DiSCO Multispectral Camera Design Review

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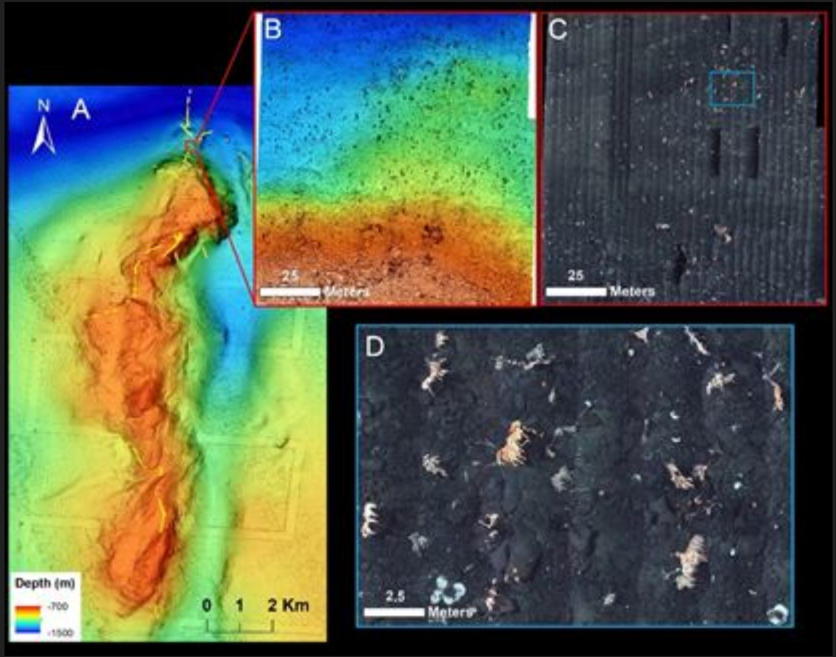
Outline

- Background
- Functional Requirements
- Concept Overview
- Optical Design
- Electrical Design
- Mechanical Design
- Risks and Mitigation

Lab Multispectral System

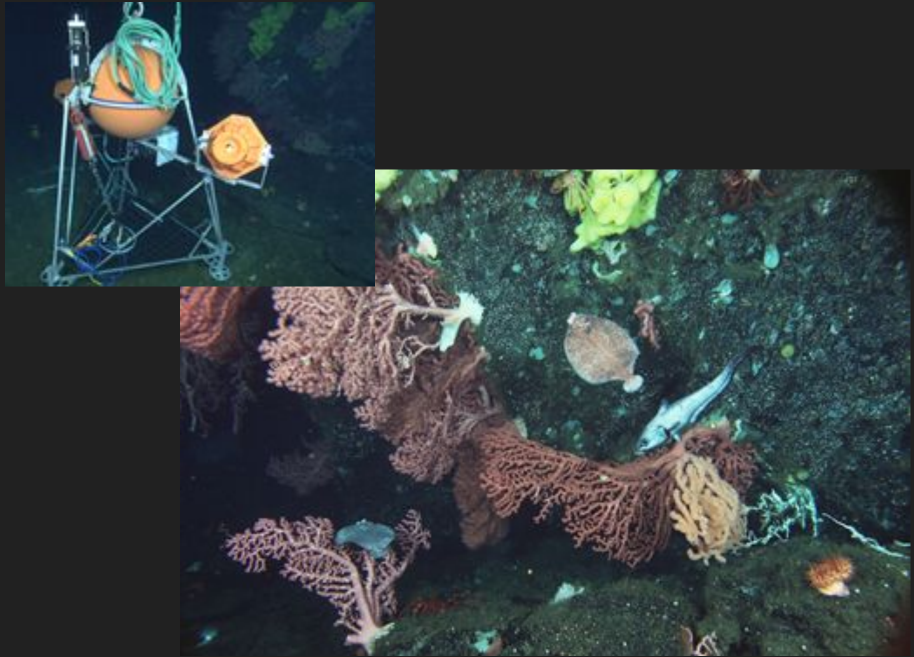
Background

Current Coral Imaging Efforts



LASS and ROV Transects:

Distribution and Environment and Topo Influences on assemblage distribution

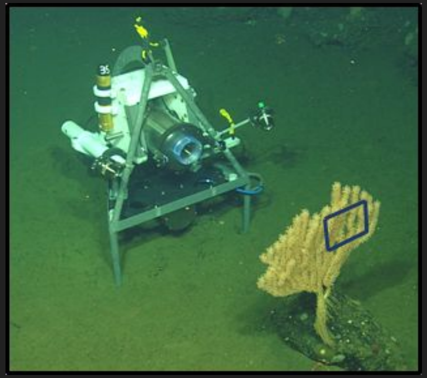


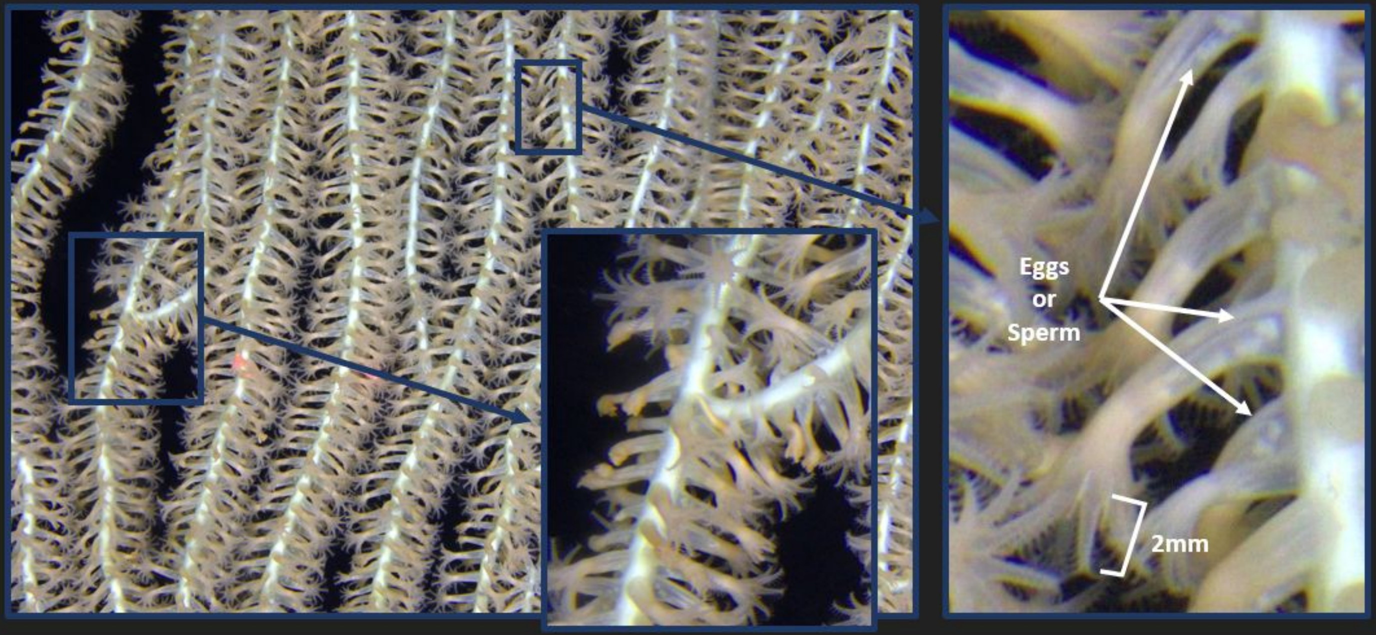
MegaCoral Camera

“Colony Scale” coral polyp behavior in the context of environmental and biological factors

Background

Current Coral Imaging Efforts



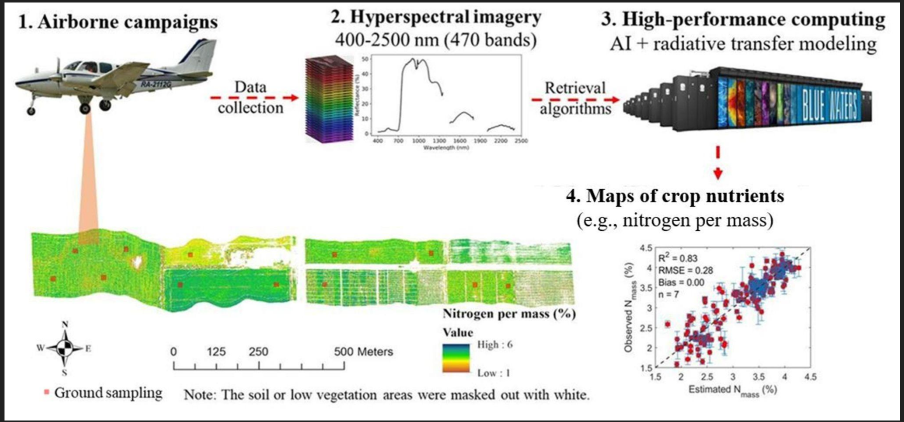


MacroCoral Camera

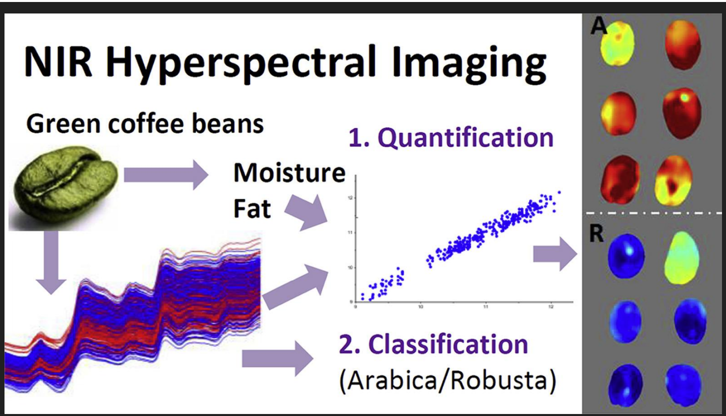
Individual polyp behavior and reproduction

Background Motivation

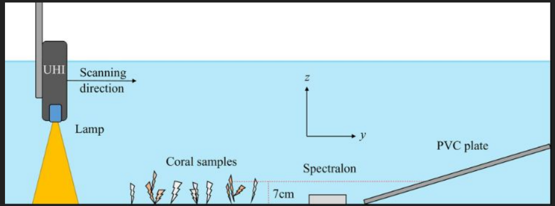
Agriculture

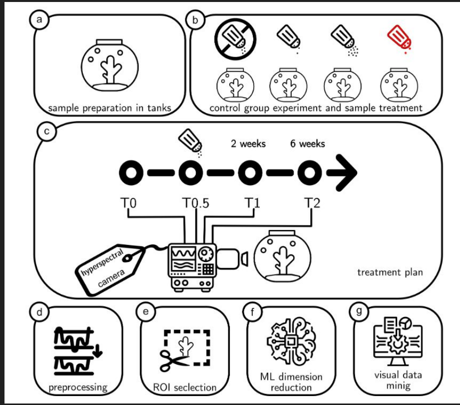


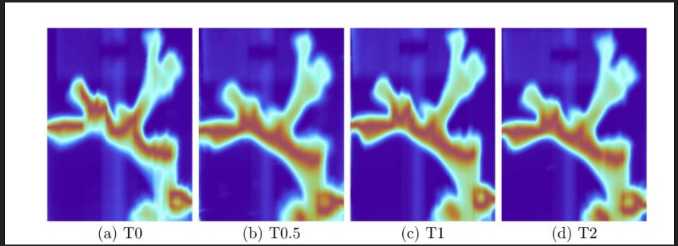
Food Science



Coral Health







Background

Motivation

- Reproduction
  - Delineation and quantification of gametes
  - Delineation of eggs from spermatozoa
- Coral “Health”
  - “Degradation” (similar to previous studies)
  - Non invasive proximate analysis (eg. fat, moister)
- Identification

Functional Requirements

ROV Multispectral Camera (V1) Functional Requirements

1. Image on the scale of the relevant coral biological structures of interest (10’s of um)
2. Have a FOV large enough to image groups of coral polyps (cm’s)
3. Possess the ability to focus and zoom
4. Provide direct color LED illumination at multiple wavelengths
5. Steam live images to a surface vessel
6. Provide real time multi-spectral image renderings
7. Record data on an external recorder on a surface vessel
8. Operate to a depth of 4000m
9. Be compatible with existing ROV power and comms
10. Be deployable on a manipulator arm of a ROV

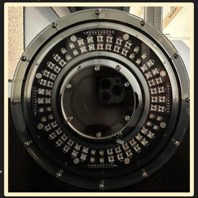
Lab Prototype

- Proof of concept
- Workflow development
- Lab validation
  - What kind of information? etc
- Lab or deck-based studies

Lab Prototype - system diagram

LED Ring

- 8 colors x 10 each
- uC: SAMD21
- C++ code: turns on LEDs on command



10 - 36 V

Est current when flashing LED:
1.5 - 2A @ 11.5 V

Wall Power Adaptor

Serial
- cmds, responses

TTL
- trigger, ready

Computer

USB-C
- camera data
- power

- Python code
- “Streaming” mode, “save all”
- Exposure times, gains set in code
- Code is specific to this camera

Lens:
Fujinon CF16ZA-1S

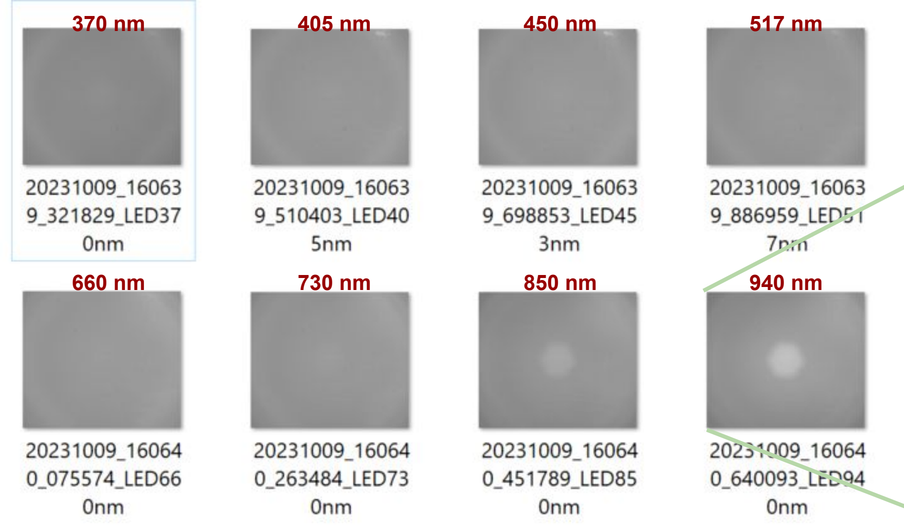
Camera:
Alvium 1800
U-2460m

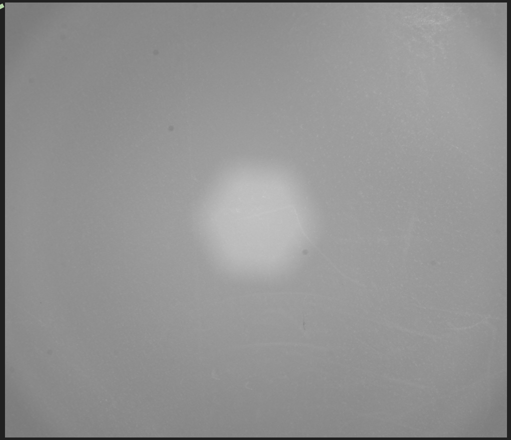
- Focal length set during assembly
- Current setting:
  - Objects in focus ~16 cm away from viewport
  - FOV ~5 x 6 cm; resolution ~11 um/px

- 25 MP monochrome
- Max 17 fps
- Global shutter

Lab Prototype - in-air results

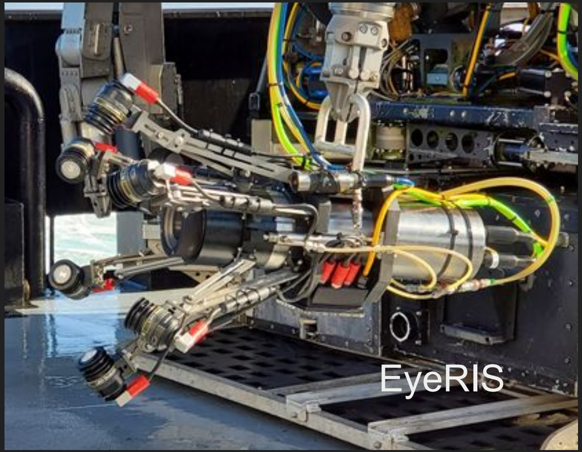
- Teflon sheet: near-even reflectance across spectrum
- Normalize images to (mostly) remove non-reflectance factors in pixel intensity
  - Exposure, gain, post-processing

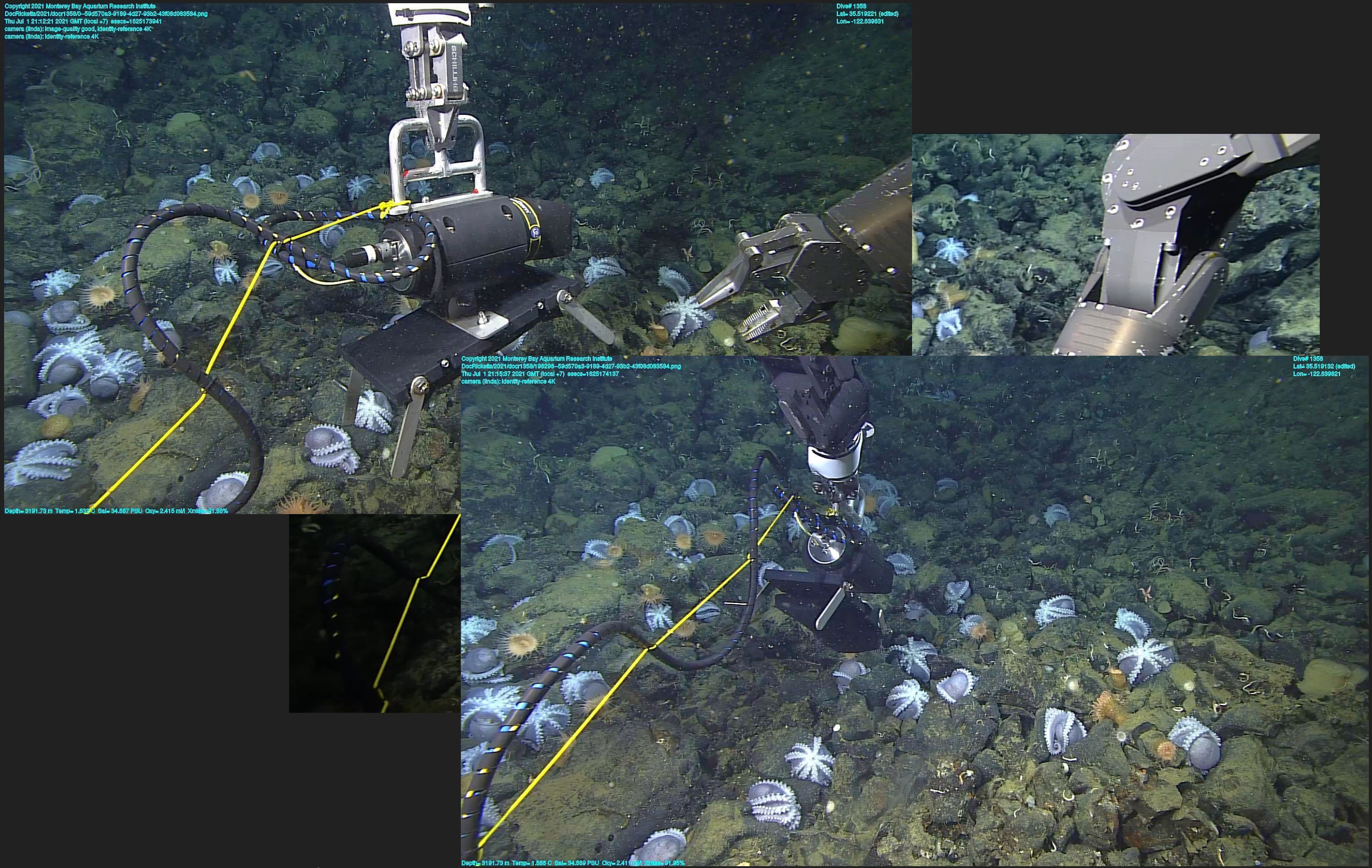




Design Approach

- Reuse designs from EyeRIS
  - Titanium housing and viewport
  - Imaging lens and lens control
  - Vehicle interface
- Reuse designs from Chiton
  - Potted LED strobes
  - Illumination geometry
- Add multispectral illumination using design from lab instrument

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Thu Jul 1 21:12:21 2021 GMT (local +7) esecs=1625173941
camera (linda): image-quality good, identity-reference 4K
camera (linda): identity-reference 4K
Dive# 1358
Lat= 35.519221 (edited)
Lon= -122.639631
Depth= 3191.73 m
Sal= 34.687 PSU Oxy= 2.415 ml/l
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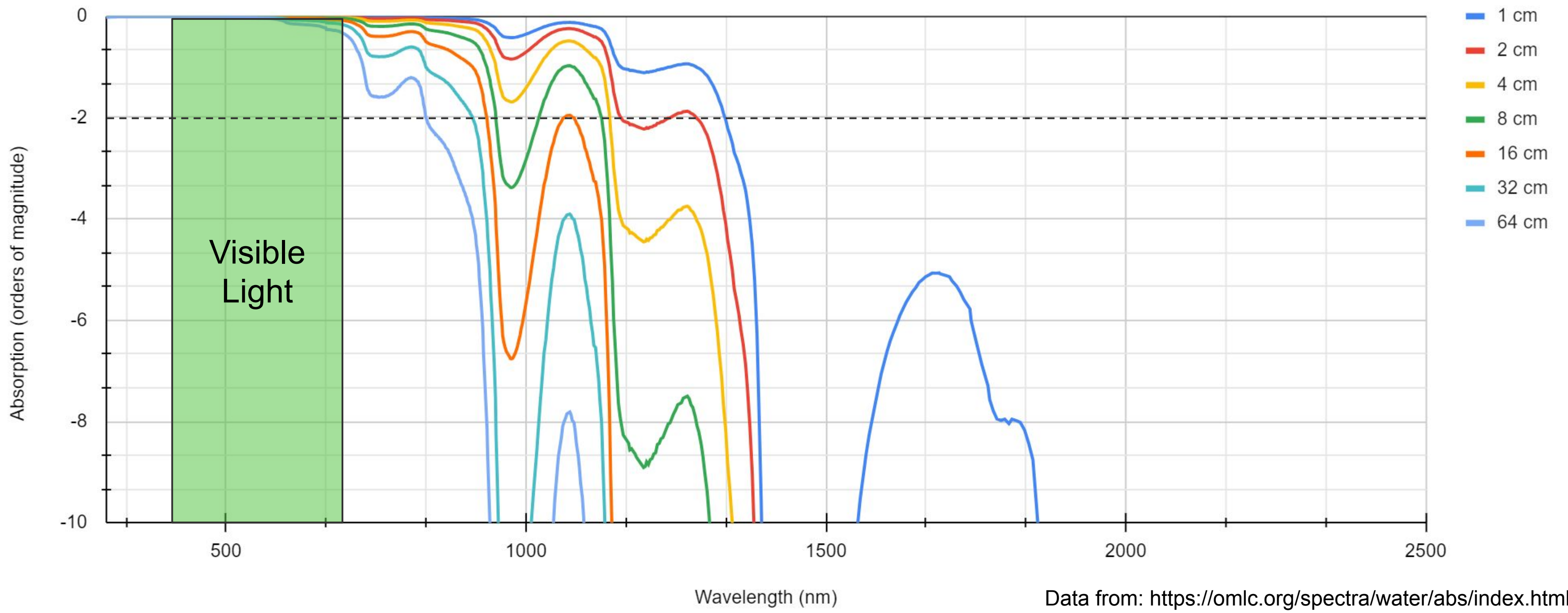
camera (linda): identity-reference 4K
Dive# 1358
Lat= 35.519132 (edited)
Lon= -122.639621
Depth= 3191.73 m Temp= 1.886 C Sal= 34.689 PSU

Optical Design

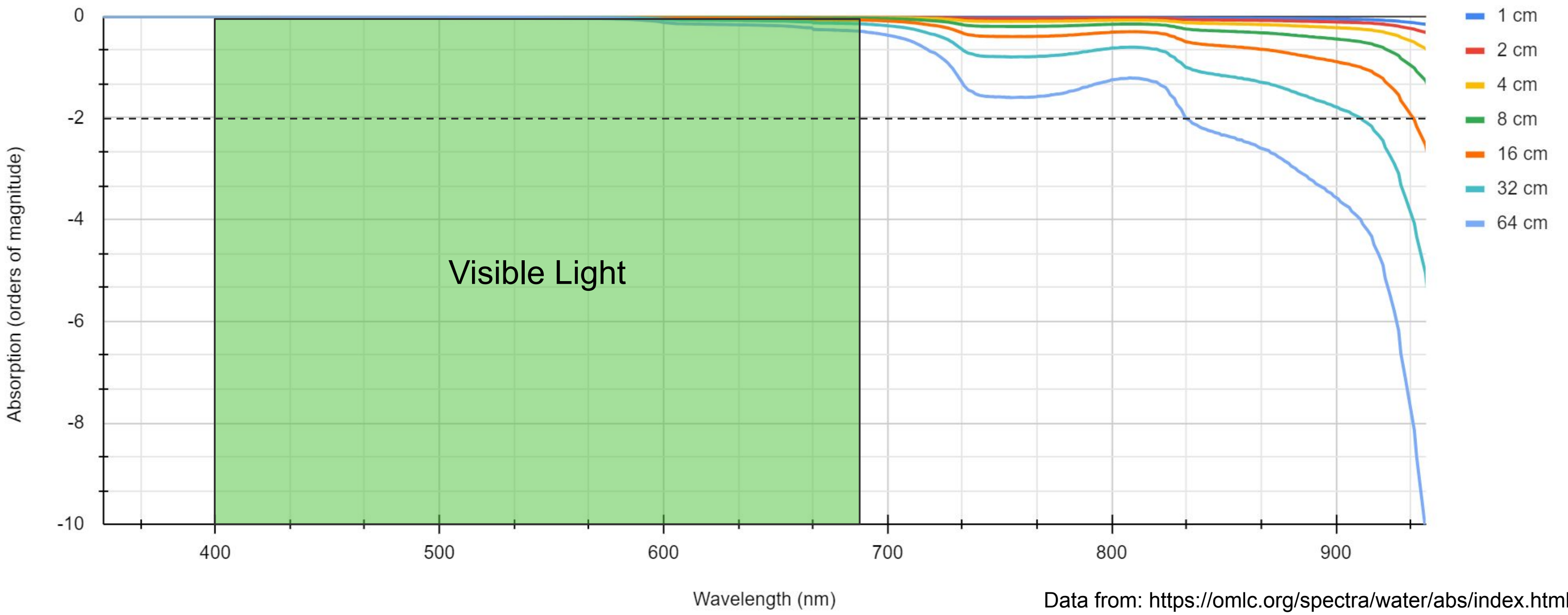
- Spectral coverage and LED selection
- Camera Selection
- Lens Selection
- Multispectral Strobe Design

Spectral Absorption in Seawater



Data from: https://omlc.org/spectra/water/abs/index.html

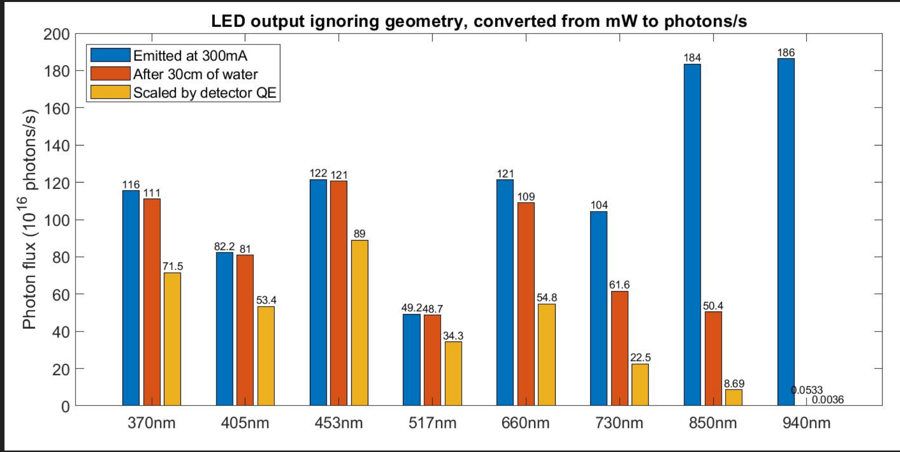
Spectral Absorption in Seawater



Data from: https://omlc.org/spectra/water/abs/index.html

LED Selection

- Direct color LEDs in the range 370 to 950 nm
- Reuse LEDs from lab system design
- LedEngin and Luminus



Camera Selection

- High resolution to enable pixel sizes in object space on the order of 10 - 30 um over the field of view
- Large pixel size (4.6 um) to work with EF mount lens
- High speed to allow multiplexing of spectral channels
- Emergent Vision Tech fiber camera

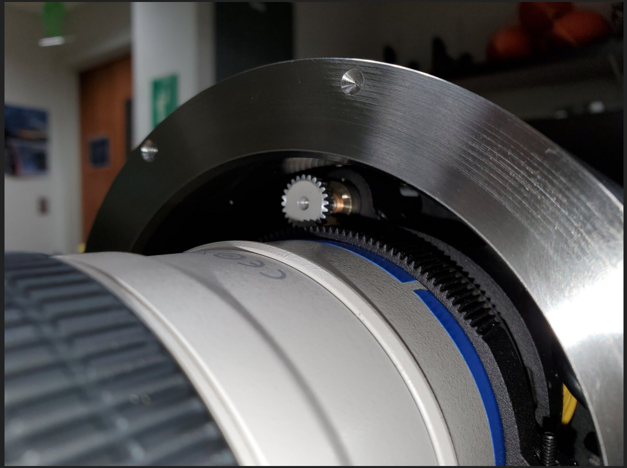
HB-50000: 25GigE camera with AMS CMV50000

- High-speed 25GigE SFP28
- 25x the speed of GigE
- GigE Vision® and GenICam™ compliant
- Available in monochrome (HB-50000-M), and color (HB-50000-C)
- Optional IP67 housing

Sensor	CMV50000
Resolution	7920 x 6004
Megapixels	50MP
Sensor Type	35mm CMOS
Max Frame Rate	30fps
Cell Size	4.6x4.6µm
Standard Mount	52mm, M52x1.5x12mm BFL, F-mount Available
Shutter	Global
Bit Depth	8 & 12 bit
GPIO / Triggering	3 in, 3 out Software, External (Pulse or Edge)
Interface	25GigE SFP28
Exposure/Integration*	100µs-1s
Dynamic Range	64 dB
Monochrome Modes	Mono8, Mono12
Color Modes	RGB8, YUV411, YUV422, YUV444, BGR8
Raw Modes	BayerRG8, BayerRG12
Operating System	Win10 (64 bit), Linux (64 bit)
Compliance	CE, FCC, RoHS, WEEE, GigE Vision, GenICam
Power Requirements	9W, 12V
Operating Temperature	0C – 45C

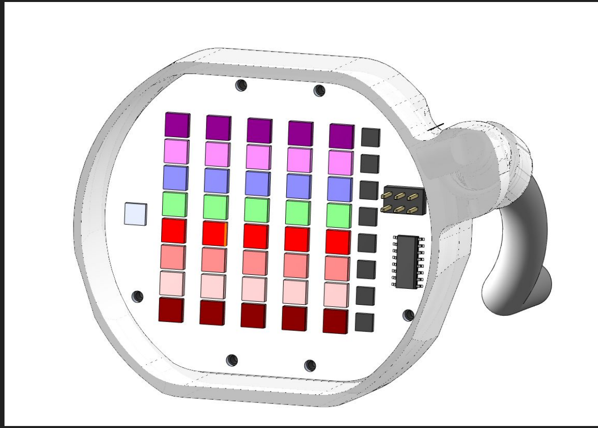
Lens Selection

- EyeRIS design reuse
    - Canon 70-200 EF mount lens
    - Birger Canon lens controller (Focus and aperture)
    - 3D printed zoom-gear with stepper motor
    - Canon 500D or 250D diopter to reduce minimum working distance to 10-30 cm in water
    - Target field of 3-10 cm at 30 cm in water, 6 to 20 um pixel size



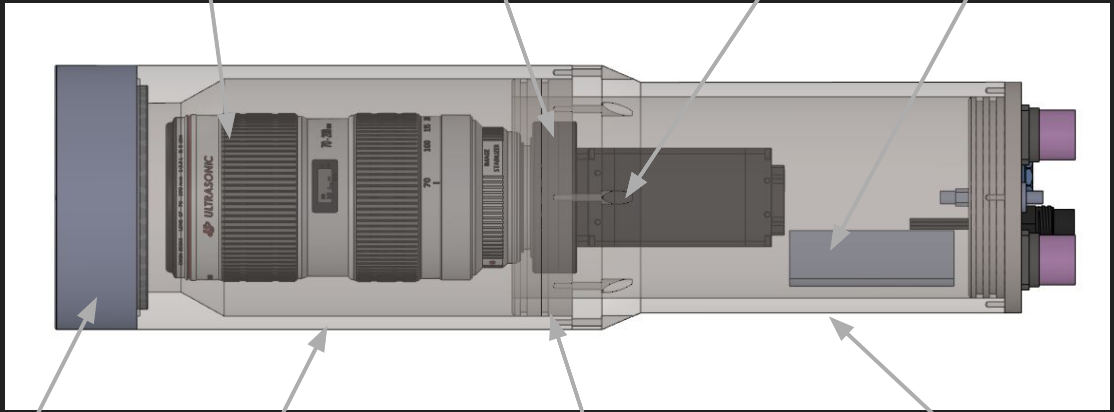
Multispectral Strobe Design

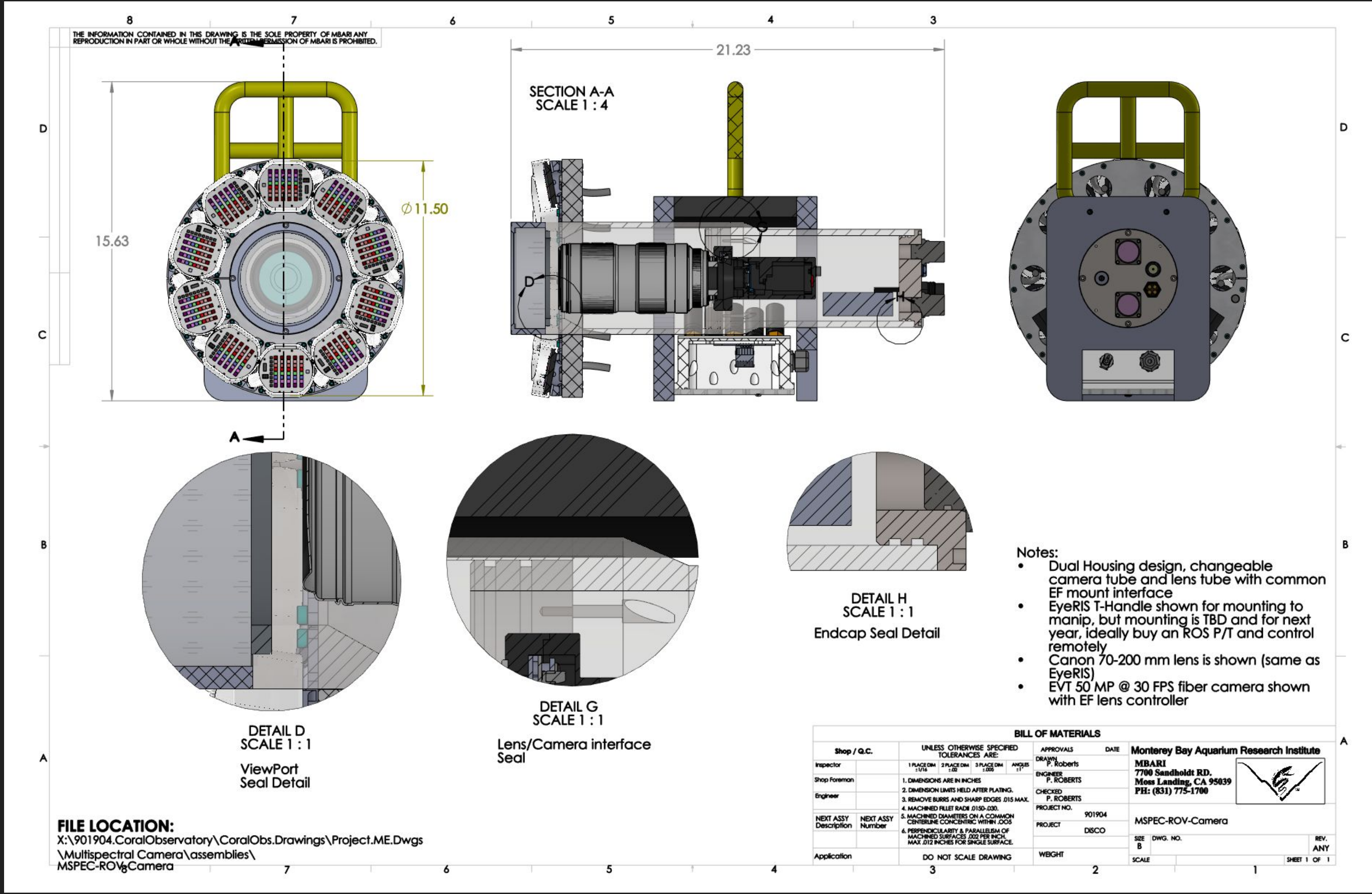
- Chiton design reuse
  - LED board with heatsink potted in 3D printed shell with Epoxacast 690
- LED board will will have LEDs, address decoder, and N-FET switches
- Assembly will be potted in Epoxacast 690 and pressure tested to 6000 psi
- No reflector will be used/needed simplifying assembly



Mechanical Design

- 4000 m Titanium and BK7 viewport
- Based on EyeRIS design
- “Modular” lens housing to allow changing lenses without complete housing redesign





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SECTION A-A
SCALE 1 : 4
15.63
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A
D
DETAIL D
SCALE 1 : 1
ViewPort
Seal Detail
DETAIL G
SCALE 1 : 1
Lens/Camera interface
Seal
DETAIL H
SCALE 1 : 1
Endcap Seal Detail
Notes:
• Dual Housing design, changeable camera tube and lens tube with common EF mount interface
• EyeRIS T-Handle shown for mounting to manip, but mounting is TBD and for next year, ideally buy an ROS P/T and control remotely
• Canon 70-200 mm lens is shown (same as EyeRIS)
• EVT 50 MP @ 30 FPS fiber camera shown with EF lens controller
BILL OF MATERIALS
Shop / Q.C.
Inspector
Shop Foreman
Engineer
NEXT ASSY Description
NEXT ASSY Number
Application
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
1 PLACE DIM ±1/16
2 PLACE DIM ±.02
3 PLACE DIM ±.005
ANGLES ±1°
1. DIMENSIONS ARE IN INCHES
2. DIMENSION LIMITS HELD AFTER PLATING.
3. REMOVE BURRS AND SHARP EDGES .015 MAX.
4. MACHINED FILLET RADII .0150-.030.
5. MACHINED DIAMETERS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005
6. PERPENDICULARITY & PARALLELISM OF MACHINED SURFACES .002 PER INCH. MAX .012 INCHES FOR SINGLE SURFACE.
DO NOT SCALE DRAWING
APPROVALS
DATE
DRAWN P. Roberts
ENGINEER P. ROBERTS
CHECKED P. ROBERTS
PROJECT NO. 901904
PROJECT DISCO
WEIGHT
Monterey Bay Aquarium Research Institute
MBARI
7700 Sandholdt RD.
Moss Landing, CA 95039
PH: (831) 775-1700
MSPEC-ROV-Camera
SIZE B
DWG. NO.
REV. ANY
SCALE
SHEET 1 OF 1
FILE LOCATION:
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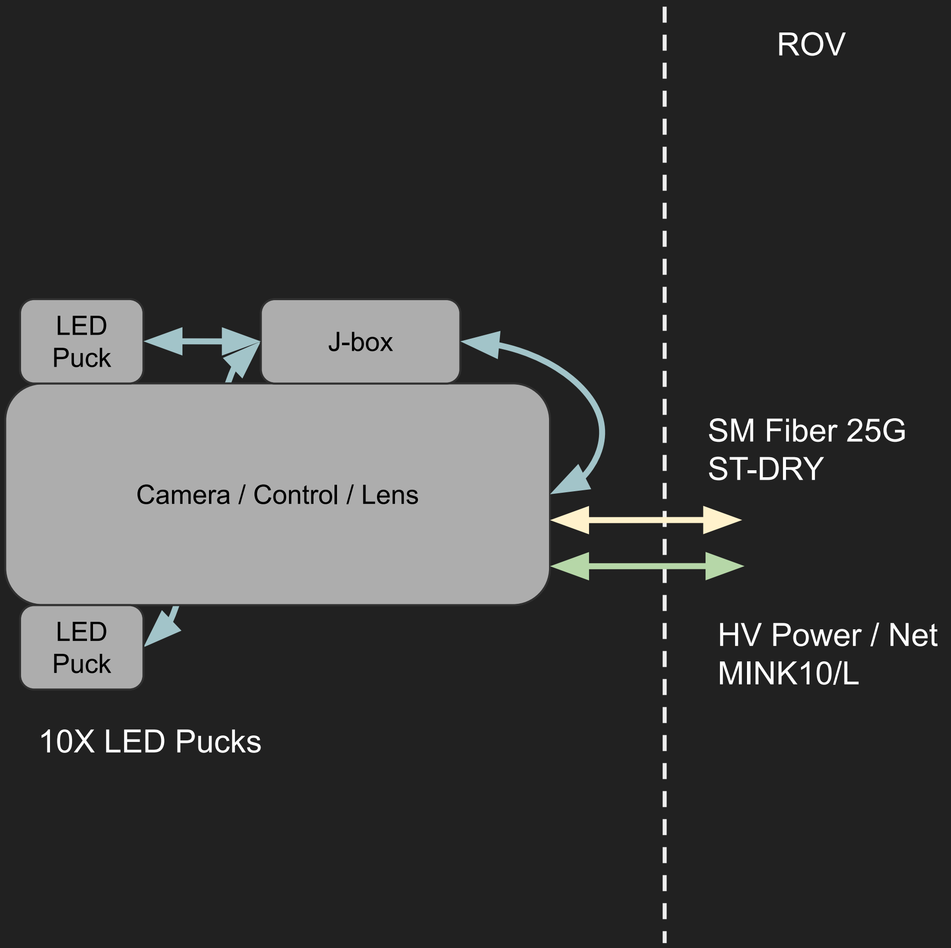
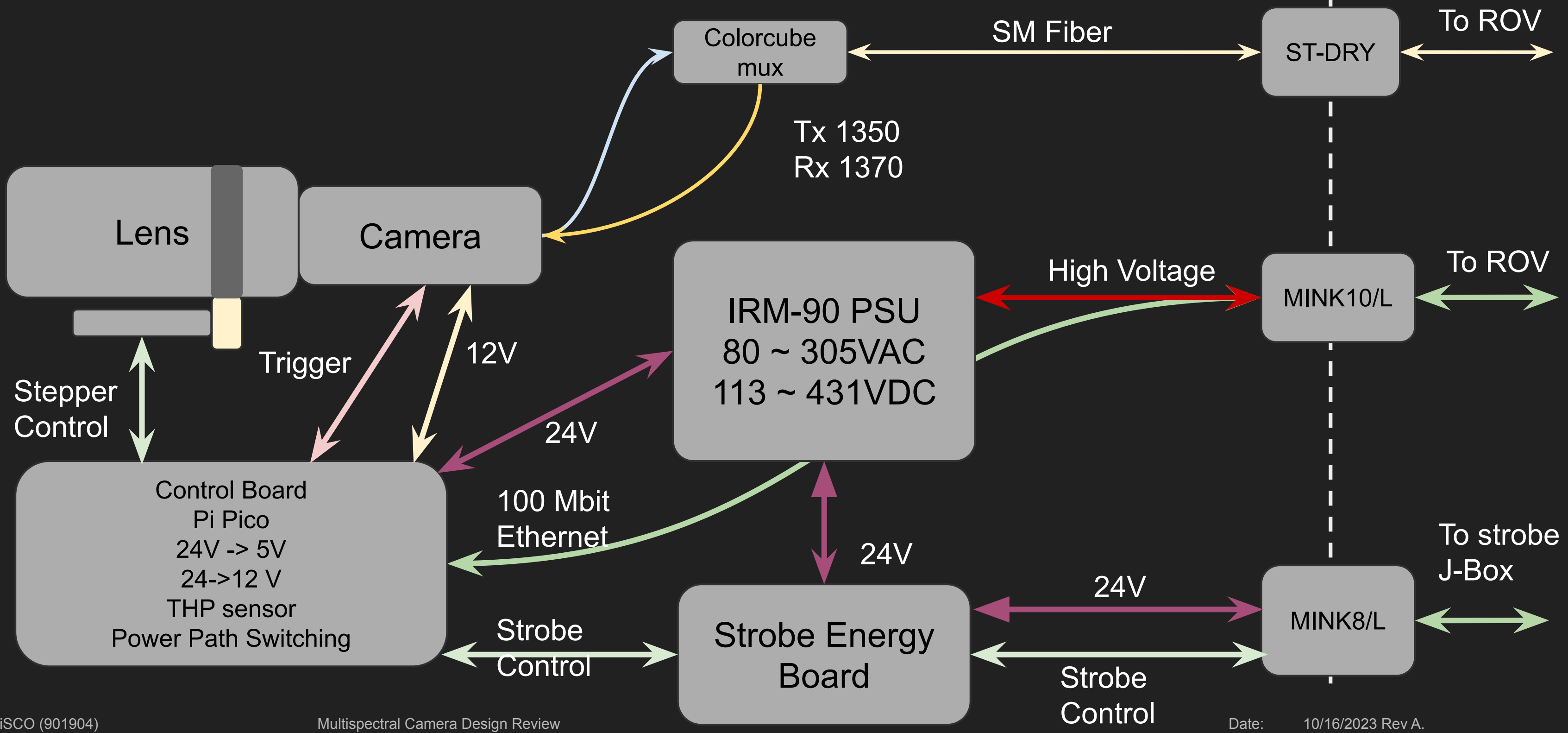
\Multispectral Camera\assemblies\
MSPEC-ROV-Camera

Electrical Design

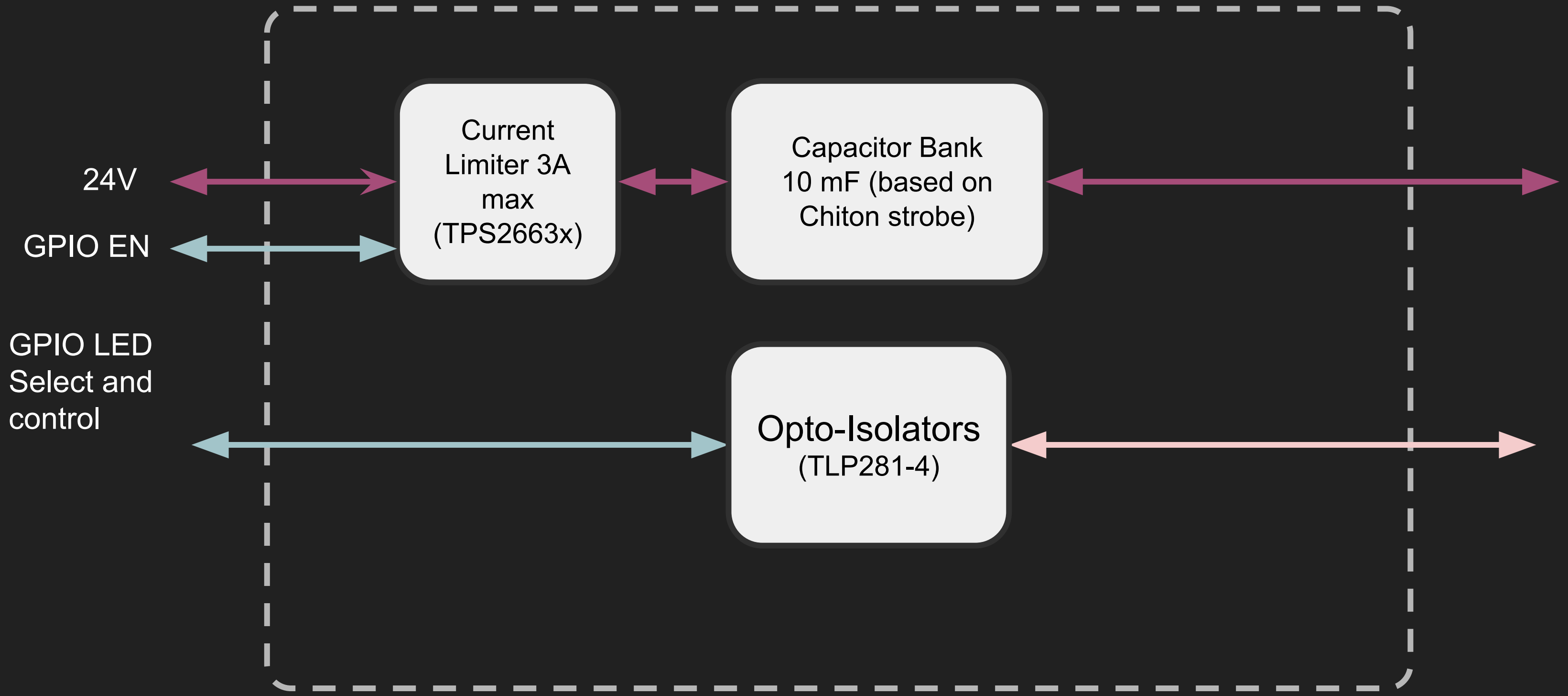
- Universal AC and DC input with Meanwell 90W PSU
- Reuse most of EyeRIS controller but integrate onto a single PCB
- Update Chiton strobe design to enable 8-wavelength control
- Standard ROV high voltage interface with 100 Mbit ethernet



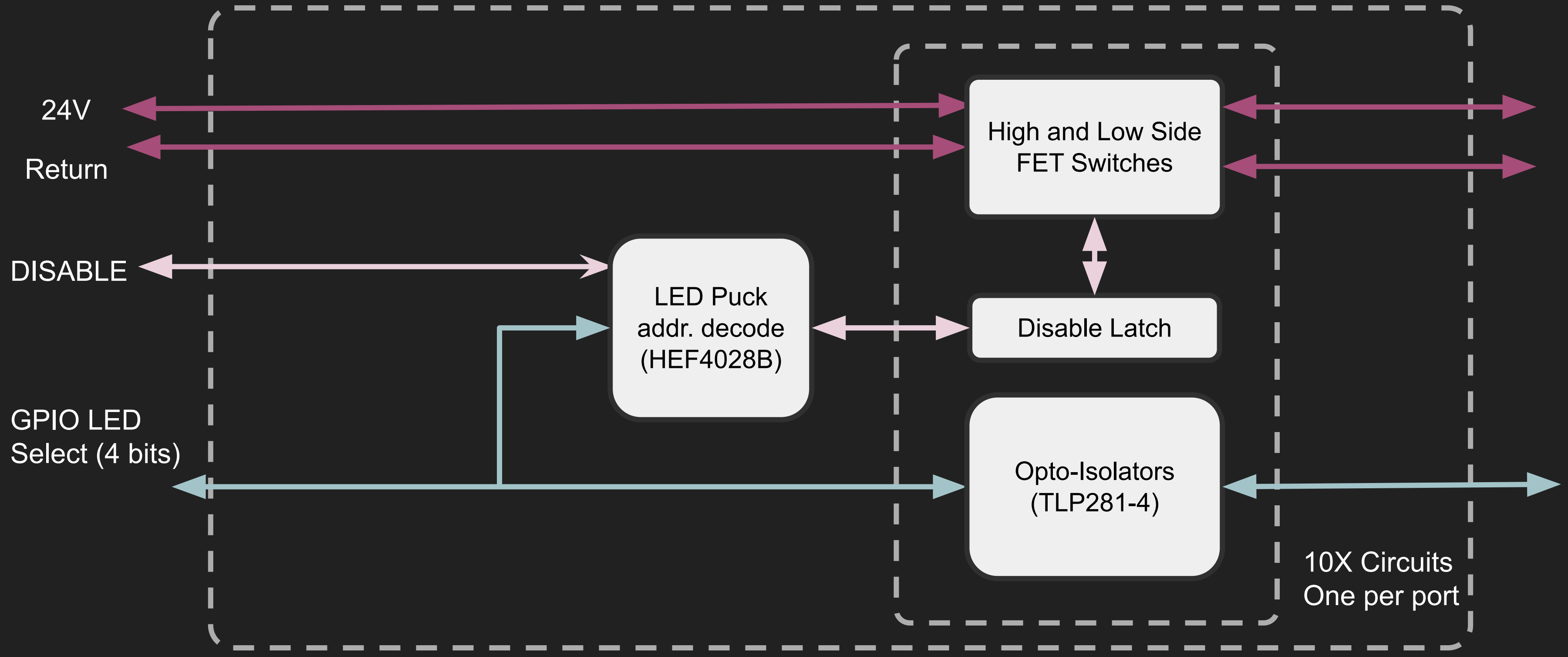
Electrical Design: Camera / Control



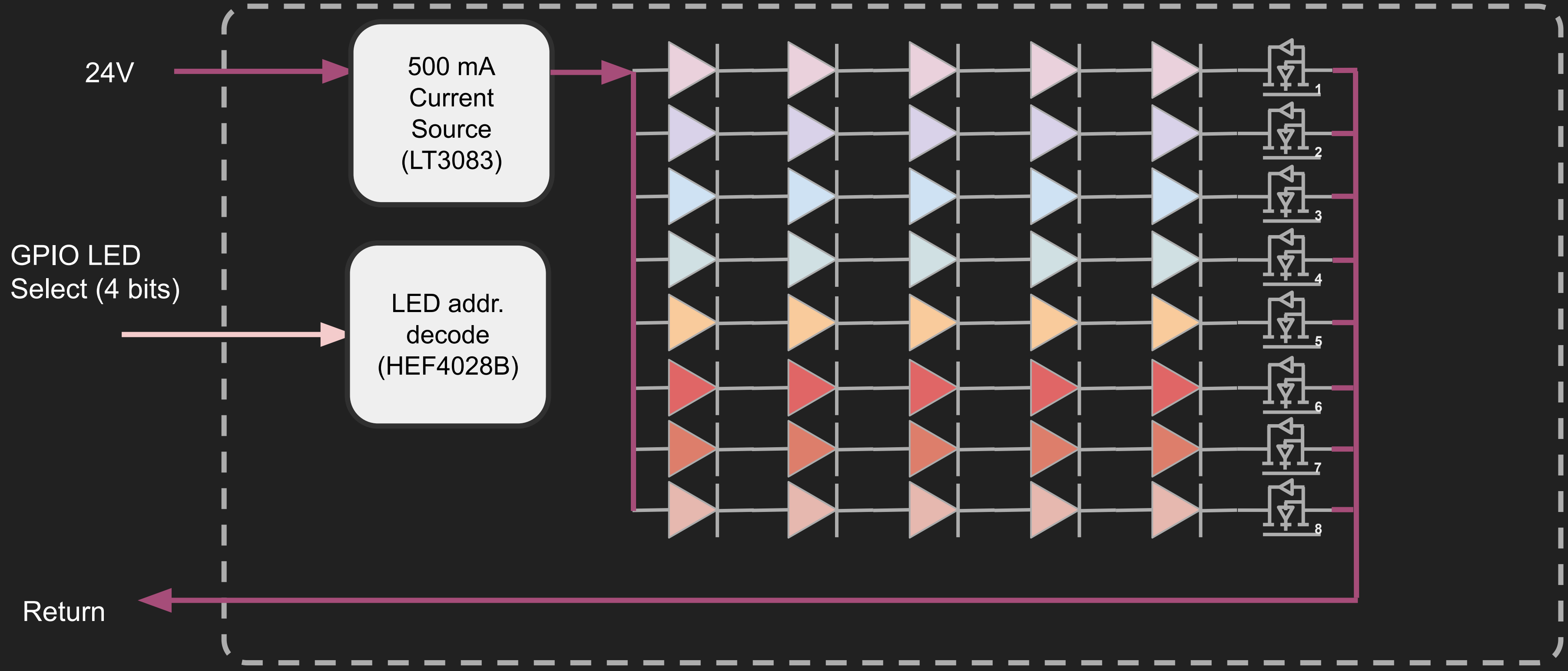
Electrical Design: Strobe Energy



Electrical Design: Strobe J-Box (Oil-filled)



Electrical Design: LED Puck



Risks and Mitigation

- LEDs not pressure tolerant
  - Revise housing to have air gap between LEDs and epoxy
  - Use 1-atm design at increased cost and size
- Vehicle and/or manip vibration creates too much motion between spectral channels
  - Place system on beanbag mount similar to Optim deployment
  - Go to higher frame rate camera (100 fps) at increased cost
  - Design stand with pan and tilt control to be placed near target and operated remotely
- Charged capacitors cause shock risk during service
  - Make sure caps have bleed resistors so they don’t stay charged