Benthic Observation System Preliminary Design Review for TNC Use Case

March 27, 2017

Team & PIs

Principal Investigators

- Mary Gleason (TNC)
- Rick Starr (MLML)

Design Team

- Chad Kecy (PM)
- Francois Cazenave
- Kent Headley
- Craig Okuda
- Eric Martin
- Mike Parker
- Jared Figurski
- Ryan Fields (MLML)
- Tyler Maricich (Collaborator)

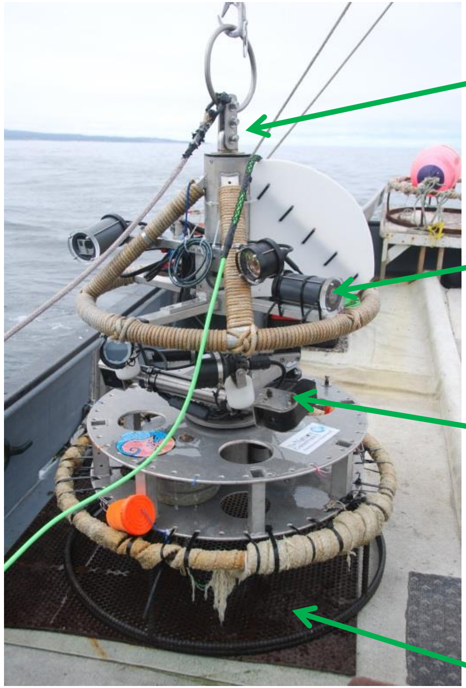
PDR Agenda

- Science Background & Motivation
- 1st Generation Lander
- Review of Functional & Derived Requirements
- Proposed Concept
  - Deck System
  - Lander
  - Camera Selection
  - Topside System
  - Software & Data Management
- Proposed Design
- Schedule
- Next Steps

Science Background

- Collaboration with NOAA-Fisheries to add visual component to the coast wide Fishery Resource Analysis and Monitoring (FRAM) trawl survey (mostly in rocky habitats)
- Provide density estimates (#/m^2) and size structure of 6-8 demersal species
  - Sizes range from 4” to 16”

First Generation TNC Lander

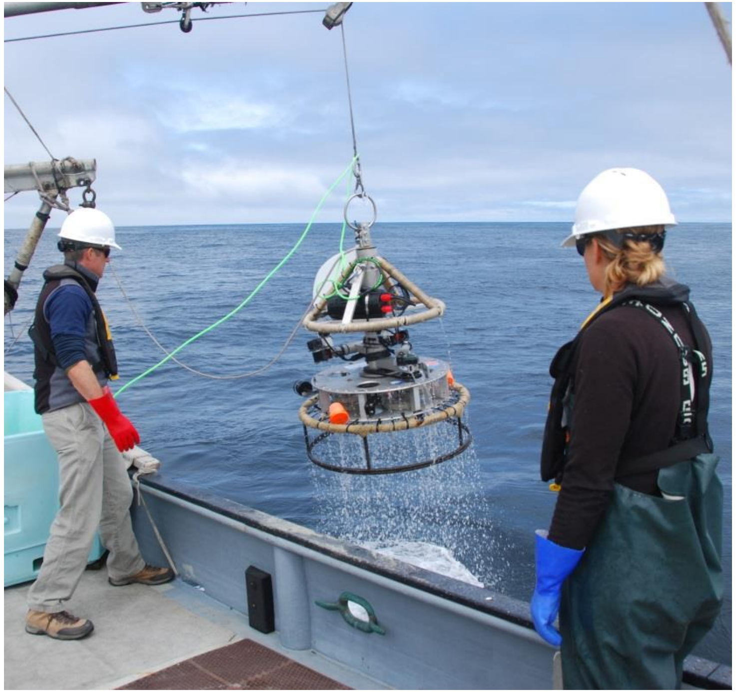


Separate handling line and electrical tether

SeeStar (not part of TNC Lander)

Stereo camera pair on a rotatable mount

Crab pot base

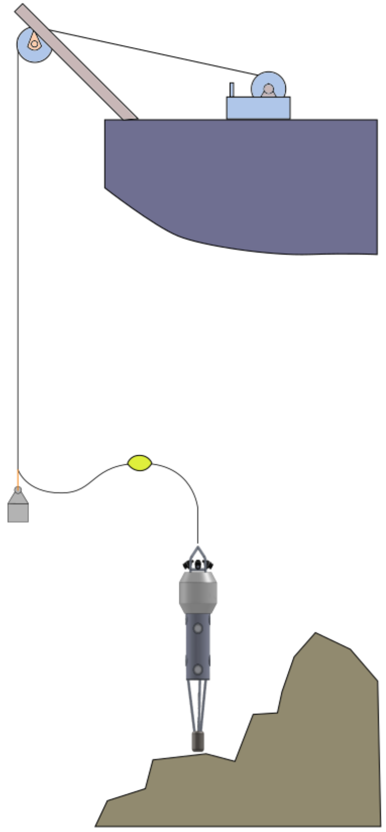


Functional Requirements

- The lander must provide the ability to identify, count, and size marine organisms by capturing video and/or still images.
- The lander must have the ability to interface and log various contextual sensors, such as O2, pH, ADCP, acoustic, and other novel sensors such as 3G-ESP.
- The lander must be a modular platform that can be reconfigured for various sensors and deployment scenarios.

Derived Requirements

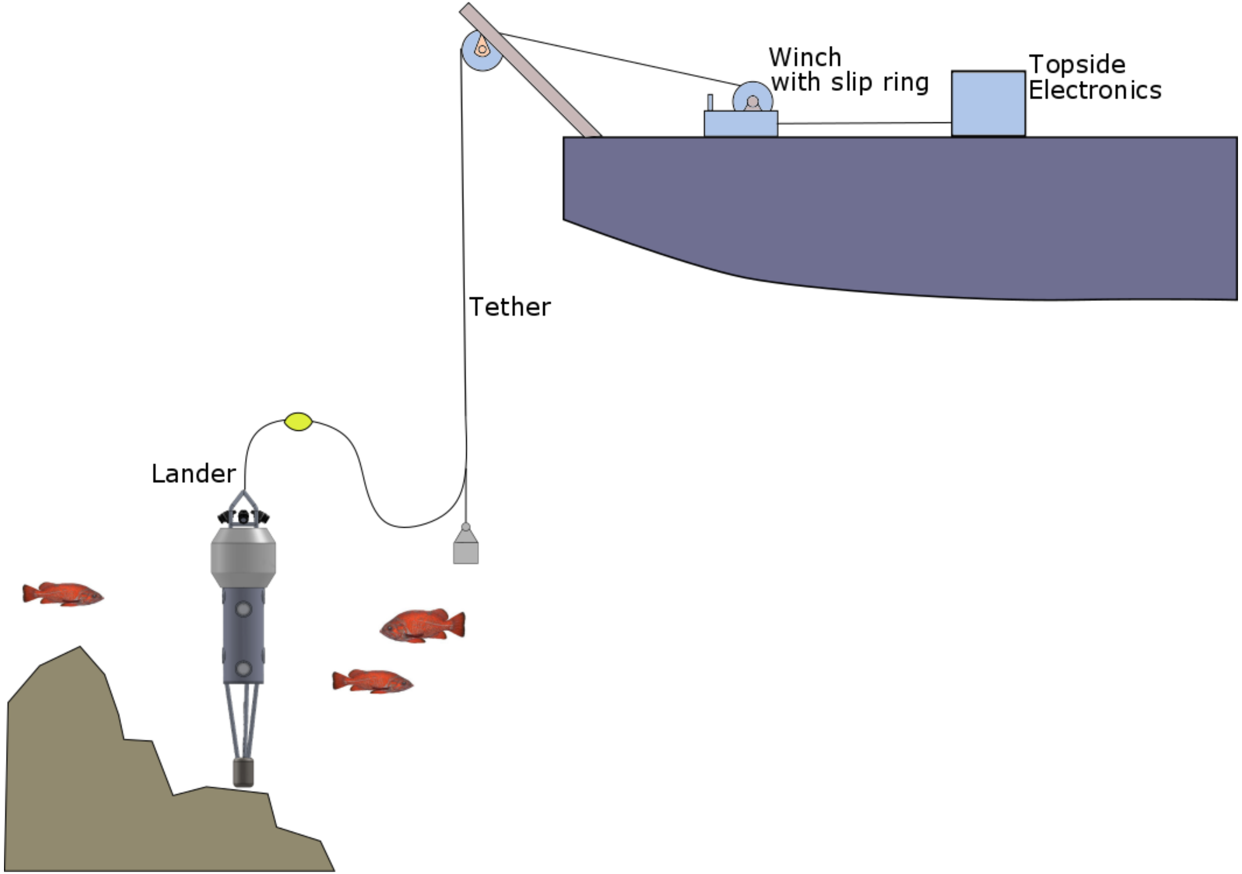
- Must operate tethered
- Must be depth rated to 300 meters
- Must operate in a benthic environment
- Must be able to land on or hover above rocky outcroppings
- Must capture stereo video
- Must have near 360 degrees of stereo video coverage
- Must be able to collect data from up to 30 sites within a normal operational ship day
- Must be able to be deployed from various vessels of opportunity
- Must provide real time telemetry data for positioning including video, depth, and heading



Additional Requirements

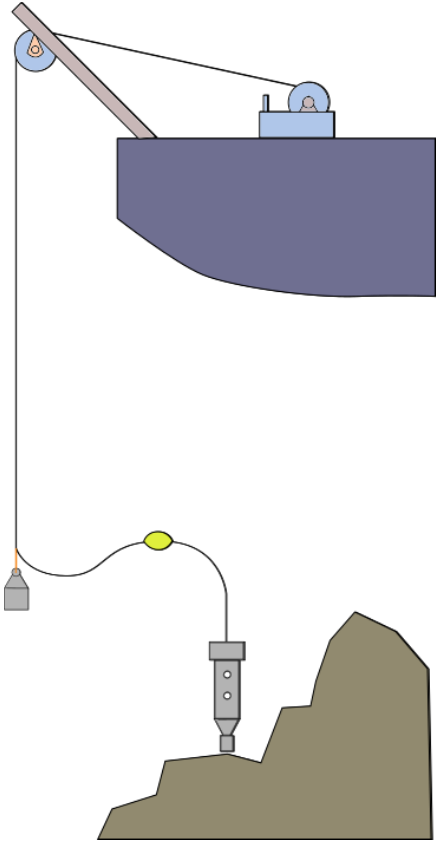
- Ability to transfer videos from lander during station transit periods
- Topside control of system
  - Cameras (start/stop REC)
  - Lights (on/off)
- Ability to stay on station for up to 6 minutes
- Ability to count fish up to 4 meters away from lander
- Ability to size fish up to 2 meters away from lander
- Ability to synchronize all 8 cameras
- Live video feed from 1 camera in each quadrant
  - Total of 5 live video feeds
- Load bearing tether (no second line)
- Simplify launch and recovery processes
- Ability to record the 8 HD video feeds topside in the future

Proposed Concept Drawing for TNC



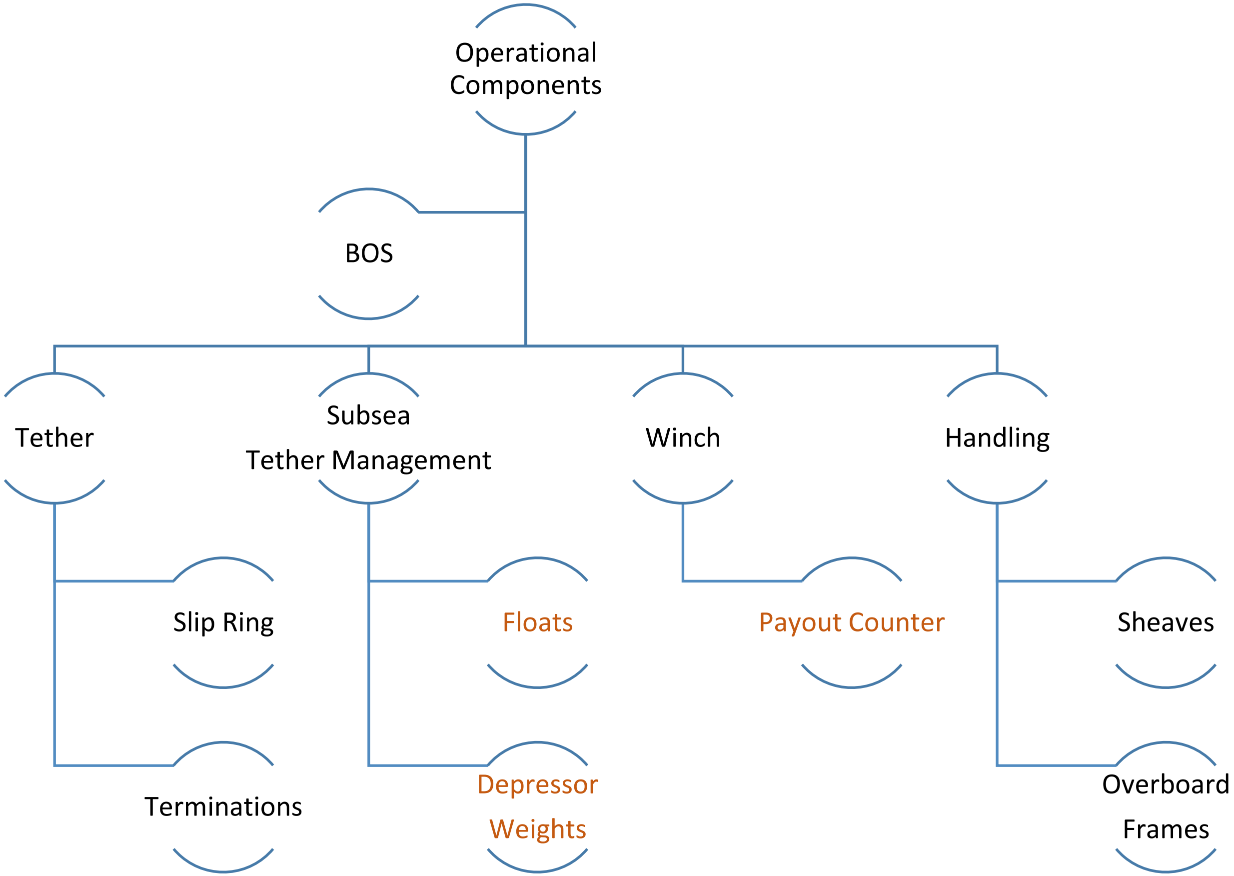
System Deployment

- In order to deploy unit on bottom, the cable must keep free from propellers, not drag on bottom, and must facilitate an acceptable watch circle for a non-DP vessel.
- For MBARI vessels and other identified ships this leads to a number of regulated safety factors that will inform the specification of the tether, and therefore the powered winch.



Considerations for Seagoing Installations

- Max system weight: 500 lbs
- Allowing for dynamic loading a tether must have an SWL of 1000 lbf, and via CFR189 the NBL of the tether must be 7000 lbf.
- The tether must be the weakest link.
- The winch must have a brake rated above 7000 lbf.
- A 3 HP winch system will facilitate 30 m/min haul rates for this system, and will integrate with ships of opportunity.


Operational Components
BOS
Tether
Subsea Tether Management
Winch
Handling
Slip Ring
Terminations
Floats
Depressor Weights
Payout Counter
Sheaves
Overboard Frames

Soft Jacket Fiber Tether Solution

TETHER	Custom Design will meet requirements.
ELECTRICAL	No batteries, independent GFI conductors
MECHANICAL	Can size SWL & NBL
DATA IMPACT	Topside data collection would be possible in future developments.
OPERATIONAL	Will require custom winch, larger sheaves. More care need be taken.
MAINTENANCE	Needs fiber kits and training. More downtime for damaged terms & tethers
COST	Estimated Costs 80k$, for winch, slip ring, and tether

Standard CTD Cable Solution

TETHER	UNOLS Standard 0.322"ø (Coax | 4C)
ELECTRICAL IMPACT	Batteries required to get to power lamps
MECHANICAL	Already supported on many ships (WF, RC, JM, SR)
DATA IMPACT	Real-Time data collection at the surface lost. Network data only.
OPERATIONAL	May Avoid depressor weight, but floats remain. More Flexible sheave options.
MAINTENANCE	Field servicable, inexpensive terminations
COST	Lower cost (~$30,000), less gear on accommodating ships

Solution Pathways

- A trade study was conducted with regards to two potential system architectures that satisfy TNC requirements.
- Option 1: Custom tether/winch to suit current needs and allow for system scalability to other applications
- Option 2: Use widely available CTD wire which meets telemetry requirements and will result in lower cost system with lower maintenance impacts.
- The study was not conclusive that either scenario was superior.

Mechanical Outline

- Camera and lens selection
- Camera placement for 360^{o} stereo imaging
- Main housing concept
- Lander concept
- Experiments to verify design concepts

Camera Requirements

Requirements

- Small size
- Relatively low cost (8x)
- Stills and HD video
- Good low light performance
- Reliable brand (long life cycle)
- Easy to interface for control
- Onboard storage

Candidate Cameras

- Sony UMC-S3C
- E1 Z Camera
- Sony A6000 Series

Sony Alpha 6300

- $1000
- Images are recorded on SD card: up to 9 hours of HD video. Download via USB
- 24.2MP APS-C Exmor CMOS Sensor
- Can be controlled using proprietary SONY connector
- Excellent image quality
- Sony E-mount: many lens options

Lens Selection

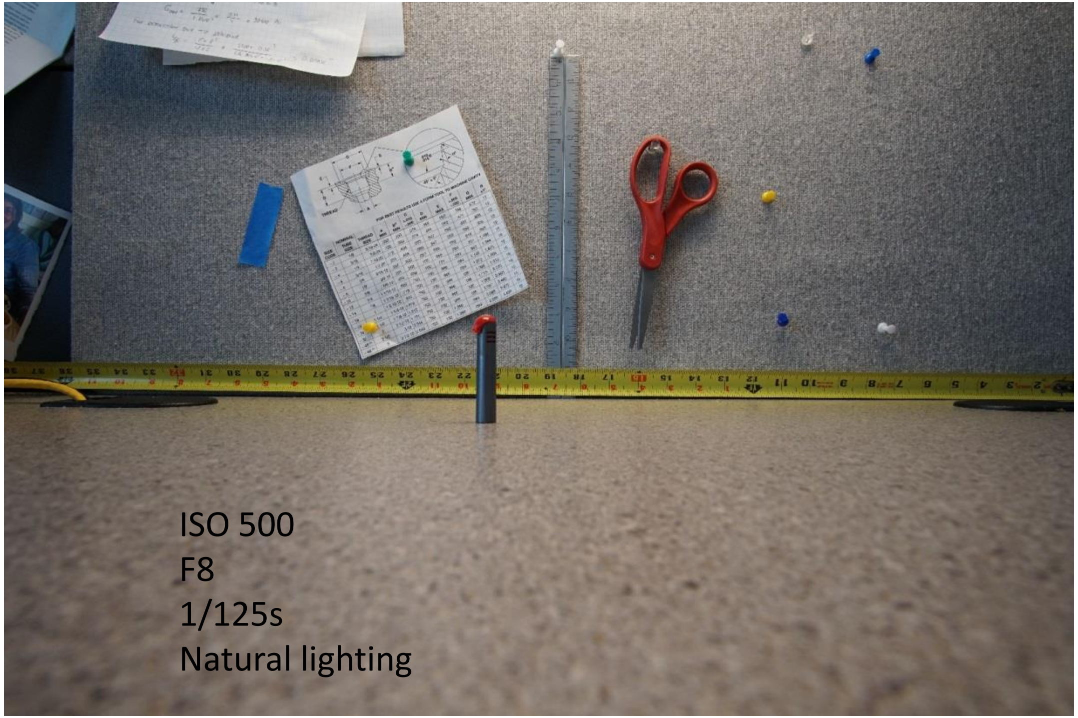
Requirements:

- Wide angle
- Low cost
- Small, light
- Autofocus not required

Rokinon 12mm is excellent solution.

$400, manual focus, F 2.0, 85 degree FOV.

Camera Tests in the Lab



ISO 500
F8
1/125s
Natural lighting

Center of image

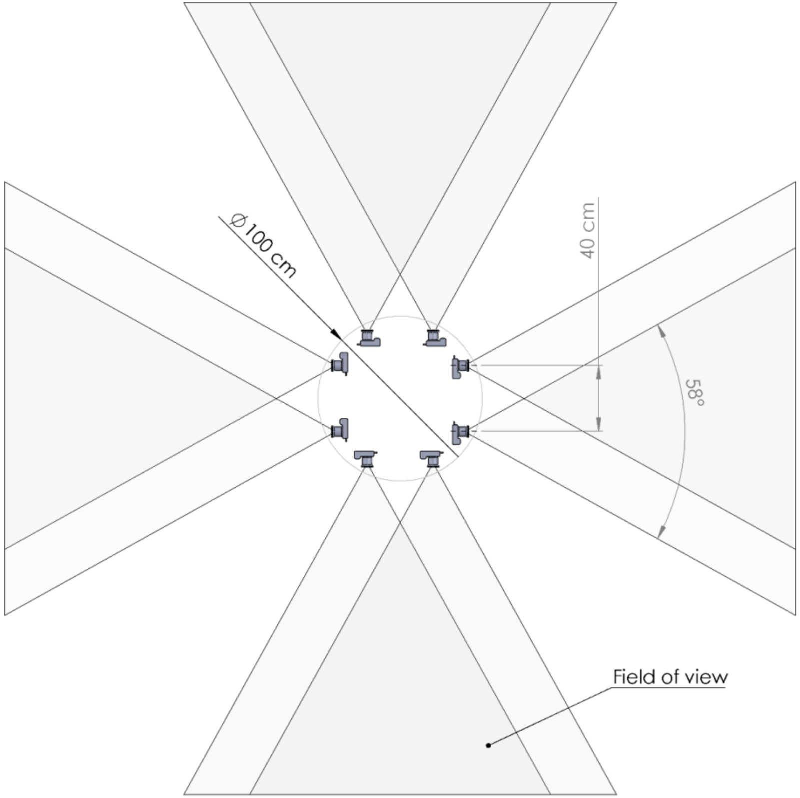
Side of image

Depth of field
(red object at ½ distance

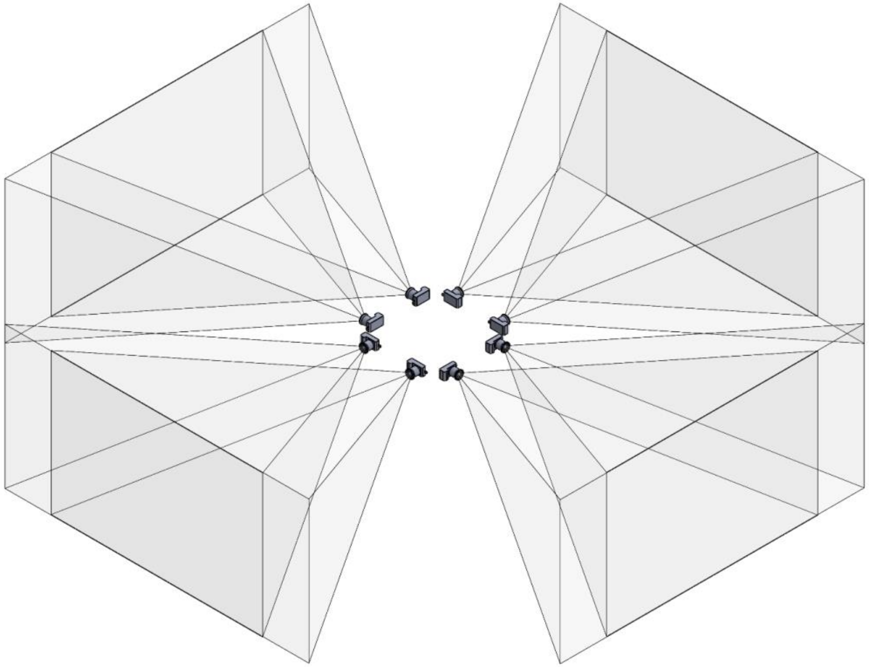
Considerations for Cameras and Lights Positioning

- 360^{o} coverage in stereo (gaps acceptable): 4 cameras pairs are needed
- Flat ports (domes are too expensive)
- Distance between cameras is 40 cm (tested by R. Starr)
- Camera pairs must be toed in a few degrees
- One camera will face down to help with lander placement
- Lighting will be provided by 5 DSPL lights
- Camera must all be in one housing:
    - reduced drag, size, weight, cost
    - much fewer connectors, higher reliability

Cameras Paired Horizontally

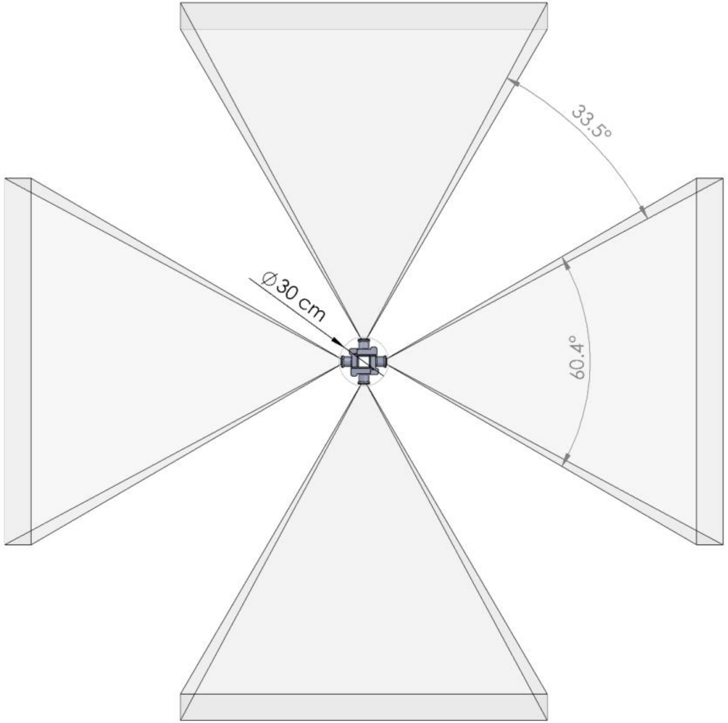


Top View



Isometric View

Cameras Paired Vertically



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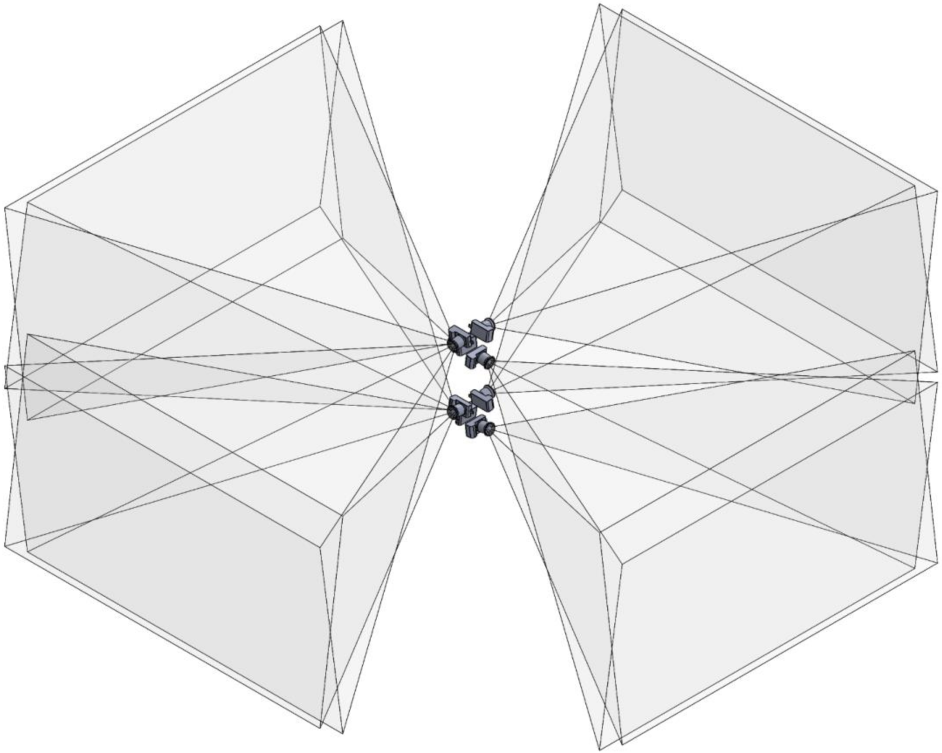
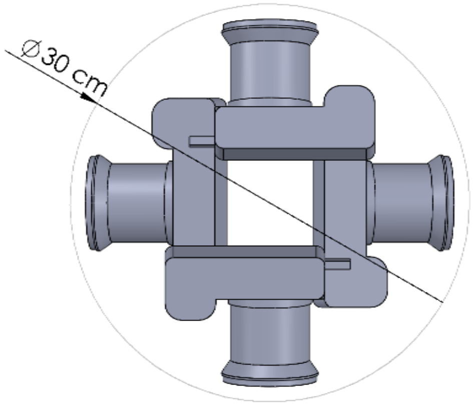
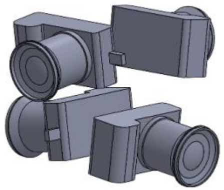
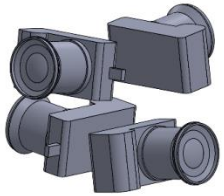


Isometric View

Cameras Paired Vertically



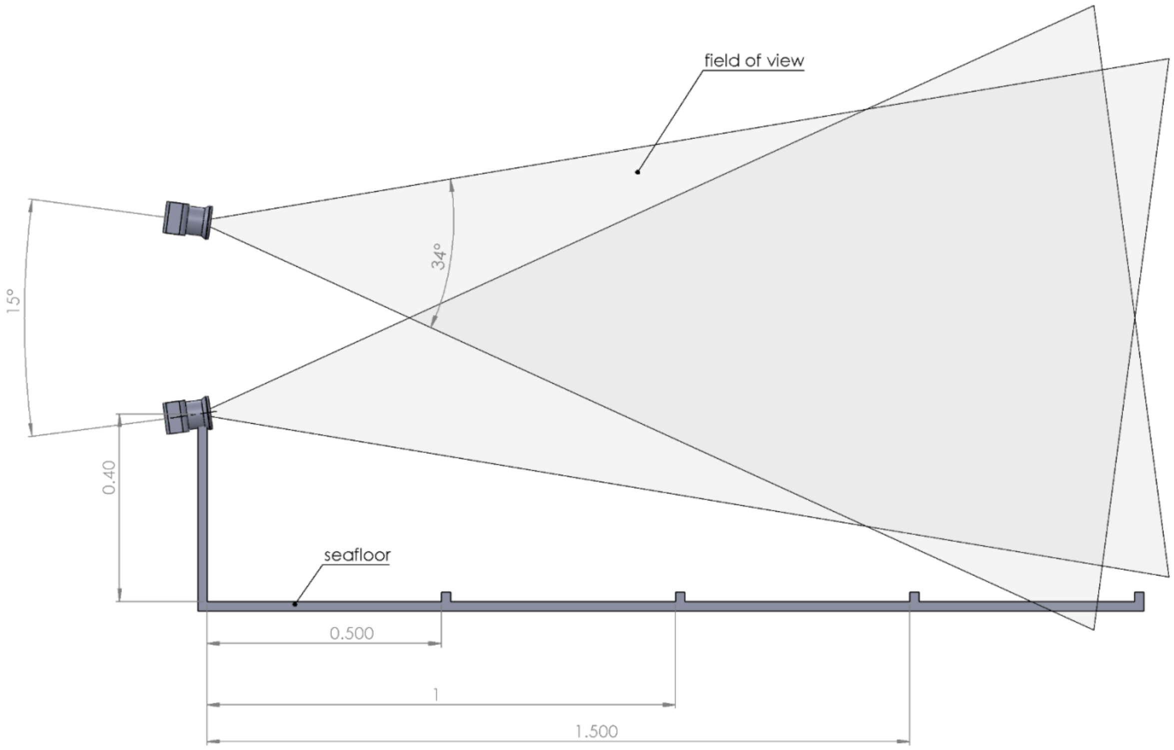




Top View

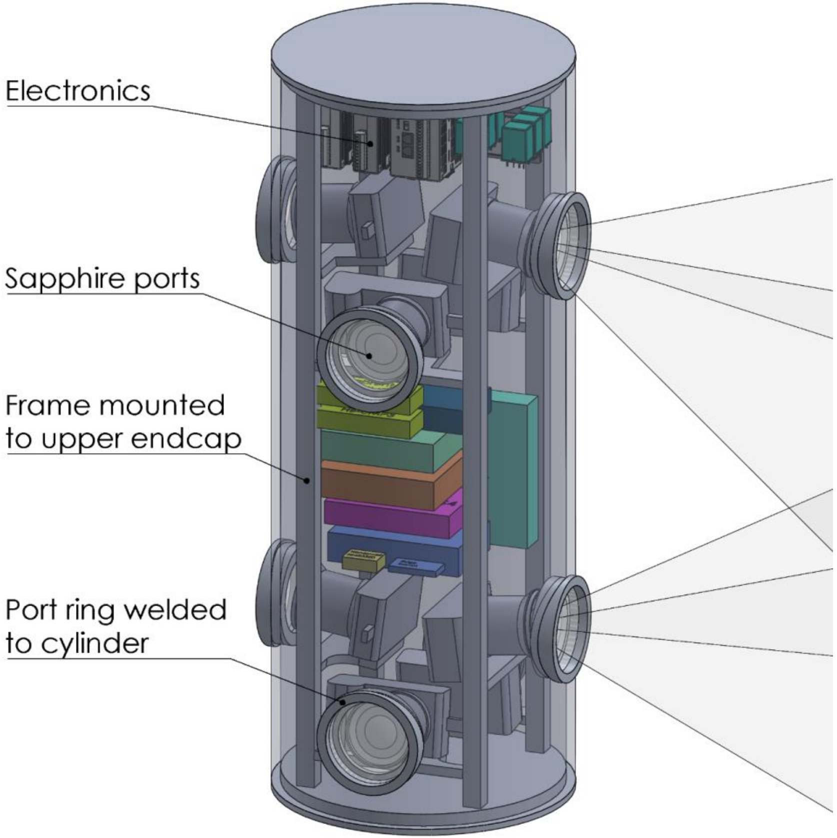
Isometric View

Camera Angle and Position Relative to Seafloor



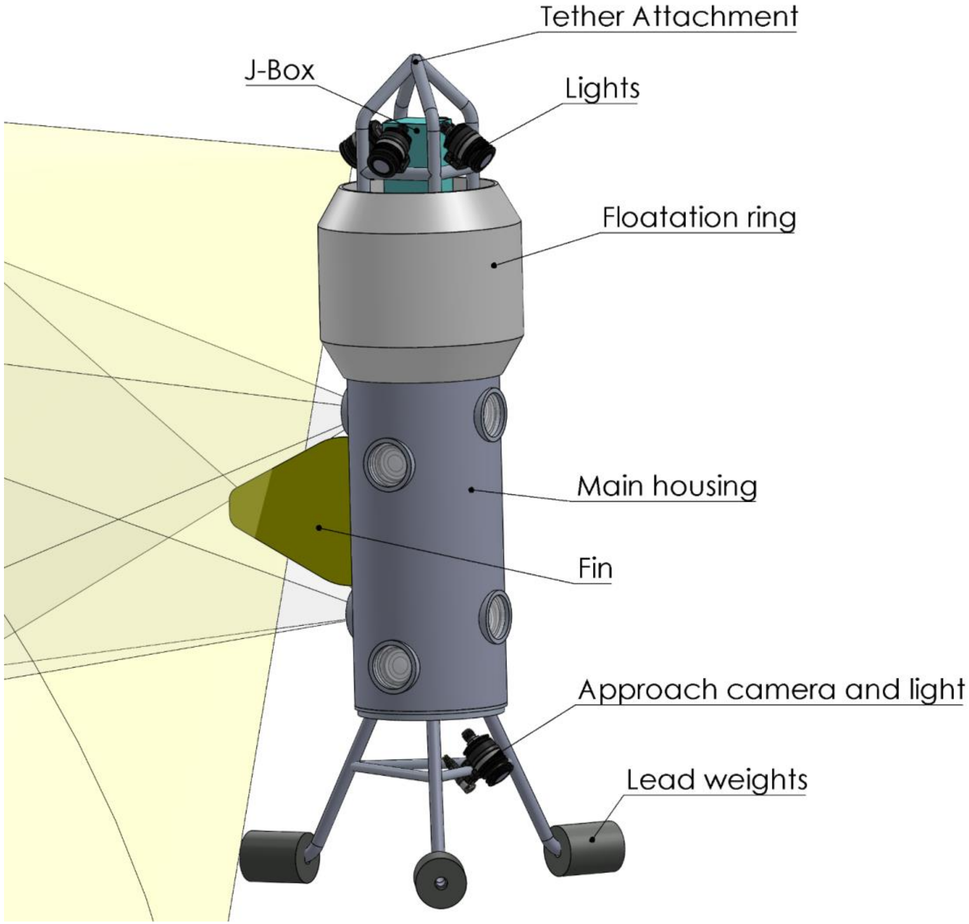
Main Housing Concept

- Anodized 6061 Aluminum
- Weight in air: 50kg
- 10kg buoyant
- 30cm diameter x 80cm tall
- Rack for electronics and cameras

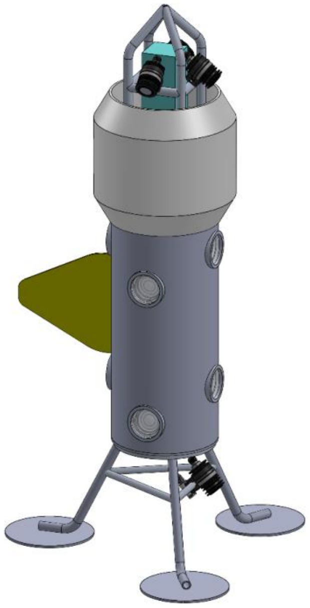


Lander Concept

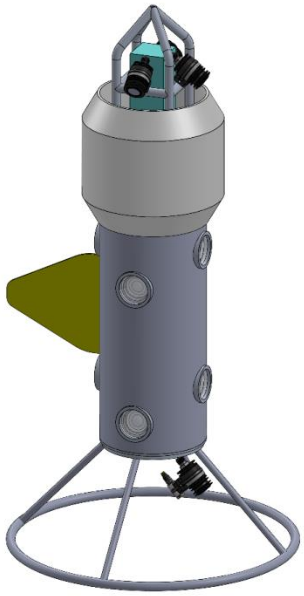
- Height: 160cm
- Weight: 75kg-200kg
- Base has weak link
- Heavy at the bottom, light at the top
- Low drag
- Different bases and float.
- Configuration can evolve after testing



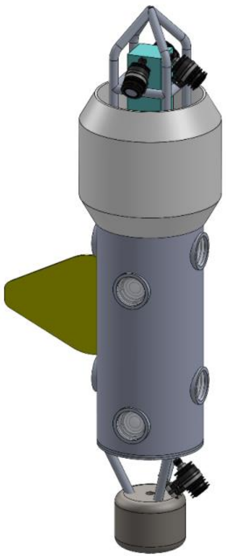
Concepts for Lander Base



Large feet for
soft flat bottom



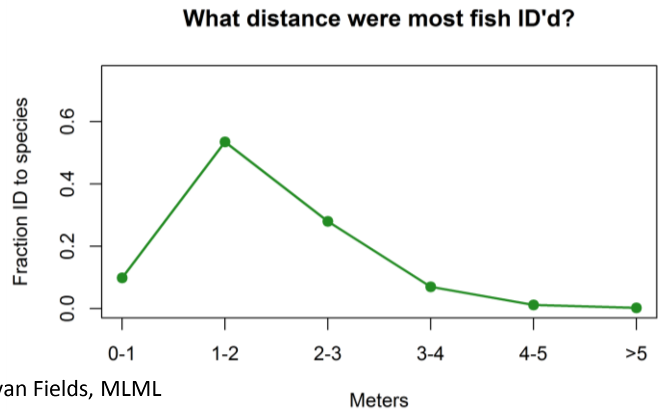
Large ring



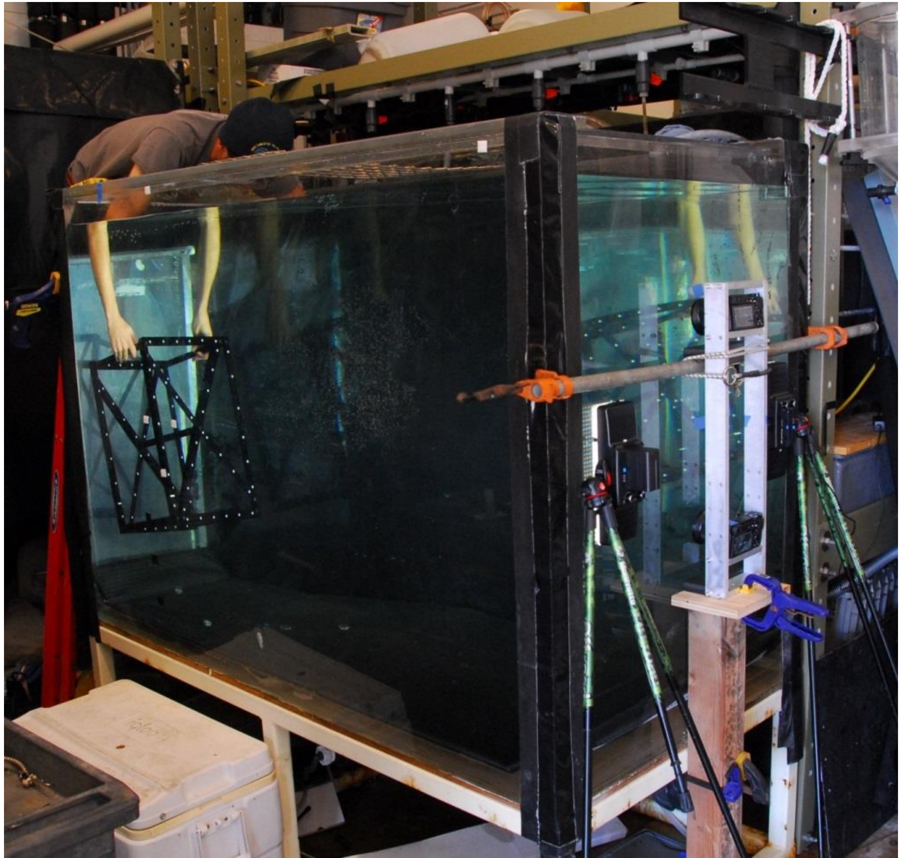
Pogo stick

Stereo Imaging Performance Tests

- Is vertical pairing of camera suitable for stereo imaging?
- Does camera angle relative to viewing port affect performance?
- Does movement of camera relative to view port affect performance?



Plot: Ryan Fields, MLML

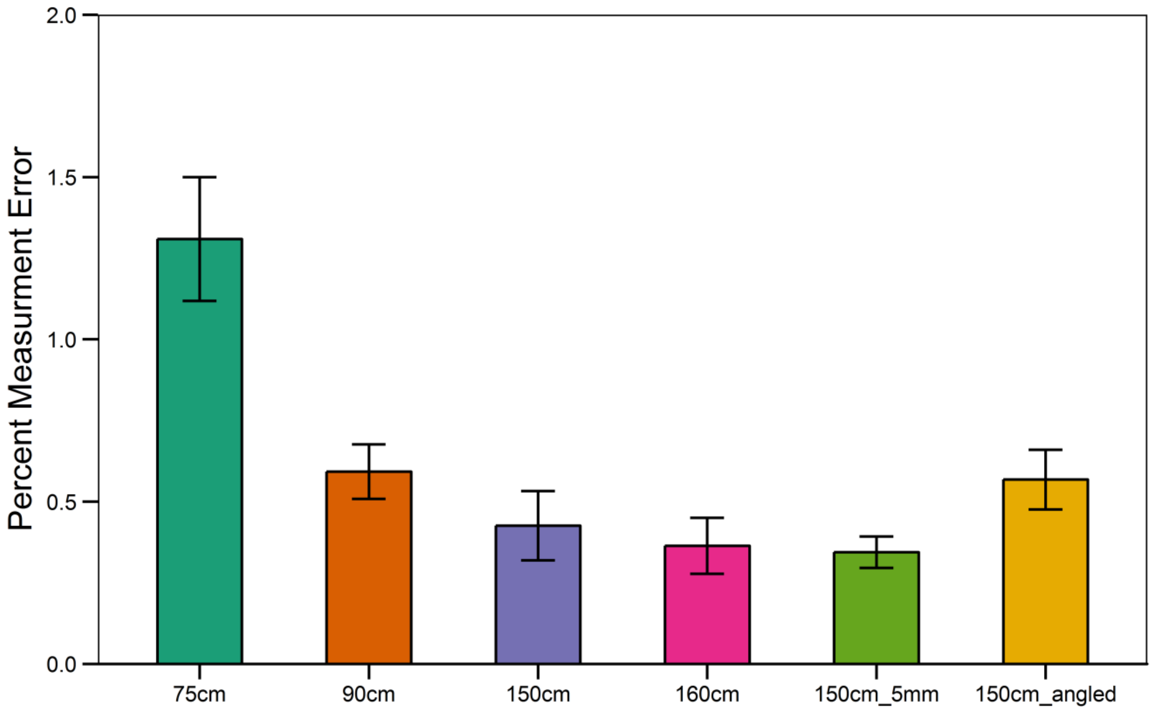


Stereo Imaging Performance Test Results

Requirement:

Less than 2% measurement at error at 1.5m.

Requirement is easily met.



Plot: Ryan Fields, MLML

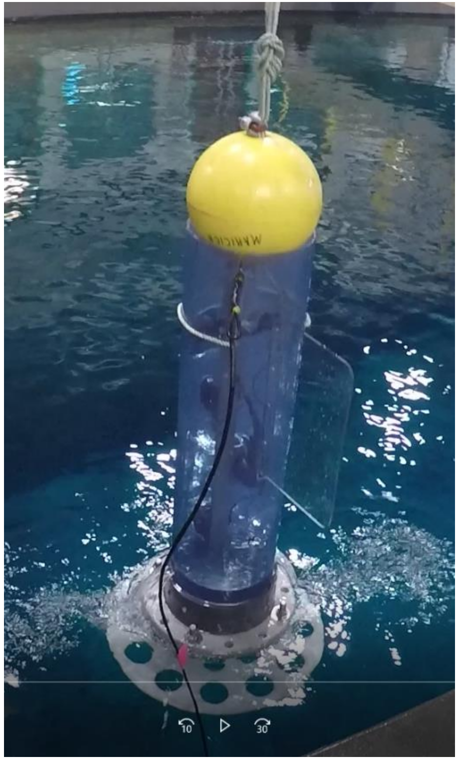
Mockup Lander Tests in MBARI Tank and Monterey Bay

Results:

- Upper camera suffered from backscatter.
- Sediment cleared in about 30s
- Fin helped stabilize lander
- Fish are scared by movement and return within 30s
- Narrow base fairly stable
- Compass very useful

Second mockup test

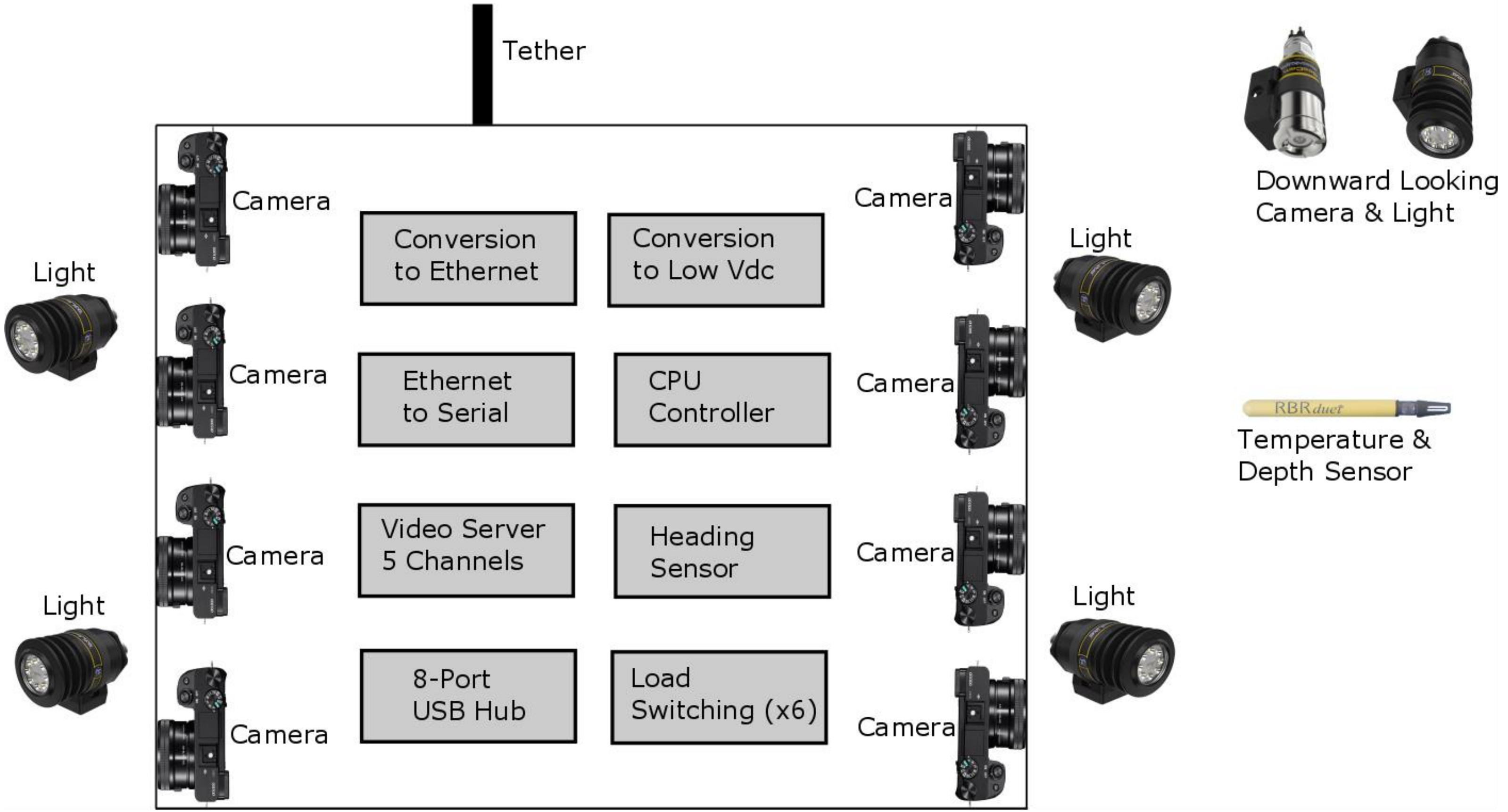
- Realistic size and weight
- Deeper test with clump weight



Electrical Outline

- Functional Concept
- Power Budget & Options
- Tether Selection
- CPU Controller Selection
- Topside Electronics

Camera Housing Concept Diagram



Estimated Power Budget

- Hotel Load: 100W
- Lights (Switchable): 250W
- Cameras (Switchable): 50W
- Total: 400W

Electrical Power Options

DC Volts

- Must generate topside
- Higher Vdc means lower i^2r losses
- Ground fault detection already designed & built
- Conversion to low volts DC required subsea

AC Volts

- Readily available on ships
- Requires isolation transformer
- Conversion to low volts DC required subsea
- Less heat generated
- Tethered only

Tether Selection

Fiber Optic

- Single mode fibers
  - **BW: 10Gbps+**
  - **Dist: >10km**
- Pair of OE converters
- Optical path on slip ring
- Future HD recording topside
- 14-16AWG for power
- 22AWG for ground fault det

Coax or Twisted Pairs

- GigE Ethernet
  - **BW: 100Mbps**
  - **Dist: 100m**
- Pair of ADSL Ethernet extenders
  - **BW: 168Mbps**
  - **Dist: 1km**
- Cheaper, smaller slip ring
- Limits HD recording to subsea
- 14-16AWG for power
- 22AWG for ground fault det

Controller (CPU) Selection

Features

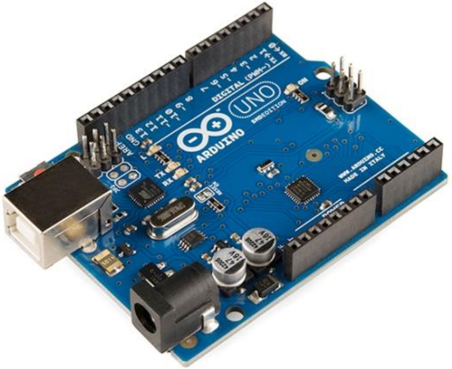
- Data storage
- Relay control
- Serial ports
- GPIO
- Analog inputs

Design considerations

- COTS or custom
  - Tech transfer
- Form factor
- Ease of programming
  - Firmware development
  - Instrument drivers
- Ease of use for end users
- Daughter boards required?
- Power consumption

Controller (CPU) Options

Oasis5



Arduino

Raspberry Pi

Programmable
Logic Controller
(PLC) Stack

Topside Electronics Design

Functions

- Electrical power generation
- Ground fault detection
- Method for system control
- Real time telemetry & video display
- Method for transferring HD videos post deployment

Design Considerations

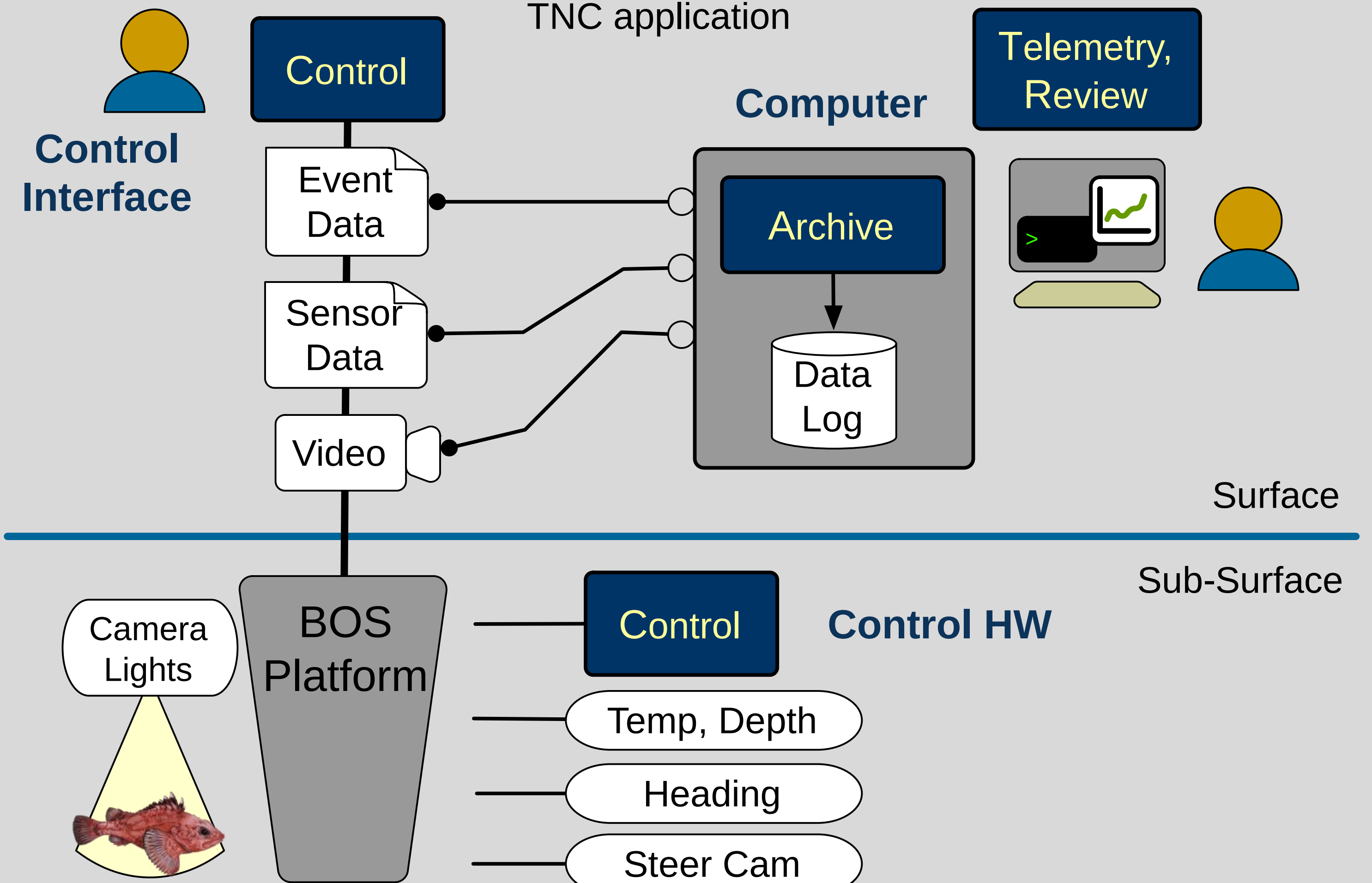
- Must be portable
- Safety features
- Prefer to not open housing to retrieve HD videos

BOS Software
Content Outline

- Where the software lives
- Functional requirements, options : CART
- At the corner of software and hardware
- Implementation approaches
- Selection and recommendations

BOS: Where Software Lives

TNC application



CART: Required Software Features

Control

- Power control
- Start/stop recording

Archive

- Record timestamped data
- Contextual sensors:
  - Temperature, depth
  - Heading, [pitch, roll?]
- Control events:
  - Camera/lights power
  - Start/stop recording

Review

- Data workflows, post-op

Telemetry

- Sensor data
- Video

Optional Features

- Computation
  - Parse telemetry data in real time
  - Generate new derived information
  - e.g. tether turns count

- Configuration
  - Sample rates
  - Instrument configuration

Constraints : Design Goals

- Minimize software development for first iteration
- Keep it Simple:
  - Make tech transfer easier
  - Minimal codebase and development environment
  - Minimize system complexity
- Architect for future expansion
  - TBD contextual sensors
  - Real time, distributed/mobile displays
  - Control interface
  - Configuration

At the Corner of HW & SW

Platform selection : combining HW and SW to cover functional requirements (CART)

Hardware choices constrain software and affect the project:

NRE	Lifecycle
HW/SW Cost	Power
Firmware	Sampling Performance
Compilers, Tools	**O&M, Tech Transfer**
Integration	

Implementation Approaches

- Many options to satisfy requirements
- Key decisions: HW/SW partitioning, Build vs Buy

Platform Technology Options

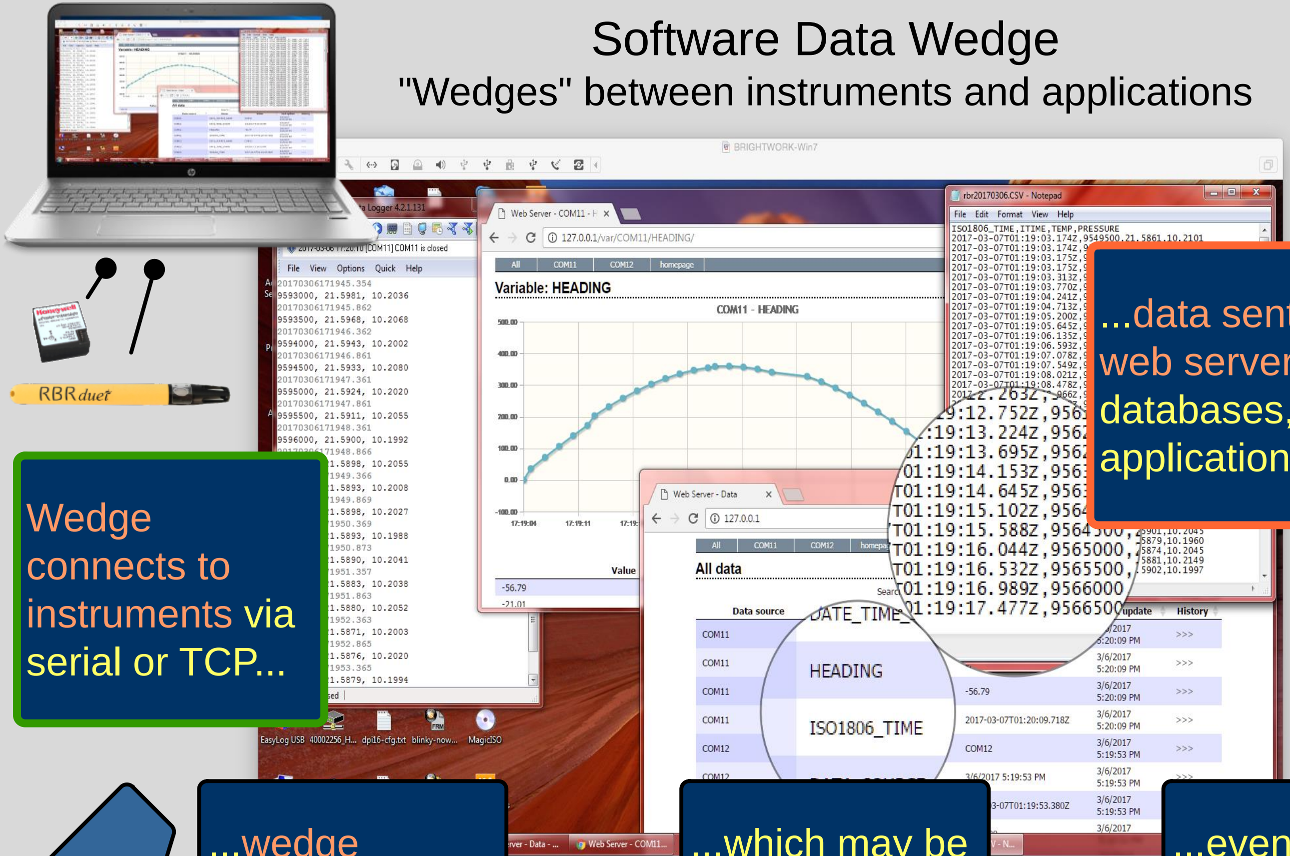
	Hardware	**Software**
Buy	PC PLC COTS Relay Stream Logger General Logger COTS Embedded	Wedge LabView Vendor Utils
Build	OASIS MMC BOS new HW	OASIS Flux SIAM BOS new SW

Selection Criteria

- CART Coverage
- Cost
- Schedule
- Performance
- Risk
- Tech Transfer
- Roadmap

Software Data Wedge

"Wedges" between instruments and applications



Wedge connects to instruments via serial or TCP...

...data sent to files, web server, databases, other applications.

...wedge acquires data via polling or streams...

...which may be timestamped and/or parsed ...

...even used to create new data via expressions...

Comparison of Selected Platforms

Circle size : Relative advantage

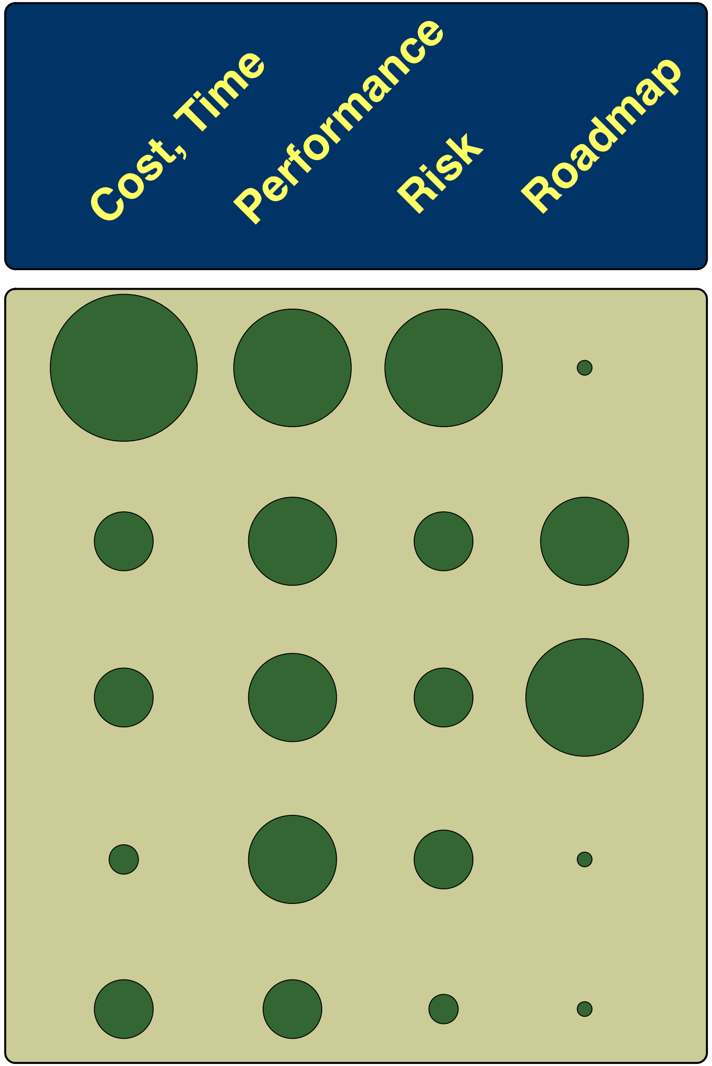
- Low Cost
- Easy to use
- ***Best Option for TNC***
- Not good fit for untethered design

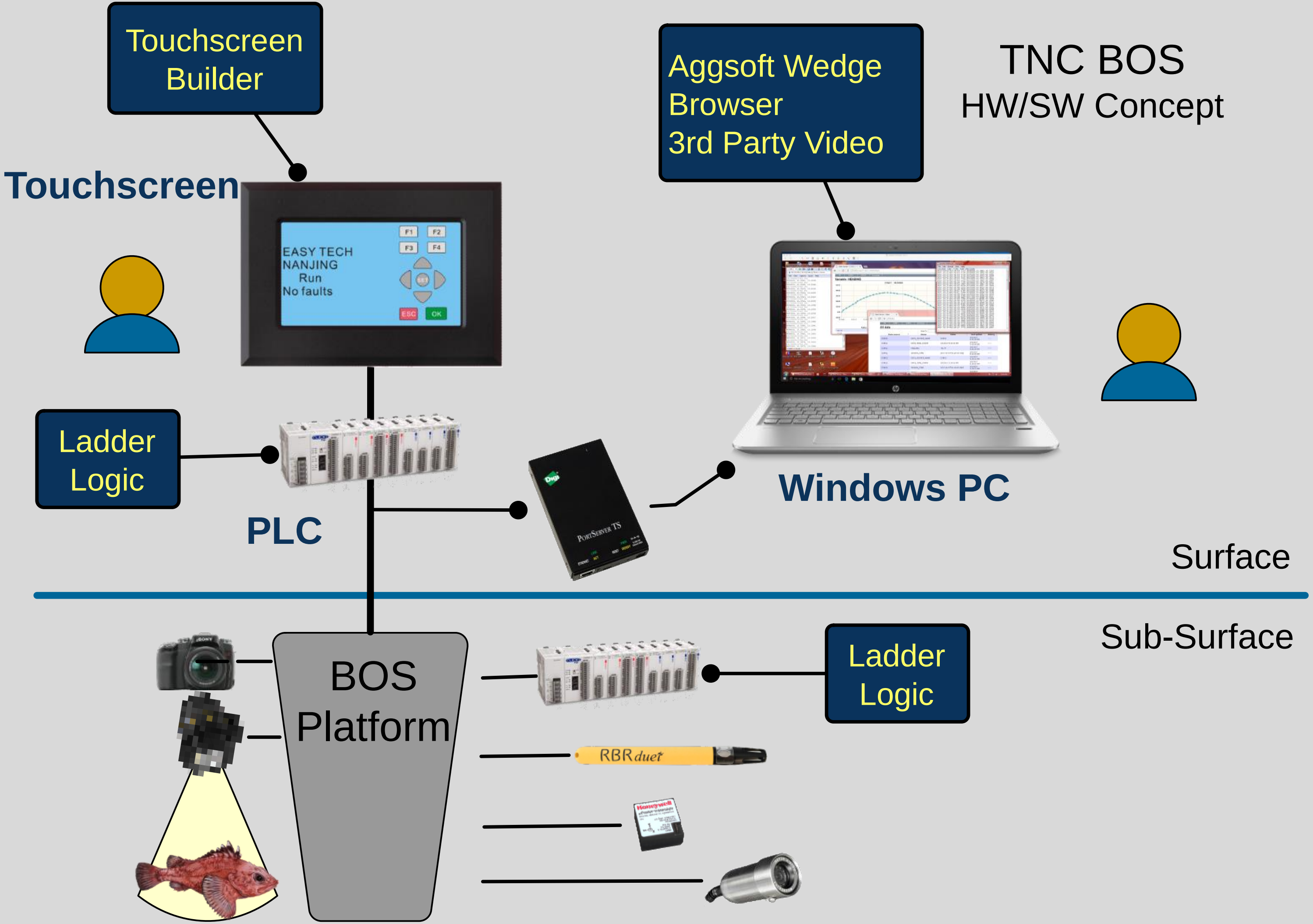
- Distributed or autonomous use
- Moderate power

- Reliable, low power
- Moderate integration effort required
- Potential candidate for untethered design

Platforms

- PC+PLC Wedge
- PC+COTS Ctrl Flux
- PC+OASIS OASIS
- PC+COTS Ctrl LabView
- COTS Emb Custom



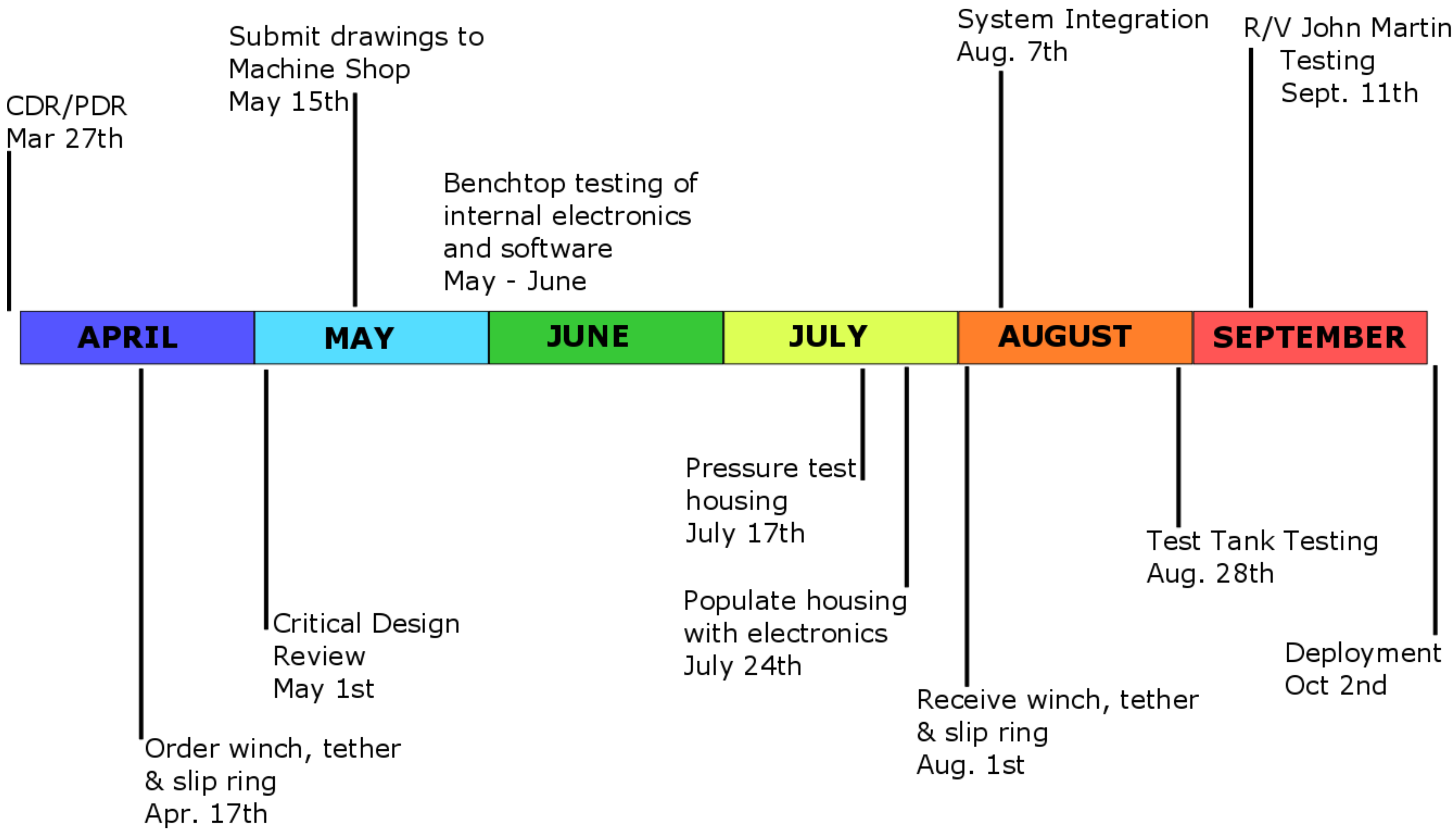


TNC BOS
HW/SW Concept
Touchscreen Builder
Touchscreen
EASY TECH
NANJING
Run
No faults
F1
F2
F3
F4
ESC
OK
Aggsoft Wedge
Browser
3rd Party Video
Ladder Logic
PLC
Windows PC
Surface
Sub-Surface
BOS Platform
Ladder Logic
RBRduet

Proposed Design

- Tether: Fiber
- Winch: Yes, model TBD
- Power: DC
- Housing: Single housing
  - with vertically mounted cameras
- Camera: Sony A6300
- Base: Detachable
- Controller: PLC
- Software: Aggsoft wedge

Tentative TNC Schedule



Next Steps

- Identify high risk & long lead time items
- Evaluate feedback from this review
- Finalize TNC system design
- Schedule critical design review (or alternate)

Discussion

Standard CTD Cable Solution

CATEGORY	KEY SPECs	IMPACT
TETHER	UNOLS Standard 0.322"ø (Coax | 4C)	
ELECTRICAL IMPACT	19AWG Conductors 1000V rated	Batteries required to get to 600W
MECHANICAL	10 klbf NBL, 5 klbf SWL	Already support on many ships (WF, RC, JM, SR)
DATA IMPACT	45 Mbps limits via VDSL	Real-Time data collection at the surface lost. Network data only.
OPERATIONAL	6” Min Bend Radius	May Avoid depressor weight, but floats remain
MAINTENANCE	Can use standard terms and splice whips	Field Servicable, inexpensive terminations
COST	~ $30,000 (Tether/Winch/SlipRing/Xverters	Lower cost, less gear on accommodating ships

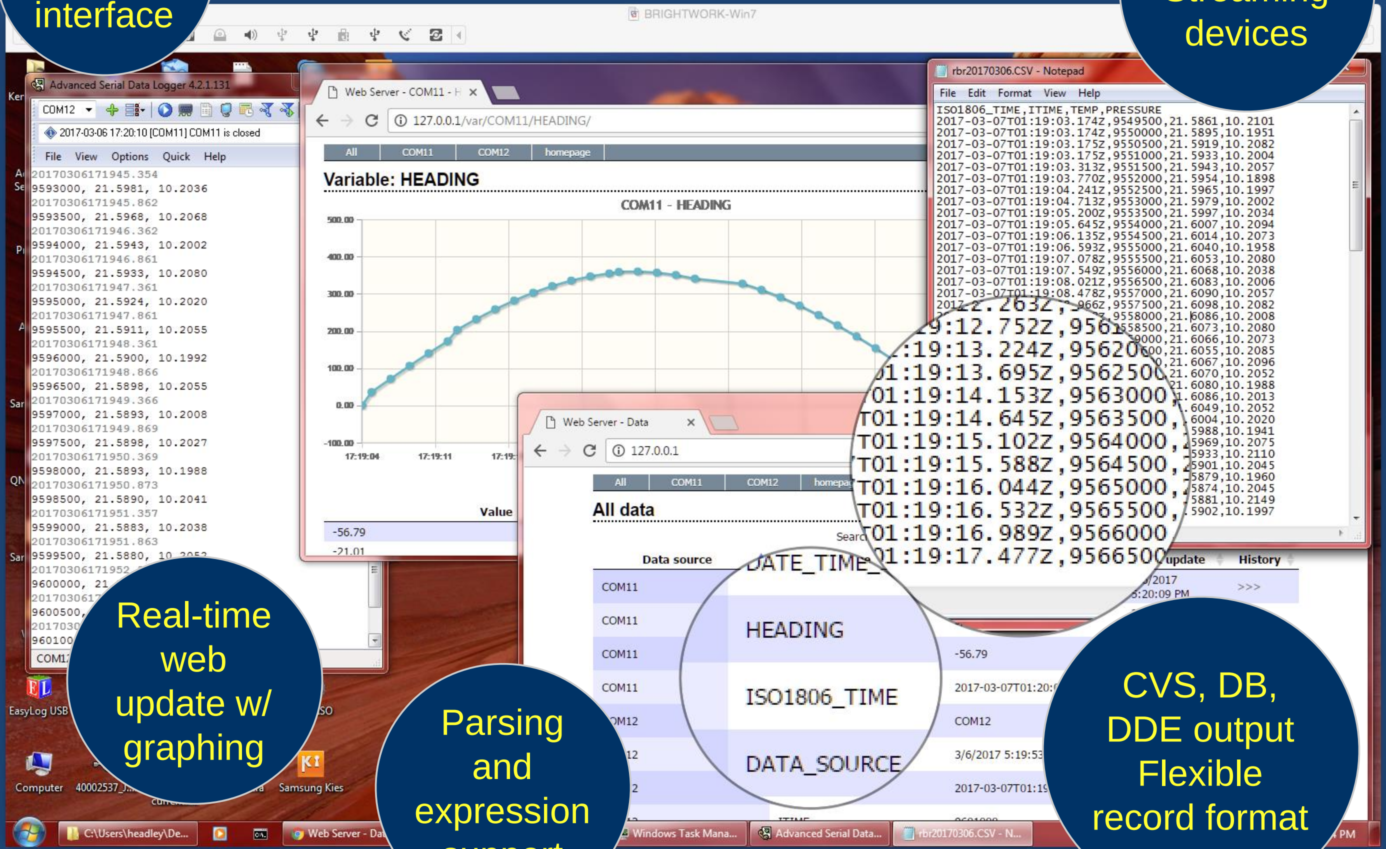
Soft Jacket Fiber Tether Solution

CATEGORY	KEY SPECs	IMPACT
TETHER	Custom Cable w SMF, GFI and 600W 400V Conductors	Custom Design will meet all requirements.
ELECTRICAL IMPACT	19AWG Conductors 1000V rated	No batteries, will add GFI safety
MECHANICAL	7 klbf NBL, 1 klbf SWL	Lower NBL will accommodate smaller ships than steel.
DATA IMPACT	Fiber facilitates 10 Gbps and CWDM for expansion	Topside data collection would be possible.
OPERATIONAL	10” Min Bend Radius	Will require custom winch, larger sheaves. More care need be take.
MAINTENANCE		Needs fiber kits and training. More downtime for damaged terms & tethers
COST	~$80,000 for winch, slip ring, and tether	Much higher cost and upkeep

Screenshot: Aggsoft Wedge Evaluation

Intuitive user interface

Polled, Streaming devices



Real-time web update w/ graphing

Parsing and expression support

CVS, DB, DDE output Flexible record format