Spectral Forest

Final Testing Results

ME 486C Section 01

Team: Tyler Lerew, Torrey King, & Derrick Doan

Design Requirements (DR) Summary

- Customer Requirements (CR)
  - Durable (CR1)
  - Semi-constant internal conditions (CR2)
  - Ease of access (CR3)
  - Environmentally sound (CR4)
  - Spectral range between 400-1000nm (CR5)
  - As light as possible (CR6)
  - As small as possible (CR7)
  - Drone mountable in operation (CR8)
  - Ambient operating range of 0-50°C (CR9)
- Engineering Requirements (ER)
  - Long lifespan (ER1)
  - Internal temperature control with vents (ER2)
  - Easy to access data in EE side (ER3)
  - Water and dust proof (ER4)
  - Optics designed for full range (ER5)
  - Drone can fly while carrying (ER6)
  - Fits within drone payload space (ER7)
  - Optics secured (ER8)

Top Level Testing Summary

Experiment/Test	Relevant DRs	Testing Equipment Needed	Other Resources
EXP 1: 3D Print Fits	• CR3 - Ease of access • CR6 - As light as possible • ER8 - Optics secured during flight	• Bambu Lab X1 Carbon printer	• Lab space • Multiple tolerance tests at once
EXP 2: Laser Alignment	• CR5 -Spectral range between 400-1000nm • CR8 - Drone mountable in operation • CR9 - Ambient operating range of 0-50°C • ER1 - Long lifespan • ER5 - Optics designed for full range • ER8 - Optics secured during flight	• 3D printed alignment jig • Laser • Optic layout	• Dark Environment

Top Level Testing Summary cont.

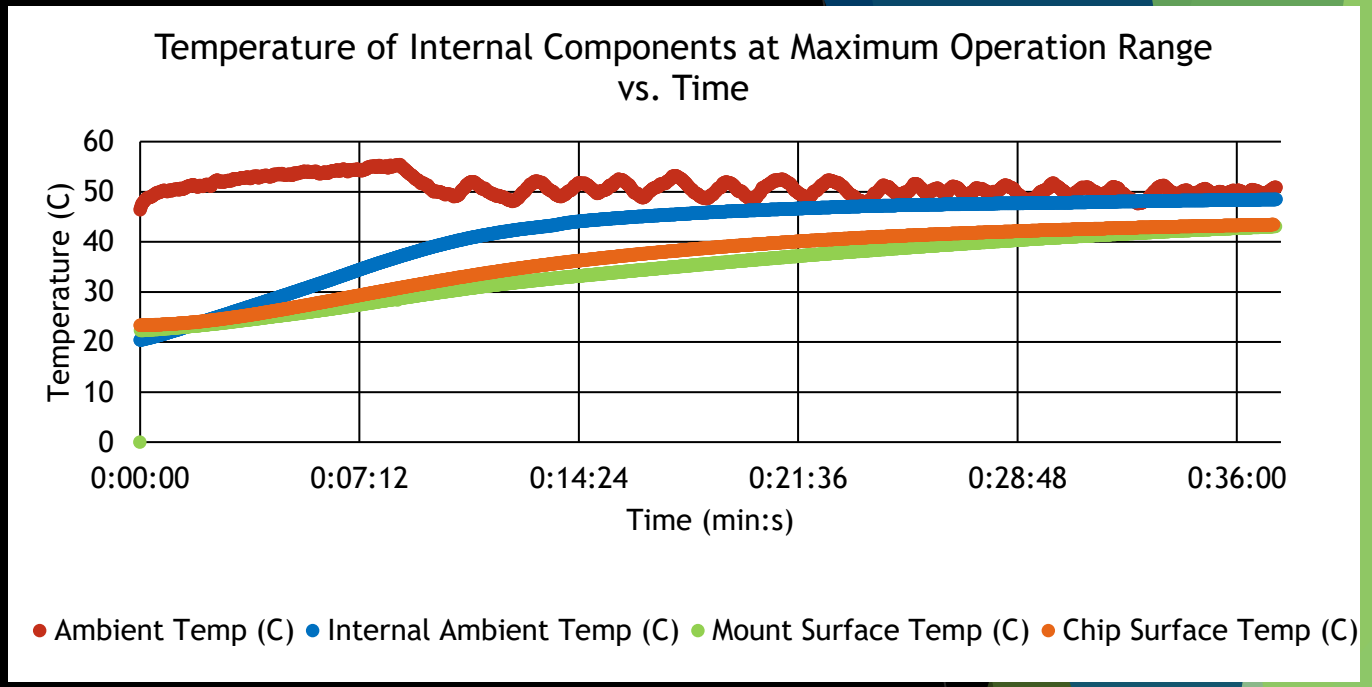
Experiment/Test	Relevant DRs	Testing Equipment Needed	Other Resources
EXP 3: Heat Test on Optics	• CR1 – Durable • CR2 –Semi-constant internal conditions • CR4 – Environmentally Sound • ER1 – Long Lifespan • ER2 - Internal temperature control with vents	• Optics chamber w/ door and screws • 1 Mount • Detector Chip • 3 – 1” pieces of foam • 4 K-Type Thermocouples • Pico Data Logger • Epoxy	• Lab 111 • PC to connect to and will collect all the data
EXP 4: Flight/drop for optics	• CR1 - Durable • CR4 - Environmentally Sound • CR6 – As Light as Possible • CR7 - As Small as Possible • ER1 - Long lifespan • ER3 – Easy to access data in EE side • ER8 - Optics secured during flight	• Fully assembled encloser (burner lenses in-place of real ones) • Range Finder • Screwdriver to open the device and inspect for damage • Extra screws	• Knoles/ San Fran parking garage

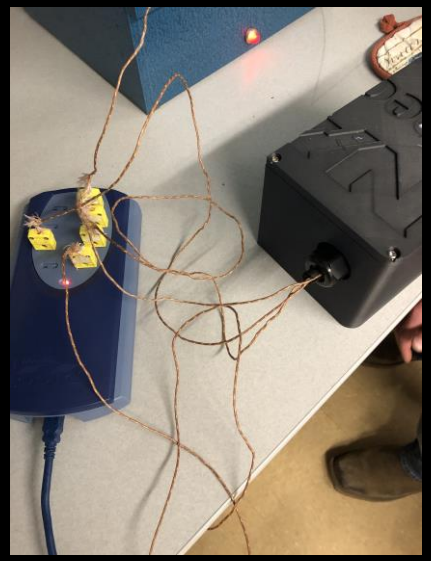
Top Level Testing Summary cont.

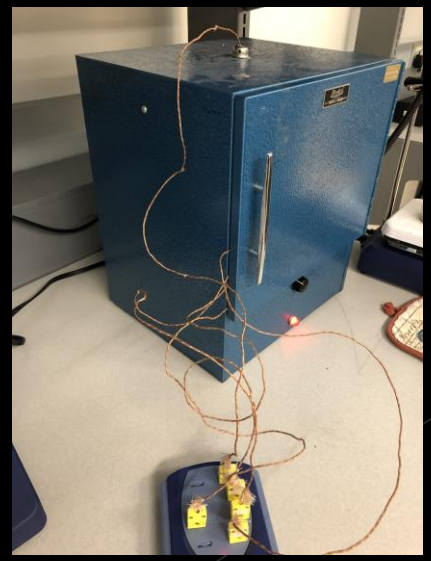
Experiment/Test	Relevant DRs	Testing Equipment Needed	Other Resources
EXP 5: Seal/vent test upon submersion and Artificial Dust Storm	• CR2 –Semi-constant internal conditions • CR4 – Environmentally Sound • ER2 – Internal temperature control with vents • ER4 - Water and dust proof	• Fully assembled device • Vessle larger than the device • DeWalt Electric Cordless Leaf Blower • Paper • Food Dye • Timer	• Open area • Water • Sand
EXP 6: Destructive Test on Enclosure	• CR1 - Durable • CR4 - Environmentally Sound • CR6 – As Light as Possible • CR7 - As Small as Possible • ER1 - Long lifespan • ER4 – Water and dust proof • ER8 - Optics secured during flight	• Fully assembled device • Range finder • Means to record the fall	• Knoles/ San Fran parking garage • Rocks • Trees

Heat Test on Optics: Completed

- DRs being tested: CR1, CR2, CR4, ER1, ER2
- Experimental test setup and results:







Heat Test on Optics Cont.: Completed

Table 1: Linear expansion

Location	With same q as mount (in)	With assumed surface temp (in)
Diff of nylon to entrance	0.0342	0.0000959
Diff of nylon to focus	0.0338	0.0000466
Diff of nylon to grating	0.0339	0.0000232

Seal/vent test upon submersion and Artificial Dust Storm: Completed

- DRs being tested: CR2, CR4, ER2, ER4
- Water submersion test: full submersion, ingress after 10 second, beyond what is required

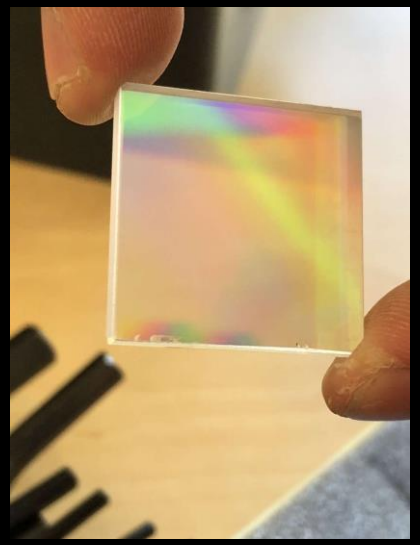
Ingress testing cont.: Completed

Ingress testing cont.: Completed

Flight/drop for optics: Completed

- DRs being tested: CR1, CR4, CR6, CR7, ER 1, ER4, ER8
- Test consisted of knocking off table, dropping from shoulder height, and dropping from roughly 20ft

Flight/drop for optics cont.: Completed

Flight/drop for optics cont.: Completed

Destructive Test on Enclosure: Completed

- DRs being tested: CR1, CR4, CR6, CR7, ER 1, ER4, ER8
- Done without any optics or mounts in the enclosure (taped a similarly weighted rock in place)
- Dropped from the top of the San Francisco parking garage, then tossed into a tree, then tossed onto cement multiple times

Destructive Test on Enclosure cont.: Completed

Destructive Test on Enclosure cont.: Completed

Destructive Test on Enclosure cont.: Completed

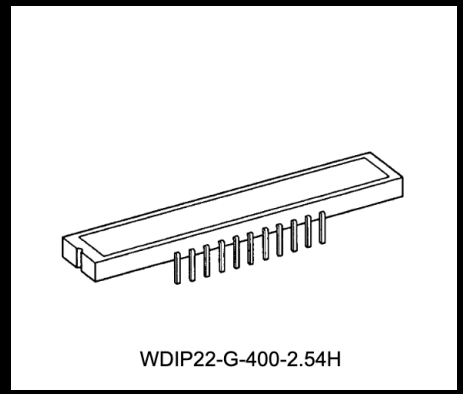
Laser Alignment: Completed

- DRs being tested: CR5, CR8, CR9, ER1, ER5, ER8
- 4.5 mW (639 nm) laser mounted to be centered on the optic system (class 3R)
- Paper represents the CCD chip placement
- Can see odd reflections (need for matte black paint)
- Can see degrees of incidences in the laser diffraction

Laser Alignment cont.: Completed

- Estimated image while looking up at a ponderosa pine

- This rainbow shows the visible wavelength being roughly 0.5 in which is 55% of total chip length, perfect
- Width of this light is slightly wider than the CCD chip detector width, great!
- This goes to show our theory design in fact does work in practice, will know more once we have use of EE board
- Expecting laser to reach the correct location and it did!



3D Print Fits: Completed

DRs being tested:
CR3, CR6, ER8
(Ease, light, small)

We put stuff in.

It fits.

Yay.

Spectrum Tube Color Adjust still will not be doing

- Will not be performing this semester due to the EE team not completing their portion as this is to assist them in calibrating their data.
  - This test will use spectrum tubes (gas filled tubes) to get exact data points of where each wavelength hits the CCD chip

total test count

Total Tests Completed:

6/6 = 100%

Specification Sheet: Customer Requirements

Customer Requirement	CR Met	Client Acceptable
CR1 - Durable	✓	✓
CR2 - Semi-constant internal conditions	✓	✓
CR3 - Ease of access	✓	✓
CR4 - Environmentally sound	✓	✓
CR5 -Spectral range between 400-1000nm	✓	✓
CR6 - As light as possible	✓	✓
CR7 - As small as possible	✓	✓
CR8 - Drone mountable in operation	✓	✓
CR9 - Ambient operating range of 0-50°C	✓	✓

Specification Sheet: Engineering Requirements

Engineering Requirement	Target	Tolerance	Measured/Calculated Value	ER Met?	Client Acceptable
ER1 - Long lifespan	5 years	± A few months	PC has a life of 10-20 years, everything else can be replaced/re-aligned	✓	✓
ER2 - Internal temperature control with vents	0-50 ℃	± 5 ℃	Ambient = 50C, Internal Ambient = 48.26 C	✓	✓
ER3 - Easy to access data	<5 sec	0 sec	Just plugs in, USB (needs 3 tries to get correct orientation)	✓	✓
ER4 - Water and dust proof	0 ml/ 0 mg	±0.01 ml/ 0.01 mg	Ingress after 10 sec of full submersion	✓	✓
ER5 - Optics designed for full range	400-1000 nm	± 0 nm	Based on Zemax Calculations, 400-1000nm fit within the CCD chip space	✓	✓
ER6 -Drone can fly while carrying	<2 lbs	+1lb	2lb 7oz	✓	✓
ER7 -Fits within drone payload space	10in*10in*5in	+ 0.5in	9.976in*8.238in*4.5in	✓	✓
ER8 - Optics secured	0 in of movement	0 in	Per greater than 5 ft drop, it moves. Will fix upon next iteration	✓	✓

Link between ERs and CRs

- Engineering Requirements (ER)
  - Long lifespan (ER1)
  - Internal temperature control with vents (ER2)
  - Easy to access data in EE side (ER3)
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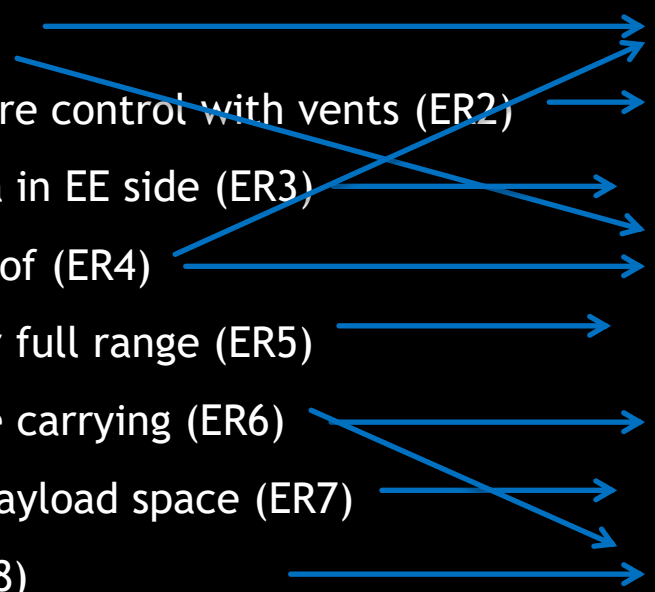

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  - Drone mountable in operation (CR8)
  - Ambient operating range of 0-50°C (CR9)

QFD

System QFD

Project:	Spectral Forest
Date:	Spring 2024

Correlation Legend	
++	Strong positive
+	Moderate positive
-	Moderate negative
--	Strong negative

1	**Long Lifespan**	++							
2	**Easy to access data in EE side**	--	++						
3	**Water and Dust Proof**	+	--	++					
4	**Optics Designed for Full Range**	-	--	+	++				
5	**Drone can fly while carrying**	-	-	--	-	++			
6	**Fit within drone payload space**	-	+	--	+	+	++		
7	**Optics Secured During Flight**	+	-	+	-	+	+	++	
8	**Internal Temperature Control with Vents**	+	--	+	-	-	-	-	++

			Technical Requirements							
	Customer Needs	**Customer Weights**	**Long Lifespan**	**Easy to access data in EE side**	**Water and Dust Proof**	**Optics Designed for Full Range**	**Drone can fly while carrying**	**Fit within drone payload space**	**Optics Secured During Flight**	**Internal Temperature Control with Vents**
1	**Durable**	4.5	9	2	5				8	
2	**Semi-constant internal conditions**	3.5			6					8
3	**Ease of access**	4		9	4			5		
4	**Environmentally Sound**	5			9					7
5	**Spectral Range Between 400-1000nm**	5			5	9		2	6	3
6	**As Light as Possible**	4.5					9			
7	**As Small as Possible**	4.5				2		9		
8	**Drone Mountable in Operation**	3.5					8	8	9	
9	**Ambient operating range of 0-50 °C**	3.5			7					9
	Technical Requirement Units		years	time in sec (to enter)	mL	nm	lbs	ins*ins*ins	Hertz	°C
	Technical Requirement Targets		5	<60	0	400-1000	<2	<331	+/- 50	0-50
	Absolute Technical Importance		40.5	45	154	54	68.5	98.5	97.5	109.5
	Relative Technical Importance		8	7	1	6	5	3	4	2

Thank you!

Questions?