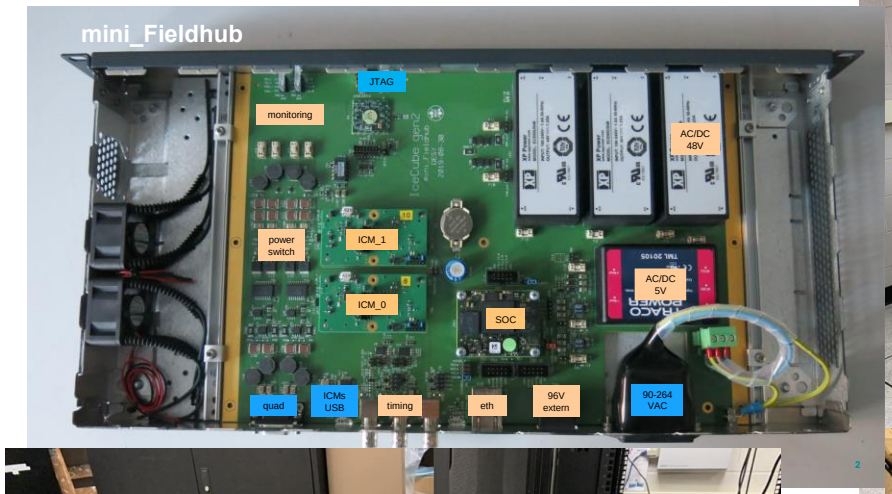
# IceCube Upgrade Rebaseline Review
April 26-28, 2022

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

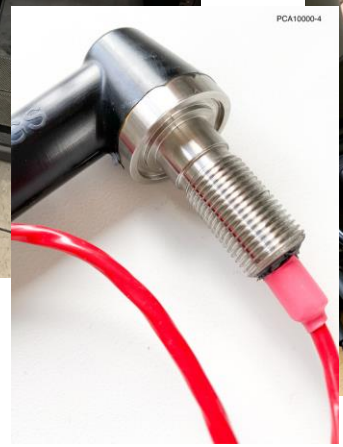
# Overview of Work to Go

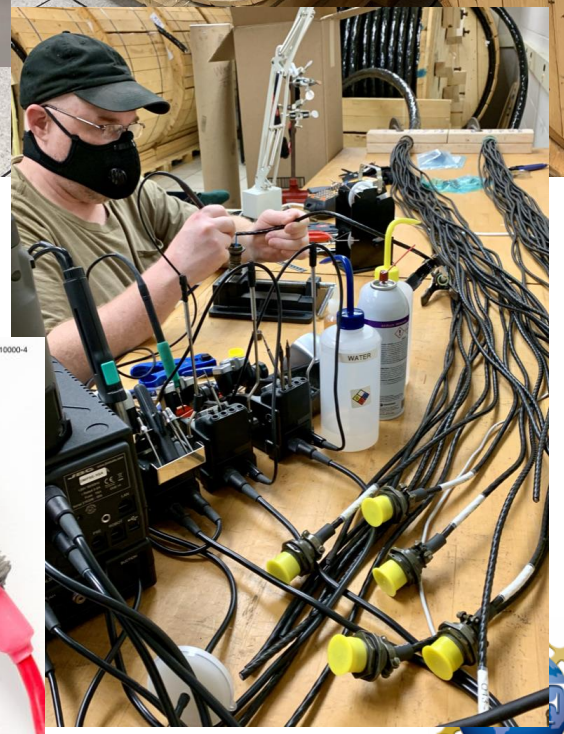
- Essentially complete (finished in PY4):
  - Penetrators
  - Surface cable assemblies
  - Cable load emulators
  - Northern Test System

- Mostly complete (need inputs to final design):
  - Surface junction boxes
  - ICL patch cabling









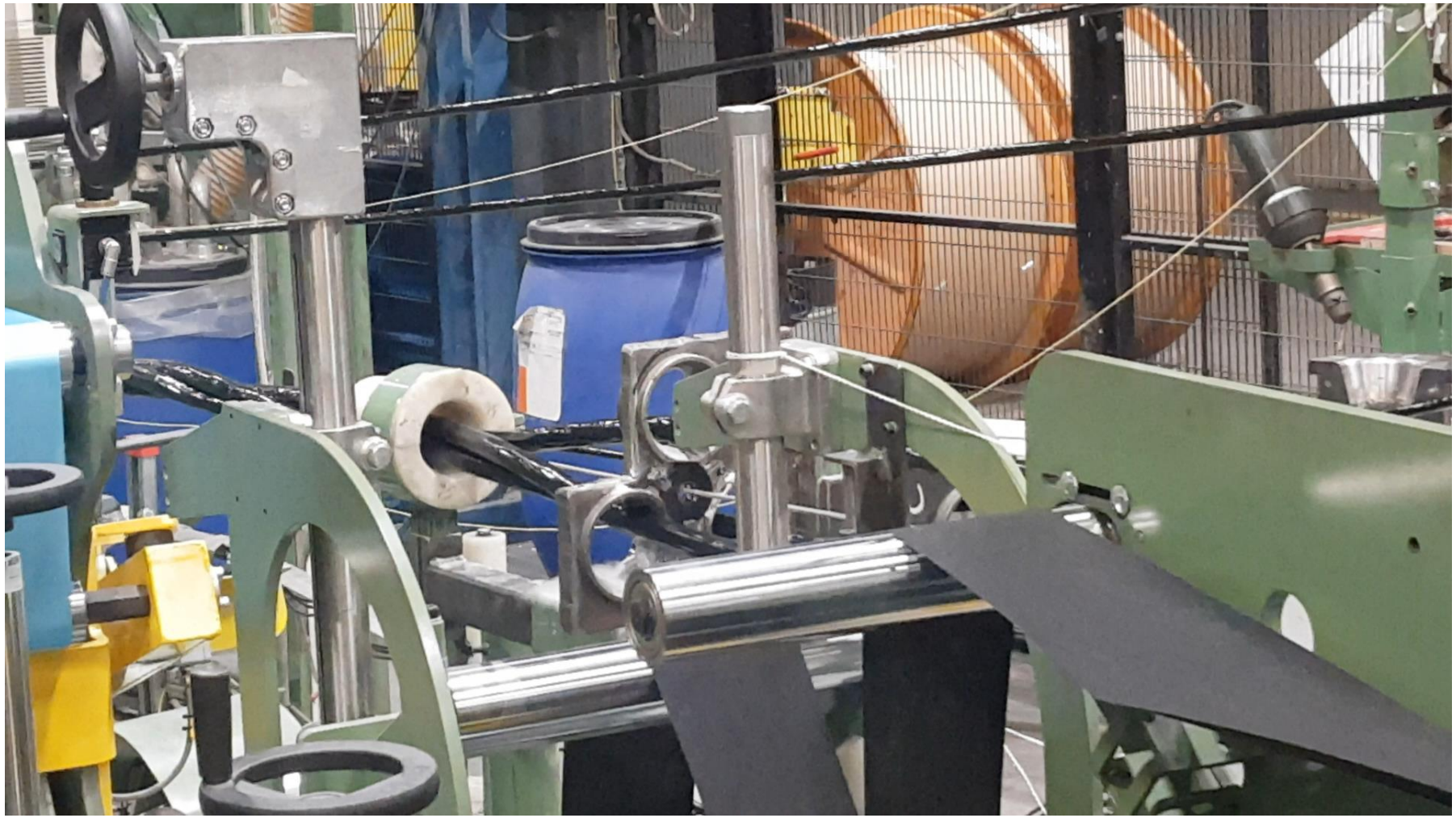
# Overview of Work to Go

- Significant effort remaining:
  - Main Cable Assemblies – cable design nearly complete, breakout connection design beginning
  - Breakout Cable Assemblies – preliminary designs
  - FieldHubs (surface readout electronics) – prototype under evaluation
  - Power systems – redesign initiated
  - Timing systems – preliminary design, based on IceCube surface array system

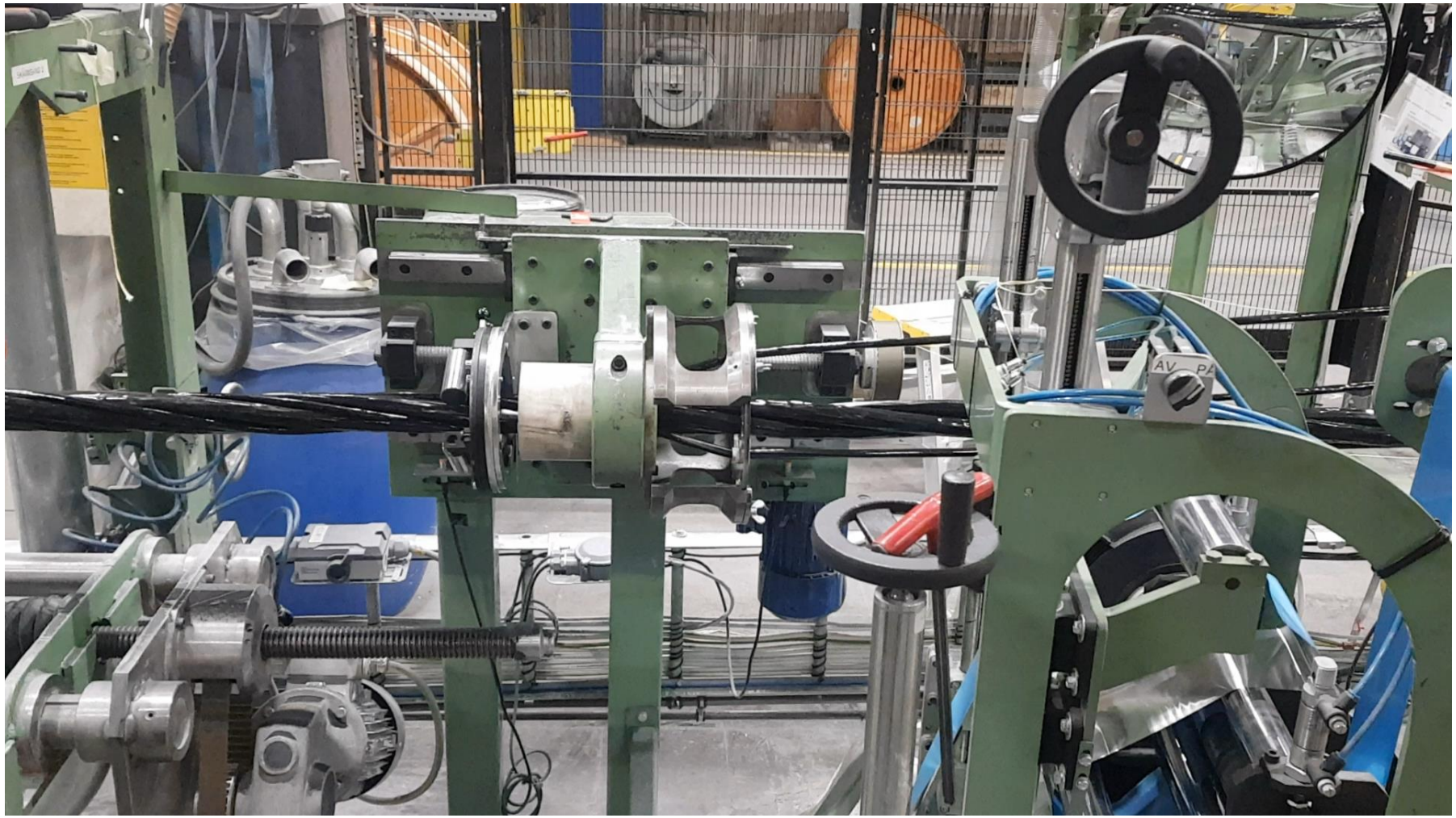
# Main Cable Assemblies (Plan A)

- Prototype cable from Hexatronic (Gen1 supplier) in production
  - Electrical performance validated – indistinguishable from Gen1 quads
  - Novel composite cable design, assembled in partnership with NKT in Falun, Sweden
  - Working closely with University of Uppsala (in-kind contribution)

# Winding primary sub-components (signal cables)



# Winding primaries with auxiliary quads



# Controlling torsion during winding

# Fully-wound cable ready for outer mantle

# Main Cable Assemblies (Plan A)

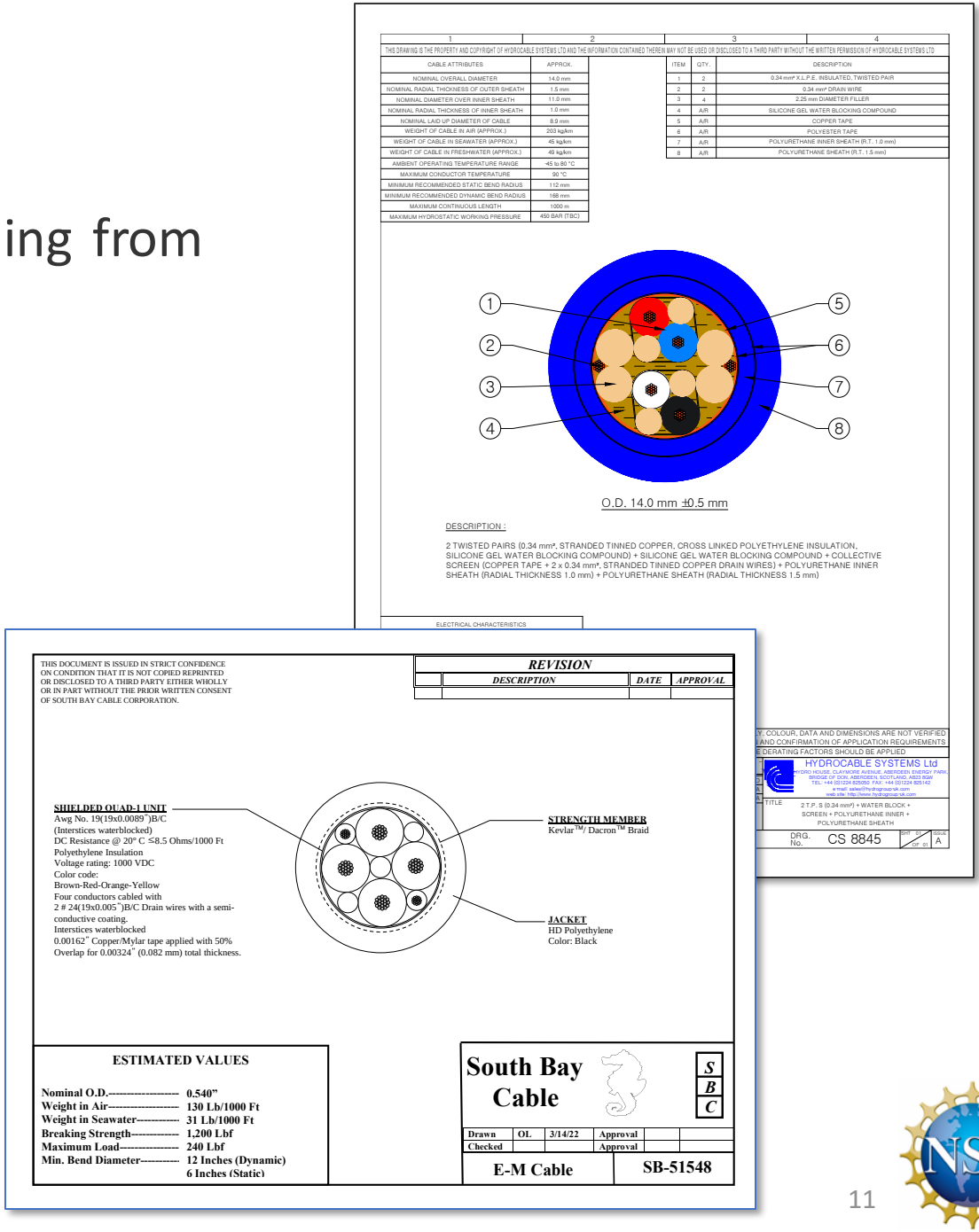
- Prototype cable from Hexatronic (Gen1 supplier) in production
  - Electrical performance validated – indistinguishable from Gen1 quads
  - Novel composite cable design, assembled in partnership with NKT in Falun, Sweden
  - Working closely with University of Uppsala (in-kind contribution)
- Pull test planned in next weeks to qualify raw cable mechanically (risk TECH38)
  - Confirm that subcomponents do not undergo relative motion under load
  - Load is applied via compressive cable grip, ensuring good frictional coupling between components…but need to test in real life
- Then select company to install breakout connectors
  - Discussions underway with subsea cable suppliers (JDR, Hydro Group, Fibron, South Bay)
  - Need to work on reducing costs
  - Samples of prototype main cable will reduce uncertainties for suppliers and facilitate finalization of design, including cost engineering
  - This work can proceed in parallel to production of raw main cables

# Main Cable Assemblies (Plans B-D)

- Plan B: test cable from alternate supplier (Fibron) also in production
  - Full-length three-quad cable for evaluation of electrical properties/comms bandwidth
  - Scheduled delivery to MSU in mid-June
  - Would be used in NTS if Fibron is selected as MCA supplier
- Traditional cable design, essentially identical to Gen1 cables from Ericsson
- Fibron would also install breakouts, deliver completed product
- Based on costs of test cable, we expect cable costs to be around twice what Hexatronic is charging us (risk TECH40)
  - Likely to exceed MSU commitment, require financial support from project
  - Comms bandwidth expected to be lower than Hexatronic cable (TBD – risk TECH45)
- Plans C&D: bid recently received from JDR; South Bay is working on another
  - Similar cost/performance concerns as for Fibron, and additional delays to obtain sample cable for qualification (around 6 months)

# Breakout Cable Assemblies

- Shorter auxiliary one-to-several cable running from Main Cable to DOMs and instruments
  - Coupled to Main Cable design
- Preliminary designs received from several companies, others expected soon
- Iterating with cable, installation teams toward a preliminary design review in late spring
- Order and test prototype(s) leading into final design review this winter
  - Production in 2023



| CABLE ATTRIBUTES | APPROX. |
|---|---|
| NOMINAL OVERALL DIAMETER | 14.0 mm |
| NOMINAL RADIAL THICKNESS OF OUTER SHEATH | 1.5 mm |
| NOMINAL DIAMETER OVER INNER SHEATH | 11.0 mm |
| NOMINAL RADIAL THICKNESS OF INNER SHEATH | 1.0 mm |
| NOMINAL LAID UP DIAMETER OF CABLE | 8.9 mm |
| WEIGHT OF CABLE IN AIR (APPROX.) | 203 kg/km |
| WEIGHT OF CABLE IN SEAWATER (APPROX.) | 45 kg/km |
| WEIGHT OF CABLE IN FRESHWATER (APPROX.) | 49 kg/km |
| AMBIENT OPERATING TEMPERATURE RANGE | -45 to 80 °C |
| MAXIMUM CONDUCTOR TEMPERATURE | 90 °C |
| MINIMUM RECOMMENDED STATIC BEND RADIUS | 112 mm |
| MINIMUM RECOMMENDED DYNAMIC BEND RADIUS | 168 mm |
| MAXIMUM CONTINUOUS LENGTH | 1000 m |
| MAXIMUM HYDROSTATIC WORKING PRESSURE | 450 BAR (TBC) |

| ITEM | QTY. | DESCRIPTION |
|---|---|---|
| 1 | 2 | 0.34 mm² X.L.P.E. INSULATED, TWISTED PAIR |
| 2 | 2 | 0.34 mm² DRAIN WIRE |
| 3 | 4 | 2.25 mm DIAMETER FILLER |
| 4 | A/R | SILICONE GEL WATER BLOCKING COMPOUND |
| 5 | A/R | COPPER TAPE |
| 6 | A/R | POLYESTER TAPE |
| 7 | A/R | POLYURETHANE INNER SHEATH (R.T. 1.0 mm) |
| 8 | A/R | POLYURETHANE SHEATH (R.T. 1.5 mm) |

O.D. 14.0 mm ±0.5 mm

DESCRIPTION :

2 TWISTED PAIRS (0.34 mm², STRANDED TINNED COPPER, CROSS LINKED POLYETHYLENE INSULATION, SILICONE GEL WATER BLOCKING COMPOUND) + SILICONE GEL WATER BLOCKING COMPOUND + COLLECTIVE SCREEN (COPPER TAPE + 2 x 0.34 mm², STRANDED TINNED COPPER DRAIN WIRES) + POLYURETHANE INNER SHEATH (RADIAL THICKNESS 1.0 mm) + POLYURETHANE SHEATH (RADIAL THICKNESS 1.5 mm)

ELECTRICAL CHARACTERISTICS

THIS DOCUMENT IS ISSUED IN STRICT CONFIDENCE ON CONDITION THAT IT IS NOT COPIED REPRINTED OR DISCLOSED TO A THIRD PARTY EITHER WHOLLY OR IN PART WITHOUT THE PRIOR WRITTEN CONSENT OF SOUTH BAY CABLE CORPORATION.

| REVISION | | | |
|---|---|---|---|
| | DESCRIPTION | DATE | APPROVAL |

**SHIELDED QUAD-1 UNIT**
Awg No. 19(19x0.0089")B/C
(Interstices waterblocked)
DC Resistance @ 20° C ≤8.5 Ohms/1000 Ft
Polyethylene Insulation
Voltage rating: 1000 VDC
Color code:
Brown-Red-Orange-Yellow
Four conductors cabled with
2 # 24(19x0.005")B/C Drain wires with a semi-conductive coating.
Interstices waterblocked
0.00162" Copper/Mylar tape applied with 50% Overlap for 0.00324" (0.082 mm) total thickness.

**STRENGTH MEMBER**
Kevlar™/ Dacron™ Braid

**JACKET**
HD Polyethylene
Color: Black

**ESTIMATED VALUES**

| | |
|---|---|
| Nominal O.D. | 0.540" |
| Weight in Air | 130 Lb/1000 Ft |
| Weight in Seawater | 31 Lb/1000 Ft |
| Breaking Strength | 1,200 Lbf |
| Maximum Load | 240 Lbf |
| Min. Bend Diameter | 12 Inches (Dynamic) 6 Inches (Static) |

South Bay Cable

| | | | | | |
|---|---|---|---|---|---|
| Drawn | OL | 3/14/22 | Approval | | |
| Checked | | | Approval | | |

E-M Cable | SB-51548

HYDROCABLE SYSTEMS Ltd

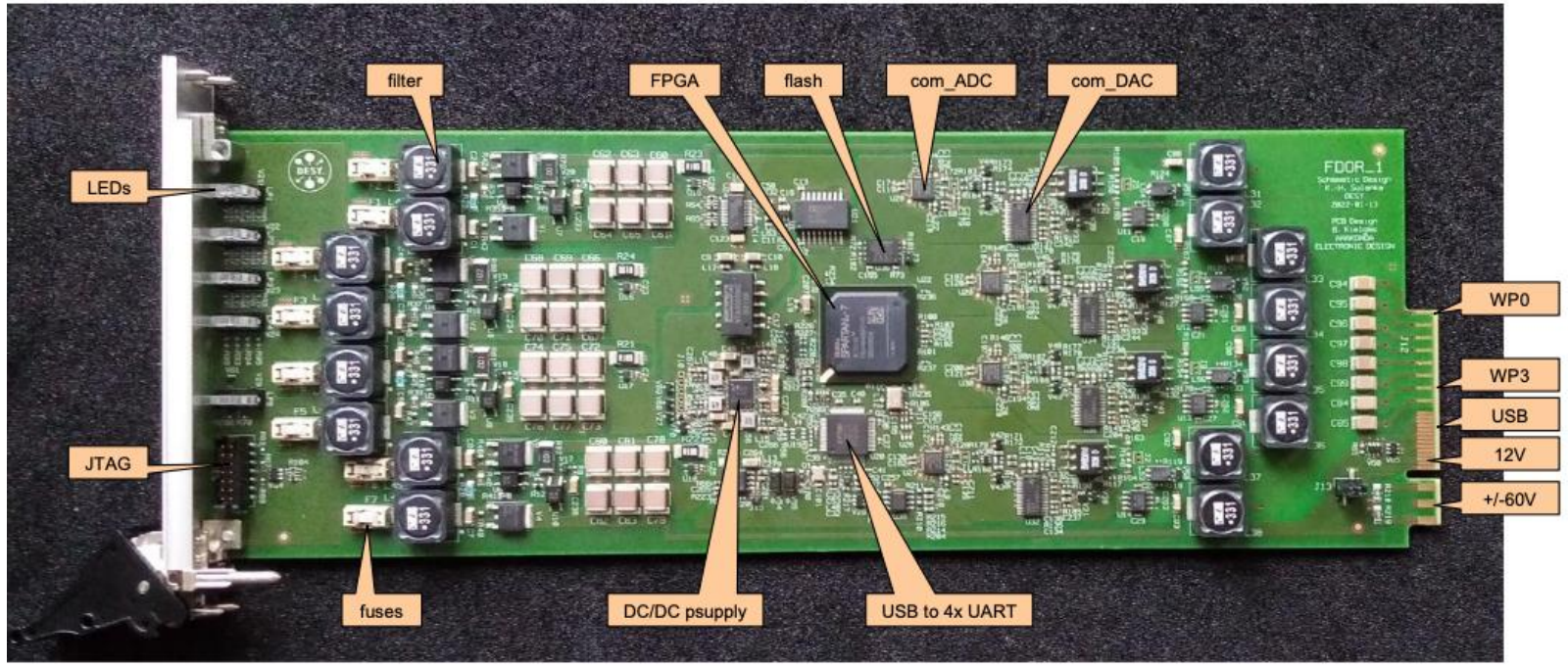
TITLE: 2 T.P. S (0.34 mm²) + WATER BLOCK + SCREEN + POLYURETHANE INNER + POLYURETHANE SHEATH

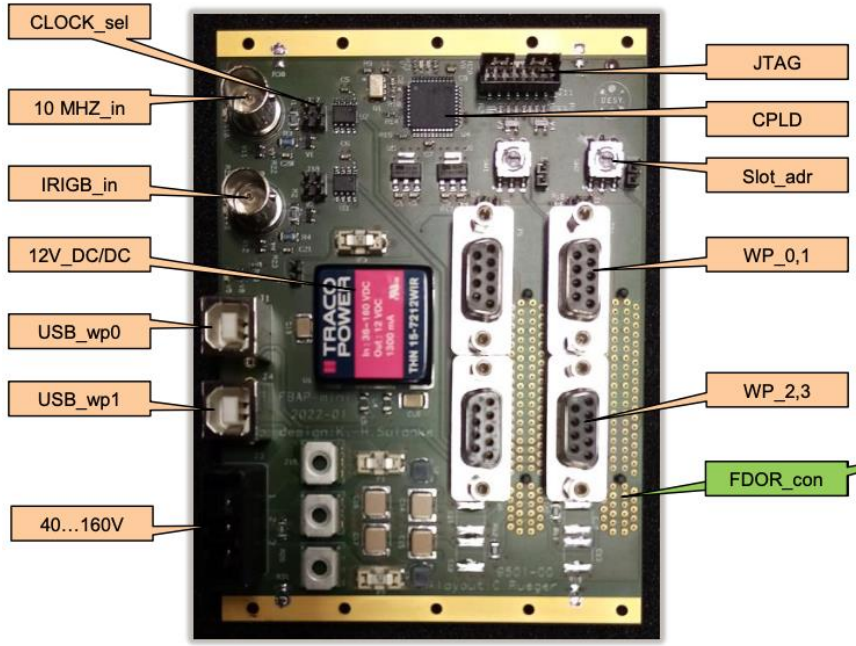
DRG. No. CS 8845 | SHT 01 OF 01 | ISSUE A

Y, COLOUR, DATA AND DIMENSIONS ARE NOT VERIFIED AND CONFIRMATION OF APPLICATION REQUIREMENTS E DERATING FACTORS SHOULD BE APPLIED

# FieldHubs

- Evolution from “mini-FieldHubs” used for DOM development, acceptance testing
- Rev1 prototype now assembled, in testing
  - Additional prototype cycles in 2022
- Production in summer/ fall 2023

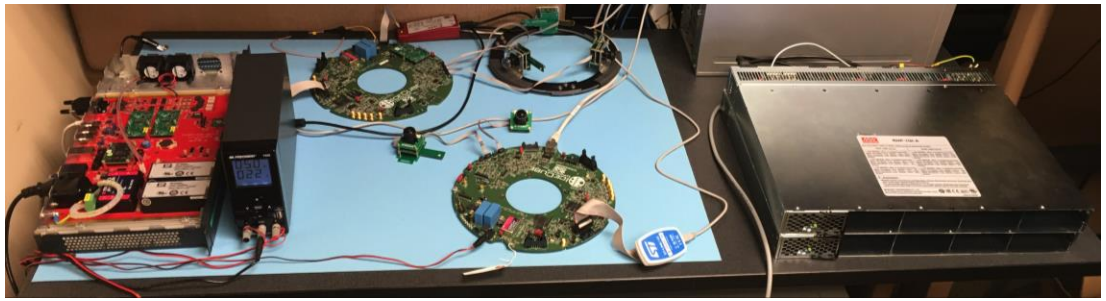


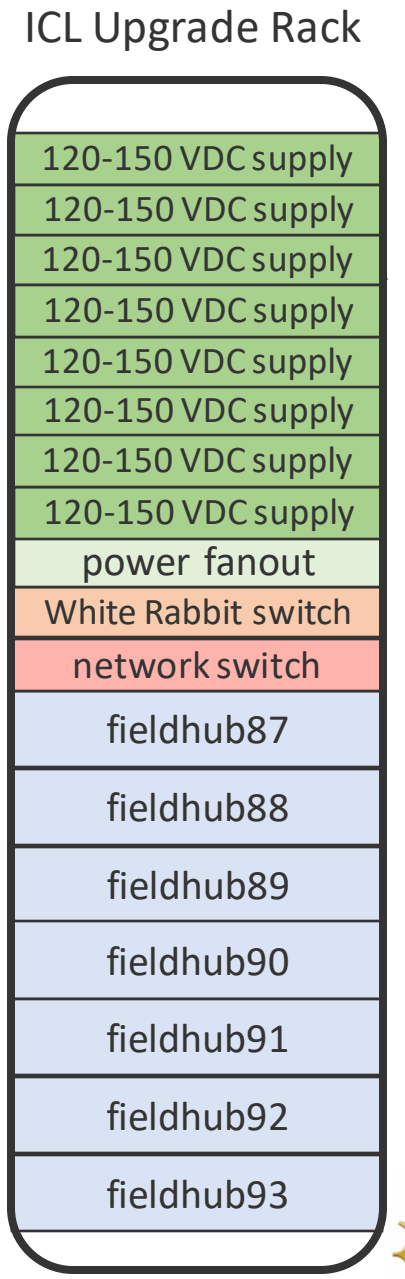

IceCube Upgrade

# Power System

- Redundant power supply to DOMs through the FieldHubs
  - Up to 1.3 kW / string, remote monitoring and control
- Preliminary design complete
  - trade study, evaluation of commercial power supplies
  - custom power control board design
- Next steps
  - Complete modifications for increased DOM power requirements (risk ORG9)
  - Testing at NTS with FieldHub prototype
  - Final design review 11/2022

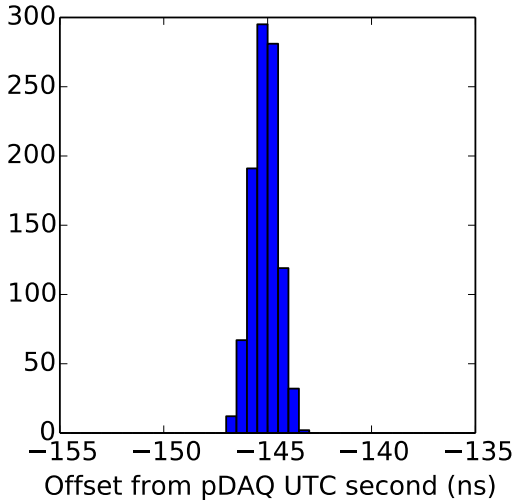


Power supply testing at DRTS



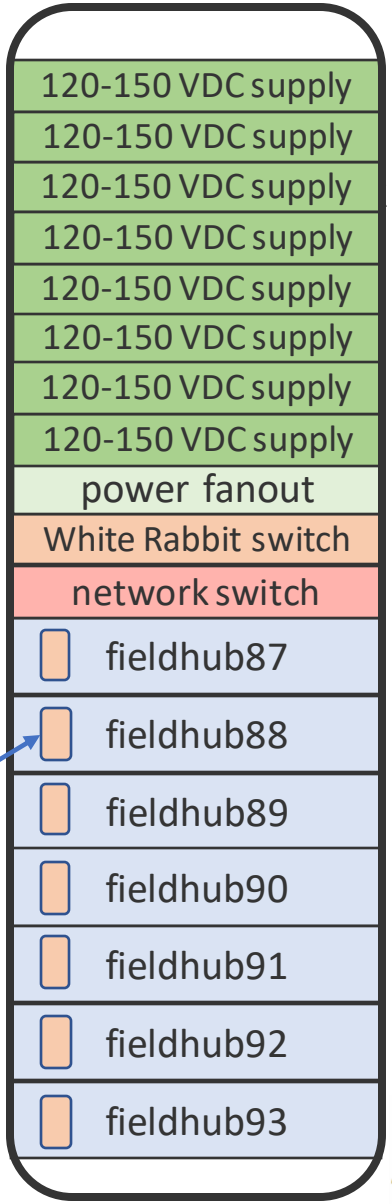
# Central Timing/Comms System

- Timing and communications via CERN White Rabbit protocol
  - Similar system currently running in ICL for IceCube surface array, timing based on existing IceCube master clock
- Preliminary design complete
  - WR switch installed at NTS
  - WR node tested with mini-FieldHub
- Will test WR node in prototype FieldHubs
  - Procure additional WR-LENs for production FHs
- Gen1/Upgrade timing offset monitoring
  - Current cross-domain timing study: $\sigma < 1$ ns
  - Final timing monitoring system production 2024




WR-LEN in FieldHubs

ICL Upgrade Rack




**CPT central timing system**