4km DWSM
CDR

4000m Deep Water Sampling Module
CDR

- Agenda
  - Functional requirements
  - Schematics
  - Operating Theory (pre-procedure)
  - Mechanicals
    - Fluidic Diagrams
    - Pressure housings
    - Running Gear
    - Weight balance
  - Electrical Designs
    - Block diagrams
    - System Schematics
    - Custom Hardware
    - Power System
  - Software
    - Software Scope
  - Testing Process
  - Risks

4000m Deep Water Sampling Module
CDR

Functional Requirement Summary

- Operations from 0 meters to 4 Kilometers
- Sequester single volume for processing
- Collect a variable sample volume, up to 10L
- Variable sample rates
- Maintain homogenous sample (stirred)
- Sample to Sample decontamination and sterilization
- Contextual Sensors
  - CTD
  - ISUS and others
- Not compromise core
  - Temperature
  - Pressure (75psig)
  - Particle size (1mm)
  - Flow rates and filter pressure drop (10psig)
- Operable by the core
- Supported Platforms
  - Standalone
  - MARS
  - ROV's
  - NEPTUNE
  - Jason
- Deployment time 1 year

4000m Deep Water Sampling Module
CDR

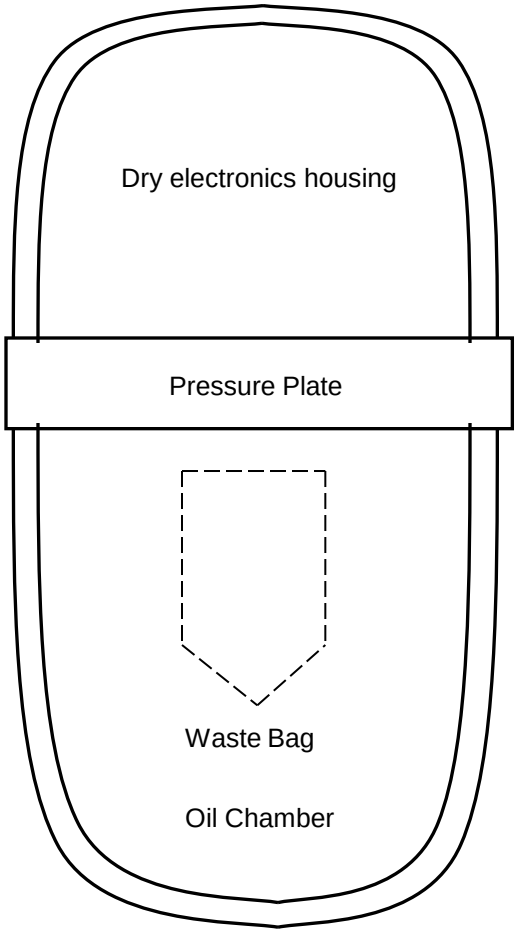
Functional Requirements (Derived)

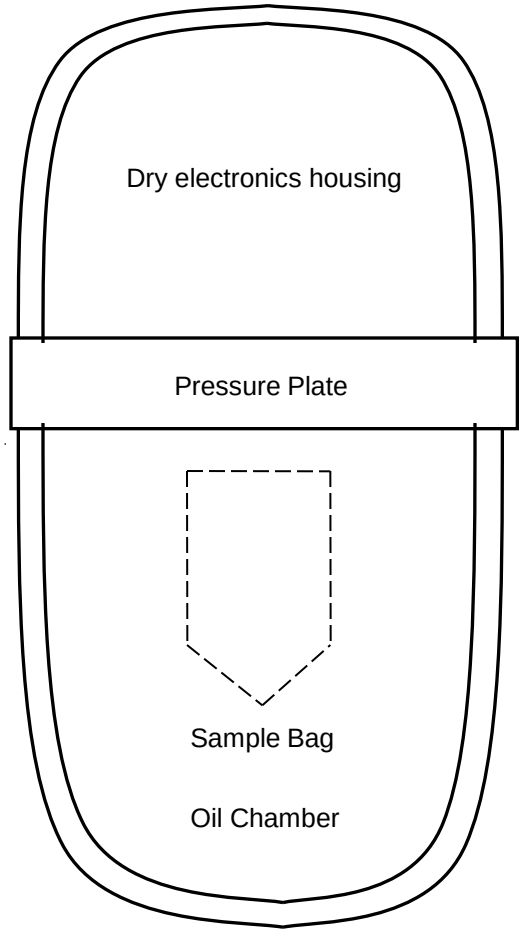
- Communications
  - Ethernet from Core to Platform
  - Serial from Core to DWSM
- Core operates DWSM
- Wetted Materials will be in contact with toxicant during non-operational times
- Provide for some if not all Toxicant storage
- Core requires 10-16V at up to 150 Watts
- Single power conversion configurable to platform power source
- Environment
  - Water Temperature
    - Maximum 35 Celsius
    - Minimum 0 Celsius
  - Sample Water Temperature
    - Maximum 200 Celsius (cool down in wand to max 35 C)
    - Minimum 0 Celsius
- Core Environment
  - 17 psia Nitrogen Atmosphere
  - 10 to 35 Celsius (*no heating plans for core)
  - Maximum Sample Temperature 100 Celsius
  - Sample Pressure 75 psig

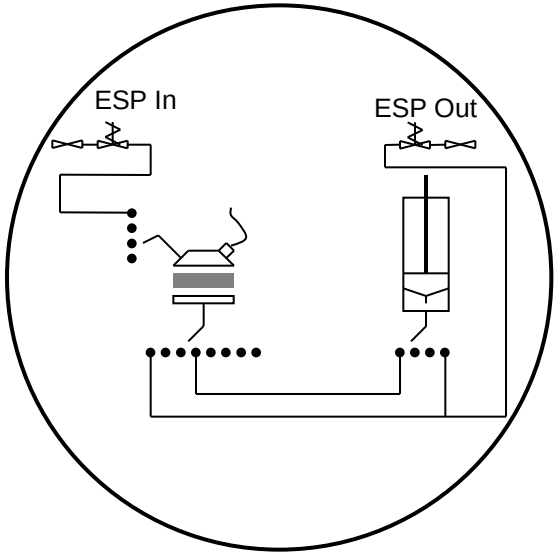
Mechanical Systems
Simple Operating Theory

- Intake seawater
- Decompress
- Transfer and release gas
- Sample (thru core)
- Recompress
- Exhaust seawater
- Decon System

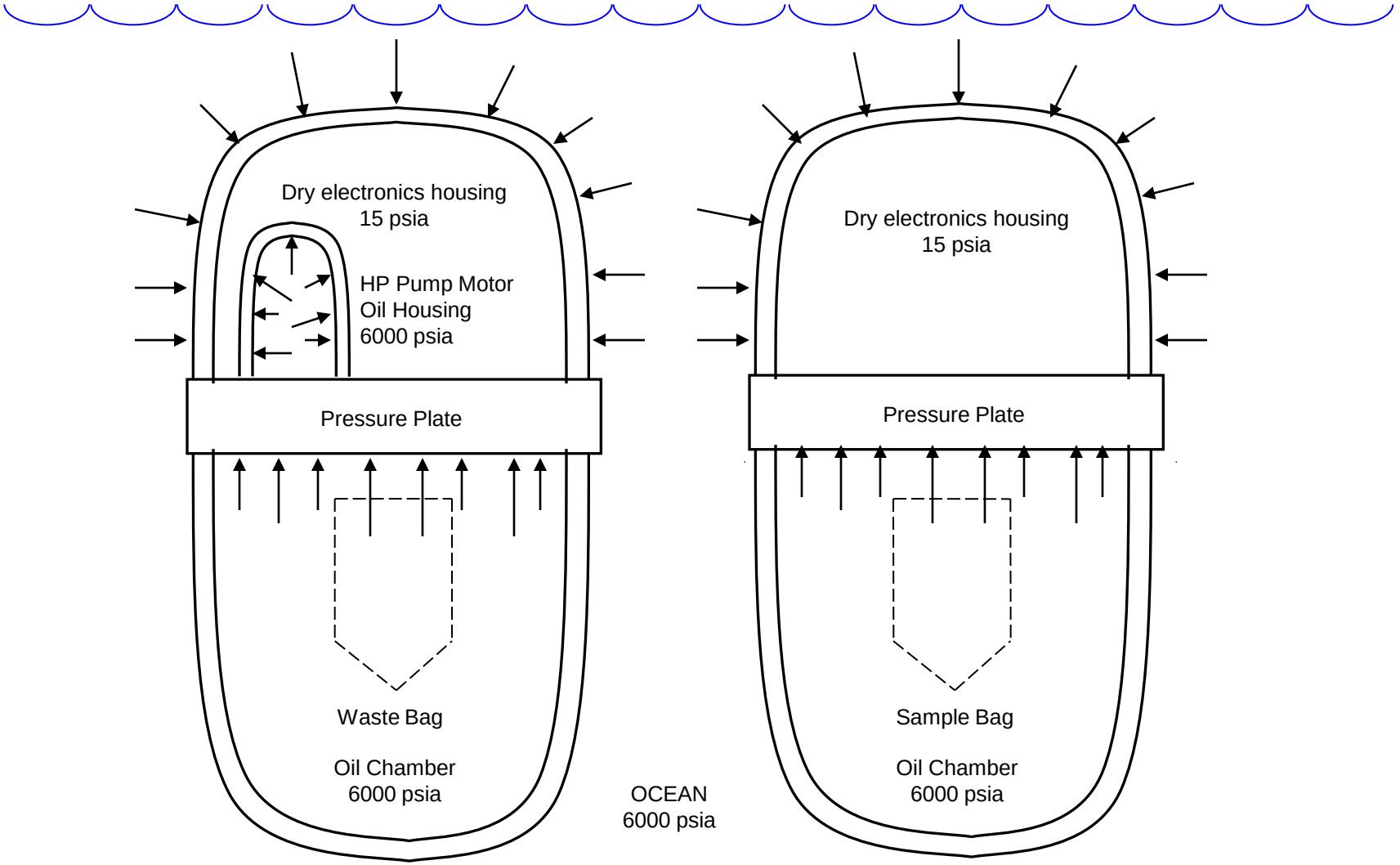
Deep Water Sampler
Aqua Lung



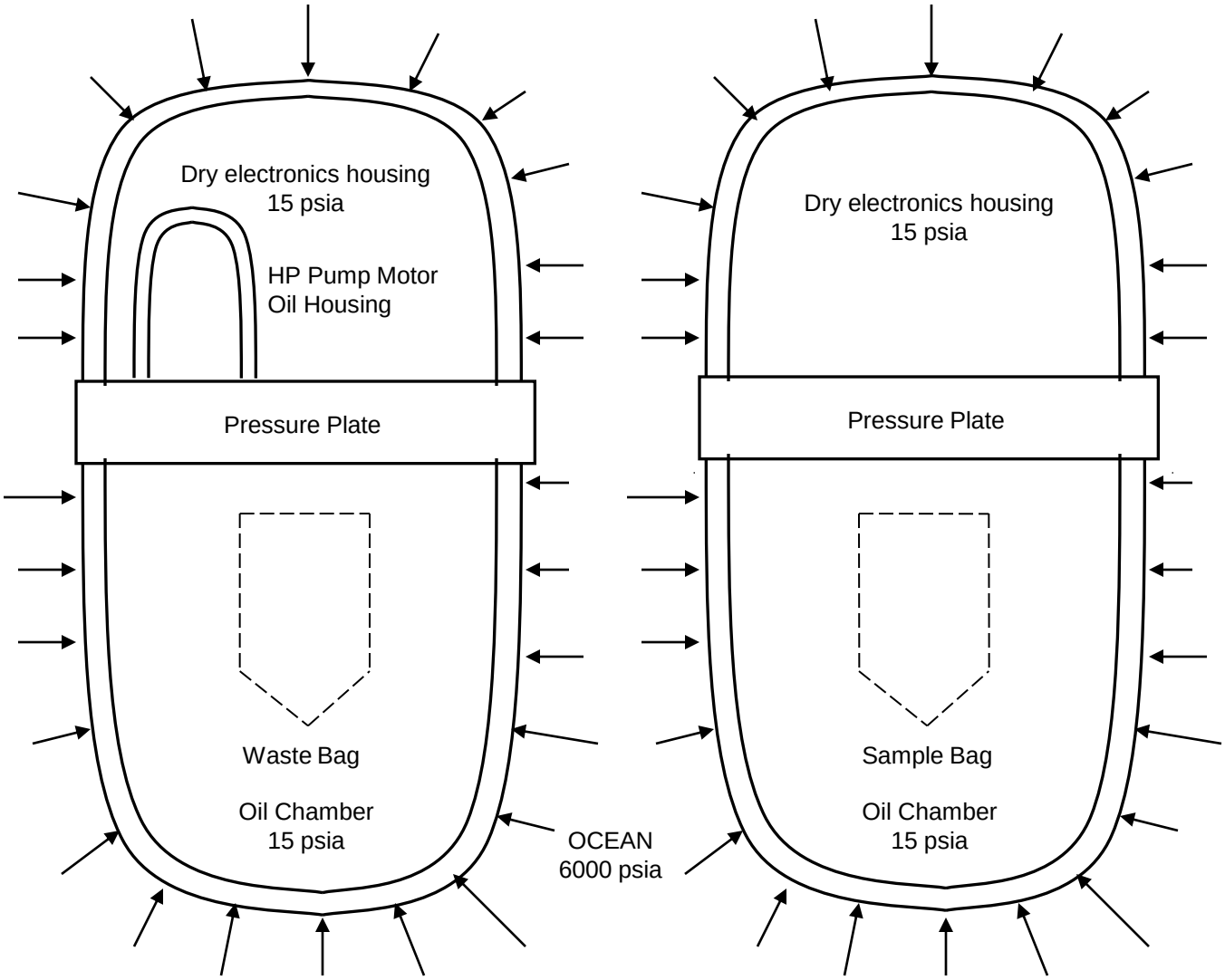




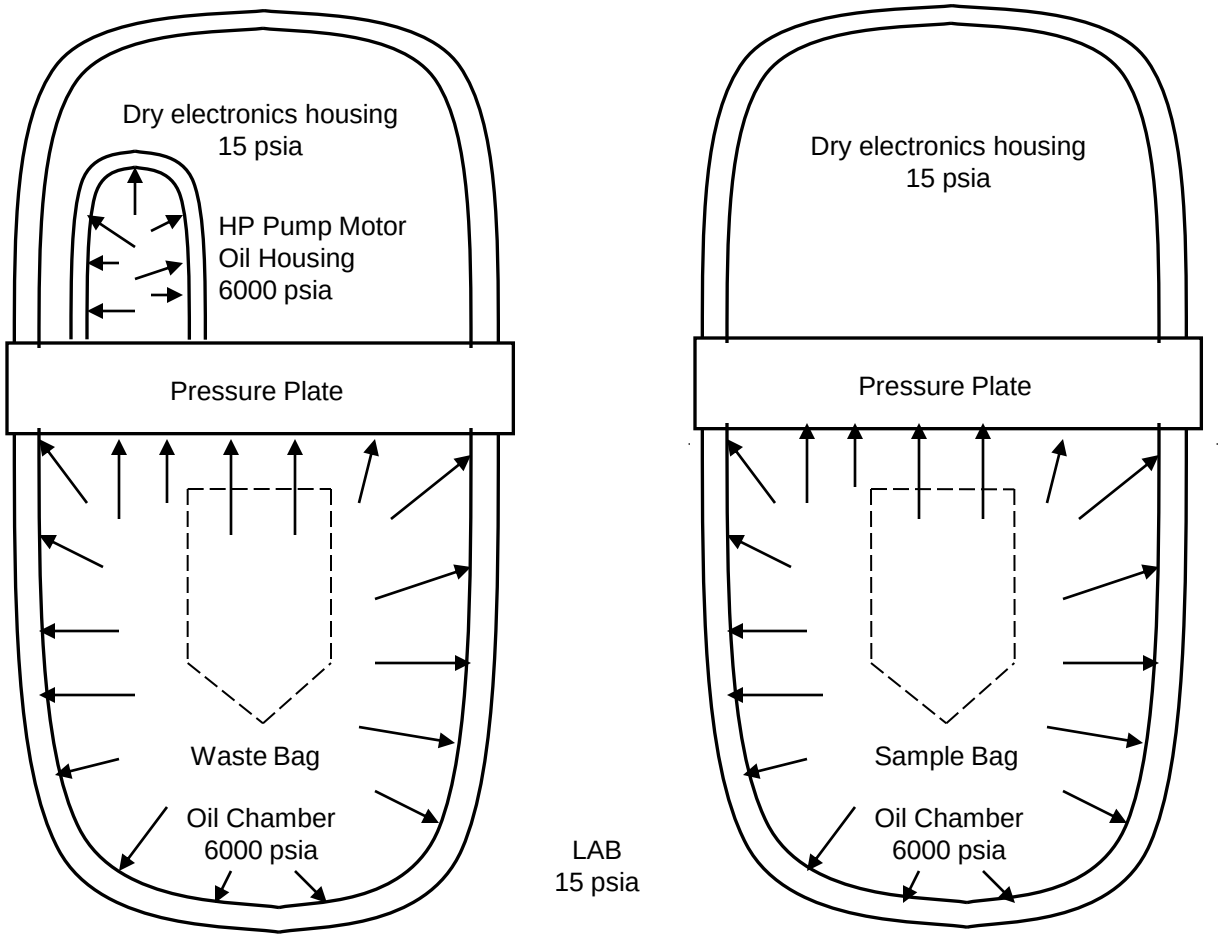
Deep Water Sampler
Ocean Condition (Normal)



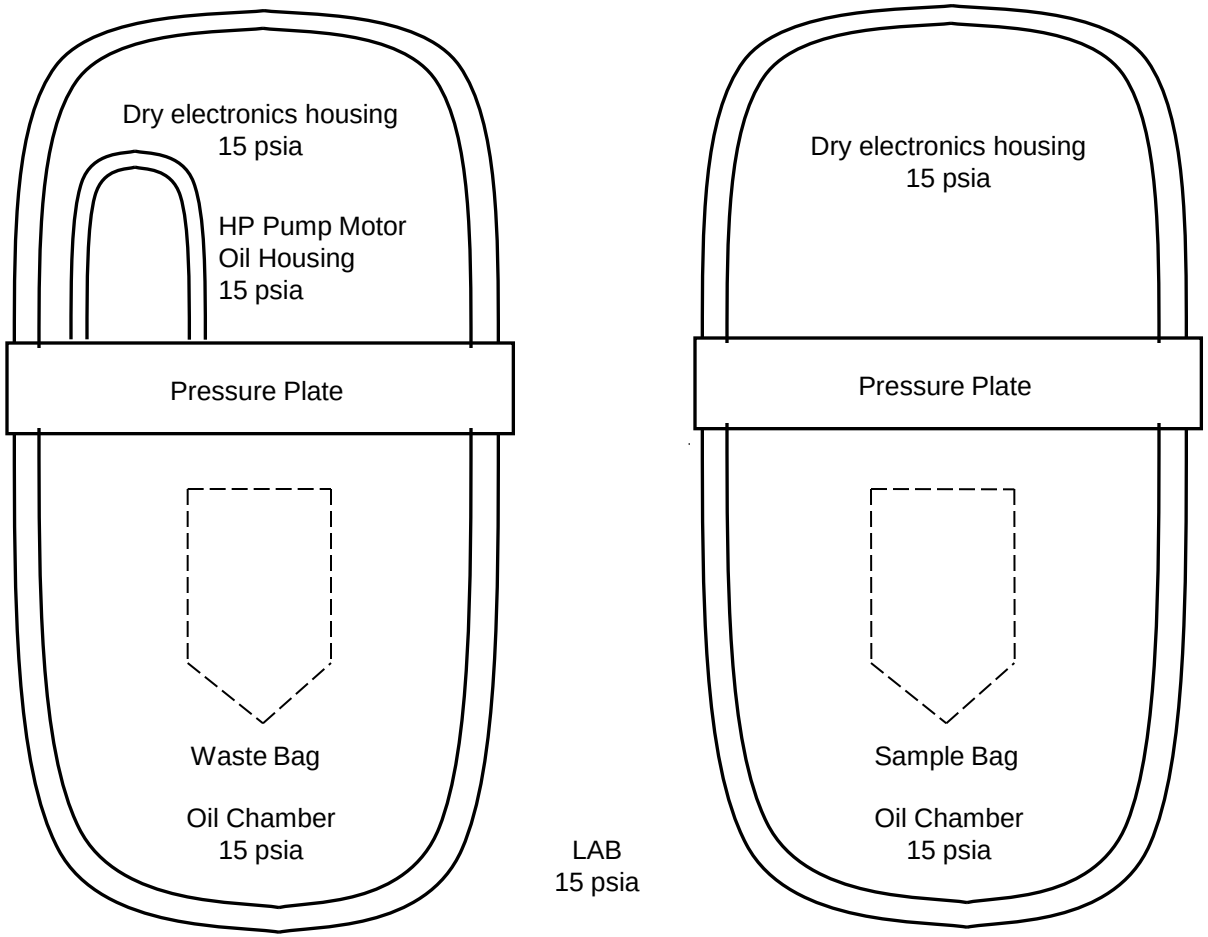
Deep Water Sampler
Ocean Condition (Depressurized)

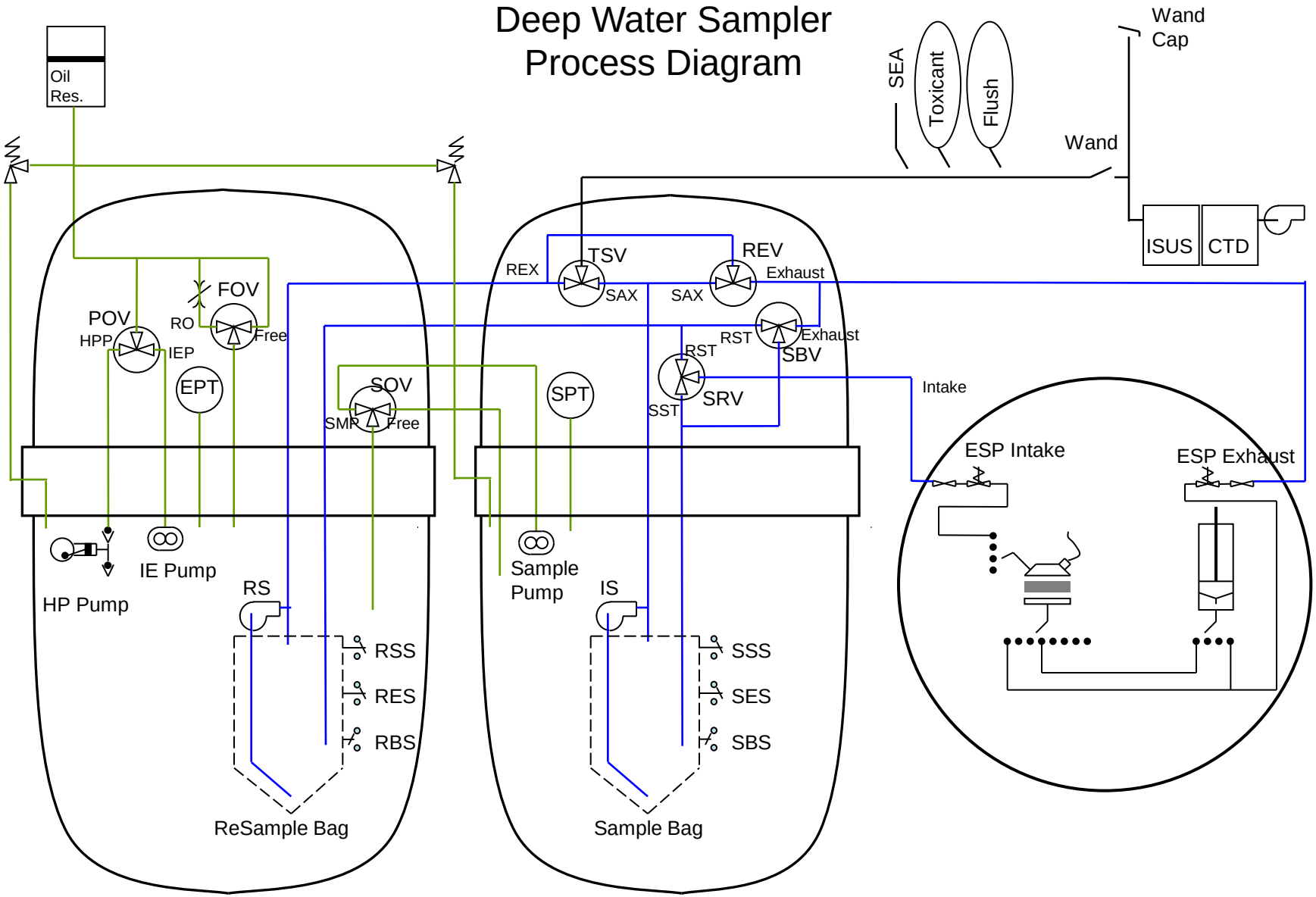


Deep Water Sampler
Lab Condition (Start)



Deep Water Sampler
Lab Condition (Depressurized)



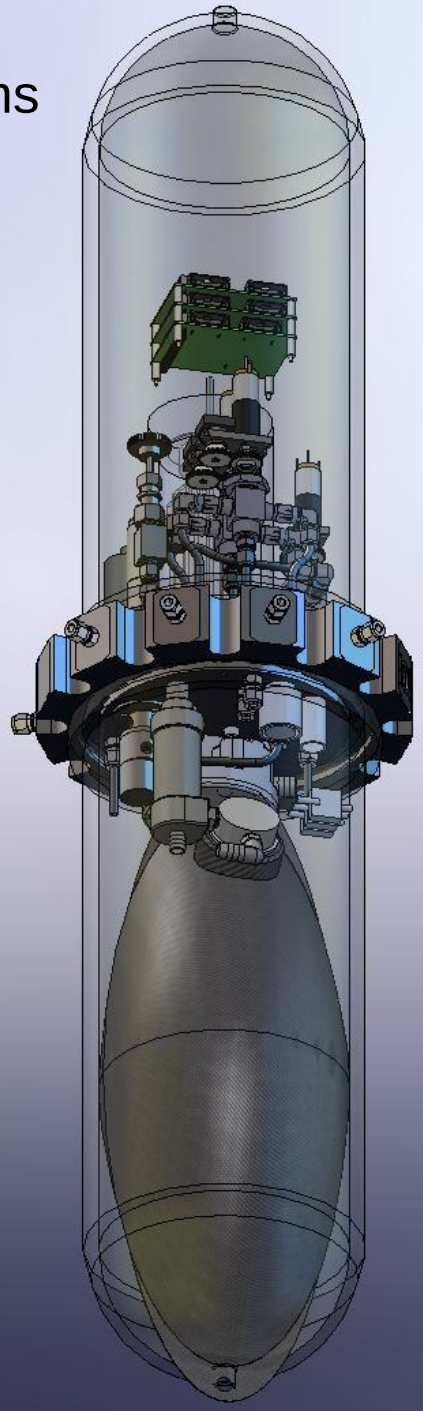

Deep Water Sampler
Process Diagram
Oil
Res.
SEA
Toxicant
Flush
Wand
Cap
Wand
ISUS
CTD
REX
TSV
SAX
REV
SAX
Exhaust
FOV
RO
Free
POV
HPP
IEP
EPT
SOV
SMP
Free
SPT
RST
SST
SRV
RST
Exhaust
SBV
Intake
ESP Intake
ESP Exhaust
HP Pump
IE Pump
Sample
Pump
RS
RSS
RES
RBS
ReSample Bag
IS
SSS
SES
SBS
Sample Bag

Mechanical Systems
Simple Operating Theory

			Oil Valves			Water Valves								
	Valve Name		POV	FOV	SOV	TSV	REV	SRV	SBV	WMV	Wand Cap	HP Pump	IE Pump	Sample Pump
	Valve description		*Pump Oil Valve*	*Flood Oil valve*	*Sample Oil valve*	*Toxicant Sample valve*	*Resample Exhaust Valve*	*Sample resample valve*	*Sample Bypass Valve*	*Wand Manifold Valve(s)*				
			Closed x2	*Closed x2*	*Closed x2*	*Closed x2*	*Closed x2*	*Closed x2*	*Closed x2*	*Toxicant*	*closed*	*OUT*	*IN*	*FWD*
	Potential Valve positions/Names		*HP Pump HPP*	*Orifice OR*	*Sample Pump SMP*	*Resample top REX*	*ESP Exhaust*	*Resample Tube RST*	*ESP Exhaust*	*Flush*	*open*	*off*	*OUT*	*RVS*
			I/E pump IEP	*Free*	*Free*	*Sample top SAX*	*Sample top SAX*	*Sample Tube SST*	*Resample Tube RST*	*Wand*			*off*	*off*
	State Description	Termininating Condition								Sea				
0	Wake up													
1	All bags/lines toxicated		Closed	Free	Free	Closed	Closed	Closed	Closed	Closed	Closed	off	off	off
2	Empty Bags	RES AND SES active	IEP	Closed	Free	REX	SAX	Closed	Closed	Sea	Closed	off	IN	off
3	Intake Flush Resample bag	Draw X flush volume	IEP	Closed	Free	REX	Closed	Closed	Closed	Flush	Closed	off	OUT	off
4	Intake Flush Sample bag	Draw XX flush volume	IEP	Closed	Free	SAX	Closed	Closed	Closed	Flush	Closed	off	OUT	off
5	Flush DWSM lines from Sample 1	SAM FWD x volume	IEP	Closed	SMP	Closed	SAX	Closed	Closed	x	Closed	off	off	FWD
6	Flush DWSM lines from Sample 2	SAM FWD x volume	IEP	Closed	SMP	Closed	Closed	Closed	RST	x	Closed	off	off	FWD
7	Flush Wand from Sample	push xx flush out wand	IEP	Closed	Free	SAX	Closed	Closed	Closed	Wand	Open	off	IN	off
	(alternate, with SMP)			Free	SMP								off	FWD
8	Empty Bags (of Flush)	RES AND SES active	IEP	Closed	Free	REX	SAX	Closed	Closed	Sea	Closed	off	IN	off
9	Seawater rinse wand, get ISUS/CTD	xxx time	IEP	Closed	Free	SAX	Closed	Closed	Closed	Wand	Open	off	off	off
9	Intake Sample	Draw XX sample volume	IEP	Closed	Free	SAX	Closed	Closed	Closed	Wand	Open	off	OUT	off
10	Isolate sample		Closed	Free	Free	Closed	Closed	Closed	Closed	x	Closed	off	off	off
	Depressurization													
11	Depressurize	Look for bubble or pressure	HPP	Closed	Free	Closed	Closed	Closed	Closed	x	Closed	ON	off	off
	PASS GAS													
13	Flush core lines	ESP push x flush out intak	Closed	Closed	Closed	Closed	Closed	RST	Closed	x	Closed	off	off	off
14	Sample	Push XX volume thru core	Closed	Closed	SMP	Closed	Exhaust	SST	Closed	x	Closed	off	off	FWD
	(Alternate, core syringe)	ESP syringe sample till do	Closed	Closed	Free	Closed	Exhaust	SST	Closed	x	Closed	off	off	off
15	Wait for core to purge	Core purges intake, exhaus	Closed	Closed	Free	Closed	Exhaust	SST	Closed	x	Closed	off	off	off
16	Isolate from Core		Closed	Closed	Free	Closed	Closed	Closed	Closed	x	Closed	off	off	off
17	High Delta P Repressurize	until pressure is close, wat	Closed	OR	Free	Closed	Closed	Closed	Closed	x	Closed	off	off	off
18	Low Delta P Repressurize		Closed	Free	Free	Closed	Closed	Closed	Closed	x	Closed	off	off	off
19	Empty sample Bag	SES active	IEP	Closed	Free	SAX	Closed	Closed	Closed	Sea	Closed	off	IN	off
20	Empty most of Resample Bag	push all but mix volume	IEP	Closed	Free	REX	Closed	Closed	Closed	Sea	Closed	off	IN	off
21	Intake toxicant mix into resample	Draw X TOX volume	IEP	Closed	Free	REX	Closed	Closed	Closed	TOX	Closed	off	OUT	off
22	Tox Wand from ReSample	push xx toxmix out wand	IEP	Closed	Free	REX	Closed	Closed	Closed	Wand	Open	off	IN	off
23	Tox DWSM lines 1	push xx toxmix into sample	Closed	Closed	SMP	Closed	SAX	Closed	Closed	x	Closed	off	off	RVS
24	Tox DWSM lines 2	push half toxmix into samp	Closed	Closed	SMP	Closed	Closed	Closed	RST	x	Closed	off	off	RVS
25	Run stir pumps	xx time	Closed	Free	Free	Closed	Closed	Closed	Closed	x	Closed	off	off	off
26	Shut down		Closed	Free	Free	REX	SAX	Closed	Closed	x	Closed	off	off	off

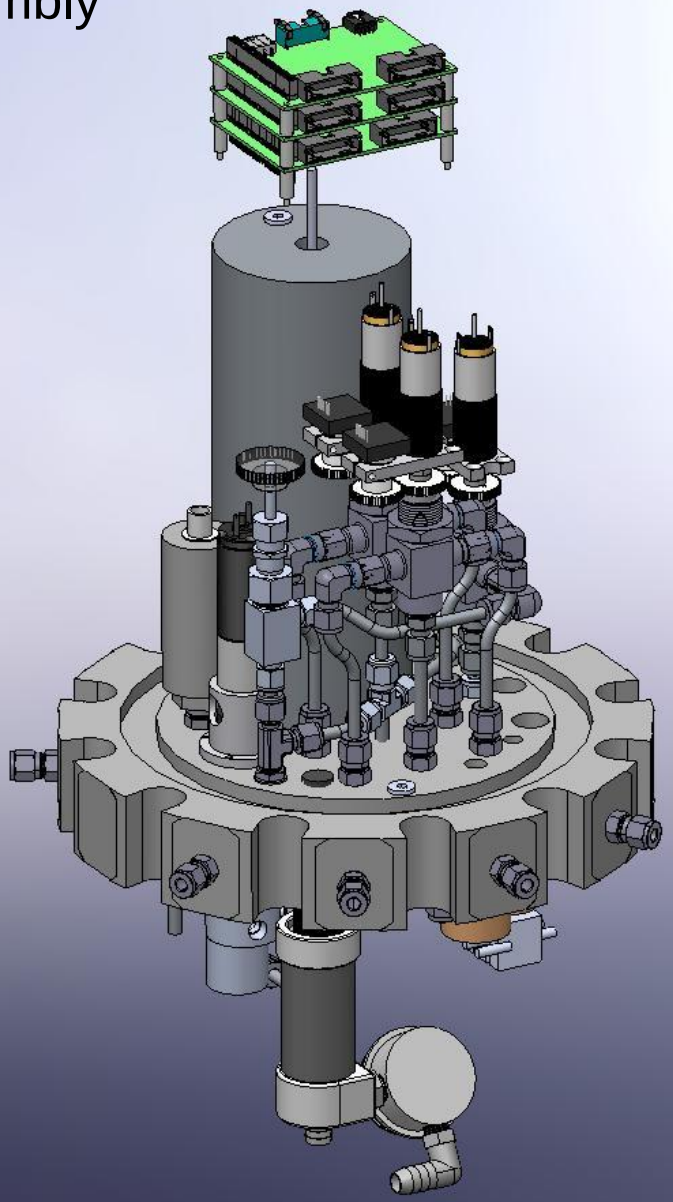
4000m DWSM Systems
System Assembly

Waste Side Cylinder Assembly



Mechanical Systems
System Assembly

- Waste Chamber Dry Housing



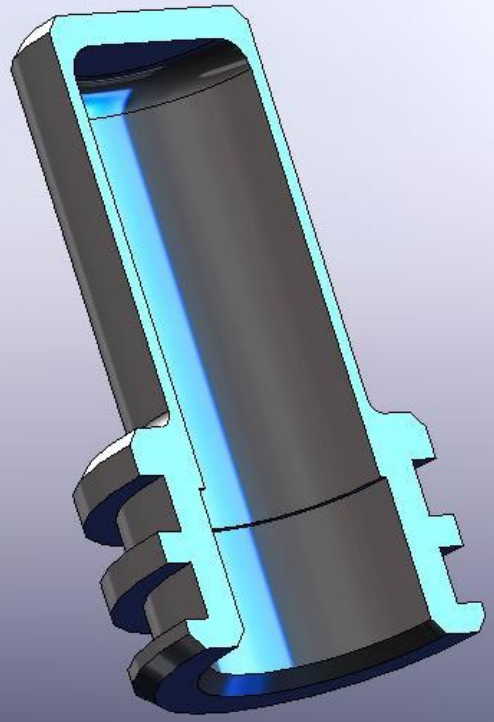
Mechanical Systems
Pressure Housings

- 10 Pressure housings/plates
  - 4 Bell Housings
  - 3 Mag coupling shrouds
  - 2 Flat Plates
  - 1 Motor housing inside another pressure shell.

- Typically 1.5 factor for yield, and 2.0 for buckling
- Material Options:
  - 6Al4V Ti Sy: 119 ksi E: 16 Mpsi
  - 17-4PH 1150 Sy: 100 ksi E: 28.5 Mpsi
  - 7068-T6511 Sy: 99 ksi E: 10 Mpsi
  - 7075-T6 Sy: 62 ksi E: 10.3 Mpsi
  - 6061-T6 Sy: 35 ksi E: 9.9 Mpsi
- Reduced pressure allowance for populated lab operation. (ASME B31.1 or B31.3) About half.
- Full pressure lab operation with evacuated lab. (pressure facility)

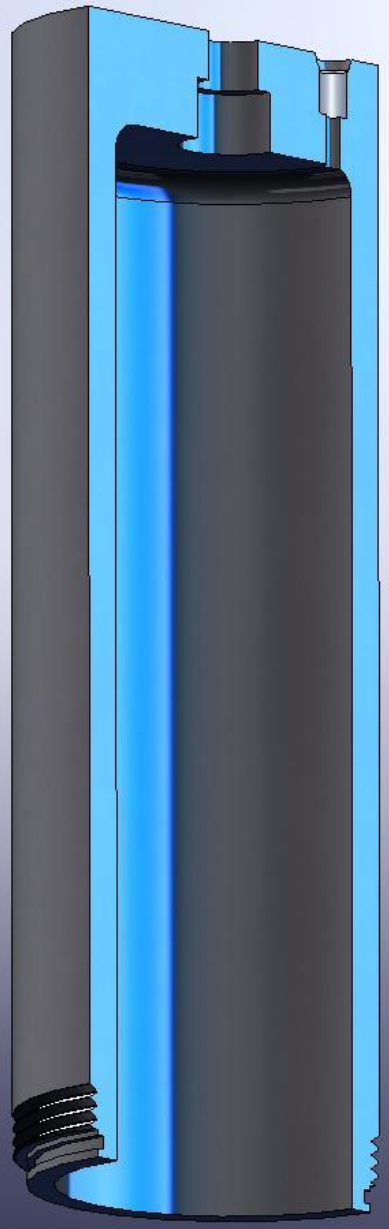
Mechanical Systems
Pressure Housings

- Magnetic Coupling Pressure Shroud
  - Designed for MTC-0.1 coupling
  - 15mm ID, 1mm Wall
  - Design factors (4000m)
    - 1.5 to Yield (8.8 ksi pressure)
    - 2.0 Buckling (11.7 ksi pressure)
  - Tube section pressure limits
    - 6Al4V Ti
      - Yield at 15 ksi
      - Buckling at 26 ksi
    - 17-4PH 1150
      - Yield at 12.7 ksi
      - Buckling at 46 ksi
    - 7068-T6511
      - Yield 12.6 ksi
      - Buckling at 16.8 ksi
  - FEA still to finish



Mechanical Systems
Pressure Housings

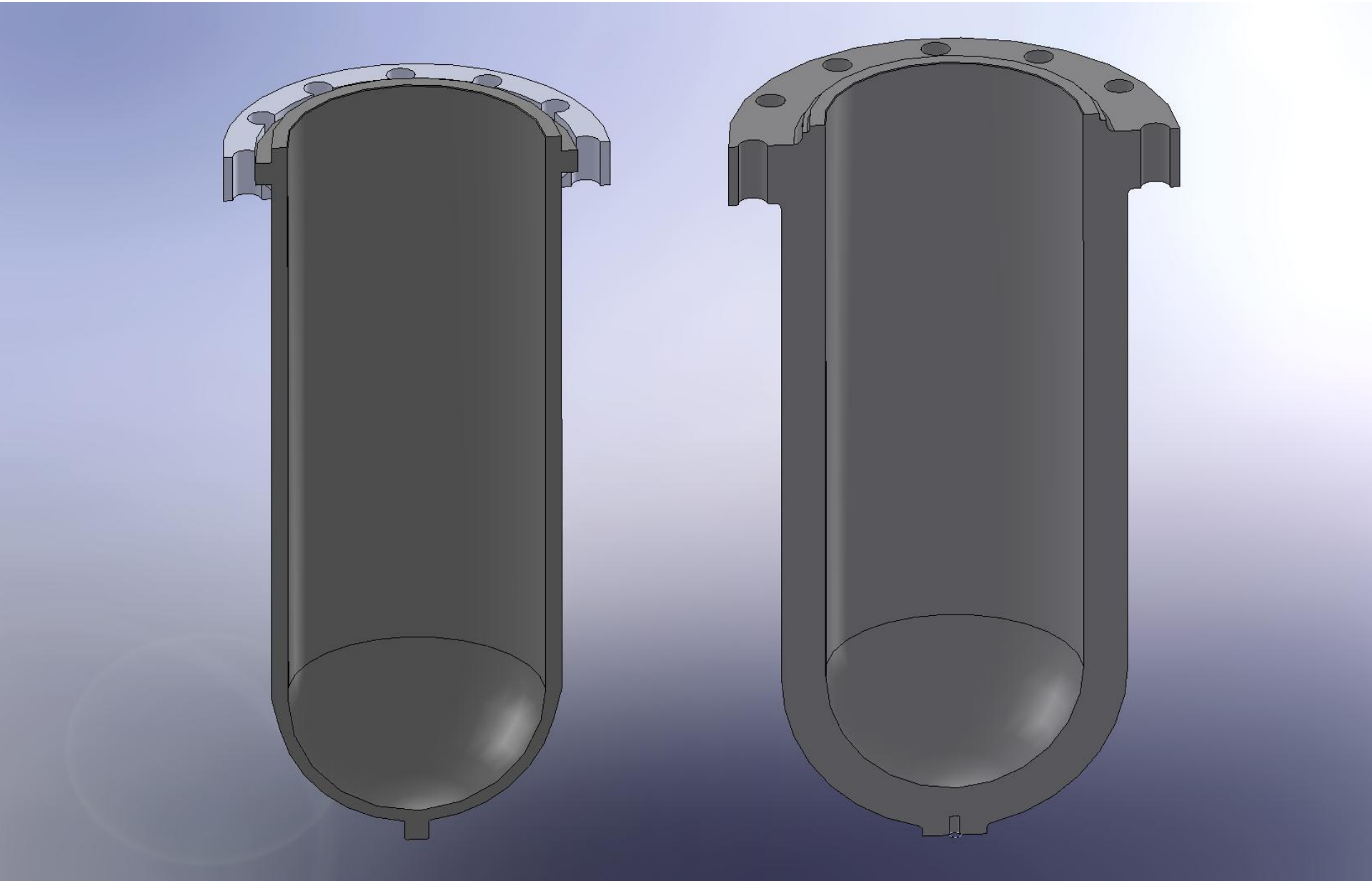
- DeComp Pump Pressure Can
  - Designed for HP Pump Motor
  - 3.25” ID, 4” OD
  - Design factors (4000m)
    - 1.5 to Yield (8.8 ksi pressure)
    - No buckling condition, internal pressure only.
  - Tube section pressure limits
    - 6Al4V, Yield at 23 ksi
    - 17-4PH H1150, Yield at 19.6 ksi
    - 7068-T6511, Yield 19.4 ksi
    - 7075-T6, Yield 12 ksi
    - 6061-T6, Yield at 6.8 ksi
  - FEA still to finish
  - Stress concentration at threads



Mechanical Systems
Pressure Housings

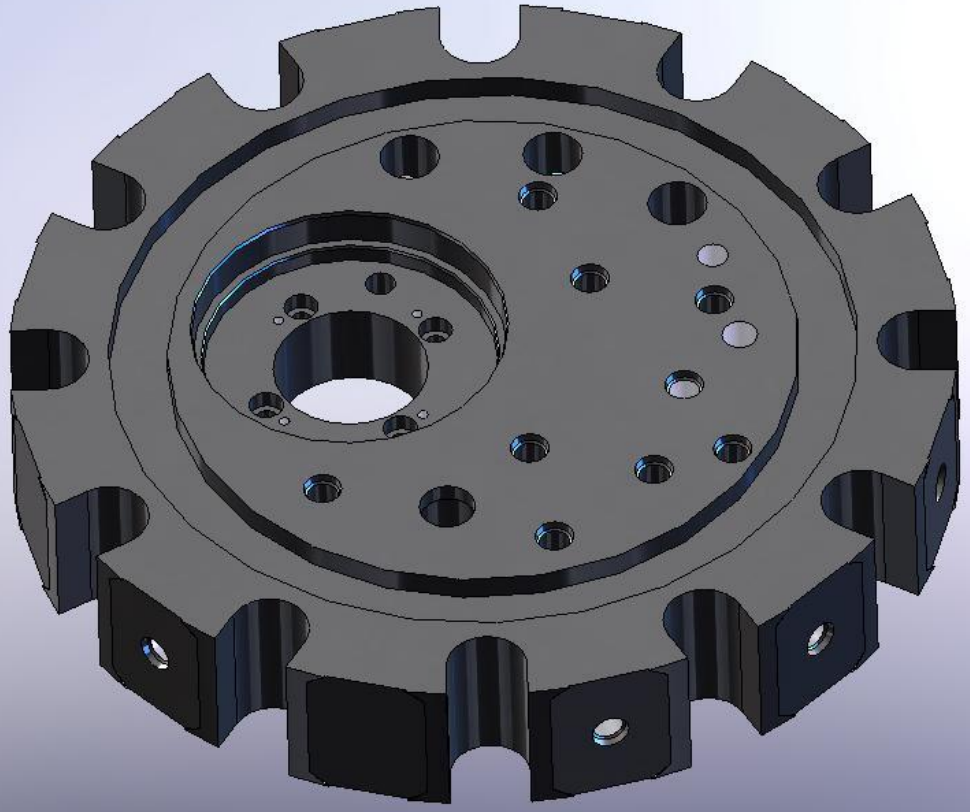
- Bell Housings
  - Common design for Oil chambers and Electronics housings.
  - Ocean deployment needs light fastening only
  - Lab operation requires large high strength bolts and Van Stone rings.
  - Near term fabrication (Aluminum)
  - Long term fabrication (Cast Ti)
  - Same Design factors (4000m)
    - 1.5 to Yield (8.8 ksi pressure)
    - 2.0 Buckling (11.7 ksi pressure)
    - Bearing faces allow up to 90% Sy of softer material.
  - Tube section pressure limits
    - 6Al4V Ti, 0.5” wall
      - Yield at 14.4 ksi
      - **Buckling at 12.5 ksi**
    - 6061-T6, 1.375” Wall
      - **Yield 9.0 ksi**
      - Buckling at 98 ksi
  - FEA still to finish
  - Issues with stress concentrator at flange and bearing face stress.

Mechanical Systems
Ti and Al Bell Housings

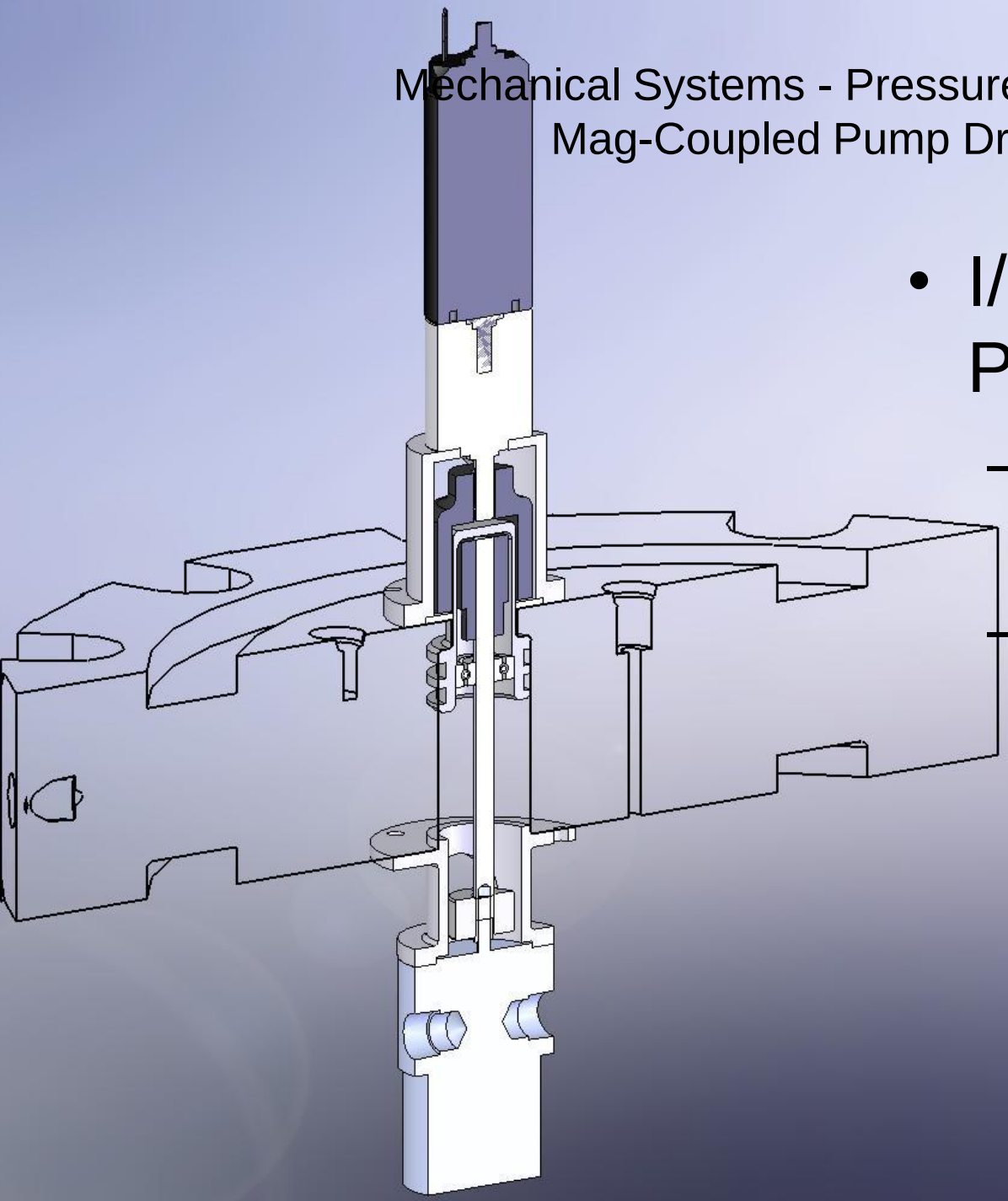


Mechanical Systems
Pressure Housings

- Main Plate
  - Sandwiched between dry housing and oil chamber.
  - Design factors (4000m)
    - 1.5 to Yield (8.8 ksi pressure)
  - Tube section pressure limits
    - 6Al4V Ti, 2” thick machined plate
  - FEA still to finish
    - Issue with large machined features and deformation
    - Easily can make plate thicker.
    - Sample housing plate still to do.
  - Heavily machined part

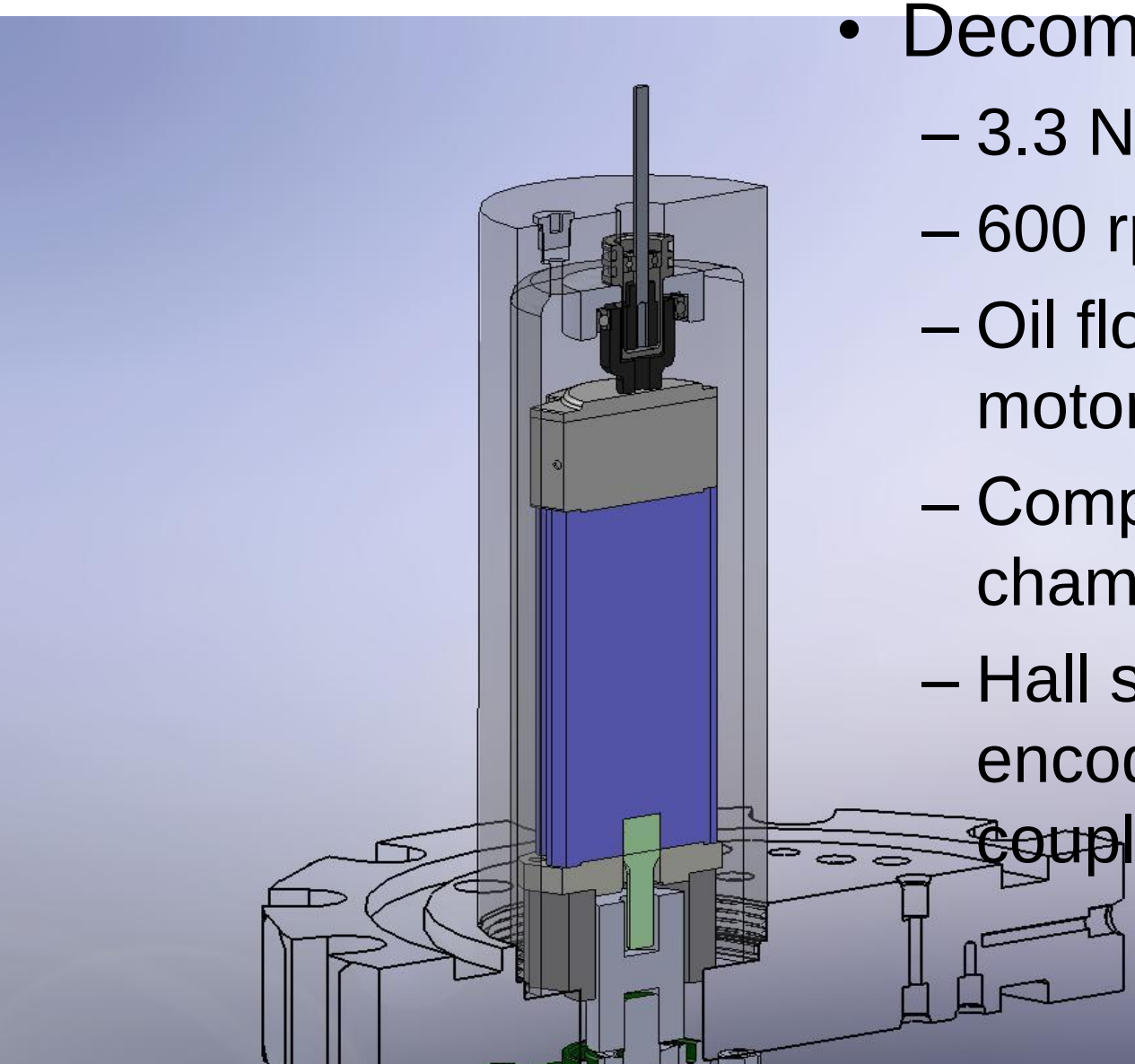


Mechanical Systems - Pressure Housings
Mag-Coupled Pump Drive



- I/E and Sample Pumps
  - 100mNm torque capacity
  - Bearing centered

Mechanical Systems - Pressure Housings
High Pressure Pump Drive



- Decomp Pump Drive
  - 3.3 Nm torque
  - 600 rpm +/-
  - Oil flooded brushless motor
  - Comp’d to main oil chamber
  - Hall sensor and encoder mag coupled thru housing

Deep Water Sampler
Fluidics

- Sample/Waste bags: MSR 10L
- Pressure Transducers: Honeywell TJF, 6000 psi scale. Same ones as 1k DWSM, we know what to expect.
- Pressure switches: PSF100A SPST, double make/break. Oil comp'd to sample/waste seawater
- Seawater exposed stainless fittings are "expendables" for short duration deployments.

Valves

- 3-way valves use standard rotary valve actuator.
- Re-pressurization restriction valve manually set.

Service	MAWP* psi	Cv	Qty	MFG, Part No.
Oil Valves	6000	0.75	3	Swagelok SS-83XPF4
Seawater Valves	6000	0.75	4	Swagelok SS-83XPF4
RP Valve	5000	0-.04	1	Swagelok SS31RS4-A

Pumps

Service	psi	Flow	Qty	MFG, Part No.
HP pump	10000	0.4 mL/rev	1	Bosch Rexroth PR4-1X/0,40-700WA01M01
I/E Pump	80	.64 mL/rev	1	Micro Pump GJ-N23
I/E Pump alt	100	0.72 mL/rev	1	FMI QP Q2CSC
Sample Pump	100	0.1 mL/rev	1	FMI RH1CKC
Stirring Pumps	-	-	2	Seabird 5M

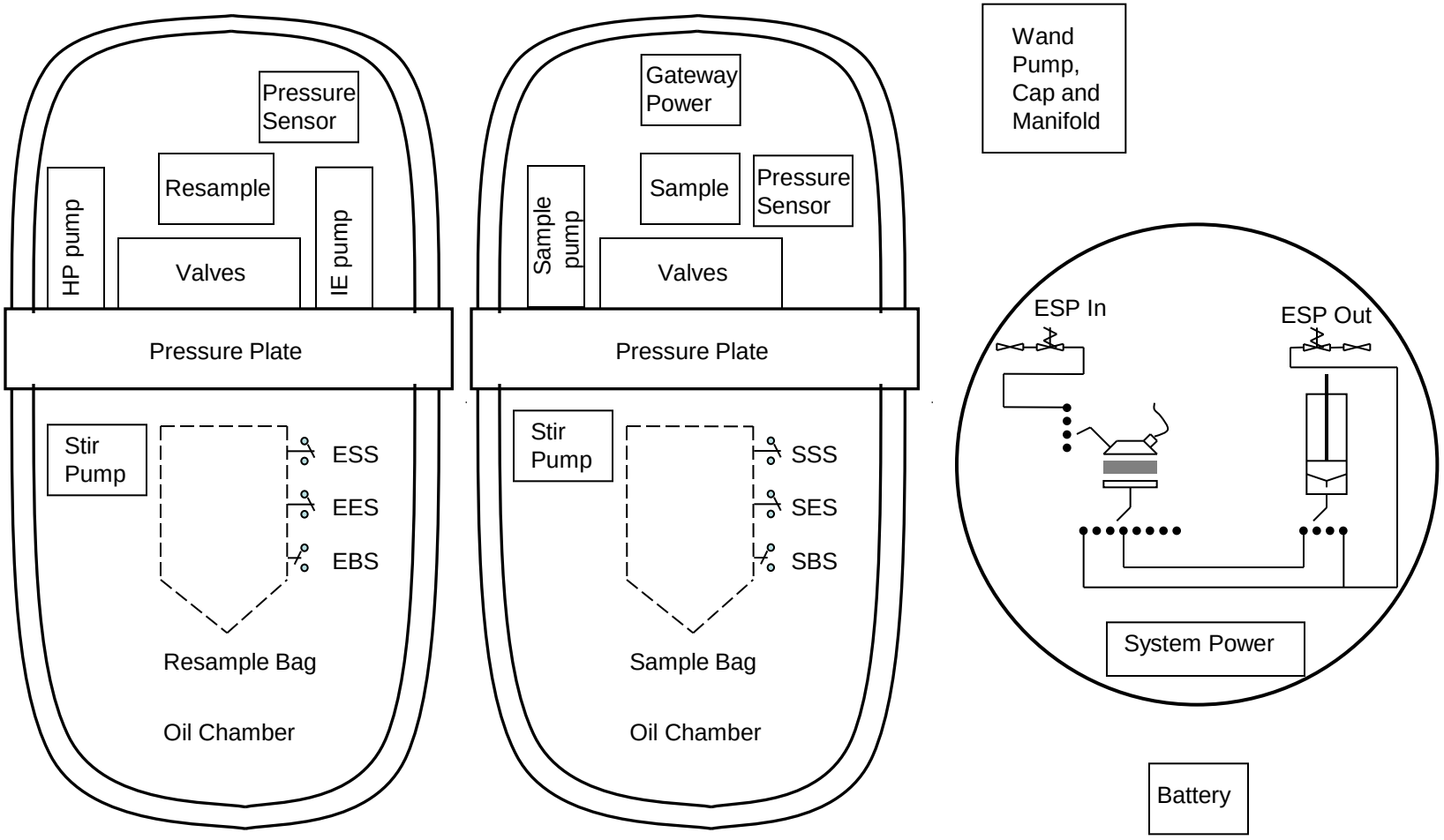
DWSM Electrical System Requirements

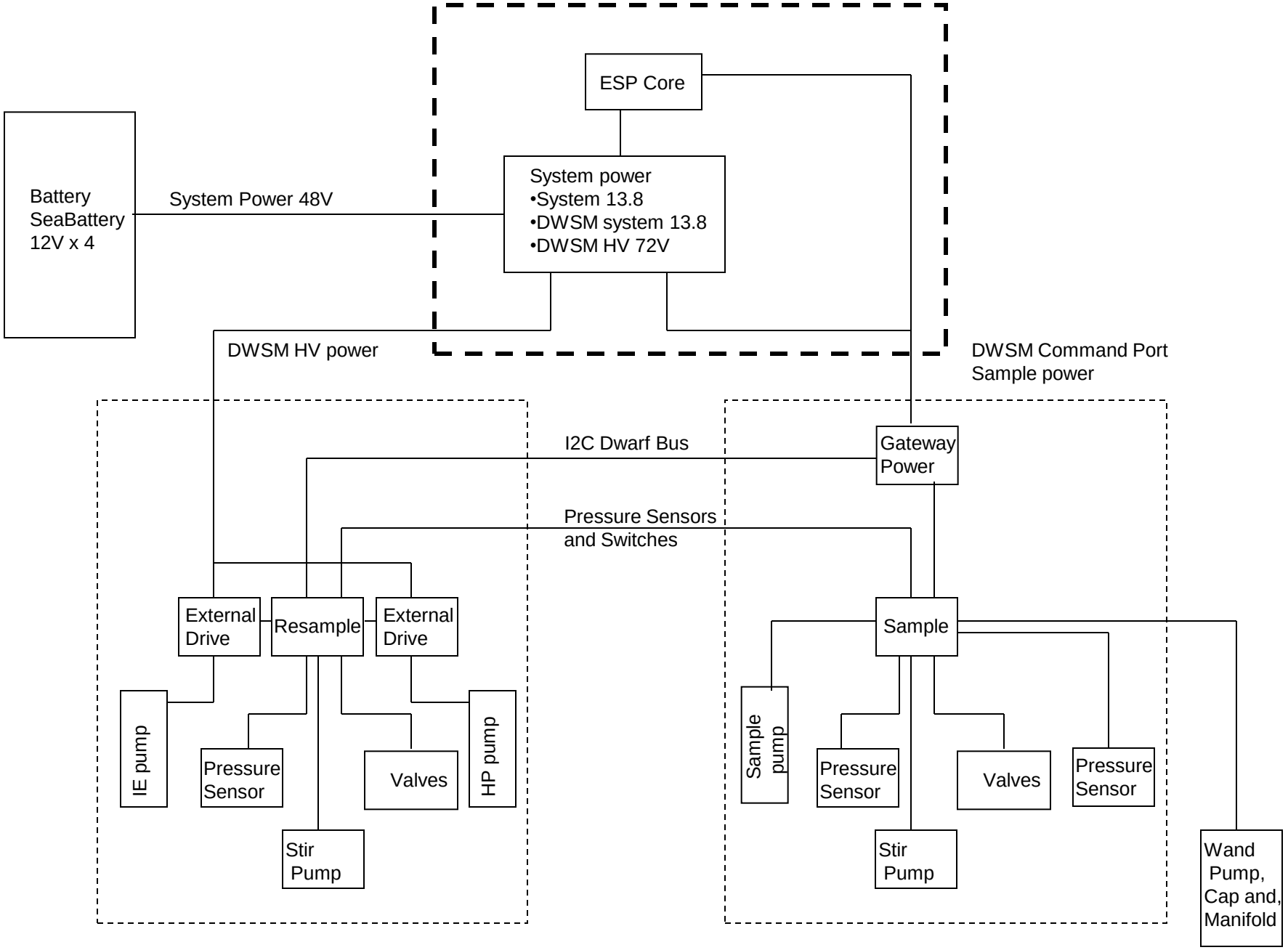
- Electrically interfaced elements
  - 7 Rotary Valves
  - 4 Solenoid Valves
  - 6 pump motors
    - 3 Oil
      - Volume pumped
      - Rate
    - 3 water
      - On and Off control
  - Pressure Sensors
    - 2 Analog
    - 6 Indicator and Safety switches
- ESP interface
  - RS-232 from Core via External Sampler port
  - ESP core power 13.8V
- Platform Interface
  - DWSM power
  - Sealed Lead Acid Battery Pack
    - Elevator
    - Supplementary Battery Elevator

DWSM Design Philosophy

- Leverage ESP
  - Mechanical
  - Electronics
  - Software

Deep Water Sampler
Aqua Lung

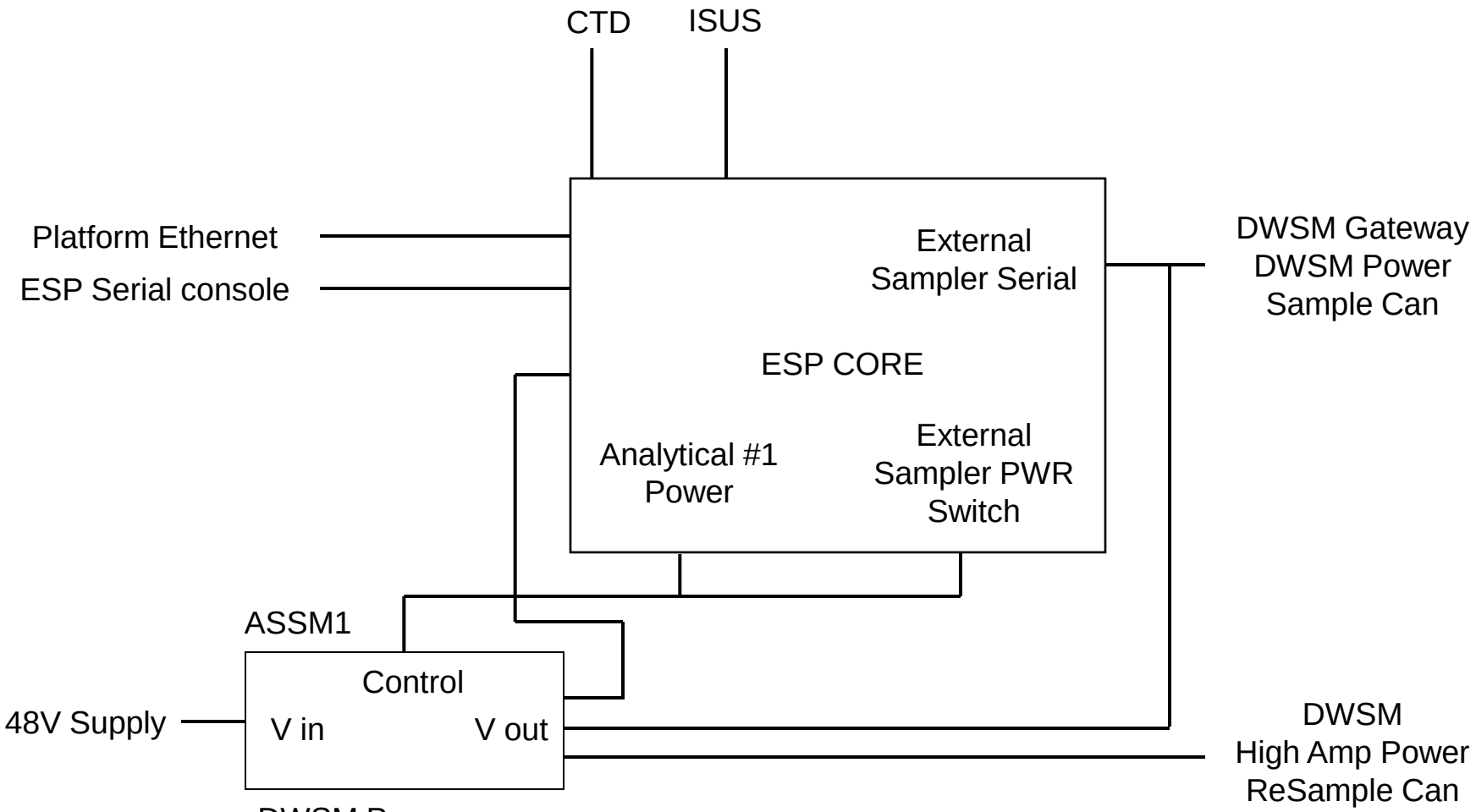



ESP Core
Battery
SeaBattery
12V x 4
System Power 48V
System power
•System 13.8
•DWSM system 13.8
•DWSM HV 72V
DWSM HV power
DWSM Command Port
Sample power
I2C Dwarf Bus
Gateway
Power
Pressure Sensors
and Switches
External
Drive
Resample
External
Drive
Sample
IE pump
Pressure
Sensor
Valves
HP pump
Stir
Pump
Sample
pump
Pressure
Sensor
Valves
Pressure
Sensor
Stir
Pump
Wand
Pump,
Cap and,
Manifold

Deep Water Sampler
Ball Electronics

- Convert Battery Power to Power for ESP core and DWSM
  - ESP core 10 – 16V
  - DWSM
    - 10 – 16 V
    - 72 V
- Power Requirements
  - 10 – 16V at 150W
  - 72V at 500W
- Battery Array
  - Deep Sea power and Light SeaBattery
  - 12V individual battery rated at 1KwHr
  - 4 SeaBattery's series connected for 48V nominal power
  - 48V selected to lower current draw
- Two Vicor ComPAC DC-DC power system
  - 48 to 13.8 at 200W for System voltage
  - 48 to 72 at 600W for Motor bus voltage
  - Various Modules support multiple power sources
  - Tiburon II, MARS, Ventana
- DWSM system and Motor Bus voltage will be power managed by the ESP core
- Batteries will not be charged

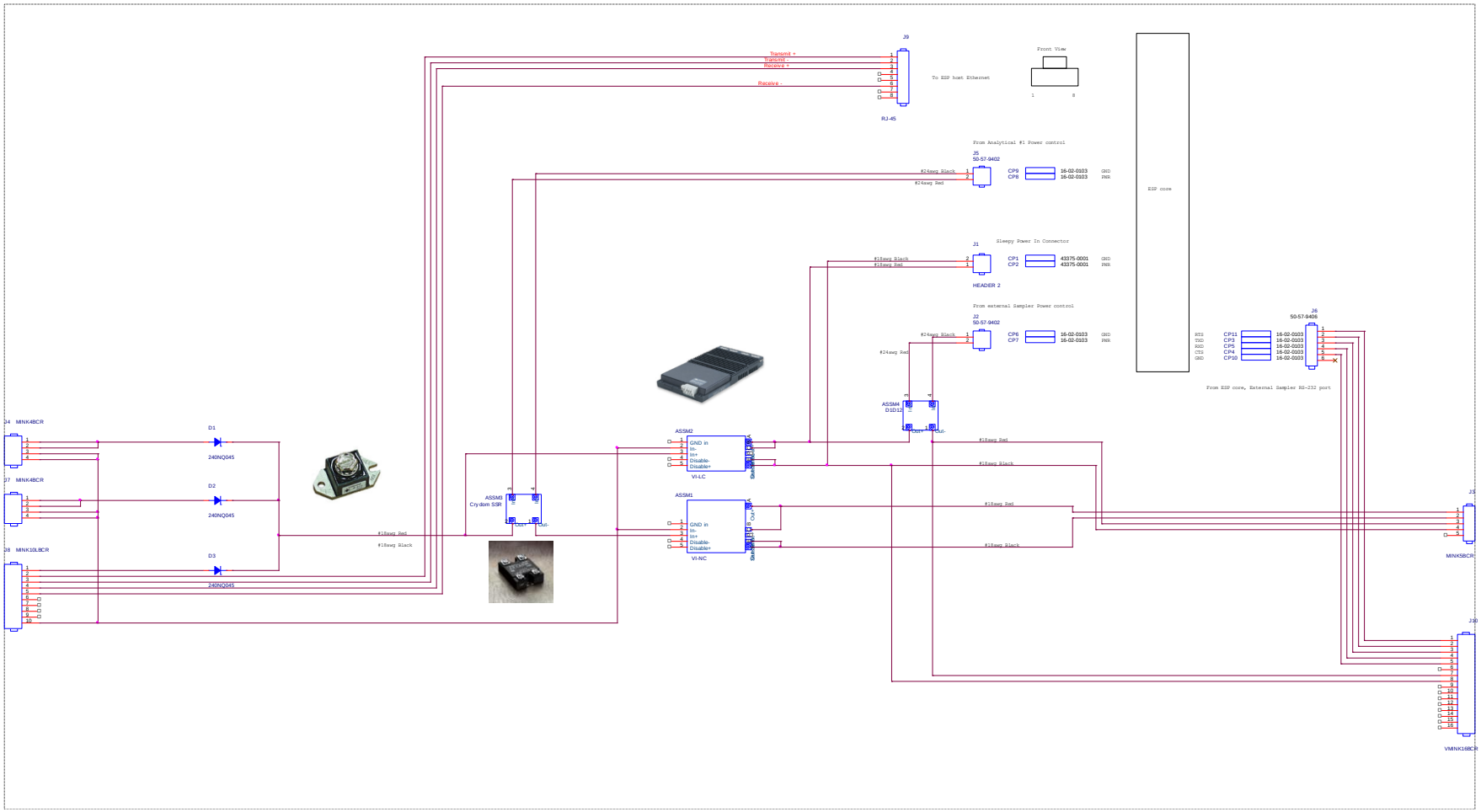
Deep Water Sampler
Ball Electronics

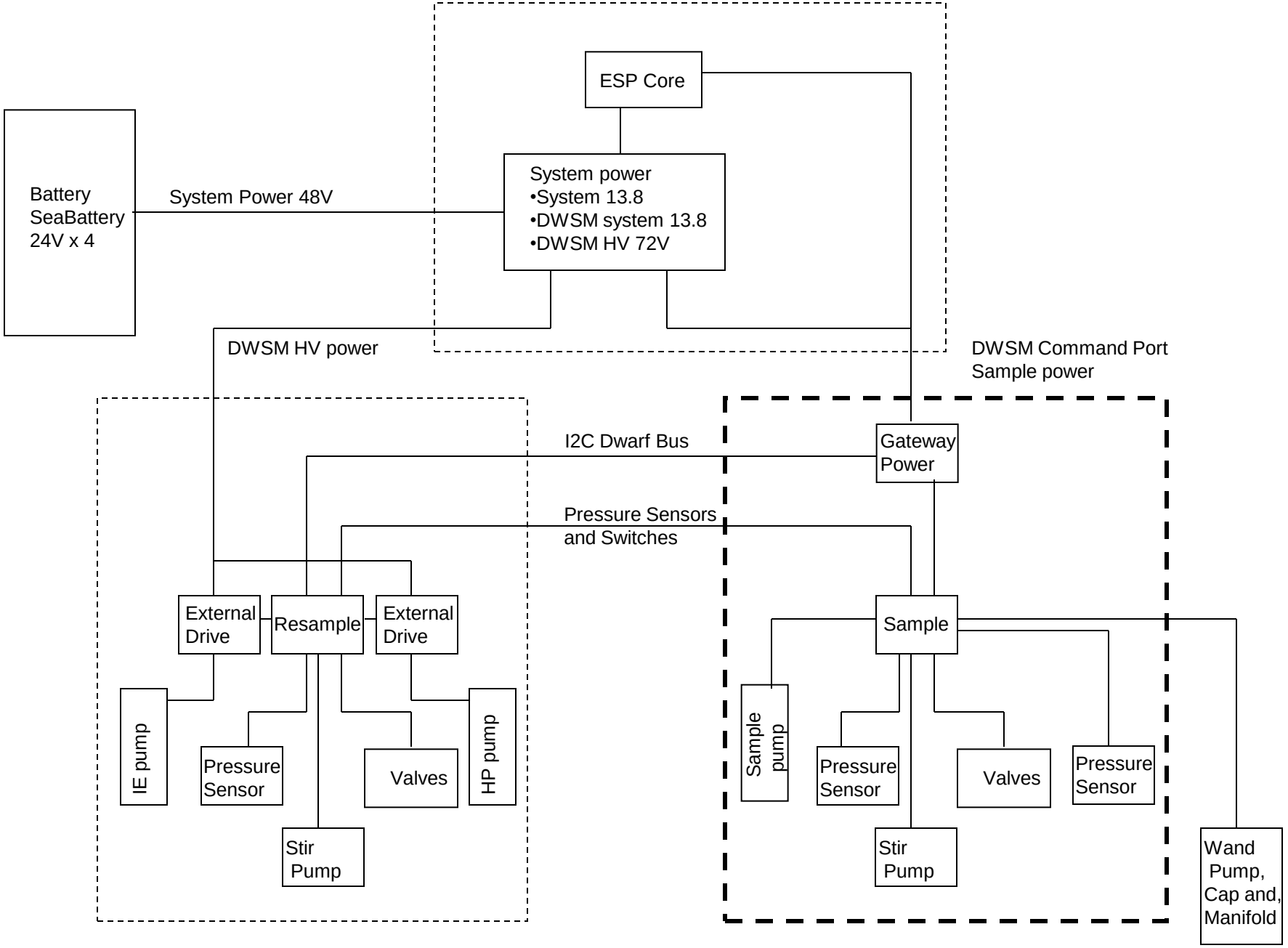


DWSM Power
Control inputs:

1) 13.8V Used as primary voltage to DWSM
2) HV Power – only turned on when high power pumps are needed.

Deep Water Sampler
Power Supply



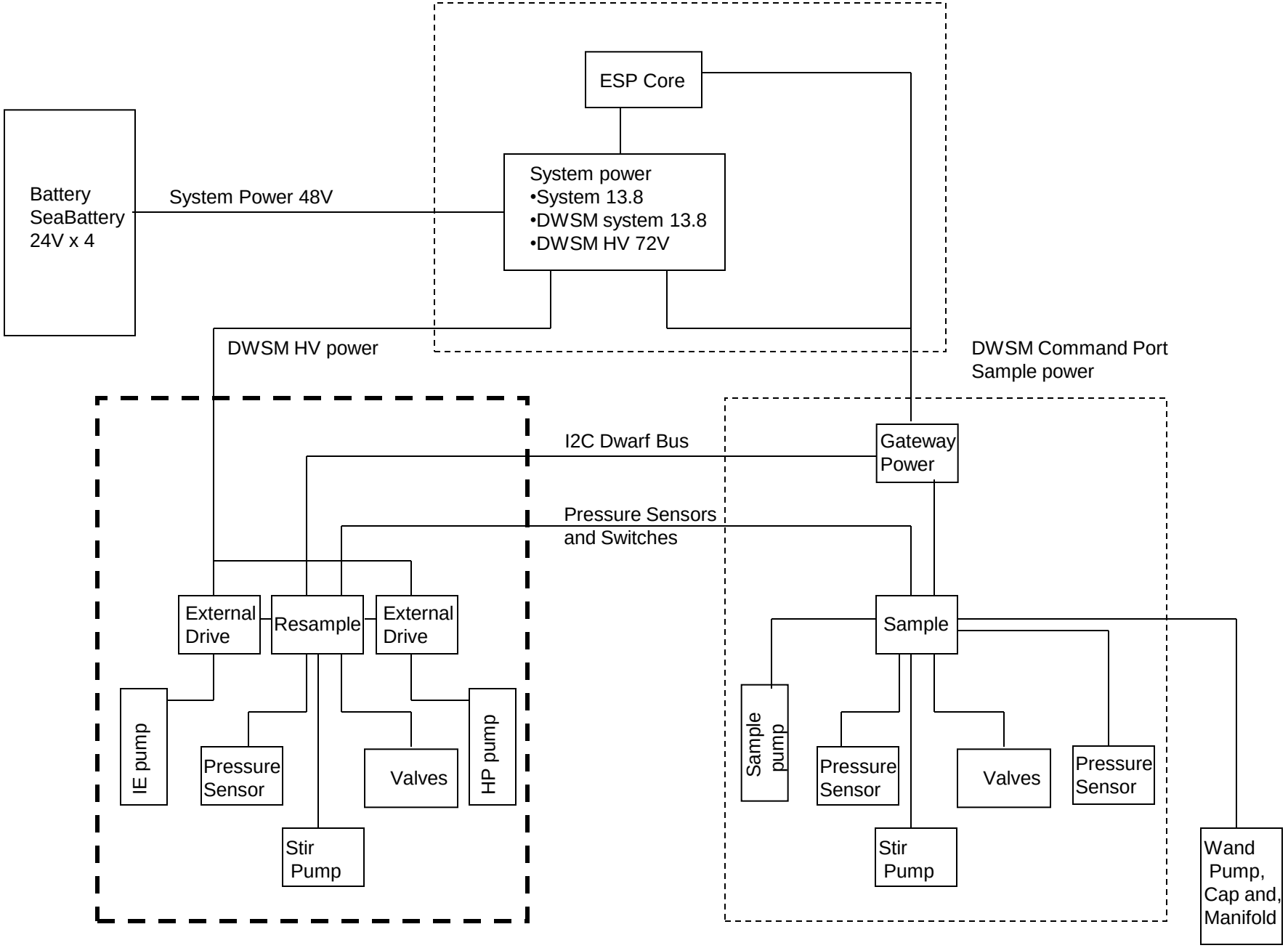

ESP Core
Battery
SeaBattery
24V x 4
System Power 48V
System power
•System 13.8
•DWSM system 13.8
•DWSM HV 72V
DWSM HV power
DWSM Command Port
Sample power
I2C Dwarf Bus
Gateway
Power
Pressure Sensors
and Switches
External
Drive
Resample
External
Drive
Sample
IE pump
Pressure
Sensor
Valves
HP pump
Stir
Pump
Sample
pump
Pressure
Sensor
Valves
Pressure
Sensor
Stir
Pump
Wand
Pump,
Cap and,
Manifold

DWSM
Requirements of Sampler

- System Interface – I2C Dwarf Bus
- 1 Brushed low power servo motor
- 4 Rotary Valves
- 3 Pressure Switches
- 2 Pressure Sensors
- 3 Limit Switches
- 3 Remote Limit Switches
- 4 Solenoid Valves
- 1 Solenoid “Wand Cap”
- 2 Brushed low power motors
- Low Voltage Power Supply
- Gateway for ESP core

DWSM
Requirements of Sampler

- Dwarf Core with Rvalve
  - 2 Servo channels
  - 4 Rotary Valves
  - 8 Solenoid Drivers
  - Limit Switch inputs for Servo Channels
  - Analog inputs but, requires conditioning
  - I2C interface
- Dwarf Core programmed to act as Serial to I2C gateway
- Missing functions handled by Dpress board on Dwarf Bus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External
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External
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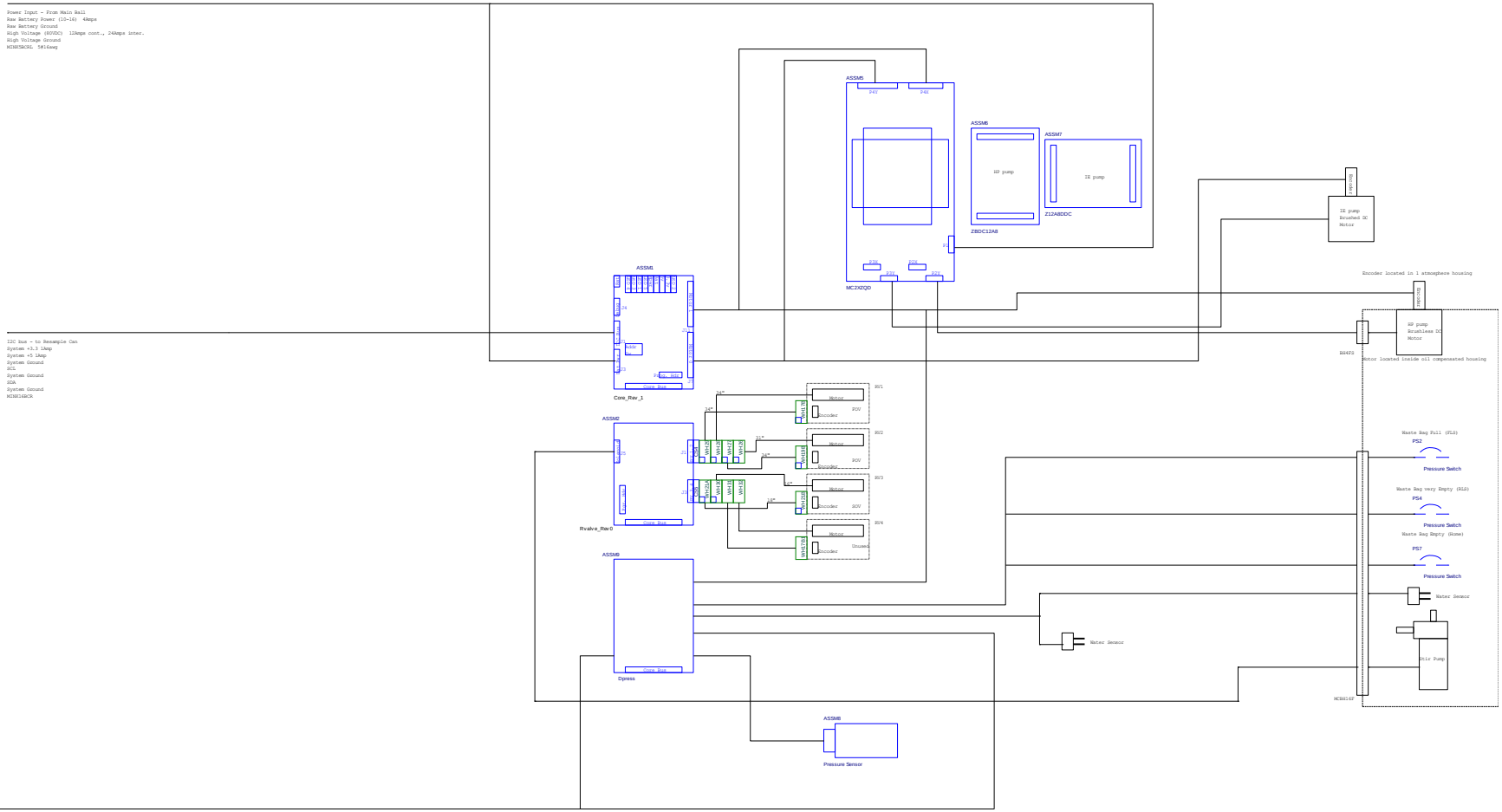
IE pump
Pressure
Sensor
Valves
HP pump
Stir
Pump
Sample
Sample
pump
Pressure
Sensor
Valves
Pressure
Sensor
Stir
Pump
Wand
Pump,
Cap and,
Manifold

DWSM
Requirements of ReSampler

- Dwarf Core with Rvalve
  - 2 Servo channels – low power directly
  - 4 Rotary Valves
  - Limit Switch for Servo Channels
  - Analog inputs but requires conditioning
  - I2C interface
- Dwarf Core modified to output PWM and Direction
- AMC Z-flex Drive
  - PWM and direction command input
  - 6amp continuous and 12 amps peak
  - Torque mode to support maximum pressure regulation
  - Brushed and Brushless support
  - 16-80V supply
- Missing functions handled by Dpress board on Dwarf Bus

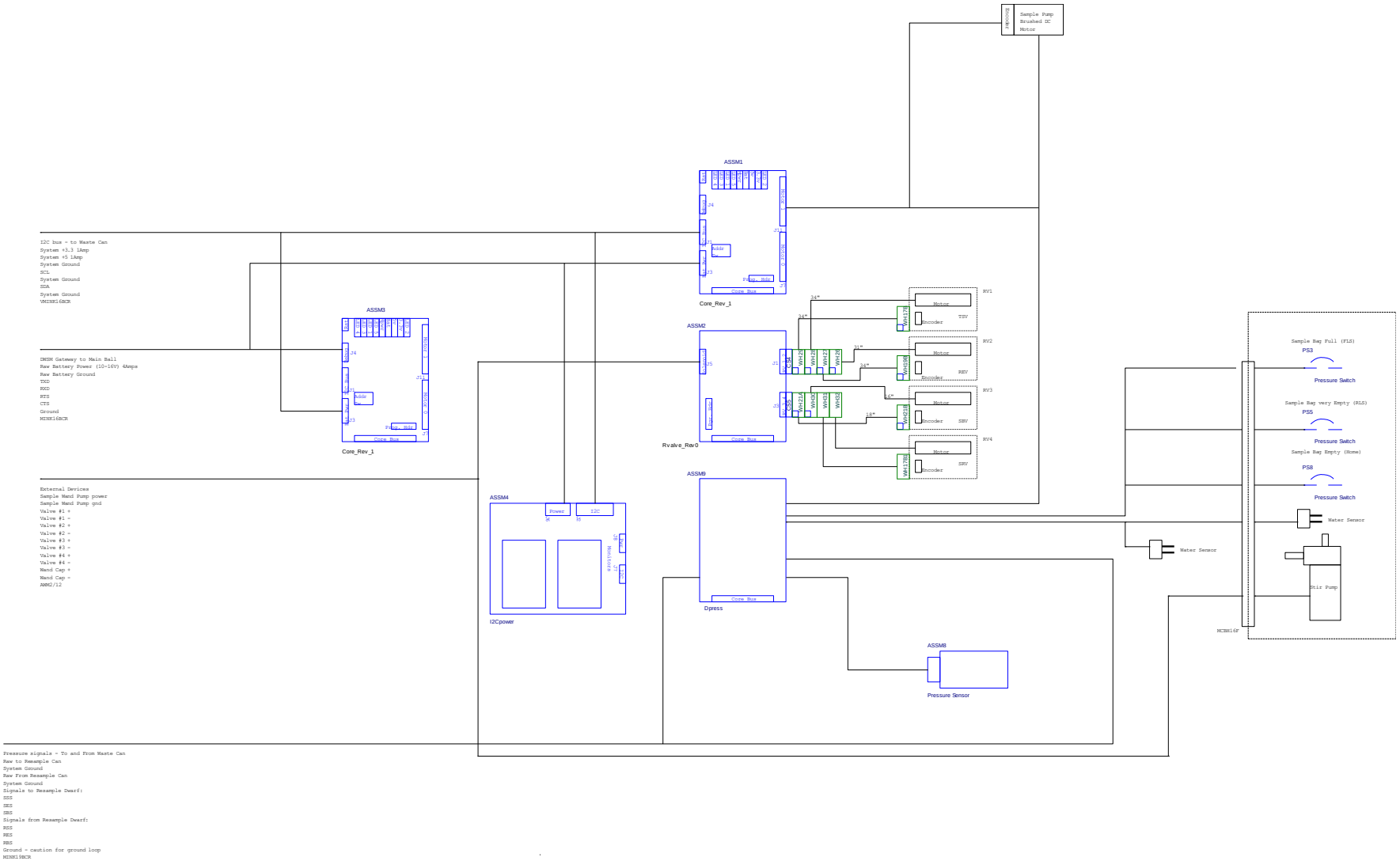
Deep Water Sampler
ReSample Can Electronics



DWSM
Requirements of Sampler

- System Interface – I2C Dwarf Bus
- 1 Brushed medium power motor
- 1 Brushless high power motor
- 4 Rotary Valves
- 3 Pressure Switches
- 2 Pressure Sensors
- 3 Limit Switches
- 3 Remote Limit Switches

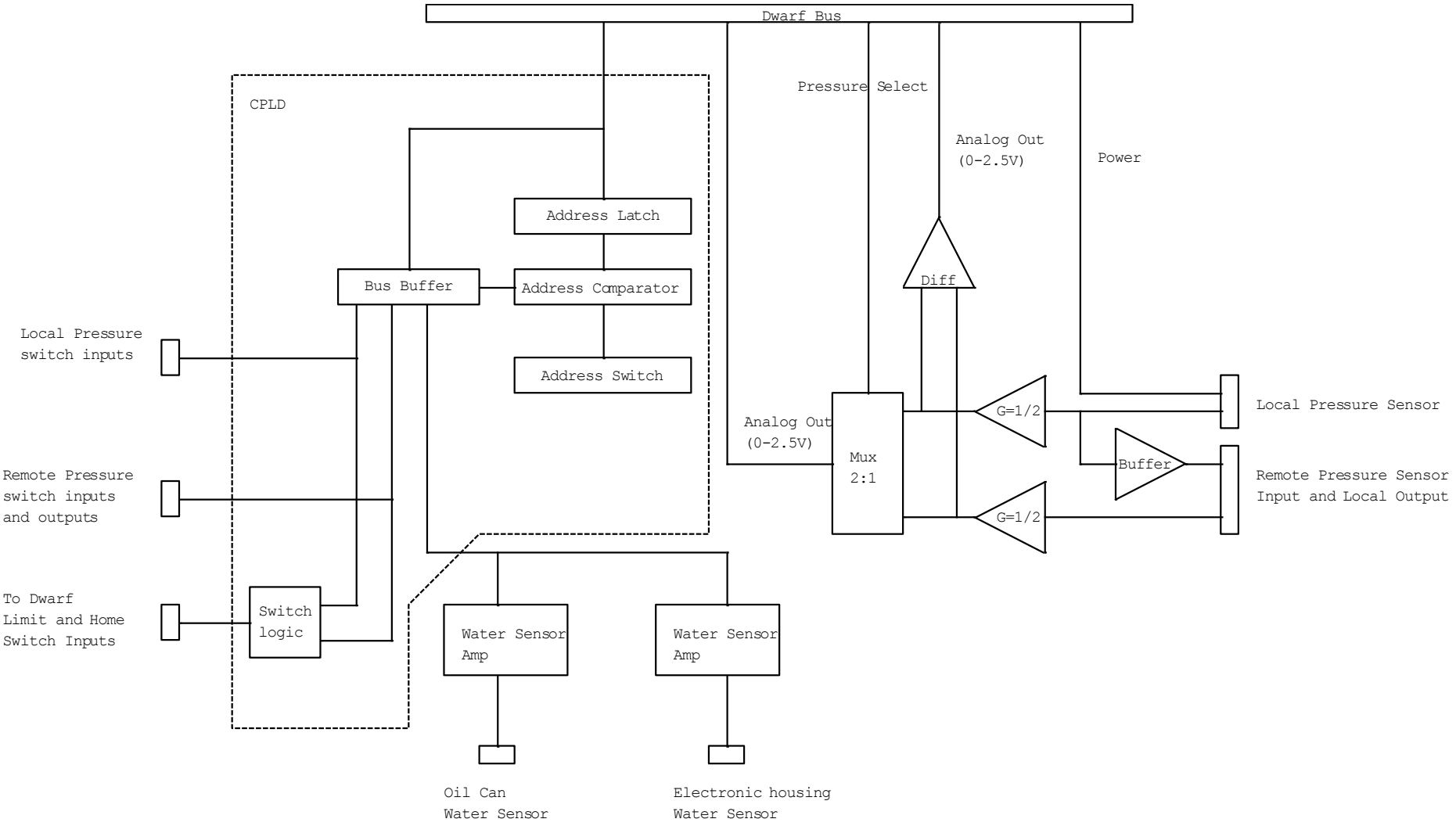
Deep Water Sampler
Sample Can Electronics



Deep Water Sampler
Dpress Interface Requirements

- Pressure Sensor conditioning
  - Sensor output 0 – 5V for 0 – 6000 psia
  - ADC input 0 to 2.5V
  - Amplified Difference (0 – 100psid)
  - Connection to Dwarf Bus (AN6 and 7)
  - Multiplexing pressure to a single ADC channel – selectable via Dwarf bus register
  - Difference signal to a separate ADC channel
- Pressure Sensor Switches
  - Contact Closure
  - Limit switch logic
  - Local limit switch states sent to remote host
  - Connector to Limit Switch input on Core
- Water Sensor interface
  - Oil
  - Air
  - Digital
- Dwarf Bus Interface
  - Dwarf Physical form factor
  - 8 bit read and write register
  - Standard Dwarf bus protocol
    - Multiplexed Address and Data
    - Auto Address increment
  - Register content
    - 2 Water sense bits
    - 6 pressure switch bits
      - 3 local
      - 3 remote

Deep Water Sampler
Dwarf Core Pressure Interface



Deep Water Sampler
Pressure Switch State Logic

			Sample			ReSample					
			Sampling Pump			Depress. Pump			IE pump		
			LVLP			LVHP			HVLP		
	Fwd Oil Direction		W to S	S to W	W to S	S to Res	Res to S	S to Res	W to Res.	Res. to W	W to Res.
Function	**Bag**	**Name**	**FLS**	**RLS**	**Home**	**FLS**	**RLS**	**Home**	**FLS**	**RLS**	**Home**
Bag Really empty	**Waste**	**Under**		**OR**						**OR**	
Bag Full of sample		**Over**	**OR**			**OR**	**OR**		**OR**		
Bag empty		**Empty**			**OR**						**AND**
Bag Really empty	**Sample**	**Under**	**OR**							**OR**	
Bag Full of sample		**Over**		**OR**		**OR**	**OR**		**OR**		
Bag empty		**Empty**			**OR**						**AND**

- Connectors
  - I2C Dwarf Bus
    - MINK16BCR
    - Sample to Resample
    - Wire and pin usage
      - System 3.3
      - System 5
      - System Ground
      - I2C SCL
      - System Ground
      - I2C SDA
      - System Ground
      - 9 spares
  - Pressure Sensor and Switch Harness
    - MINK19BCR
    - Sample to Resample
    - Wire and Pin usage
      - Raw to Waste Can
      - System Ground
      - Raw From Waste Can
      - System Ground
      - SSS - Signals to Waste Dwarf:
      - SES
      - SBS
      - ESS - Signals from Waste Dwarf:
      - EES
      - EBS
      - 9 spares

- Connectors
  - DWSM HV power
    - MINK5BCR
    - ESP core to Resample
    - Wire and pin usage
      - DWSM system power (13.8)
      - DWSM system power ground
      - DWSM system High Voltage (72)
      - DWSM system high Voltage Ground

  - DWSM command and power
    - MINK10BCRL
    - ESP Core to Sample
    - Wire and Pin usage
      - DWSM system Power (13.8V) 4Amps #10awg
      - DWSM system power Ground #10awg
      - TXD
      - RXD
      - RTS
      - CTS
      - Ground
      - 3 spares

- Connectors
  - Sample can Signal connector
    - MCBH16F
    - Sample Oil to Air
    - Wire and pin usage
      - SSS
      - common
      - SES
      - common
      - SBS
      - Common
      - Stir Pump power
      - Stir Pump common
      - Water Sense
      - Water Sense
      - 6 spares

  - Resample can Signal connector
    - MCBH16F
    - Resample Oil to Air
    - Wire and pin usage
      - SSS
      - common
      - SES
      - common
      - SBS
      - Common
      - Stir Pump power
      - Stir Pump common
      - Water Sense
      - Water Sense
      - 6 spares

- Connectors
  - ESP/DWSM Battery power
    - MINK4BCR
    - Battery Junction to ESP core
    - Wire and Pin usage
      - Battery power 48V
      - Battery power 48V
      - Battery Ground
      - Battery Ground
  - Wand Pump
    - AWM2/12
    - Pie connector from Sample to External elements
    - Pin and wire usage
      - Pump pwr
      - Pump ret
      - Wand Cap +
      - Wand Cap -
      - Manifold Valve1 +
      - Manifold Valve1 -
      - Manifold Valve2 +
      - Manifold Valve2 -
      - Manifold Valve3 +
      - Manifold Valve3 -
      - Manifold Valve4 +
      - Manifold Valve4 -

- Connectors
  - High Pressure Pump
    - BH-4-FS
    - Resample Oil to Air
    - Pin and wire usage
      - Phase A
      - Phase B
      - Phase C
      - Ground
  - Platform cable
    - MINK10L
    - Wet-Mate to Battery Junction
    - Pin and wire usage
      - 48V power
      - 48V return
      - Ethernet TX+
      - Ethernet TX-
      - Ethernet RX+
      - Ethernet RX-
  - Platform connector
    - MARS connector
    - Pin and wire usage
      - 48V power
      - 48V return
      - Ethernet TX+
      - Ethernet TX-
      - Ethernet RX+
      - Ethernet RX-

Deep Water Sampler
Σοφτωαρε

- Reuse of “electrical stuff” enables reuse of most “software stuff”
- Ruby scripting for high-level control of pumps and valves.
  - 1km DWSM control code will serve software template
- Dwarf Firmware mods: (The time hog.)
  - I/E and Sample pumps need firmware modification for current control.
  - High power motors require dwarf firmware enhancements. Speed and direction output for external amp. (Done and tested.)
  - Settable home condition.
  - Servo or threshold on an external analogue input
- ESP core mods:
  - Scripts must be modified to allow bypassing internal sampler. (Hardware mods made, need to modify and test the core scripts.)
  - Investigate multi-threaded clean up
  - Investigate of acoustic modem (rover style)
- Error conditions and recovery

4Km Deep Water Sampler
Software Notes

- Must safely transition from any mechanical state to one with both bags equalized and open to sea
  - This facilitates safe recovery from transient failure
  - Also the first stage of initialization procedure on deck
- 6000psi pressure sensors are temperature sensitive
  - Observed +/- 200psi indicated pressure delta from 0C to 22C at 1 bar
  - 1Km DWSM dealt with this by re-“tareing” sensors before each sample
    - This does not compensate for changes in sensors' gain
- Support both internal and external sampling modes
  - Internal sampling uses the ESP's 25ml sample syringe
    - Unlike 1km, this DWSM remains passive during internal sampling
  - External sampling relies on precise control of DWSM's Sample Pump
    - Active, faster, allows continuous flow through filter puck
- MARS and ROV will interface directly to 100Mbit/s ethernet port
- Acoustic Modem supplies PPP link previously provided by Freewave
  - Sufficient bandwidth for terminal sessions and script file transfers
  - Image upload will require aggressive (lossy) JPEG compression

4Km Deep Water Sampler
Initialization

- Power up to dive-safe state with no knowledge of history
- To open water bags and oil reservoir to sea:
  1. Isolate ESP core: SRV to Close, REV to Close, TSV to Close
  2. Equalize oil pressure between cans: Open SOV to Free
  3. Equalize water pressure between bags: Open REV to SAX (Exclude Exhaust)
  4. Gradually equalize oil with oil reservoir (sea): Open FOV to RO
  5. Finish equalizing oil with oil reservoir (sea): Open FOV to Free
  6. Equalize bags with sea: Open Wand to Sea, TSV to SAX
- Timeouts waiting for pressure to equalize imply:
  - Blockage, valve (actuator) failure, or leaks
  - Won't be very sensitive in practice because sensor offset varies
- Only after equalized can PSI sensors' relative offsets be computed
  - Their absolute offsets can be corrected by CTD if it's available
- Pressure relief valves between both cans and oil reservoir
  - Ensure that water is not expelled under pressure on deck
  - Avoids stretching bolts if DWSM raised while powered off

4Km Deep Water Sampler
Predive preparation

- Flush DWSM with clean water on deck
  - Same as flushing with Flush fluid, but wand opens to cap port
- Tare pressure sensors
  - Only a first approximation, as temperature will change at depth
- Leak checks
  - Pressurize oil to max safe pressure, verify stable
  - Probably not practical
- Dummy Sample run
  - Replace ESP core with filter tube

Platform Issues

- Investigate acoustic recall
  - Two tethered elevators

4000m Deep Water Sampling Module
Test Plan

- Subsystem testing
  - Power supply testing
  - New electronics functional testing
  - HP pump test assembly
    - Current draw
    - Output pressure and flow rate
    - Hall sensor thru mag coupling
  - I/E Pump and Sample pumps test assembly
    - Current draw
    - Pump back flow
    - Mag coupling break away torque
  - One rotary valve test assembly (under pressure, seawater and oil)
    - Current draw
    - Torque capacity
  - Primary Assembly System Testing
    - Un-pressurized condition
    - Low pressure condition testing (<100 psi, in bldg B lab)
    - High pressure condition testing (>100 psi, in pressure lab)
  - Integrated Core System Testing
    - Integrate with GG
    - Low pressure testing in Bldg B lab
    - High Pressure testing in pressure lab.
  - Science Certification Testing

4000m Deep Water Sampling Module
RISK

- Schedule: Machining time, assembly time, testing time, etc.
- Cost; overruns due to machining, material costs, fuel surcharge.
- Material interactions:
  - Stainless/Titanium/Aluminum mitigate with dielectrics and zincs where possible.
  - Near term deployments only 30 days. Long term (1-year deployment) will require parts replacement.