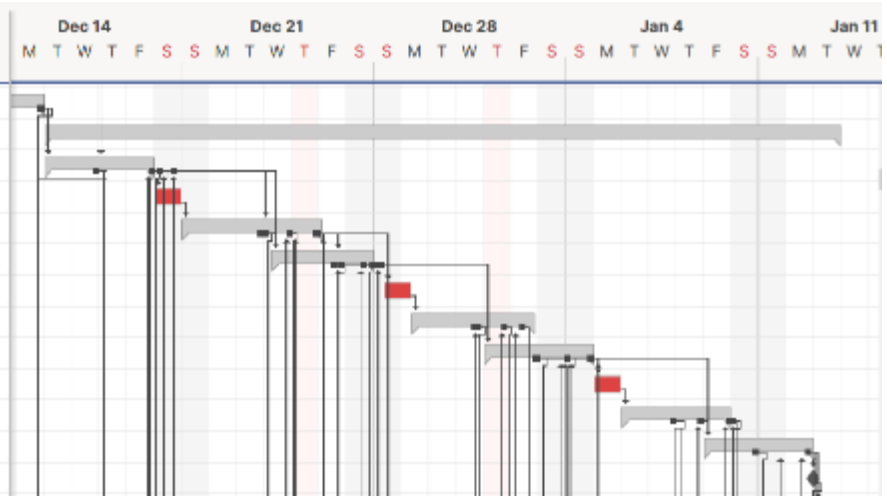


WBS	Task Name
1.2.8.7.9.3	**DRILL HOLE 2 / String 88**
1.2.8.7.9.3.1	Drill Hole 2 / String 88
1.2.8.7.9.3.2	Hole 2 Drilling Complete, Turn Over to Installation Team
1.2.8.7.9.3.3	Installation - Hole 2 / String 88 - Driller Supported
1.2.8.7.9.3.4	Relocate Hose, Cable Reels to Hole 3 / String 89
1.2.8.7.9.3.5	Heavy Support for Main Hose Reel Relocation to Hole 3 / String 89 (USAP)
1.2.8.7.9.3.6	Relocate Sensor Handling Structure to Hole 3 / String 89
1.2.8.7.9.3.7	Uncover Hole 4 / String 90
1.2.8.7.9.3.12	Prepare MCA (Mount on TU20, test slip ring) - Prep for Hole 4 / String 90
1.2.8.7.9.3.13	Heavy Support for Main Cable Loading - Hole 4 / String 90 (USAP)
1.2.8.7.9.3.8	Closeout & Relocate Tower & TOS2 to Hole 4 / String 90
1.2.8.7.9.3.9	Heavy Support to Relocate Tower & TOS2 to Hole 4 / String 90 (USAP)
1.2.8.7.9.3.10	Trench & Install Reel Anchors at Hole 4 / String 90
1.2.8.7.9.3.11	Trenching Support at Hole 4 / String 90 (USAP)
1.2.8.7.9.4	**DRILL HOLE 3 / String 89**
1.2.8.7.9.4.1	Drill Hole 3 / String 89
1.2.8.7.9.4.2	Hole 3 Drilling Complete, Turn Over to Installation Team
1.2.8.7.9.4.3	Installation - Hole 3 / String 89 - Driller Supported
1.2.8.7.9.4.4	Relocate Hose, Cable Reels to Hole 4 / String 90
1.2.8.7.9.4.5	Heavy Support for Main Hose Reel Relocation to Hole 4 / String 90 (USAP)
1.2.8.7.9.4.6	Relocate Sensor Handling Structure to Hole 4 / String 90
1.2.8.7.9.4.12	Prepare MCA (Mount on TU20, test slip ring) - Prep for Hole 5 / String 91
1.2.8.7.9.4.13	Heavy Support for Main Cable Loading - Hole 5 / String 91 (USAP)
1.2.8.7.9.4.7	Uncover Hole 5 / String 91
1.2.8.7.9.4.8	Closeout & Relocate Tower & TOS1 to Hole 5 / String 91
1.2.8.7.9.4.9	Heavy Support to Relocate Tower & TOS1 to Hole 5 / String 91 (USAP)
1.2.8.7.9.4.10	Trench & Install Reel Anchors at Hole 5 / String 91
1.2.8.7.9.4.11	Trenching Support at at Hole 5 / String 91 (USAP)
1.2.8.7.9.5	Operational Debrief / Drill Maintenance
1.2.8.7.9.6	**DRILL HOLE 4 / String 90**

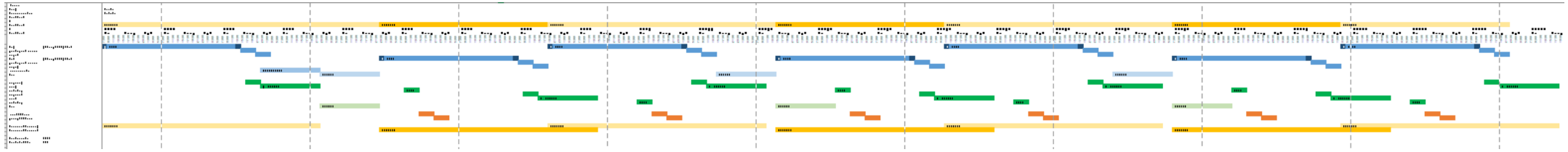
Field Season 3 – High Level Drill Cadence

<u>SmartSheets Schedule</u>
Drilling Start: 12/15
Install End: 1/13
Includes days off
Overall duration: 28.3 days

WBS	Task Name	Start Date	End Date
1.2.8.7.8	EHWD: Drill Commissioning	11/25/25	12/15/25
1.2.8.7.9	Deep Drilling FS3	12/15/25	01/13/26
1.2.8.7.9.1	DRILL HOLE 1 / String 87	12/15/25	12/20/25
1.2.8.7.9.2	Operational Debrief/Drill Maintenance	12/20/25	12/21/25
1.2.8.7.9.3	DRILL HOLE 2 / String 88	12/21/25	12/26/25
1.2.8.7.9.4	DRILL HOLE 3 / String 89	12/24/25	12/28/25
1.2.8.7.9.5	Operational Debrief / Drill Maintenance	12/28/25	12/29/25
1.2.8.7.9.6	DRILL HOLE 4 / String 90	12/29/25	01/02/26
1.2.8.7.9.7	DRILL HOLE 5 / String 91	01/01/26	01/05/26
1.2.8.7.9.8	Operational Debrief	01/05/26	01/06/26
1.2.8.7.9.9	DRILL HOLE 6 / String 92	01/06/26	01/10/26
1.2.8.7.9.10	DRILL HOLE 7 / String 93	01/08/26	01/13/26
1.2.8.7.9.11	Drilling & Installation Complete	01/13/26	01/13/26



<u>Independent Detailed Exercise</u>
“Nominal” schedule
Includes days off
Overall duration: 24.6 days



Schedule currently has overall drilling duration ~15% longer than nominal

Continuing to work on increasing this as much as possible

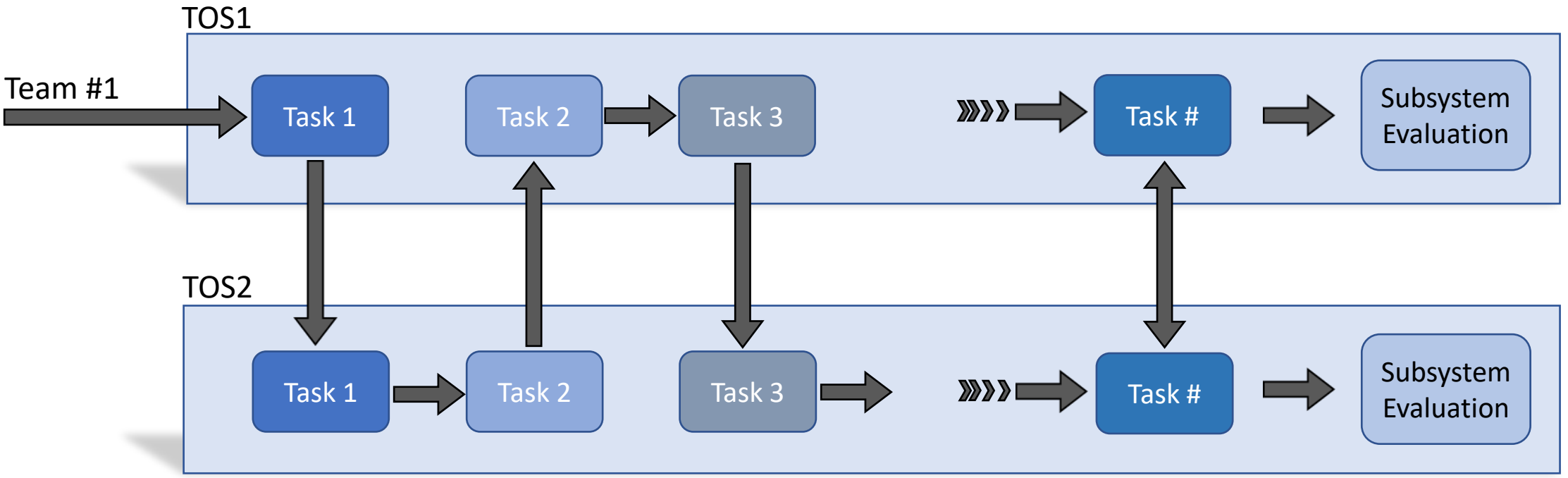
Field Seasons

Questions?

FS1 Workflow Diagrams

April 2022

Workflow Diagrams

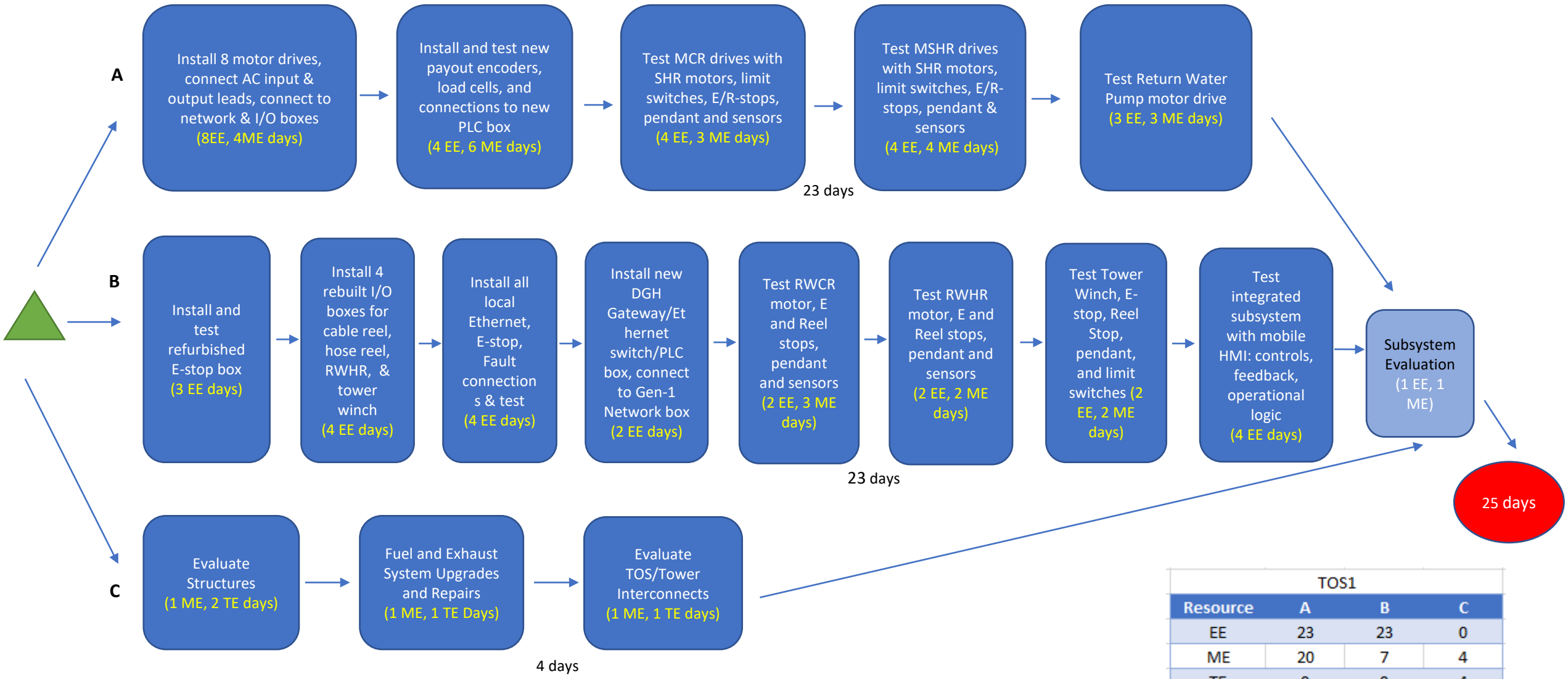


Tower Operation Site buildup

- (3) Teams working independently and concurrently
- Alternating between TOS1 & TOS2 allows teams to share limited workspaces

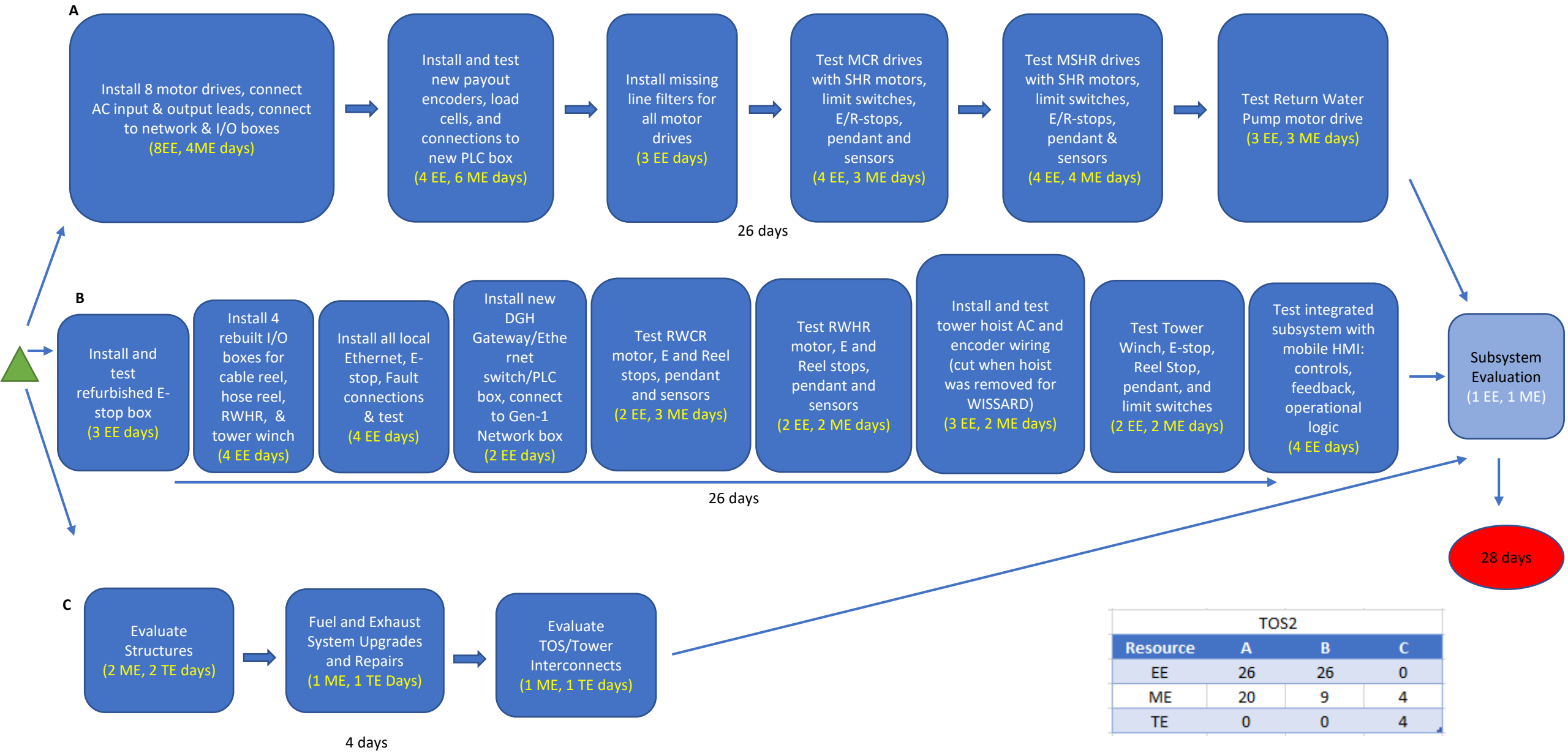
Team #	Task 1	Starting Location
1	Install Motor Drives	TOS1
2	Install Estop Box	TOS2
3	Evaluate Structure	TOS1

TOS1



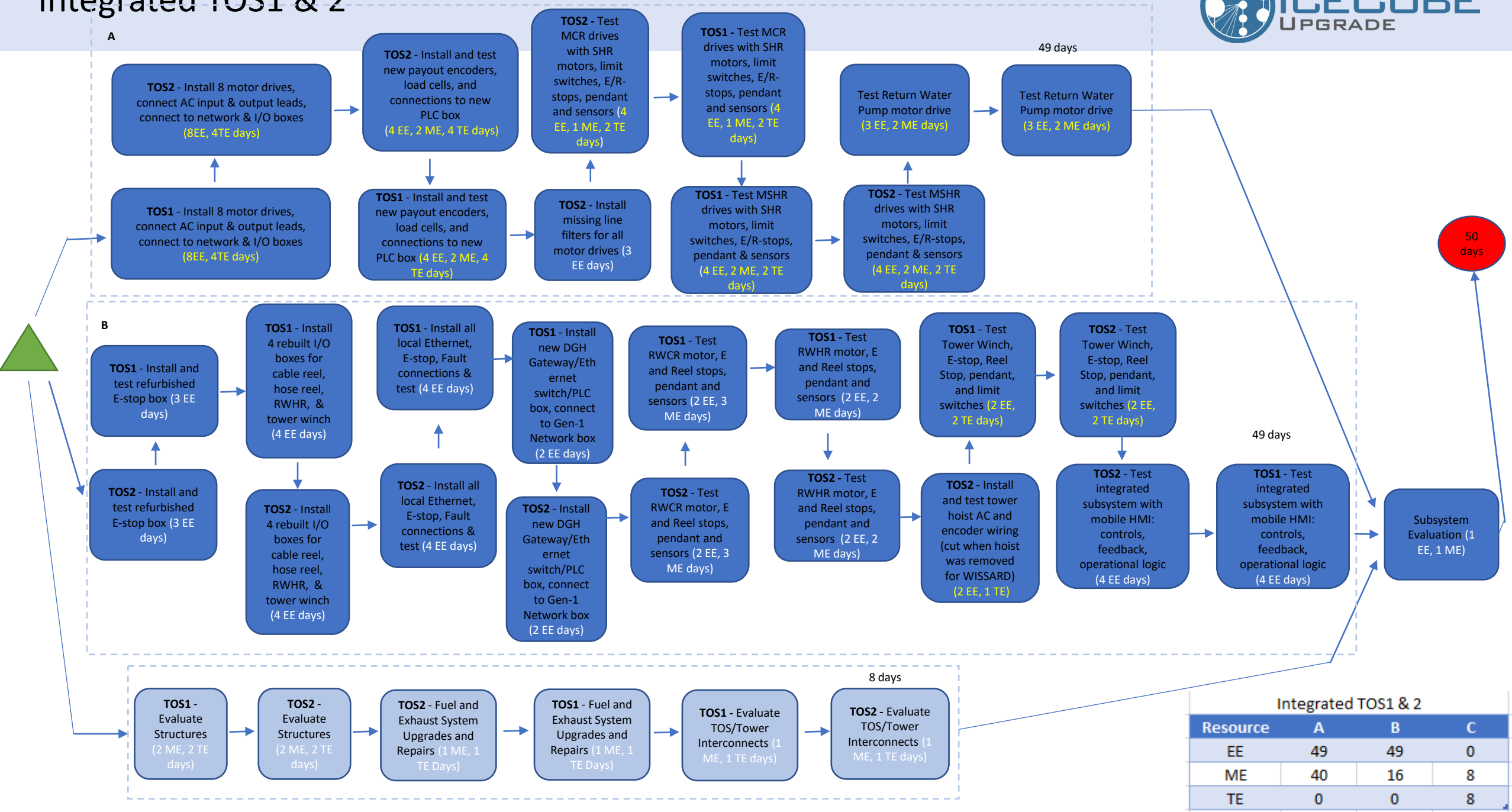
TOS1			
Resource	A	B	C
EE	23	23	0
ME	20	7	4
TE	0	0	4

TOS2



TOS2			
Resource	A	B	C
EE	26	26	0
ME	20	9	4
TE	0	0	4

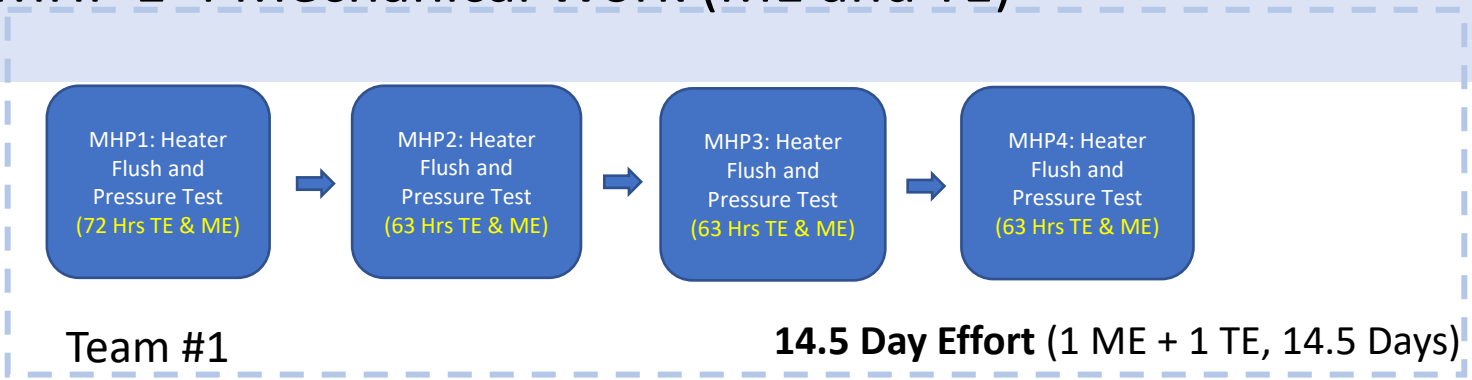
Integrated TOS1 & 2

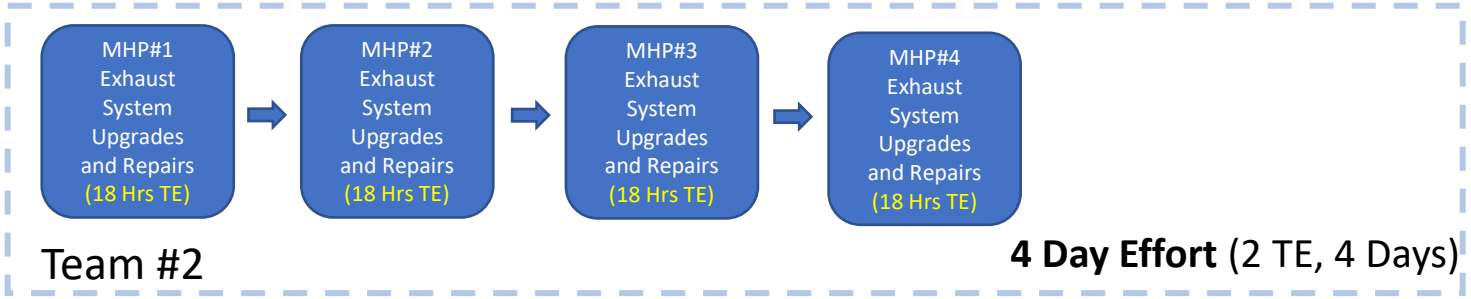


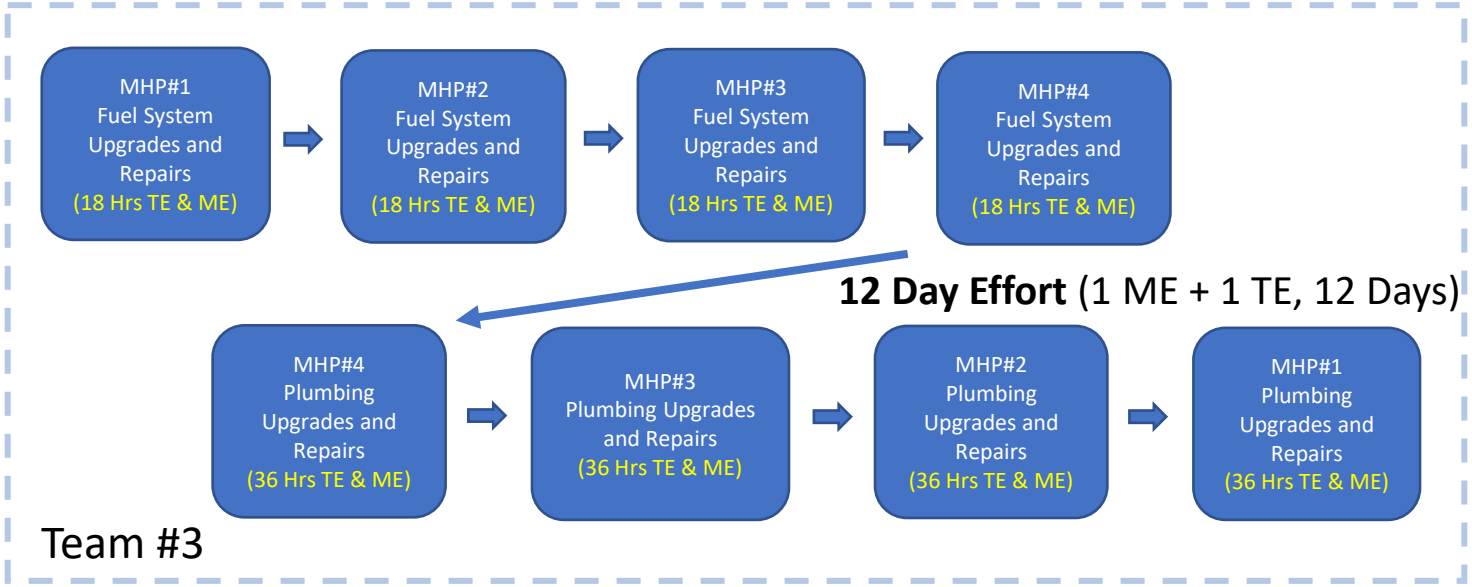
Integrated TOS1 & 2

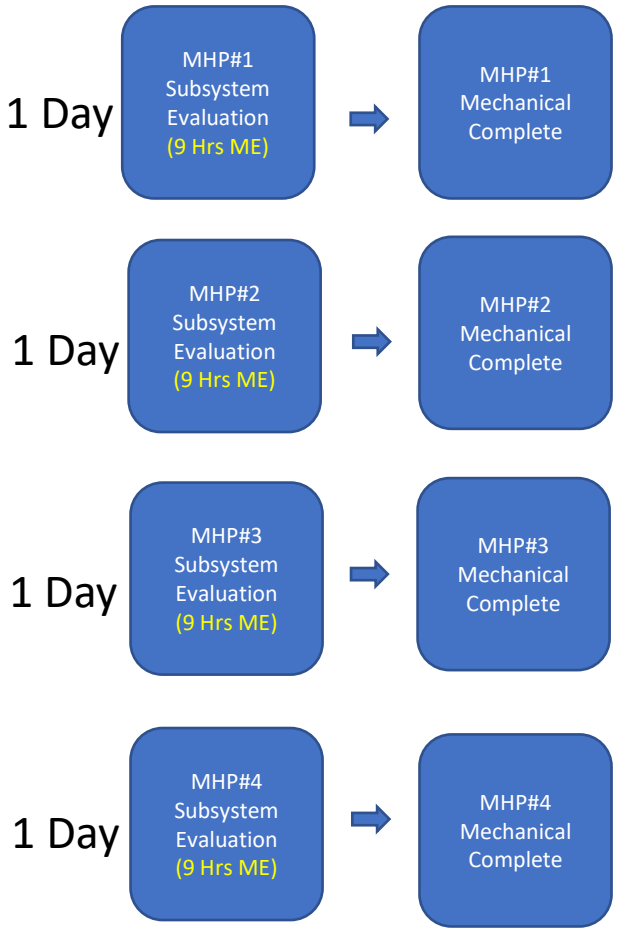
Resource	A	B	C
EE	49	49	0
ME	40	16	8
TE	0	0	8

MHP 1-4 Mechanical Work (ME and TE)









MHP 1-4 Mech	585 HRS TOTAL
ME + TE	585

MHP 1-4 EE Work

MHP4: Install PLC-to-DGH Gateway in Network Box, Install M-DGHs, & Test (9 Hrs EE)

MHP3: Install PLC-to-DGH Gateway in Network Box, Install M-DGHs, & Test (9 Hrs EE)

MHP2: Install PLC-to-DGH Gateway in Network Box, Install M-DGHs, & Test (9 Hrs EE)

MHP1: Install PLC-to-DGH Gateway in Network Box, Install M-DGHs, & Test (9 Hrs EE)

MHP1: Reconfigure MHP E-stop Panel to Function with N.C. Slap Switch Contacts (9 Hrs EE)

Green Team: 8.5 Day Effort
(2EE 8.5 Days)
Gold Team: 12 Day Effort
(2EE 12 Days + 1ME 4 Days)

8.5 Day Effort (2EE, 8.5 Days)

MHP1: Test E-stop and Heater Controls with No Water (18 Hrs EE)

MHP2: Test E-stop and Heater Controls with No Water (18 Hrs EE)

MHP3: Test E-stop and Heater Controls with No Water (18 Hrs EE)

MHP4: Test E-stop and Heater Controls with No Water (18 Hrs EE)

MHP4: Install Ethernet Switch, Connect to Network Box, Route Cable to DCC & Test (9 Hrs EE)

MHP3: Install Ethernet Switch, Connect to Network Box, Route Cable to DCC & Test (9 Hrs EE)

MHP2: Install Ethernet Switch, Connect to Network Box, Route Cable to DCC & Test (9 Hrs EE)

MHP1: Install Ethernet Switch, Connect to Network Box, Route Cable to DCC & Test (9 Hrs EE)

Complete

MHP1: Install Refurbished Heater Control Assemblies on All Heaters (M-DGHs pre-installed) (27 Hrs EE) (9 Hrs ME)

MHP2: Install Refurbished Heater Control Assemblies on All Heaters (M-DGHs pre-installed) (27 Hrs EE) (9 Hrs ME)

MHP3: Install Refurbished Heater Control Assemblies on All Heaters (M-DGHs pre-installed) (27 Hrs EE) (9 Hrs ME)

MHP4: Install Refurbished Heater Control Assemblies on All Heaters (M-DGHs pre-installed) (27 Hrs EE) (9 Hrs ME)

MHP4: Replace Thermostats in Heaters & Test (18 Hrs EE)

MHP3: Replace Thermostats in Heaters & Test (18 Hrs EE)

MHP2: Replace Thermostats in Heaters & Test (18 Hrs EE)

MHP1: Replace Thermostats in Heaters & Test (18 Hrs EE)

12 Day Effort (2 EE 12 Days, 1 ME 4 Days)

MHP1: Test Flow Sensor Operation with No Water (9 Hrs EE)

MHP2: Test Flow Sensor Operation with No Water (9 Hrs EE)

MHP3: Test Flow Sensor Operation with No Water (9 Hrs EE)

MHP4: Test Flow Sensor Operation with No Water (9 Hrs EE)

Complete

MHP 1-4 EE Work	405 HRS TOTAL
EE	369
ME	36

ARA Drill Work

ARA Electrical

ARA Drill: White Gen Electrical Rework (9 Hrs EE, 9 Hrs TE)

ARA Drill: Install Control Interface Panel, Downhole Pump Controller, Ext. E-stop Slap, & Power up from Cryo (9 Hrs EE, 9 Hrs TE)

ARA Drill: ARA DCC Upgrades & Install (9 Hrs EE, 9 Hrs TE)

ARA Drill: Hose Reel Commissioning (18 Hrs EE)

ARA Drill: Global Controls & E-stop Testing (9 Hrs EE, 9 Hrs TE)

6 Day Effort (1 EE 6 Days, 1 TE 4 Days)

ARA Drill	423 HRS TOTAL
EE	63
ME	162
TE	198

ARA Mechanical

ARA Drill: Deliver ARA Drill To Cryo Worksite - Precommission (18 Hrs TE & ME)

ARA Drill (White Gen): Warm-up, Inspect Gen, Fill fluids, Install Fire Extinguisher, & Test-run with External Load (18 Hrs TE & ME)

ARA Drill (Sled 2): Warm-up & Inspect, Check HMW Sheets, & Tie-offs, Glycol Tank, Glycol Heater, Hoses & Connections (18 Hrs TE & ME)

ARA Drill: Install ePump, Accessories, & ePump Controller (DNF-requires power) (18 Hrs TE & ME)

ARA Drill: Checkout & Testing Sled 2 (18 Hrs TE & ME)

ARA Drill (Sled 3): Warm-up & Inspect Components, Install Stacks, Install Hoist, Top-off Fuel Tank, Reel Brake, Heat Trace (18 Hrs TE & ME)

ARA Drill: Plumbing Upgrades & Repairs (18 Hrs TE & ME)

ARA Drill: Hose Cable Bundle Replace (27 Hrs EE, TE & ME)

ARA Drill: Locate Components, Set-up Drillheads on Bench, Inspect, Sensor tests (18 Hrs TE & ME)

18 Day Effort (1 ME + 1 TE 18 Days, 1 EE 1 Day)

ARA Drill: Drillhead Chain Testing & Verification (18 Hrs TE & ME)

ARA Drill: System Commissioning Set-up Tasks & Global Tests (18 Hrs TE & ME)

ARA Drill: Hose Reel Commissioning (18 Hrs ME)

ARA Drill: Circulation Testing, w/ Glycol - Staged Approach (18 Hrs TE & ME)

ARA Drill: Heater Commissioning (18 Hrs TE & ME)

ARA Drill: System Testing in Test Well (18 Hrs TE & ME)

ARA Drill: Drain & Blow-out System (18 Hrs TE & ME)

ARA Drill: Remove and Store DNF Hardware (18 Hrs TE & ME)

ARA Drill: Tarp, Cover, & Plug (18 Hrs TE & ME)

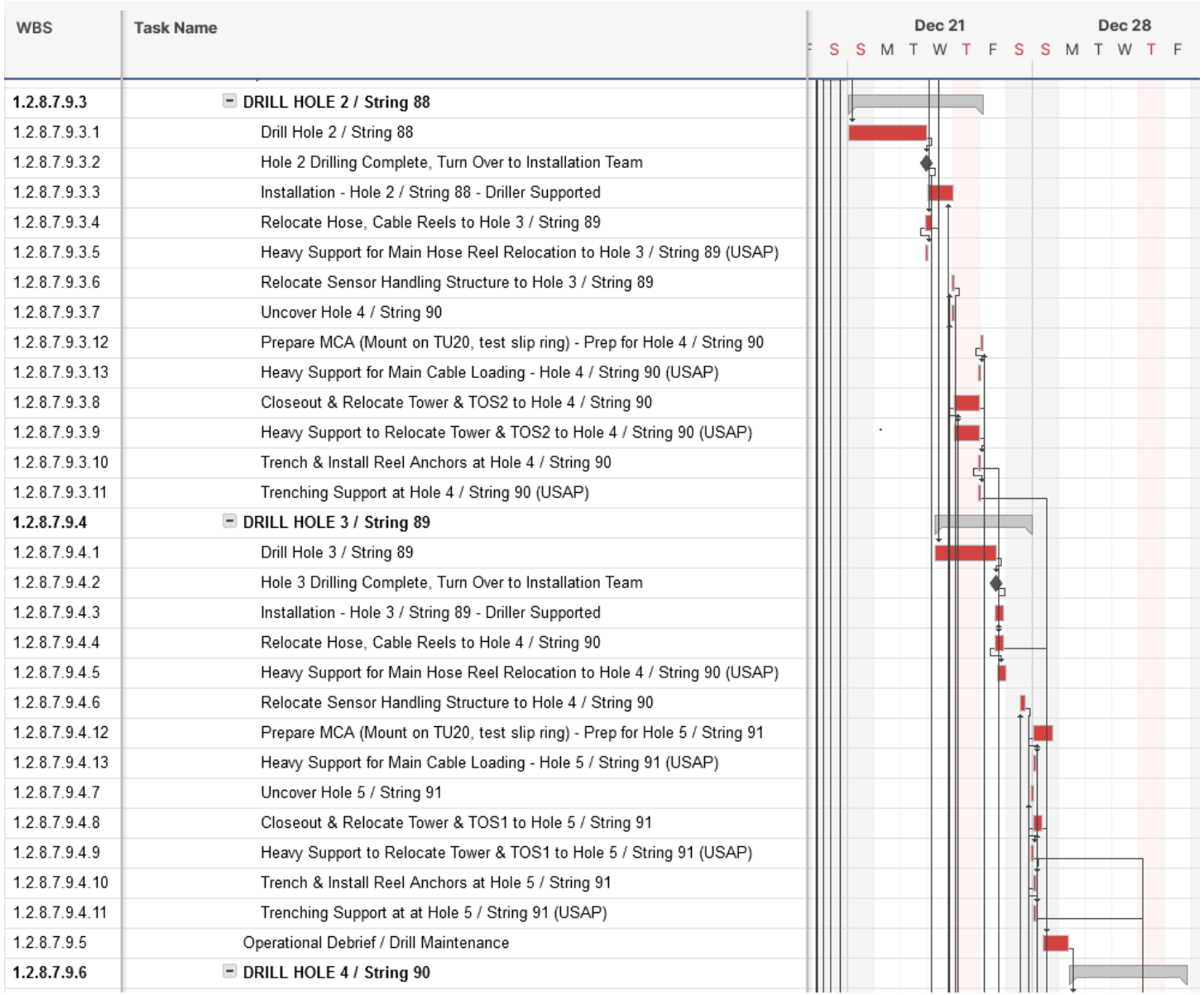
Field Season 2 – 2024/2025

Systems Integration and Test

Primary Electrical/Controls tasks

- Work to be completed at Seasonal Equipment Site
  - Prep site power, water, and fuel systems
    - Water Tank 1&2 – test controls
    - Fuel Tower – install new Point I/O, connect to DCC, and configure/troubleshoot
    - Generators and Power Distribution Module – integrate new generator into PDM controller & Point I/O
    - Load test generators using resistance heaters
  - Drill Control Center (DCC) & Tower Operations Site (TOS1 & TOS2)
    - Estop controllers install and test
    - Mount new motor drives in DCC
    - Computer and network components install and connected
    - Install core PLC and SCADA systems
    - Install and commission latest software for SCADA and Database
    - Connect & configure I/O and motor drives
    - Connect to Reels – test operation and perform QA checkout of controls
    - Connect to Drill Head – test data chain
  - Install remaining system interconnects
  - Integrate all subsystems into fully functioning Enhanced Hot Water Drill (EHWD)
- System Operation
  - Readiness Review, Safety Refresher, Emergency & Safety Systems Tested
  - Full System Wet Test with Drill in Rodwell location
  - Complete and demonstrate full controls system capability – thorough QA checkout procedure

Field Season 3 – Schedule Example



WBS	Task Name
1.2.8.7.9.3	**DRILL HOLE 2 / String 88**
1.2.8.7.9.3.1	Drill Hole 2 / String 88
1.2.8.7.9.3.2	Hole 2 Drilling Complete, Turn Over to Installation Team
1.2.8.7.9.3.3	Installation - Hole 2 / String 88 - Driller Supported
1.2.8.7.9.3.4	Relocate Hose, Cable Reels to Hole 3 / String 89
1.2.8.7.9.3.5	Heavy Support for Main Hose Reel Relocation to Hole 3 / String 89 (USAP)
1.2.8.7.9.3.6	Relocate Sensor Handling Structure to Hole 3 / String 89
1.2.8.7.9.3.7	Uncover Hole 4 / String 90
1.2.8.7.9.3.12	Prepare MCA (Mount on TU20, test slip ring) - Prep for Hole 4 / String 90
1.2.8.7.9.3.13	Heavy Support for Main Cable Loading - Hole 4 / String 90 (USAP)
1.2.8.7.9.3.8	Closeout & Relocate Tower & TOS2 to Hole 4 / String 90
1.2.8.7.9.3.9	Heavy Support to Relocate Tower & TOS2 to Hole 4 / String 90 (USAP)
1.2.8.7.9.3.10	Trench & Install Reel Anchors at Hole 4 / String 90
1.2.8.7.9.3.11	Trenching Support at Hole 4 / String 90 (USAP)
1.2.8.7.9.4	**DRILL HOLE 3 / String 89**
1.2.8.7.9.4.1	Drill Hole 3 / String 89
1.2.8.7.9.4.2	Hole 3 Drilling Complete, Turn Over to Installation Team
1.2.8.7.9.4.3	Installation - Hole 3 / String 89 - Driller Supported
1.2.8.7.9.4.4	Relocate Hose, Cable Reels to Hole 4 / String 90
1.2.8.7.9.4.5	Heavy Support for Main Hose Reel Relocation to Hole 4 / String 90 (USAP)
1.2.8.7.9.4.6	Relocate Sensor Handling Structure to Hole 4 / String 90
1.2.8.7.9.4.12	Prepare MCA (Mount on TU20, test slip ring) - Prep for Hole 5 / String 91
1.2.8.7.9.4.13	Heavy Support for Main Cable Loading - Hole 5 / String 91 (USAP)
1.2.8.7.9.4.7	Uncover Hole 5 / String 91
1.2.8.7.9.4.8	Closeout & Relocate Tower & TOS1 to Hole 5 / String 91
1.2.8.7.9.4.9	Heavy Support to Relocate Tower & TOS1 to Hole 5 / String 91 (USAP)
1.2.8.7.9.4.10	Trench & Install Reel Anchors at Hole 5 / String 91
1.2.8.7.9.4.11	Trenching Support at at Hole 5 / String 91 (USAP)
1.2.8.7.9.5	Operational Debrief / Drill Maintenance
1.2.8.7.9.6	**DRILL HOLE 4 / String 90**