Remote Sensing
Supplemental Material/Information

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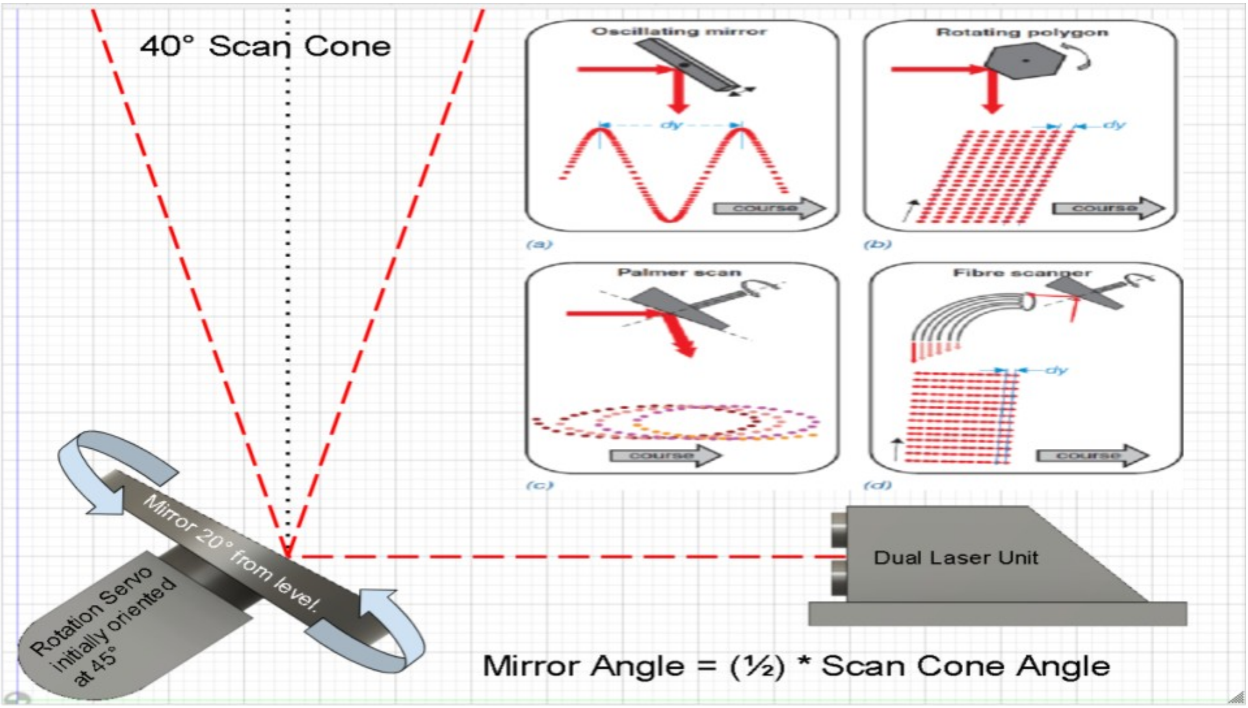
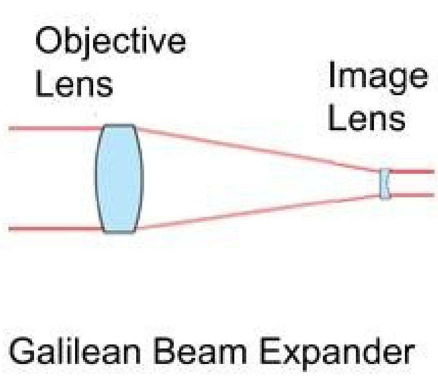
Laser Scan Pattern

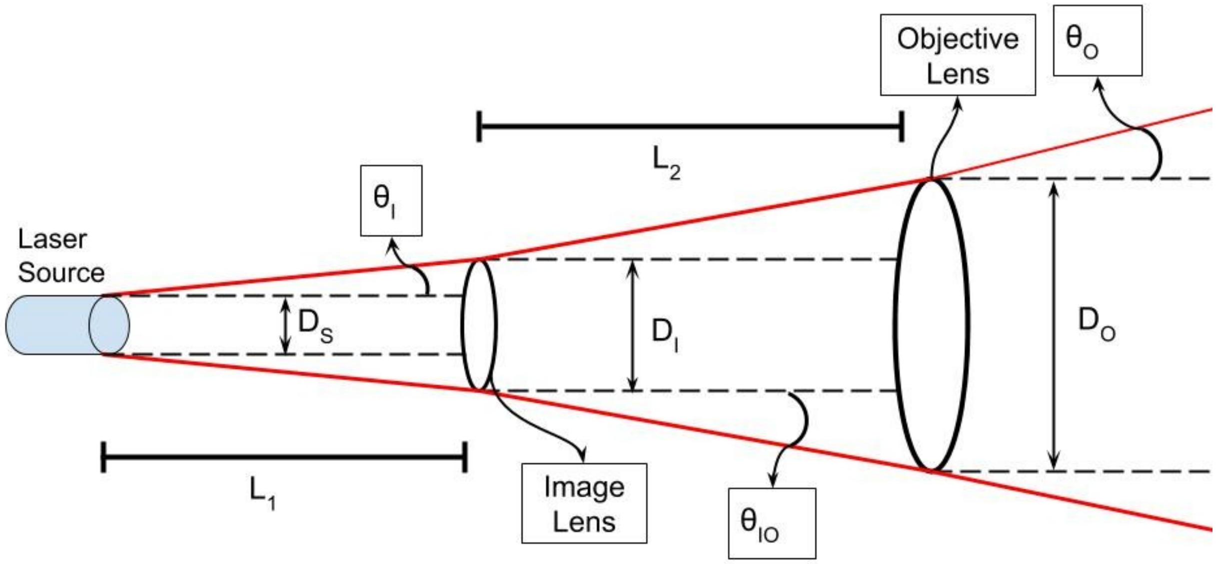


When choosing a scanning method for the LiDAR, the Palmer scan pattern was decided on due to its ease of fabrication and affordability. Rotating polygonal, and even cubic, mirrors were expensive and even buying multiple smaller mirrors to make our own rotating polygonal/cubic mirrors were more expensive than buying a single mirror. The fiber scanner involved the extra cost of the fibers which also made it a more costly option. The Oscillating mirror scan would require the same mirror that the Palmer scanner would use so it was a viable option in terms of price. The Palmer scanner would be easier to work with though since it can be set to a constant rpm. This makes it easier to obtain the laser pulse direction by comparing the time of a laser pulse to the amount of time that has elapsed since the mirror had begun rotating.

Galilean Beam Expander

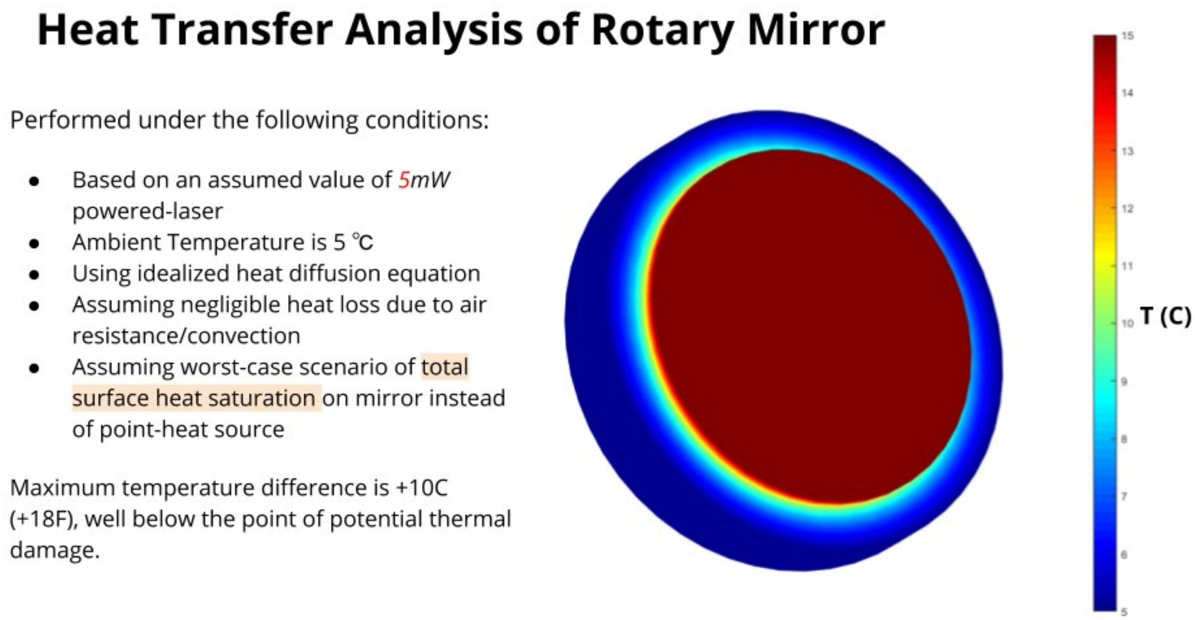


To control beam divergence to be within optimal range, the Galilean beam expander will be employed. This can be achieved by controlling certain laser parameters, namely the output beam diameter, as can be seen in the equation: $\frac{D_O}{D_I}=\frac{\theta_I}{\theta_O}$ where D_O is the beam's output diameter, D_I is the beam's input diameter, θ_I is the input beam divergence, and θ_O is the output beam divergence. If the laser has a set beam divergence then the output beam divergence can be changed based on the distance the image lens is from the laser source and the distance between the objective lens and the image lens.



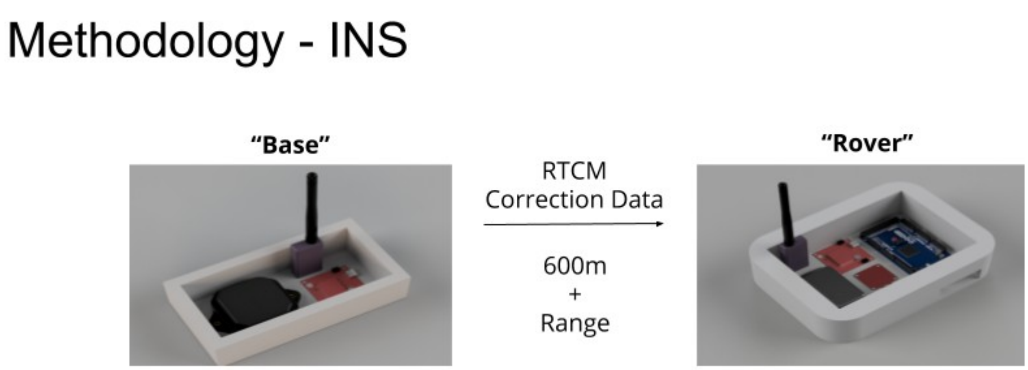
The distance between the image lens and the laser source determines the input diameter following the equation: $D_I = D_S + L_1 \tan(2\theta_I)$ where D_I is the beam's input diameter, D_S is the laser source diameter, L_1 is the distance to the laser source, and θ_I is the input beam divergence. The distance between the objective lens and the image lens can be used to calculate the output diameter following a modified version of the previous equation: $D_O = D_I + L_2 \tan(2\theta_{IO})$ where D_O is the output diameter, D_I is the input diameter, L_2 is the distance between the objective lens and the image lens, and θ_{IO} is the beam divergence angle produced by the image lens.

Mirror Heat Transfer



A heat transfer analysis on a rotary mirror set at 5°C was conducted as a reference point for potential spring temperatures in Northern Texas. Further analysis will be necessary with warmer temperatures for Southern Texas. Much colder temperatures will be required for Alaska but since it will be very cold the analysis probably won't be necessary.

Base Station Antenna



A larger antenna for the base station is currently being looked into. This will be used to match the range that it's able to communicate with the rover to that of the Drone's range. The base station doesn't have the same set of constraints as the rover since it can be used in a vehicle. It won't need to conform to any weight requirements or take the temperature into account (just turn on the heater if it's too cold or AC if it's too hot). A larger antenna could be placed outside of the vehicle, possibly on the roof, for further communication range. One of the Remote Sensing teammates are planning to get a Ham license over winter break to legally operate the base station.

Critical Interfaces

Interface Name	Brief Description	Potential Solution
TRANS/REC	Transmitter laser pulses bounce back to receiver.	Fire transmitter at known region and monitor receiver input
TRANS/REC/SYNCH	Synchronizer controls and time stamps transmitter and receiver	Transmitter & Receiver connected to Synchronizer
M600/ARD	Arduino microcontroller is mounted to the drone and needs protection from the elements.	The Arduino will be in a protective case mounted on the Matrice 600 drone with screws.
RTK/ARD	GPS-RTK2 requires 5V or 3.3V, logic is 3.3V. GPS-RTK2 draws 35mA.	A 3.3V regulator can regulate the 5V USB to 3.3V.
ARD/POW	Arduino requires 5 - 12 [V] of power. Seperate power supply connected to Arduino.	Can use voltage regulator to get desired voltage for the Arduino.

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Requirement Verification Table

Requirement	Verification Method	Description
Emit/receive 1064 nm and 532 nm laser pulses	Test	Will fire laser at a surface with the receiver aimed at the surface to generate data.
System is under 4 kg	Inspection	Weigh the system
Synchronizer controls & time stamps laser pulse generation	Test	Connect laser and receiver to synchronizer
Data can be used to make accurate maps	Analysis	Run data generated through algorithms and input them into a mapping software
Data generated must be saved to flash drive	Test	Run device and check SD card afterwards
Must have two way communication between LiDAR and ground station	Test	Send data to LiDAR from ground station then check SD card

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Risk Assessments

Avionics Risk Assessment

Severity						
	5					
	4		AVI-2			
	3	AVI-3	AVI-1			
	2					
	1					
		1	2	3	4	5
		Likelihood				

Risk ID	Severity	Likelihood	Risk Rating	Description
AVI-1	3	2	6	Communication error between microcontroller and connected components
AVI-2	4	2	8	Electronics get too cold and can cause sudden failure for the entire payload system
AVI-3	3	1	3	All electrical components and wires become disorganized and shifted in-flight

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Risks - Receiver System

	Description
RS1	The amplifier will amplify any noise present in the received signal. This will produce a distorted output. This situation will be tackled by using filters that will filter out unwanted frequencies.
RS2	If light is reflected at an angle back to the receiver (due to hitting uneven ground surfaces), the output signal produced will be smeared and produce faulty altitude readings.
RS3	Diodes are sensitive to temperature changes. Voltage will change with changes in temperature since for diodes the voltage is proportional to the temperature. This scenario will mainly affect the photodiode being used.
RS4	Time delays caused during receiving data will produce faulty output.

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Risks Assessment - Receiver System

Severity	5					
	4		RS1			
	3				RS3	
	2					RS4
	1					RS2
		1	2	3	4	5
		Likelihood				

Likelihood	severity
Very rare, < 25% certain	Minimal
> 25% Certain	Mission delay or minor effects
> 50% Certain	Significant reduction in capability
> 75% Certain	May cause failure
> 90% Certain	Total Mission Failure

Risks - Transmitter System

	Description
TS1	Laser Diodes are sensitive to current. Any shifts in drive current will alter the devices' wavelength and output power. Any instability in the drive current caused by noise, drift or induced transients will affect the laser diode's performance characteristics such as the output power and voltage.
TS2	Temperature of diode junction is directly affected by current. Current instability of the source will cause junction temperature swings resulting in different output characteristics for the laser diode. The power values and wavelength will be affected the most.
TS3	Laser diodes require 1.5 V of power but cannot receive that from a bench-top voltage source. Voltage sources cannot control current which affects the diode functionality since they require a constant current. This in turn might create further instability in the wavelength. Voltage sources pose the risk of experiencing thermal shock and/or transients due to a quick change in current.

Risk Assessment - Transmitter System

Severity						
Severity	5			TS3		
	4		TS1			
	3					
	2					
	1	TS2				
		1	2	3	4	5
		Likelihood				

Likelyhood	severity
Very rare, < 25% certain	Minimal
> 25% Certain	Mission delay or minor effects
> 50% Certain	Significant reduction in capability
> 75% Certain	May cause failure
> 90% Certain	Total Mission Failure

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LiDAR Requirements/Parameters

	Min	Prefered	Max	Units
Wavelength	532	X	1064	nm
LiDAR Distance	25	50	100	m
Distance (ft)	82	164.4	328	ft
Scan Distance	26.6	53.2	106.4	m
Scan Dist. (ft)	87.3	174.5	349.1	ft
Pulse Repetition Frequency	5	Depends on recording speed and power consumption	150	kHz
Voltage Consumption	5	5	25	V
Beam Divergence	0.1	0.5	1	mrad
Power consumption	0.1	0.5	10	W
Operating temp range	-10	-	25	C (celcius)

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References

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