Environmental Sample Processor 4000m Deep Water Sampling Module
PDR

Agenda

- Functional Requirements Review
- Implementation Schemes
- Mechanical Design Elements
- Electrical Design Elements
- Software Design Elements
- Test Plan
- Schedule
- Risk Elements

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 rate
- Maintain homogenous sample (stirred)
- Sample to Sample contamination 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

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
  - nominal 12V
  - configurable to platform power source
- Environment
  - Water Temperature
    - Maximum 35 Celsius
    - Minimum 0 Celsius
  - Sample Water Temperature
    - Maximum 200 Celsius
    - Minimum 0 Celsius
- Core Environment
  - 17 psia Nitrogen Atmosphere
  - 10 to 35 Celsius
  - Maximum Sample Temperature 100 Celsius
  - Sample Pressure 75 psig

Sampling Implementation Schemes

- Piston/ Cylinder (1Km version)
  - Large due to 10L Requirement
  - High forces due to Piston Size
  - Waste to Sample contamination path via Wall
  - Multiple Siding seals
  - Always 10L volume
  - Supports Resampling once
  - Complicated compliance

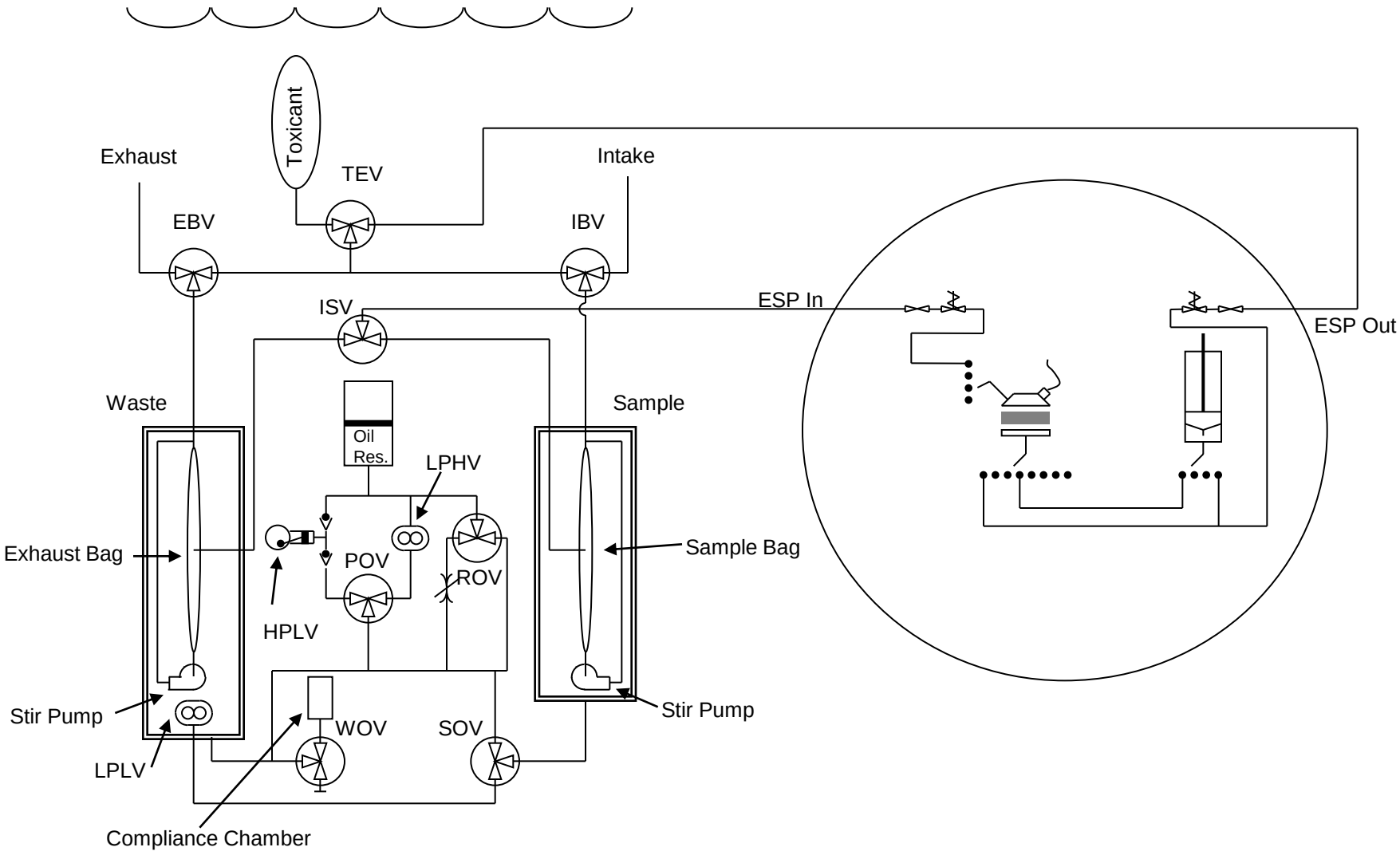
Sampling Implementation Schemes

- Sphere with Diaphragm
  - No sliding seals
  - Requires pumps not sliding seals
  - Pumps move raw sea water
  - Always has 10L volume
  - Supports Resampling once
  - No sample to waste contamination
  - Compliance chamber
  - Passes sample itself

Sampling Implementation Schemes

- AquaLung
  - No sliding seals
  - Pumps only move oil
  - Entire sample waste volume can be emptied
  - Supports Resampling once
  - No sample to waste contamination
  - Compliance chamber
  - Passes sample itself
  - Replaceable sample containers
  - Scalable sample volume design
  - Large volume of oil to decompress (30L)
  - Complicated

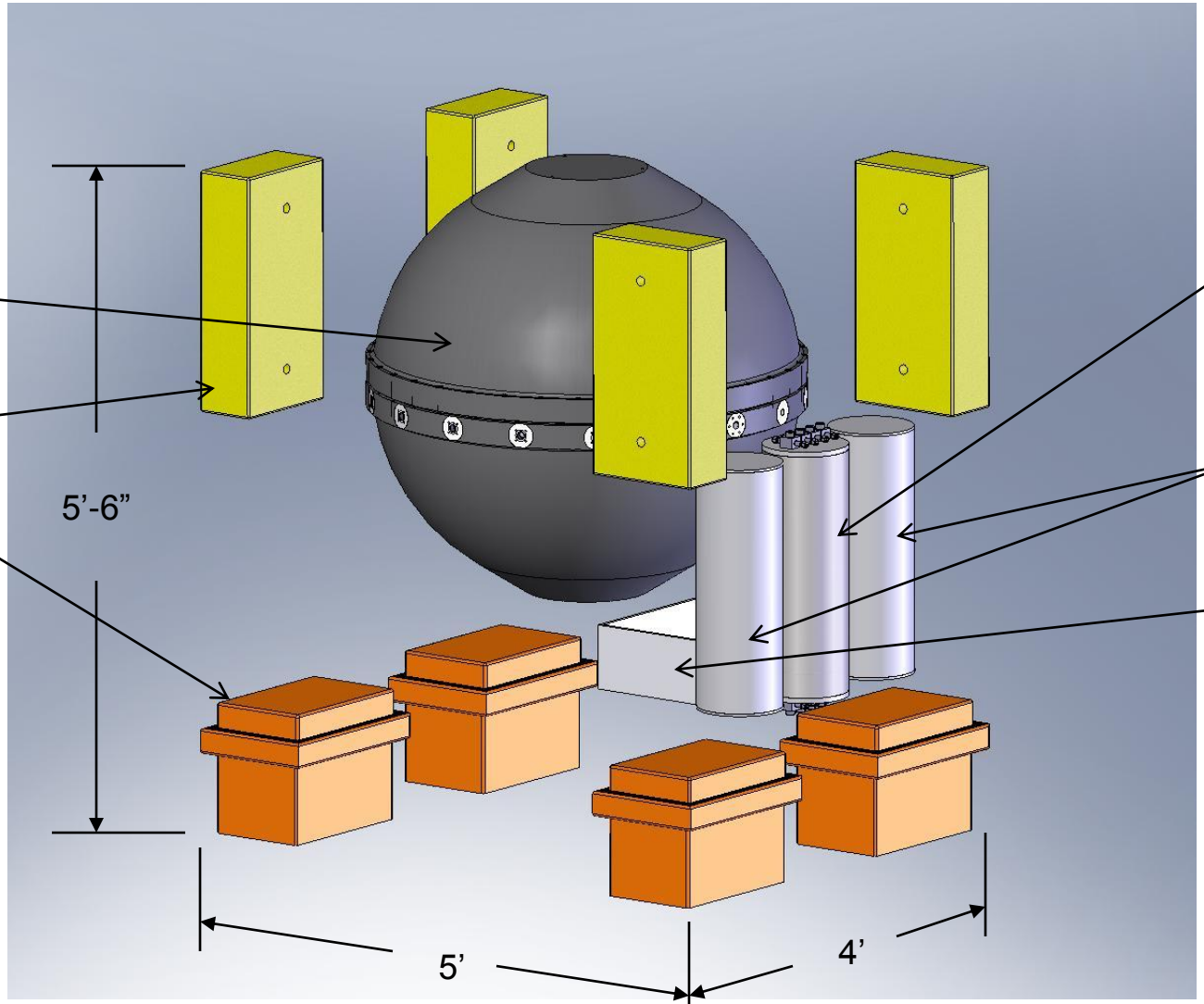
ESP with Deep Water Sampler
Selected Configuration
AquaLung



Aqualung Process Technologies

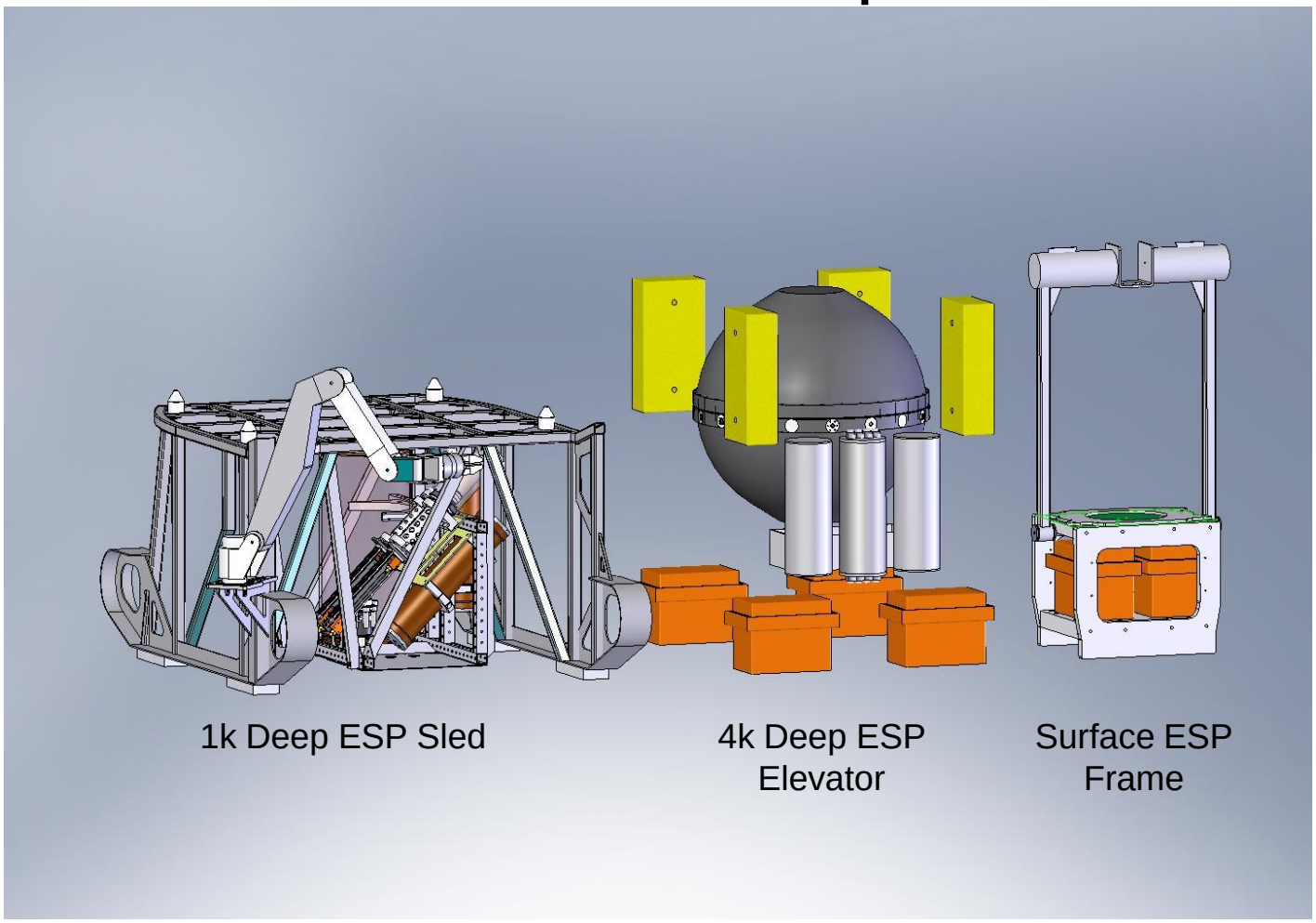
- Low Pressure pumps: positive displacement gear or progressive cavity
- High pressure pumps: positive displacement piston pumps, possibly in series.
- Stir Pumps: Seabird CTD pumps
- High pressure valves: Trunion ball valves
- Oil reservoir: fuel bladder

Environmental Sample Processor
Deep Water Sampling Module
Preliminary Design Review



Not Shown
Frame
Drop weight
Release

Elevator Size Comparison



Weight Estimate

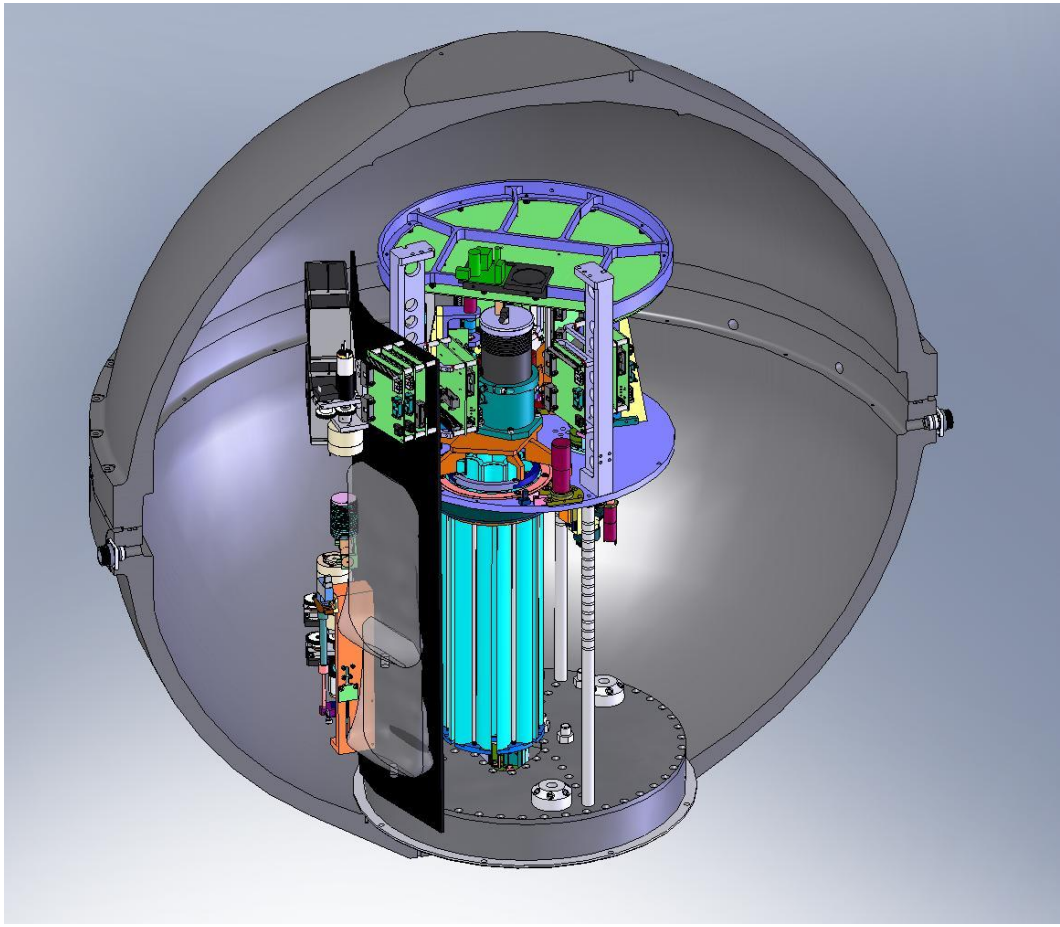
Elevator frame (Al)				160.0	est	wet	60.52		99.5	
Syntactic Foam (40lb		6	cf	240.0		wet	384.26		-144.3	
Drop Weight				140.0		wet	18.29		121.7	
Release mech				10.0		wet	3.78		6.2	
Support Brackets (UHMW P.E.)				40.0	sw	wet	44.14		-4.1	
Transponder				8.0					8.0	
40" ID Ti sphere (empty)				860.0	wt	wet	1438.70		-578.7	
ESP core				86.0	wt	dry			86.0	
MFB's				40.0		dry			40.0	
ESP fluid load, waste full				80.0	est	dry			80.0	
DWSM val	8.5x24 cyl			75.0	wt	wet	50.00		25.0	
Pumps				25.0		dry			25.0	
Valve actuators		8		15.0		dry			15.0	
Interconnect tubing/fittings				20.0	est				20.0	
Batteries		4	ea	432.0		wet	264.0		168.0	
Cables				10.0	est	wet	10.0		0.0	
Sample cyl				75.0	wt	wet	50.00		25.0	
Oil		15	L	30.2	wt	dry			30.2	
Waste cyl				75.0	wt	wet	50.00		25.0	
Oil		15	L	30.2	wt	dry			30.2	
Oil container (plastic)				5.0	est	wet	5.0		0.0	
Oil		5	L	10.1	wt	wet	11.37		-1.3	
TOTAL				**2466.5**					**76**	

Main Housing Requirements

- Fit current and planned deployable hardware that would also deploy in surface housing.
- Allow expansion for 1 year deep ESP operations.
- Design depth: 4000m, FS of 2.0 to buckling, or 1.5 to yield. (grade 5 Ti)
- Penetrations
  - All penetrations for internal connections to be in bottom half.
  - 14 MinK;s
    - 4 batteries
    - 1 DWSM power
    - 1 Mooring/Cable power
    - 3 context sensors
    - 1 external sampler
    - 1 modem
    - 1 ethernet
    - 1 console
    - 1 spare
  - Sample/Exhaust: Two face sealed ports to allow ¼" NPT feed thru (similar to surface and 1k deep architecture.
  - Venting: Two SAE #4 ports, with tube on the interior running to top and bottom.
  - Pressure relief: No pressure relief port req'd if face seal design leaks under bolt stretch.
- Fasteners sized to compress o-rings plus 5 psid internal pressure (purge venting)

Main Housing Design

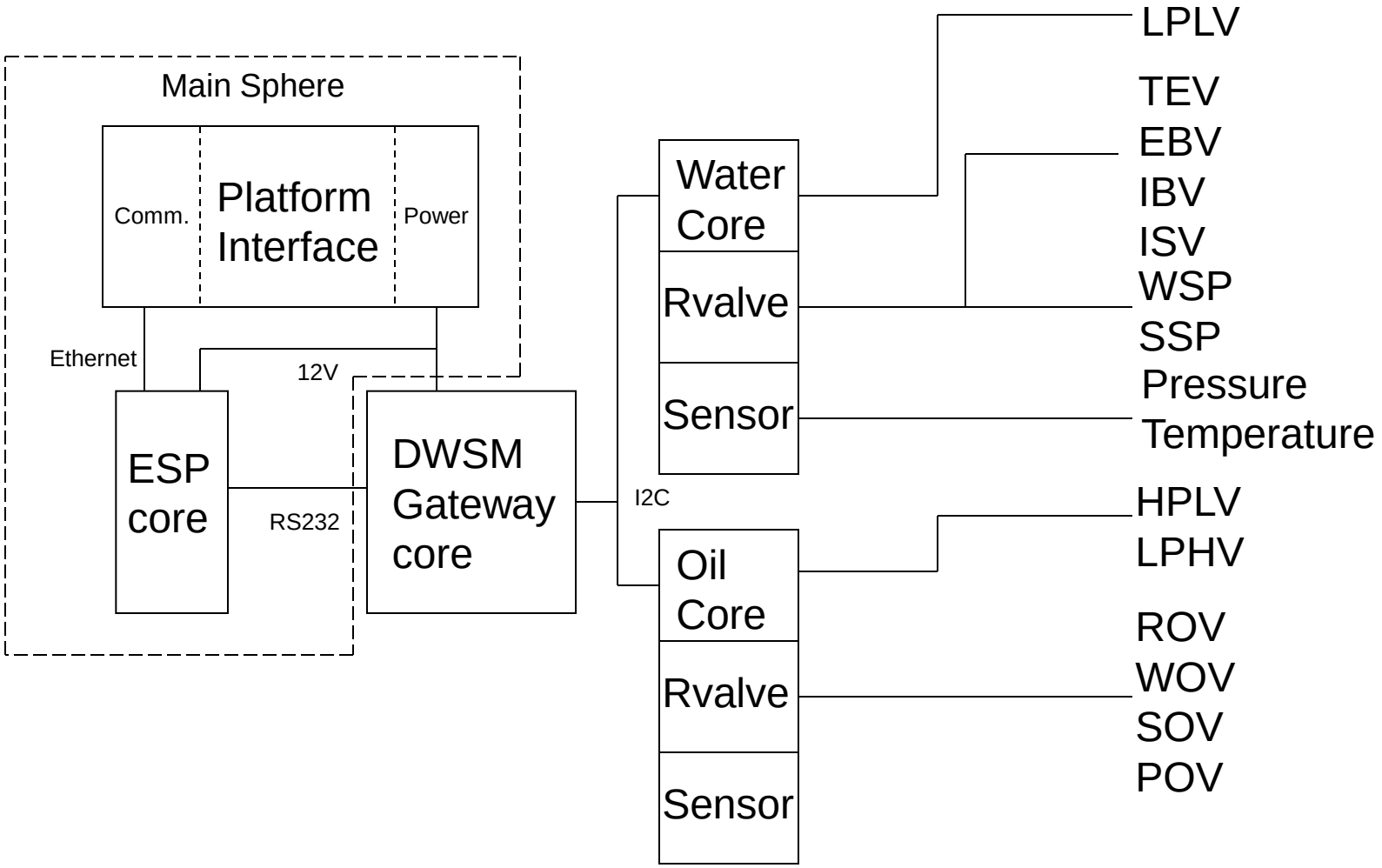
- 40 in ID, gr. 5 Titanium cast hemispheres.
- Common mold pattern
- Radial penetrations at flange
- Concentric face seal o-rings
- All equipment mounts and connects in bottom half, top half is just a lid.
- 36- ¼” Gr 2 Ti thru-bolt fasteners
- Preliminary design (to buckling) within weight balance.
- 0.938 spherical wall (prelim)
  - –Roark: FS 1.8 to Yield, FS 2.0 to buckling
  - –FEA: FS 5 to buckling, more analysis needed



Electrical stuff

- Use as much current Electrical hardware as possible (Dwarf – Core, Rvavle and, Sensor)
- Maintain current system power 12V nominal 10-16V range
- Due to wide range of source voltages and backup requirement have a single point of power conversion
- Oil pumps will require greater than the Dwarfs 24W capability
  - –Use Solenoid to run relay
  - –Consider modifying Core to output PWM and Direction signal for secondary driver.
  - –Core's Encoder input will still be used to count and monitor.
- Power supply will need to be increased to handle these pumps, about 200watts total.

Electrical Configuration



Software stuff

- Reuse of “electrical stuff” enables reuse of most “software stuff”
- Majority of effort will go into high-level control for myriad pumps and valves
- 1Km DWSM required active control to maintain ESP working pressure
  - ***This design does not. No clever servos just to keep the ESP safe!***
- ***1Km DWSM could not be tested in lab at ocean pressure***
  - ***This design can be pressurized safely for development tests***
- High Pressure Pumps will require dwarf firmware enhancements
  - ***Must drive them until the instant an analog threshold is exceeded***
- ESP core scripts must be modified to allow bypassing internal sampler
  - Removal of liquid from pucks will still require the internal sampler
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Test Plan

- Throw it over the side and see if it sinks, implodes, rusts, attracts sharks or generates electricity.
- Turn it on and DUCK!

Test Plan

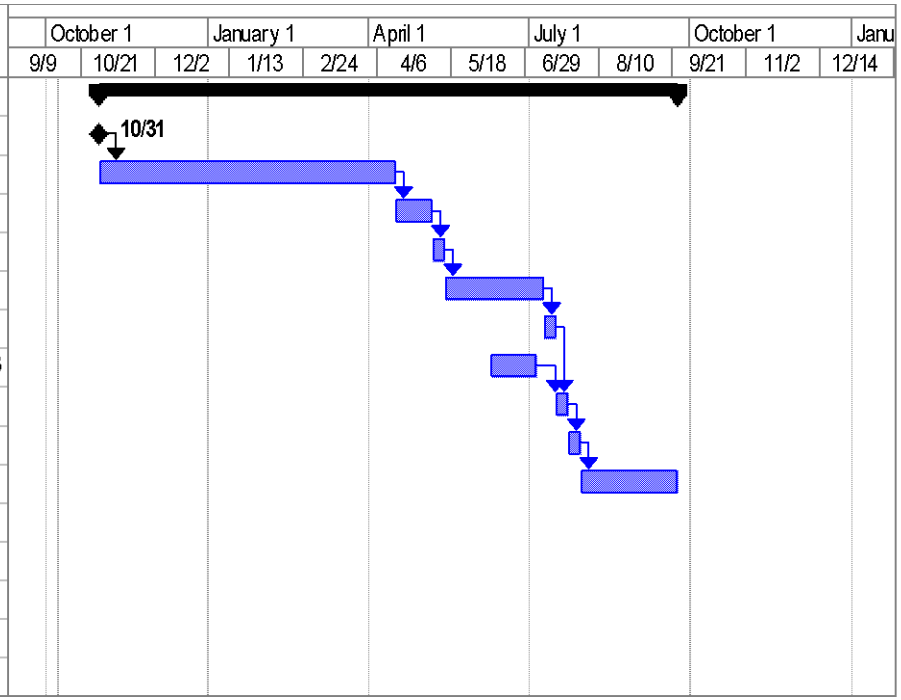
- Main Housing
  - –X-ray and dye-pen castings.
  - –Casting coupon material testing
  - –Hydrotest 110% of milestone deployment. (Pt H 72” chamber limited to 5500 psi, test to 110% of planned deployments to limit risk.)

Test Plan

- Sample Processing System
  - Build it and run it under low pressure to test depressurized sampling processes
  - Test under high pressure with additional housing structures and relief valves for complete depressurization and sampling system.

Main Housing Schedule

ID	Task Name	Duration	Start
1	**4kHousing**	**235 days**	**Wed 10/31/07**
2	Order	0 days	Wed 10/31/07
3	Casting	120 days	Wed 10/31/07
4	X-ray	15 days	Wed 4/16/08
5	Shipping	5 days	Wed 5/7/08
6	Machining	40 days	Wed 5/14/08
7	Shipping	5 days	Wed 7/9/08
8	Make w ood filler	20 days	Mon 6/9/08
9	Assemble	5 days	Wed 7/16/08
10	Hydrotest	5 days	Wed 7/23/08
11	Cruise prep time	40 days	Wed 7/30/08



Risk

- It is a fun game!
- Schedule: casting time, machining time, etc.
- Cost; overruns due to casting, machining, material costs.
- Software risk mitigated by ability to test at pressure and passive pressure management.
- Ruby Bug may still bite.
- Sphere failure (during test) mitigated by testing only to deployment depth, and/or monitoring volume distortion during hydro-test.
- Material interactions: Stainless/Titanium/Aluminum mitigate with dielectrics where possible. Near term deployments only 4 days. Long term (1-year deployment) will require additional study and possible parts replacement.
- Tubing and bag materials may affect sample. We have many options with the bag materials, however tubing and valve material interactions are common to all the processes.