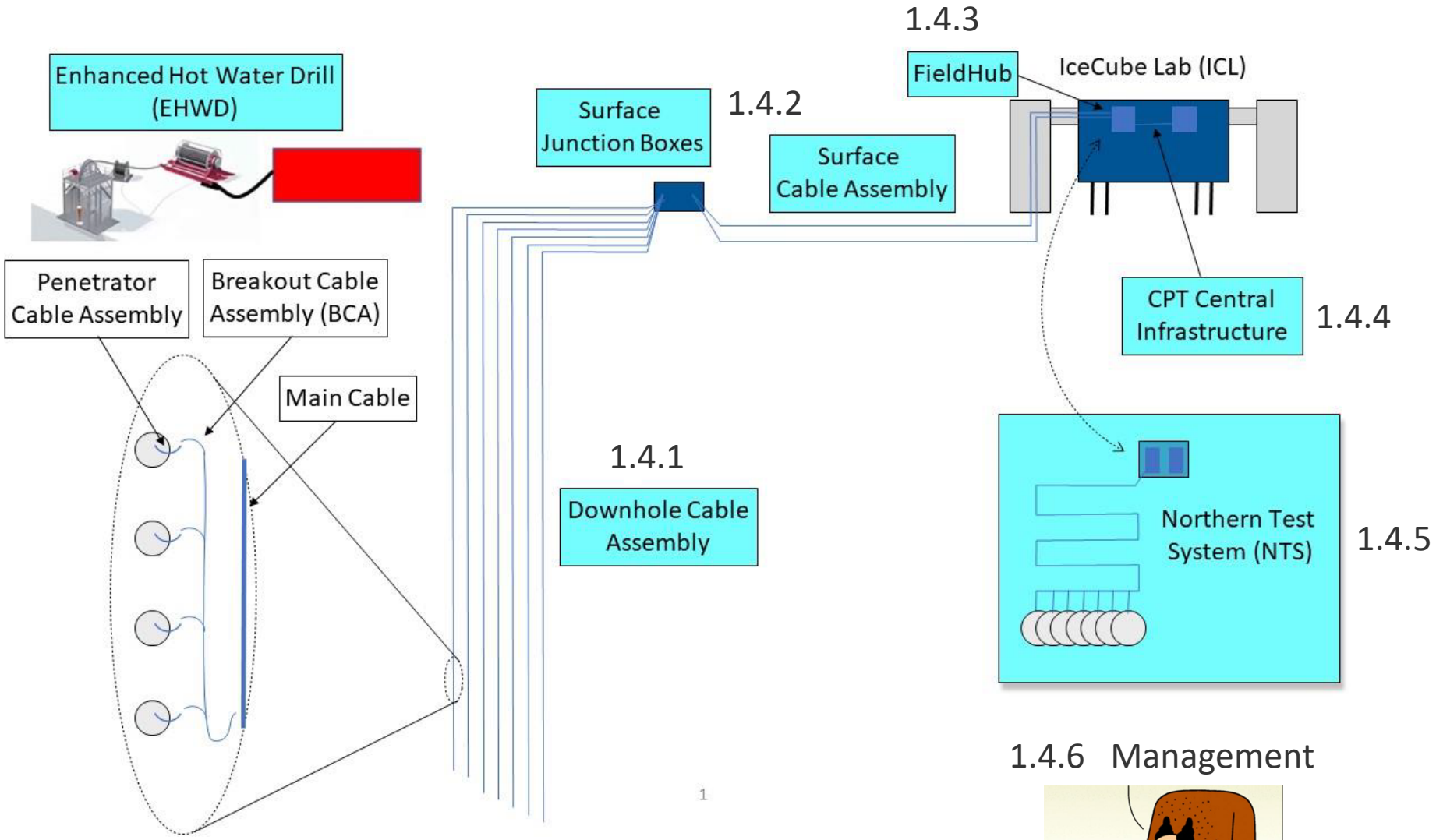
IceCube Upgrade Rebaseline Review
April 26-28, 2022

Tyce DeYoung
WBS 1.4 Comms/Power/Timing (CPT) Systems

Brief Bio – Tyce DeYoung

- Michigan State U. professor
- L2 for CPT Systems and co-PI of NSF award
- Previous experience:
  - Grad student on AMANDA (IceCube predecessor), involved in IceCube since 2003
  - L3 lead for AMANDA-IceCube Integration during IceCube construction MREFC
  - Lead for online data systems during HAWC construction

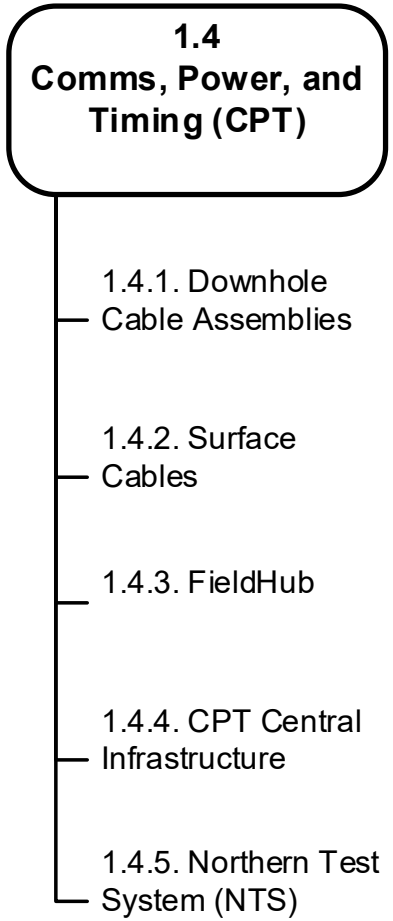
1.4 CPT area



1.4.6 Management

L3 Team

- 1.4.1: Chris Ng, MSU mechanical engineer
  - Prior experience on SNOLab projects, part of IceCube Upgrade since the beginning
- 1.4.2: John Kelley, UW senior scientist
  - IceCube detector operations manager, long experience on IceCube and AMANDA
- 1.4.3: Kalle Sulanke, DESY electrical engineer
  - Prior experience on electronics design for IceCube
  - Also owns the Ice Comms Module (on-board DOM main board electronics interface to FieldHubs)
- 1.4.4: John Kelley
- 1.4.5: Rob Halliday, MSU postdoc
  - Electronics expert, prior experience on Pierre Auger DAQ



Deliverables

- Main Cable Assemblies (7, no spares)
- Breakout Cable Assemblies (150 + 22 spares)
- Penetrator Cable Assemblies (879 + 127 spares*)
- PCA connector kits (1,081 + 39 spares*)
- SPAT Cables (2 + 1 spare)
- Surface Cable Assemblies (7, no spares)
- Surface Junction Boxes (7, no spares)
- ICL patch cables (174 + 15 spares)
- Mini-FieldHubs (29 + 1 spare**)
- FieldHubs (11 + 4 spares)
- Timing Monitoring systems (2 + 1 spare)
- Timing Distribution switches/nodes (2/14 + 2/6 spares)
- Power Supply Chassis/Modules (4/20 + 3/15 spares)
- Power Distribution units (2 + 2 spares)
- Power Control units (2 + 2 spares)

* Includes only unallocated spares; additional spares are held at specific institutions
** Peak requirement; units are returned to supply of spares as tasks are completed

Current Technical Status and Work to Go

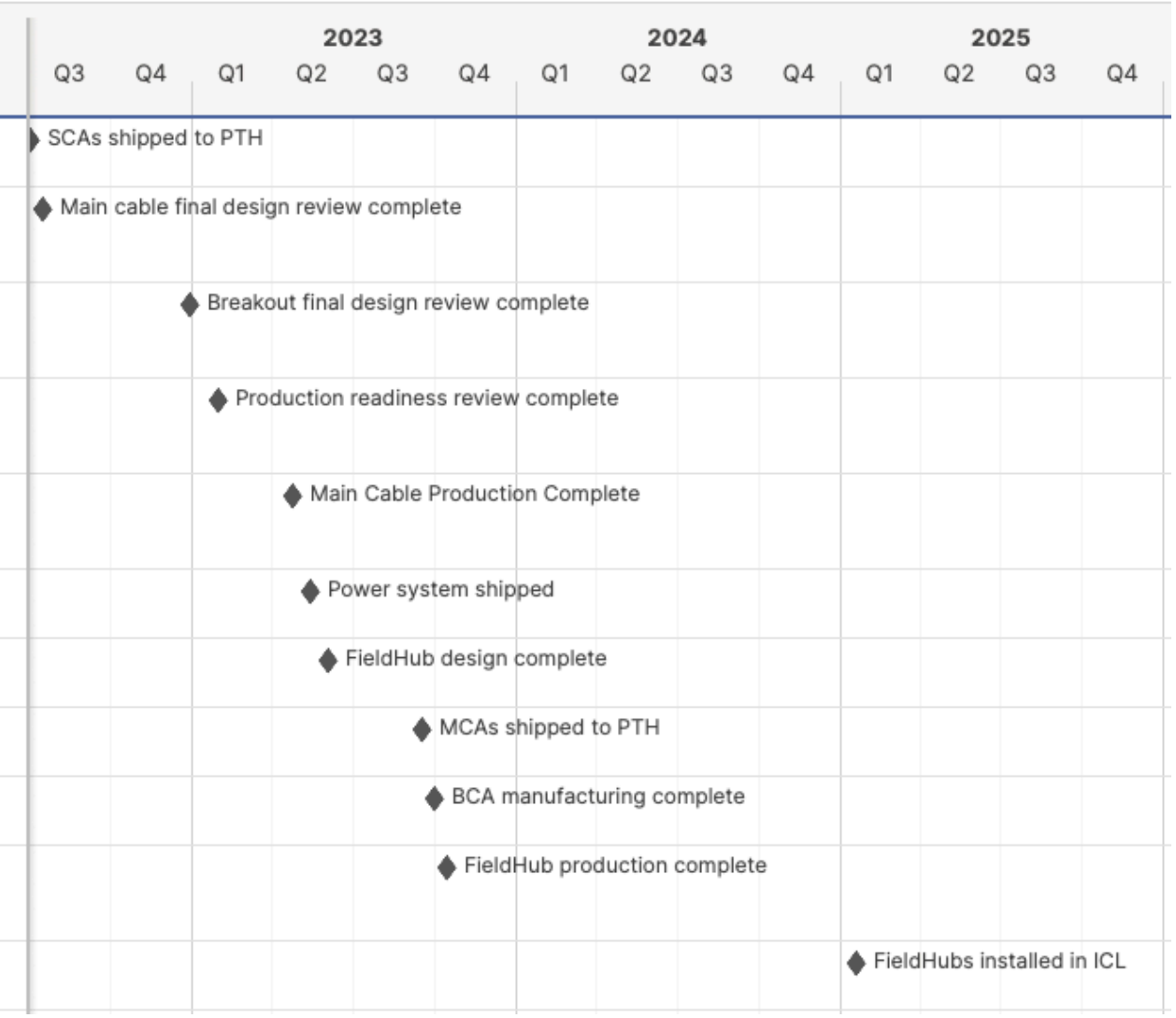
- Mini-FieldHubs, penetrators, NTS: essentially complete
- Surface cables: 2 complete, tested; waiting on backordered milspec connectors
  - Promised for April, >5 months schedule float for Nov. delivery to Pt. Hueneme
- FieldHubs: rev1 in production, design mature but several iterations planned
  - Potentially exposed to chip supply constraints, but a design iteration could be eliminated
- Timing system: design mature, based on commercial White Rabbit solution
  - Some concerns about chip supply, alternative fanout designs identified
- Power system: concerns about ICL circuit layout, mDOM consumption
  - Initiating redesign for lower density/higher voltage and capacity
- Main Cables: prototype from Hexatronic (Gen1 supplier) in production now
  - Assuming tests satisfactory, need to identify a supplier for breakout connections (have preliminary bids from two companies, in discussions with others)
  - Two potential alternatives for main cable, but costs are higher and performance uncertain. Prototype from one alternate supplier in production
- Breakout cable assemblies: RFI issued, preliminary designs received from suppliers, no significant technical issues expected

Interfaces

- Surface to DOM cables (connectors)
  - PCA – BCA: custom Hydro Group Systems connectors (already purchased)
  - BCA – MCA: TBD pending MCA final design / supplier selection
  - MCA – SJB – SCA – ICL patch panel: Amphenol milspec MS3114/ MS3116 connectors
  - ICL patch panel – FieldHub: DSub9
- FieldHub-DOM comms interface: via Surface Comms Module firmware
- FieldHub – DOM power system: 12AWG cable with Bulgin 3-pin connector
- FieldHub – timing system: White Rabbit over simplex single-mode ST/UPC fiber
- FieldHub – DAQ: via Ethernet through White Rabbit switch
- FieldHub monitoring/reset: Ethernet (PoE) over RJ45

L2 Milestones

Primary	WBS
SCAs shipped to PTH	1.4.2.1.9
Main cable final design review complete	1.4.1.1.1.2.5
Breakout final design review complete	1.4.1.1.2.2.5
Production readiness review complete	1.4.1.1.1.3.3.1
Main Cable Production Complete	1.4.1.1.1.3.5
Power system shipped	1.4.4.2.4.5
FieldHub design complete	1.4.3.1.1.11
MCAs shipped to PTH	1.4.1.1.3.5
BCA manufacturing complete	1.4.1.2.4.3
FieldHub production complete	1.4.3.1.2.5
FieldHubs installed in ICL	1.4.3.1.2.9



On-Project Cost and Main Cost Drivers, PY5-PY8

Total Cost: $1,147,559

Cost (k$)	Element	Notes
353	Breakout cable assemblies	Incl. $235k (est.) of equipment
168	Deployment and on-ice labor	FS2 and FS3
146	Management	
118	Timing systems	Incl. $29k of equipment
113	Main cable assemblies	Breakout final design, procurement. Capital costs are an in-kind commitment from MSU
109	Power systems	Incl. $60k (est.) of equipment. Not fully re-costed after retiring redesign risk ORG9
101	ICL patch cables and panels	
1,108		

Main Risks

- **TECH40 Alternate Main Cable**: Hexatronic main cable is not satisfactory/new supplier is required. Project funds are required to supplement MSU commitment due to higher costs. Hexatronic prototype in production, will be tested shortly.
- **TECH38 Main Cable strength member needed**: Add a separate rope to relieve the mechanical load on the main cable. Requires co-deployment on separate winches, similar to drill ops. Additional equipment and engineering labor (tune load-balancing) required.
- **TECH52 Breakout costs**: Project funds are required to supplement MSU commitment to purchase Main Cable Assemblies. Working with several potential suppliers to foster competition, reduce costs
- **EXT15 Main Cable delay**: Main Cable Assembly production is not complete in time for shipment on FY24 vessel. Requires shift to FY25 vessel, which remains consistent with planned SPOT transit to South Pole. *Availability of space on FY25 vessel uncertain*.
- **ORG9: DOM power limit**: Redesign power supply system to accommodate higher voltage power supplies with lower rack density. Due to high probability of occurrence, we have decided to initiate the redesign and accept schedule delay in this area. Additional CapEx costs are nearly balanced by reduced labor for monitoring system.
- **EXT13 FieldHub delay**: parts availability issues cause delays in rev2/3 FieldHub prototyping. Requires elimination of one prototyping cycle before entering production. Unlikely to have technical impact.

Conclusion

- Changing supplier landscape and supply chain disruptions made cable procurement more challenging and slower than expected
  - Penetrator cable procurement is complete
  - Surface cable assembly production nearly complete
  - Main cable design and procurement is (finally) nearing completion
  - Breakout cable assemblies are typical subsea products – no major technical issues
- Electronics development is progressing well
  - Power system redesign is required to increase delivered power capacity, but most components will be commercial off-the-shelf
  - Considerable experience from IceCube with readout and timing electronics
- CPT effort begins ramping down soon
  - Most off-ice on-project activities will be completed by the end of PY5