

BOS R2018A Handling System Critical Review

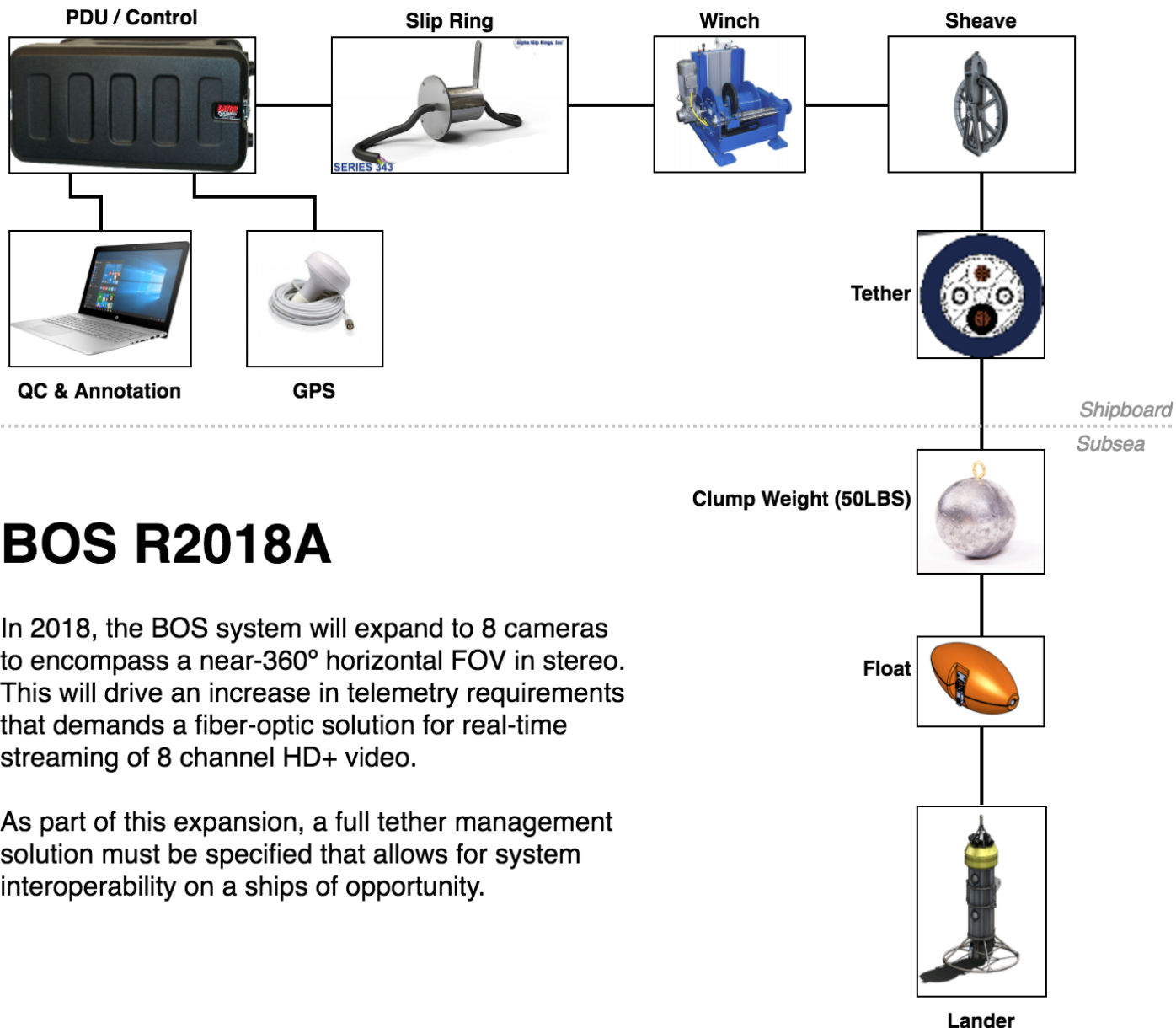
901704 NEXT GENERATION OBSERVATION PLATFORM

MBARI 2018 – C. KECY, F. CAZENAVE, K. HEADLEY, E. MARTIN, C. OKUDA



Summary

- Functional Requirements Review
- Relevant Derived Requirements (2017 Concept Discussion)
- System Components Review
 - Tether
 - Winch
 - Sheave



BOS R2018A

In 2018, the BOS system will expand to 8 cameras to encompass a near-360° horizontal FOV in stereo. This will drive an increase in telemetry requirements that demands a fiber-optic solution for real-time streaming of 8 channel HD+ video.

As part of this expansion, a full tether management solution must be specified that allows for system interoperability on a ships of opportunity.

BOS At A Glance



Functional Requirements

- Must be able to be deployed from ships of opportunity
- Must be a tethered system
- Must have a load bearing tether
- Must be able to launch and recovery quickly
- Must be able to operate in sea state two
- Must be able to land on rocky habitats with as little impact as possible
- Must be able to stay on bottom for five minutes
- Must be able to hopscotch (be towed) between sites during each dive
- Must have swappable bases for multiple sea floor types



Functional Requirements (non-handling)

- Must be able to record stereoscopic video in (near) 360 degrees
- Must have the ability to remotely control iris/ISO of the cameras
- **Must provide adequate lighting for all cameras**
- Must have the ability to add in contextual sensors
- Must be able to attach transponder onto lander
- Must have a downward looking camera to assist with positioning
- Must provide downward video and lander depth to bridge and winch operator
- Must be able to provide live video topside
- Must be able to record topside
- Must provide synchronization between the multiple cameras
- Must combine meta-data (telemetry) into one file for each recording session
- Altimeter sensor for safe approach operations



Derived Requirements (Telemetry)

- Integral sensors: lander depth and lander directional orientation
 - Lander pitch and roll are nice to have
- Connections for up to 4 additional sensors
 - Power: 12Vdc
 - Comms: Serial
- Sensor data viewable in real time topside
- Live video from all 9 cameras available in real time topside
 - Recording performed topside
 - Downward looking camera available to bridge and winch operator
 - Primary reason for move to fiber, as 8 HD streams are ~11.6Gbps



Derived Requirements (Power)

- Using 480VAC for power transmission down tether
 - 1:4 topside transformer from shipboard 110VAC
- Maximum power draw for lander no more than 1300 watts
 - 1300 watts -> 11 amps topside 110VAC
 - Worst case lights: 215 watts each (x5)
 - Nominal draw probably around 900 watts
- Subsea AC:DC converters
- Define acceptable power/voltage loss in tether
 - 4:1 subsea transformer; <10 volt loss on 110VAC subsea line
- Cross sectional area of Copper vs power loss vs overall tether diameter
 - Minimum Cu: 16AWG: 1 pair, 18/20AWG: 2 pair, 22AWG: 3 pair



Derived Tether Strength Requirements

- Max Design weight is 350-lbs
- Working from existing design and adding a ~40-lbs payload margin, the tether will have a minimum working load of 530-lbf (SF 1.5) and a minimum breaking load of 2,700-lbf (UNOLS SF 5xSWL).
- Towing of the system should not exceed 2-knots.
- At speeds greater than 2.5-knots, tow forces may begin to exceed the static lifting requirements of the system.



Xtreme-Marine® EO

Subsea Electro Fiber-Optic Cables



Application

Falmat's subsea fiber + power cable designs can be used for a multitude of underwater applications from shallow, rugged shorelines to deepwater installations (to depths of 6km). A sample offering of our more common designs below can also be modified with additional fibers, larger conductors, higher voltage, increased workloads or addition of steel armoring.

Design

Tried and proven materials are carefully chosen for long-term exposure and submergence in marine environments of sea or fresh water, polar to tropical, fully water-blocked with pressure resistant designs to 6km depths.

Selected Tether

FM021814-2

- Doubled NBL (2,800-lbs) brings diameter to 0.394-in
- Min Bend Radius 6-in
- \$4,880.00 for 400-m
- 80-lbf/kft (air) | 27-lbf/kft (sw)
- Meets All Requirements

Cable Properties	Fiber Optics:	Single-mode type SMF28E 9/125 micron, multi-mode 62.5/125 micron and 50/125 micron. Fiber components: Xtreme-Light® PUR Simplex fiber, Xtreme-Light® PUR Multi-fiber (3, 4 or 6 fibers) or stainless steel tube (3 to 72 fibers).				
	Conductors:	Insulated with premium copolymer insulation with excellent long-term moisture resistance. -20C to 90C, 600VDC typical with 1kv, 1.5kv, 3kv, 4.5kv to 3.5kb also available. Higher temperature insulations are offered at 105C, 125C, 150C, 200C				
	Strength Members:	Synthetic fibers of Kevlar® or Vectran® in braid or torque-balance served layers. Typical BS values for marine instrumentation as listed. Higher strength designs up to 36k lbs can be ordered. Steel armor, GIPS dual-serve can also be added.				
	Jackets:	Xtreme-Marine® grade Polyurethane 90C is standard. Other available jackets of HDPE, light-weight TPE, foam jackets for buoyancy. Also available: High temperature jackets 105C, 125C, 150C, 200C				
PART NUMBER	FIBER OPTIC	POWER COND.	VDC	STRENGTH (LBS.)	WALL	DIA.
FM021814-1	2x SMF Xtremelight	2x 18AWG	2.0 kv	1,400	0.055	0.360
FM021814-2	2x SMF Xtremelight	2x 16AWG	1.0 kv	1,400	0.065	0.380
FM021814-3	2x SMF Xtremelight	2x 14AWG	600 v	2,700	0.065	0.392
FM021814-4	3x SMF Xtremelight	3x 12AWG	4.0 kv	2,700	0.075	0.625
FM021814-5	3x SMF Xtremelight	3x 10AWG	3.6 kv	2,700	0.090	0.655
FM021814-6	3x SMF Xtremelight	3x 8AWG	3.6 kv	4,000	0.090	0.670
FM021814-7	3x SMF SS-Tube Core	6x 22AWG	600 v	2,700	0.052	0.292
FM021814-8	3x SMF SS-Tube Core	6x 20AWG	300 v	2,700	0.070	0.332
FM021814-9	3x SMF SS-Tube Core	6x 18AWG	1.0 kv	4,000	0.080	0.455
FM021814-10	3x SMF SS-Tube Core	6x 16AWG	1.0 kv	4,000	0.090	0.475

* This preliminary product data release is under engineering review and values are subject to change before official release.

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Monterey Bay Aquarium
Research Institute



Falmat, Inc.
1873 Diamond Street
San Marcos, CA 92078 USA
MBARI PROJECT 901704 NEXT GEN OBS LANDER

760.471.5400 Tel
760.471.4970 Fax
www.falmat.com

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Derived Requirements (Operational)

- Operate in 6-8 Foot Seas (SS2), 15 knots wind.
- Operations:
 - Conduct Surveys with 10-15 *drops* per *site* without bringing the BOS onboard.
 - A 12 hour day should achieve 5-10 *sites*.
 - No more than 5-minutes on-bottom per *drop*.
- 30 m/min for hauling is optimal.
- System must transport via truck/trailer.
- Must operate on *ships of opportunity*, i.e.



Ships of Opportunity

Miss Linda	Shana Rae	Shearwater/Fulmar	Derek Baylis	Danny C
Type: Fishing	Type: Fishing	Type: Research Catamoran	Type: Sailing/Research	Type: Utility Vessel
Location: Coos Bay	Location: Santa Cruz	Location: Monterey / Channel Islands	Location: Richmond CA	Location: Santa Barbara CA
				
Image: 1	Image: 1	Image: 1	Image: 1	Image: 1
Spec Sheet 1	Spec Sheet 1	Spec Sheet 1	Spec Sheet 1	Spec Sheet 1
Electrical: Unspecified	Electrical: 220VAC 6KW	Electrical: 220VAC 20KW	Electrical: Requires Extra Generator	Electrical: 1Ø ??V 20KW
Mechanical: A-Frame 2000LBS SWL		Mechanical: A-Frame 1600LBS SWL	Mechanical: A-frame (600LBS SWL)	Mechanical: No Structure
Add a card...	Add a card...	Add a card...	Add a card...	Add a card...

Winch Minimum Ratings

Specification	Minimum Rating
Mechanical Power	2-HP
Dead-Lift Capacity	530-lbs
Haul Rate	30-m/min
Winch Brake Rating	2,700-lbs
Primary input	1Ø 220-V or 110-V AC 60-Hz
Payout Counter	Desired
Drum Capacity	1300-ft of 0.394-in OD PUR hybrid fiber/copper tether
Drum & Sheave Diameter	12-in
Slip Ring	2-pass 480VAC 3A Electrical 1-pass SM Optical

Winch Selection

- The mechanical loads of the system drives options away from common compact ROV solutions, but the larger drum requirement drives away from compact CTD and tow system systems as well.
- No standard systems meet all requirements, but some can be modified.
- 4 Vendor solicited (MacArtney, Okeanus, Interocean, and Brock @ OI)
 - Interocean has not completed full quote but full spec has been provided.
 - MacArtney's standard options are expensive and not as flexible, no single phase power options exist.
 - Brock only had large reels, that while inexpensive, would results in less reliability and more external sensors and costs.
 - Okeanus has been very responsive and down-scaled a larger system to accommodate the lower power requirements demanded by ships-of-opportunity.



Okeanus ECO-2000

- Meets Requirements
- Best Fleet Angle
- Self-contained counter
- UNOLS option (adaptor plate and cert doc)
- 1Ø220V 10A
- Optional Liebus Shell
- Can integrate Focal/Alpha slip ring



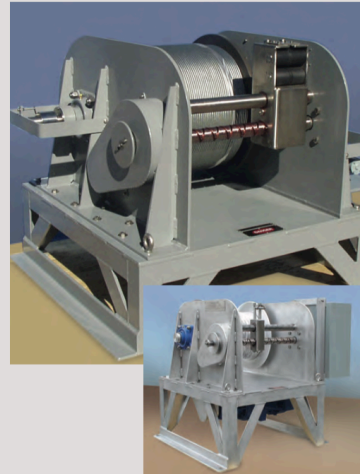
Specifications (3 HP Single Phase Option):

Width:	52 in. (1,320 mm)
Length:	53 in. (1,346 mm)
Height:	43 in. (1,092 mm)
Drum flange dia:	24 in. (610 mm)
Drum core dia:	12.75 in. (325 mm)
Drum width:	22 in. (560 mm)
Weight:	1,170 lbs. (xx kg)
Maximum Line Pull:	750 lbs. (340 kg) at bare drum
Maximum Line Speed:	98 fpm (30 m/min) at bare drum
Brake Hold Capacity:	1,500 lbs. (681 kg)
Drum Storage Capacity:	0.394 in. (10.0 mm) cable: 1,500 feet (457 m)
Input Power:	220 VAC single phase, 50/60 Hz

InterOcean Model 1673

- Meets Requirements
- Aluminum Body (700-lbs)
- A little slower, 28 m/min bare drum
- Machined Leibus grooves on drum
- 4' Cube

Model 1673



Model 1673

Light to Medium Duty, Hydrographic

InterOcean Systems Model 1673 is a proven multi-purpose hydrographic winch for CTD, side-scan sonar, and water sampling applications. The 1673 is fully self-contained and incorporates an electric or hydraulic motor in the range of 1hp to 5 hp with infinitely-variable joystick speed control, brake, level-wind, and optional slip-ring.

The Model 1673 is fabricated from lightweight aluminum alloy using high-quality construction for portability and long-term use in the marine environment.

Specifications:

Capacity (typical):	3,500 m of 3 mm (1/8") 1,500 m of 6.4 mm (1/4") 1,000 m of 8.2 mm (0.322")
Bare Drum Load (typical):	Up to 600 kg (1,320 lb)
Drum Diameter:	12 in (30.5 cm)
Drum Width:	18 in (45.7 cm)
Flange Diameter:	23 in (58.4 cm)
Level Wind:	Yes, Diamond Screw
Power:	1 to 5 hp 115/220/380/440 VAC or Hydraulic

A summary of winch primary specifications:

Capacities: 1,300' of 0.380" diameter cable
Load/Speed: 650 lbs @ 25 m/min Bare Drum
600 lbs @ 30 m/min Mid Drum
550 lbs @ 35 m/min Full Drum

Horsepower: 2
Power Input: 220 VAC 1 phase, 1.5 kW

Drum Diameter: 14in / 36.0cm
Flange Diameter: 22in / 55.9cm
Drum Width: 18in / 45.7cm
Grooved Drum: Yes
Level Wind: Yes - Diamond Screw
Brake: Dynamic motor braking, electric fail safe brake
Control: Local control includes joystick on 10m tether cable.

Overall Dimensions:
Length: 43in / 109cm
Width: 52in / 132cm
Height: 44in / 112cm
Weight (approx): 600lbs / 270kg (w/o cable)
Material: Aluminum

Okeanus DT Marine

- Meets Requirements
- Poor Levelwind System
- No counter
- 22 m/min (slower)
- 1Ø220V 10A
- Aluminum (350lbs)
- Hydraulic
- \$14,500.00



SPECIFICATIONS

MODEL DT303EM ELECTRO-MECHANICAL WINCH

DIMENSIONS:

WIDTH	32 INCHES
DEPTH	32 INCHES
HEIGHT	38 INCHES
DRUM DIAMETER	14 INCHES
FLANGE DIAMETER	28 INCHES
DRUM WIDTH	10 INCHES

CAPACITY:

1,300 FEET OF .394" DIA. CABLE (LEAVES 2" CLEAR FLANGE)

CONSTRUCTION:

ALL WELDED ALUMINUM WITH STAINLESS STEEL
HARDWARE

COATING:

SYSTEM IS BLASTED TO NEAR WHITE METAL AND PAINTED WITH
THREE-COAT EPOXY SYSTEM, ZINC PRIMER, TIECOAT, TOP COAT OF
EPOXY.

BEARINGS:

SEALED, SELF-ALIGNING BALL BEARINGS

ELECTRIC MOTOR:

3HP, 230VAC, SINGLE PHASE TOTALLY ENCLOSED FAN COOLED
BRAKE MOTOR DRIVING A RIGHT ANGLE GEARBOX CONNECTED TO
THE DRUM THROUGH SPROCKETS AND CHAIN.

LINE PULL & SPEED:

900 LBS BARE DRUM RATING @ 75 FPM .

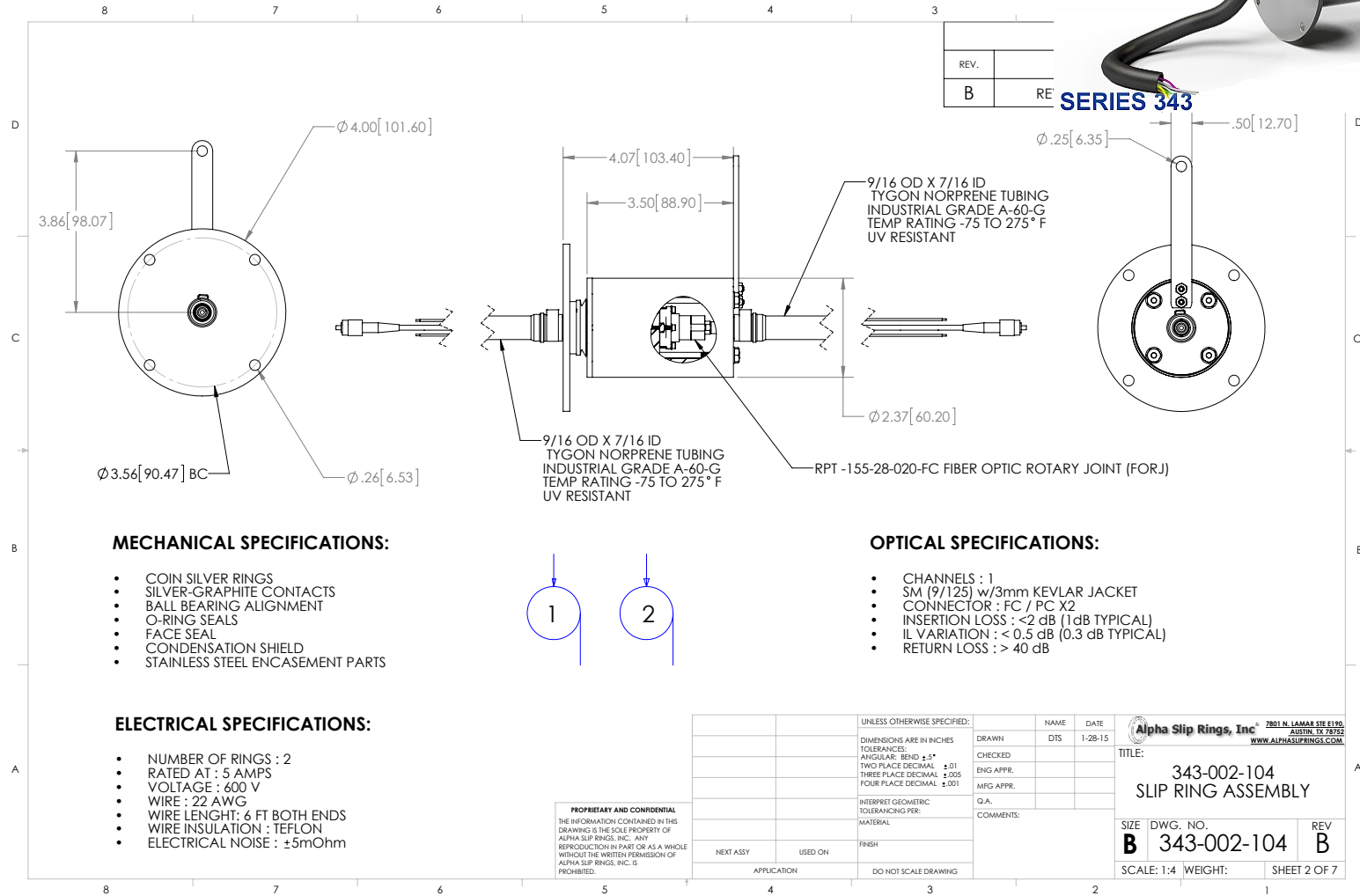


Slip Ring Selection

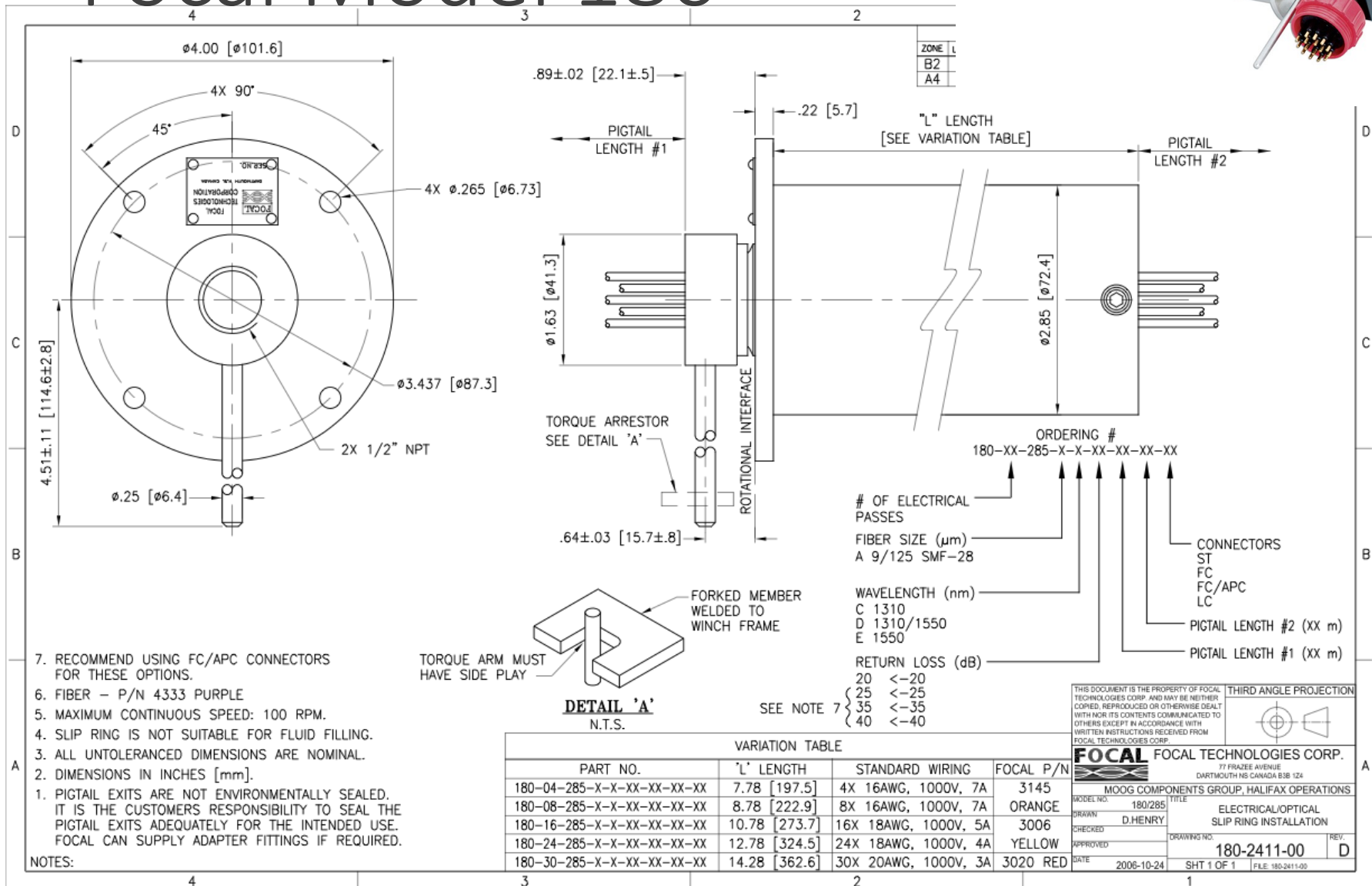
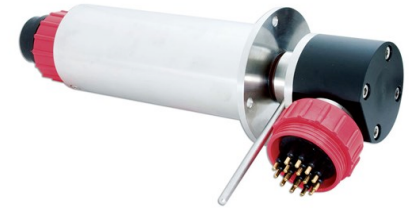
- Slip ring is 2-pass electrical, single SM fiber pass.
- 3 Vendors Solicited:
 - Moog/Focal
 - Alpha
 - Moflon
- Alpha and Moog seem interchangeable in size and capability, with Moog being the highest build quality. Both would terminate easily via pipe fittings into junction boxes.
- Moflon is the least expensive (\$900) but may not mount as easily.
 - With more time a test purchase would be advisable.



Alpha Model 343



Focal Model 180



Slip Ring Comparison

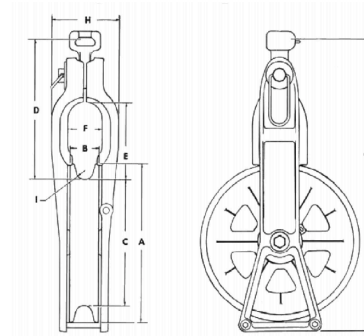
FOCAL Model 180	Alpha Slip Ring	Moflon
Model 180	Model 343-002-104	MFO108-S02-01-ST-01-IP68-M738
Diameter: 2.85" Core 4" Flange	Diameter: 2.37" Core 4" Flange	Diameter: 2.20" Core & Flange
Cost: \$3,500	Cost: \$2,450	Cost: \$875
Electrical: 1000VAC / 7A	Electrical: 600VAC / 5A	Electrical: 600VAC 3A
Rotation Speed: 100 rpm max	Rotation Speed: 250 rpm max	Rotation Speed: 250 rpm max
Housing: SS	Housing: SS 300	Housing: Aluminum
Termination: 1/2" 3/4" NPT-F	Termination: 7/16" ID Tygon Tube	Termination: Bare Wire
IP 67 68	IP 65	IP 68
Other: Temp, Shock, Humidity MIL-STD-810D/F	Other Options to increase voltage and current ratings.	Other: Can down to IP65 and save 150\$ No Tube big detractor.
Reference 1	Reference 1	Reference 1
Add a card...	Add a card...	Add a card...



Sheave Options

Sherman & Reilly 74 Series

- 12" Diameter
- Aluminum
- 6,500-lbf SWL
- 0.6" Groove radius (tether 0.39)
- Can go larger, but groove radius opens
- \$589.00



Okeanus Eco-Sheave

- 12"
- Steel/Delrin
- 2,000-lbf SWL
- Specified Groove Width
- Cable-keeper option
- \$2,295.00

Interocean

- 12" Instrumented
- Steel/Delrin
- Cost Included with winch estimate



Question: What is the best tolerance for groove radii specifications?

Handling System Budget

Item	Part Number	Unit Cost	Quantity	Extended
Winch	ECO-2000	\$33,000.00	1	\$33,000.00
Levelwind	"	\$15,000.00	1	\$15,000.00
Linespeed & Payout Display	"	\$1,850.00	1	\$1,850.00
Tether (400-m)	FM021814-2	\$4,880.00	1	\$4,880.00
Slip Ring	Focal 180	\$3,499.00	1	\$3,499.00
Sheave	S&R 78	\$589.00	1	\$589.00
Subtotal:				\$58,818.00
Tax (7.75%):				\$4,411.35
Total:				\$63,229.35



System Transport

- A brief survey of car trailers apply the following limits on total towable system weights:
 - 2-Wheel Trailers support ~3,000-LBS
 - 4-Wheel Trailers support ~6,000-LBS
- Weight Estimates for Budgeted System:

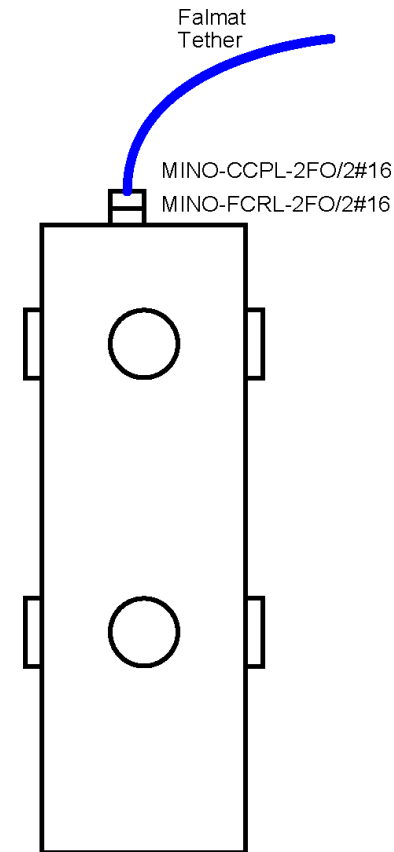
Item	Weight (lbs)
ECO 2000 Winch	1,170
BOS System	350
Tether (80-lbs/kft)	104.96
Crates/Covers (estimated)	200
Total:	1,825



Connector Option: Seaconn

Seaconn MiniCon with Fiber Optics

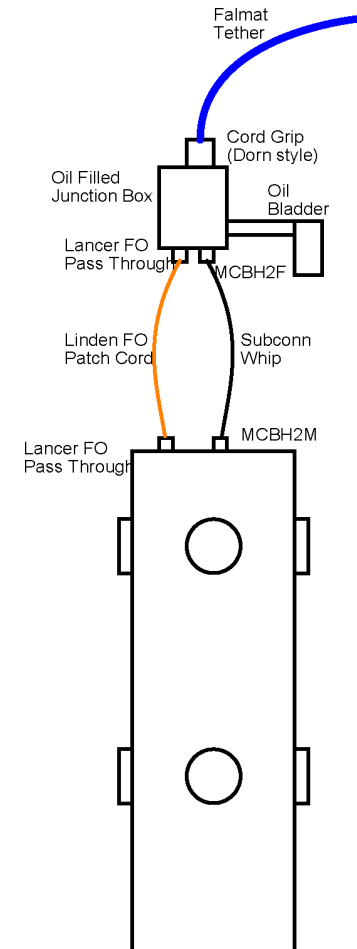
- CCPL potted to tether (Manufacturer)
- FCRL on lander endcap
- Insert: 2 FO and 2#16
- Simple and space efficient
- Cannot service in the field
- Mechanical strain relief required
- ~\$3500.00 (awaiting quote)



Connector Option: Patch Cord

Lancer/Linden Fiber Optic Connection

- Copper/Fiber terminated in J-Box
- Lancer pass throughs to Linden patch cord
- Power passed through Subconn connectors
- Inexpensive and serviceable
- Bulky solution, will add height to lander
- Bladder required
- Mechanical strain relief required
- ~\$2350.00 (awaiting final quotes)



Future Decisions

- Improved Cable clump attachment:
 - Current option is a yale grip.
 - With a standard tether, we can design a clamping solution in house.
- Decide on subsea connector

The End



Supplementary Slides



Tether Electrical Requirements

- 16AWG Cu minimum requirement for single pair.

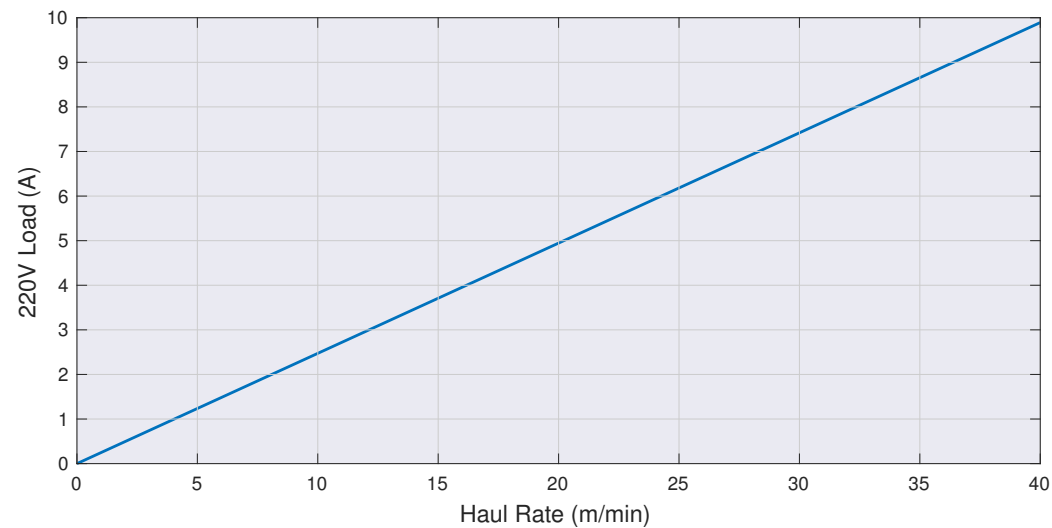
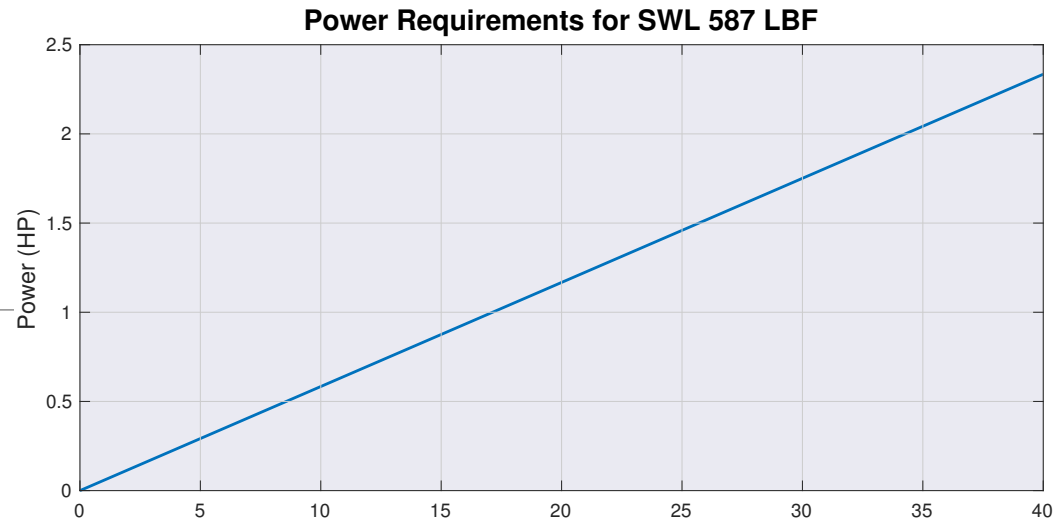
Copper Losses

Wire Gauge	Pairs	Total Area (in ²)	Max Loss (W) (@ 1300W)	480V V Drop (Volts)	120V V Drop (Volts)
22	1	0.001006	323	119	29.75
22	2	0.002012	162	60	15
22	3	0.003018	108	40	10
22	4	0.004024	81	30	7.5
20	1	0.001608	202	75	18.75
20	2	0.003216	101	37	9.25
20	3	0.004824	67	25	6.25
20	4	0.006432	51	19	4.75
18	1	0.002560	127	47	11.75
18	2	0.005120	64	23	5.75
18	3	0.007680	42	16	4
18	4	0.010240	31	12	3
16	1	0.004060	80	29	7.25
16	2	0.008120	40	15	3.75
16	3	0.012180	27	10	2.5
16	4	0.016240	20	7	1.75

* Calculated using a length of 400 meters

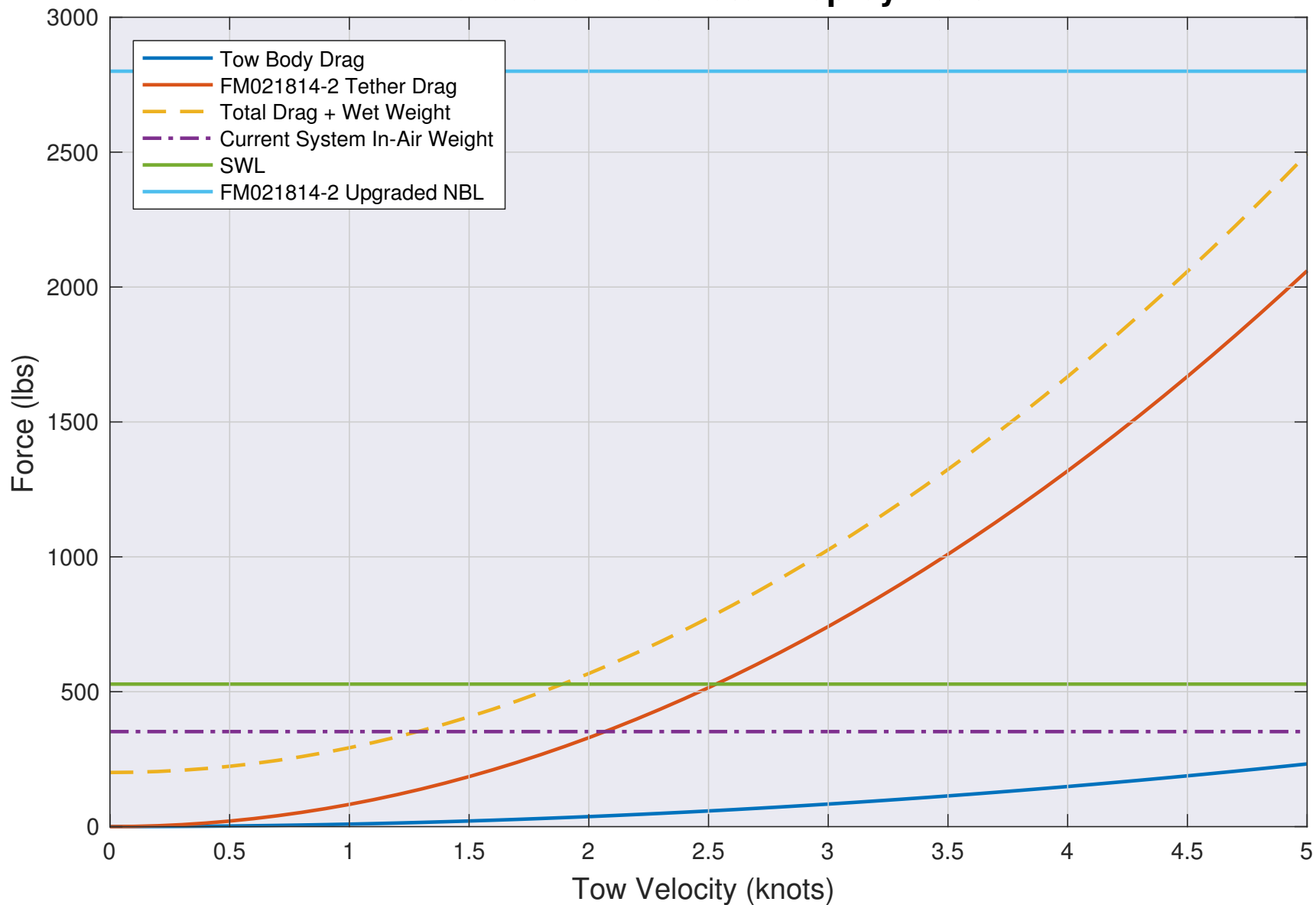
Lift Specs

- Derived Requirements:
 - Must lift with force greater than SWL 600-lbf
 - Must lift with minimum speed 30-m/min
 - Must brake higher than tether NBL 3,000-lbf
 - Storage of 400-m cable (includes working length & 2 re-terminations)
- Power Demand:
 - < 2HP required
 - < 10A likely for a electric winch on 220VAC1Ø.



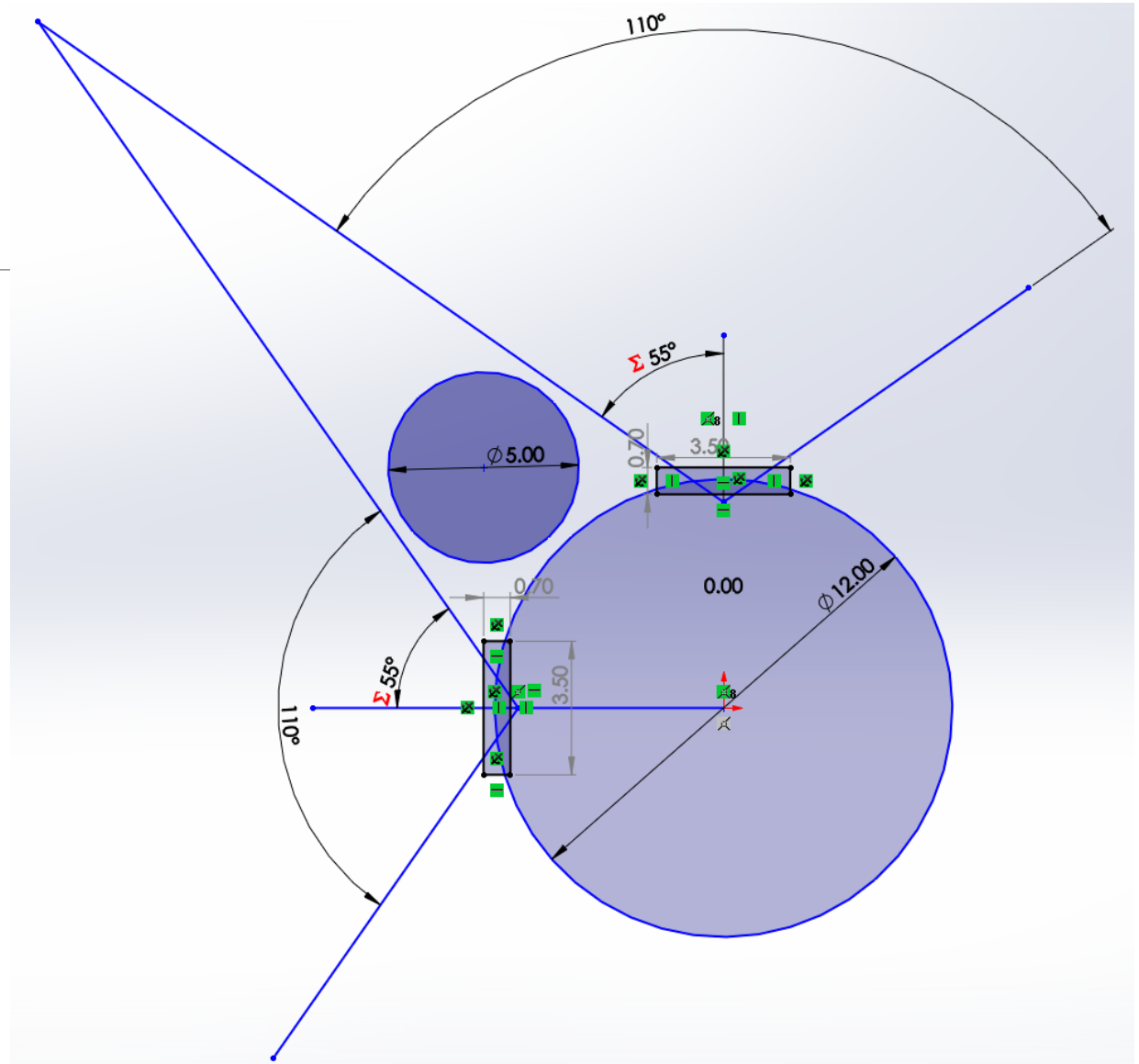
220V1Ø AC current assuming a 75% electromechanical efficiency

Forces for 270 Meter Deployment



Payload

- Room for some as shown
- Will still need handles in 2 of the 4 sectors
- Displacement of 2 filled sectors ~40 lbs
- Best to remove lead for weight added.



Top Down View BOS Main Housing



Winch Solution Trades

LINE HAULER

○Pros:

- Removes slip-ring need
- Essentially a Capstain solution
- Low-cost (\$3,000)

○Cons:

- Bucket storage
- Significant Weight reduction demanded.
- Limited to 1/2" Cable
- Manual Payout Counter



TRADITIONAL WINCH

○Pros:

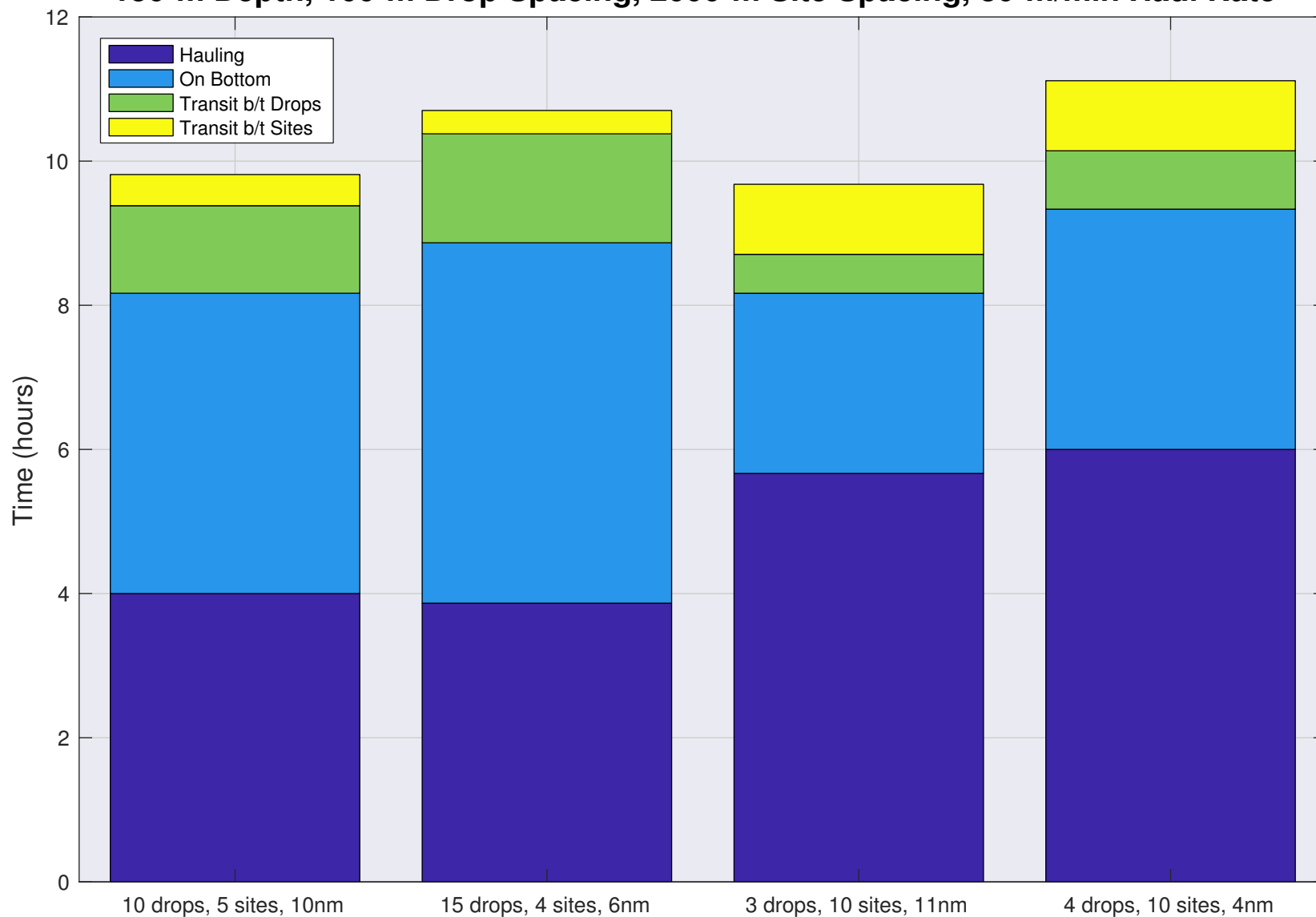
- Self contained
- Safe
- Bolt-down installation

○Cons:

- Higher Cost
- Higher Maintenance Requirement
- Requires Slip-ring



150-m Depth, 100-m Drop Spacing, 2000-m Site Spacing, 30-m/min Haul Rate



150-m Depth, 100-m Drop Spacing, 2000-m Site Spacing, 40-m/min Haul Rate

