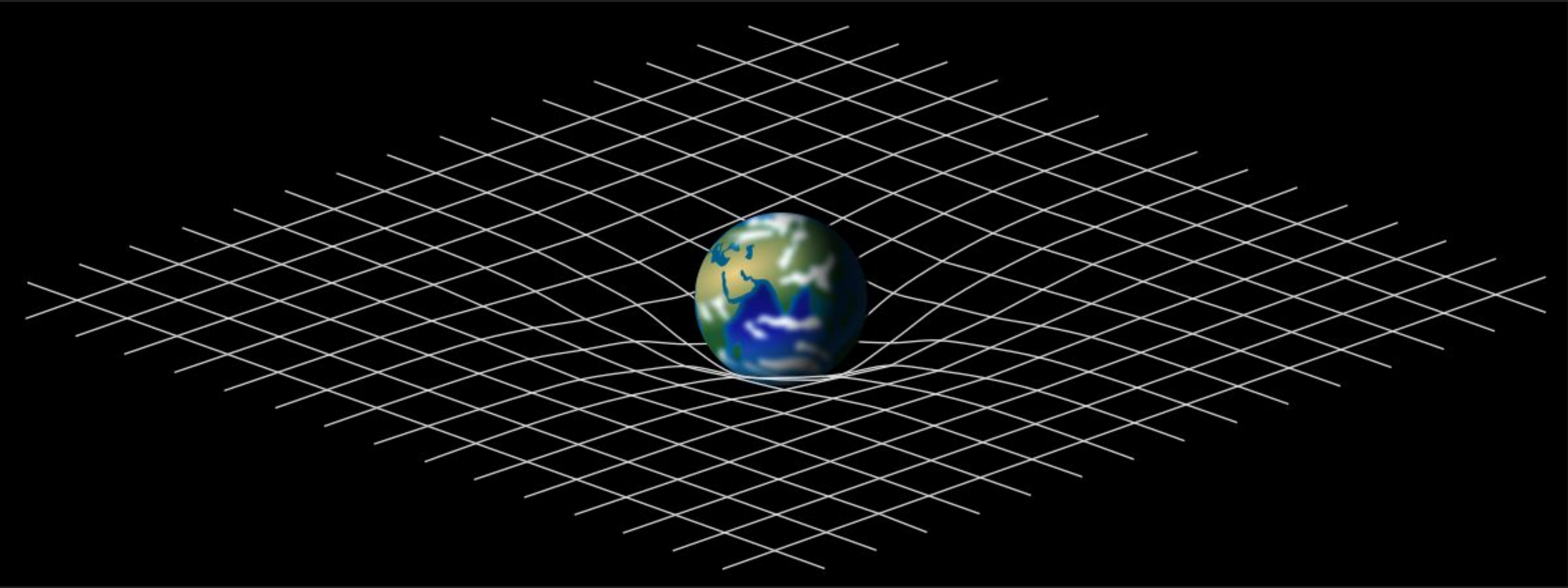
Flying LiDAR in Atlantic-Sahel

A regional analysis and technical inquiry into the field of General Relativity

Emma Rose Colburn, December 2020

What is needed to fly LiDAR in the Sahel region of West Africa?

How would such a mission fit into the existing landscape of remote sensing in the region, historically and today?



Future-Now: The theory of General Relativity asserts the possibility of traveling through time.

Imagine with me ...

It is the year 2030.

The wealth amassed by top executives during the 2020 Pandemic has been taxed by the International Criminal Court (ICC) to create a fund that reverses the extractive flow of capital from Global South towards Global North by using remote sensing technologies (themselves developed for militaristic gains that once benefited GN interests) to create value based on humanistic capacity of every individual within global society.

United Nations Educational, Scientific, and Cultural Organization (UNESCO) has won a bid from ICC to research the linguistic heritage of the Sahel-Atlantic region, building on the shoulders of Cheikh Anta Diop to trace migration between Egypt and West Africa through the Wolof language, issuing a Request For Proposals for LiDAR products to aid in this research.

Moth GeoMatics has been asked to present their LiDAR flight proposal to a UNESCO panel …

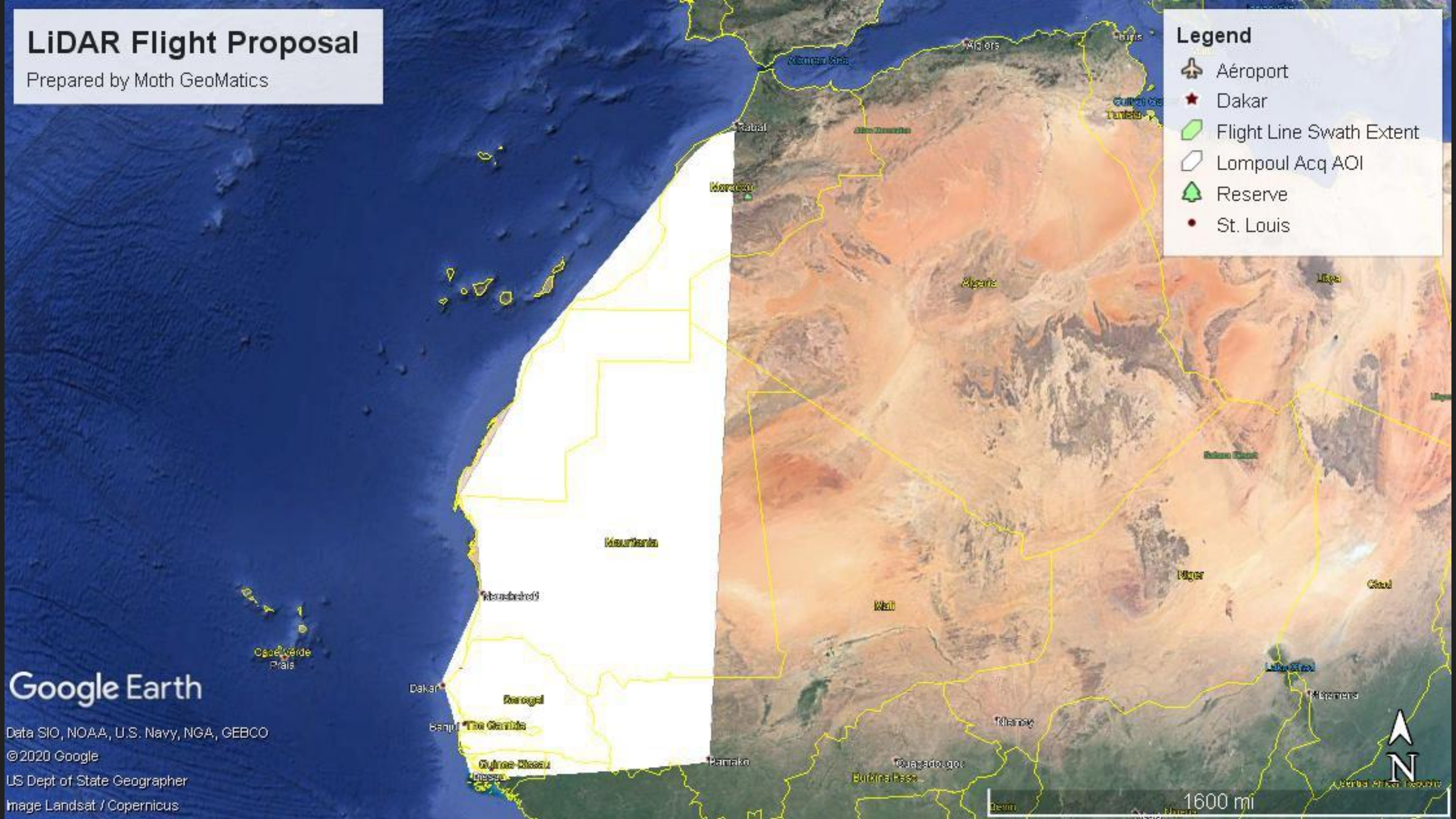
UNESCO RFP: Project Specifications

Task 1: LiDAR Flight

Task 2: Data Analysis

Task 3: Deliverables

Task 4: Support and Fee Schedules


LiDAR Flight Proposal
Prepared by Moth GeoMatics
Legend
Aéroport
Dakar
Flight Line Swath Extent
Lompoul Acq AOI
Reserve
St. Louis
Rabat
Algiers
Tunis
Morocco
Algeria
Libya
Mauritania
Mali
Niger
Chad
Senegal
The Gambia
Guinea-Bissau
Dakar
Banjul
Bamako
Niamey
Ouagadougou
Burkina Faso
Cape Verde
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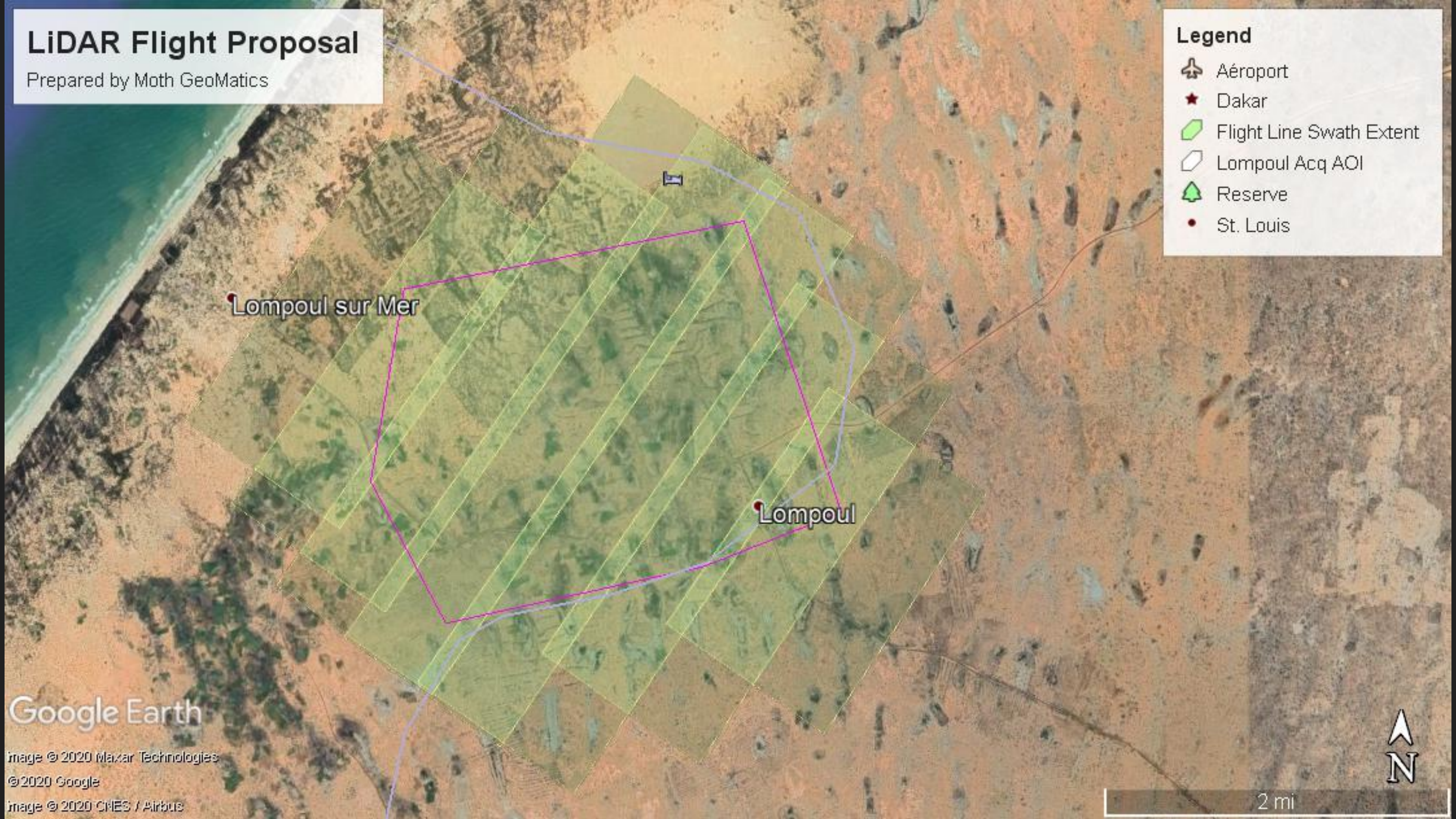
LiDAR Flight Proposal
Prepared by Moth GeoMatics
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Aéroport
Dakar
Flight Line Swath Extent
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LiDAR Specifications

Sensor: Galaxy T2000

Scanning Pattern: North-South

Scanning Angle: 33 Degrees

Footprint Diameter: 1,800 m

Pulse Density: 19 PPM

Sidelap: 55%

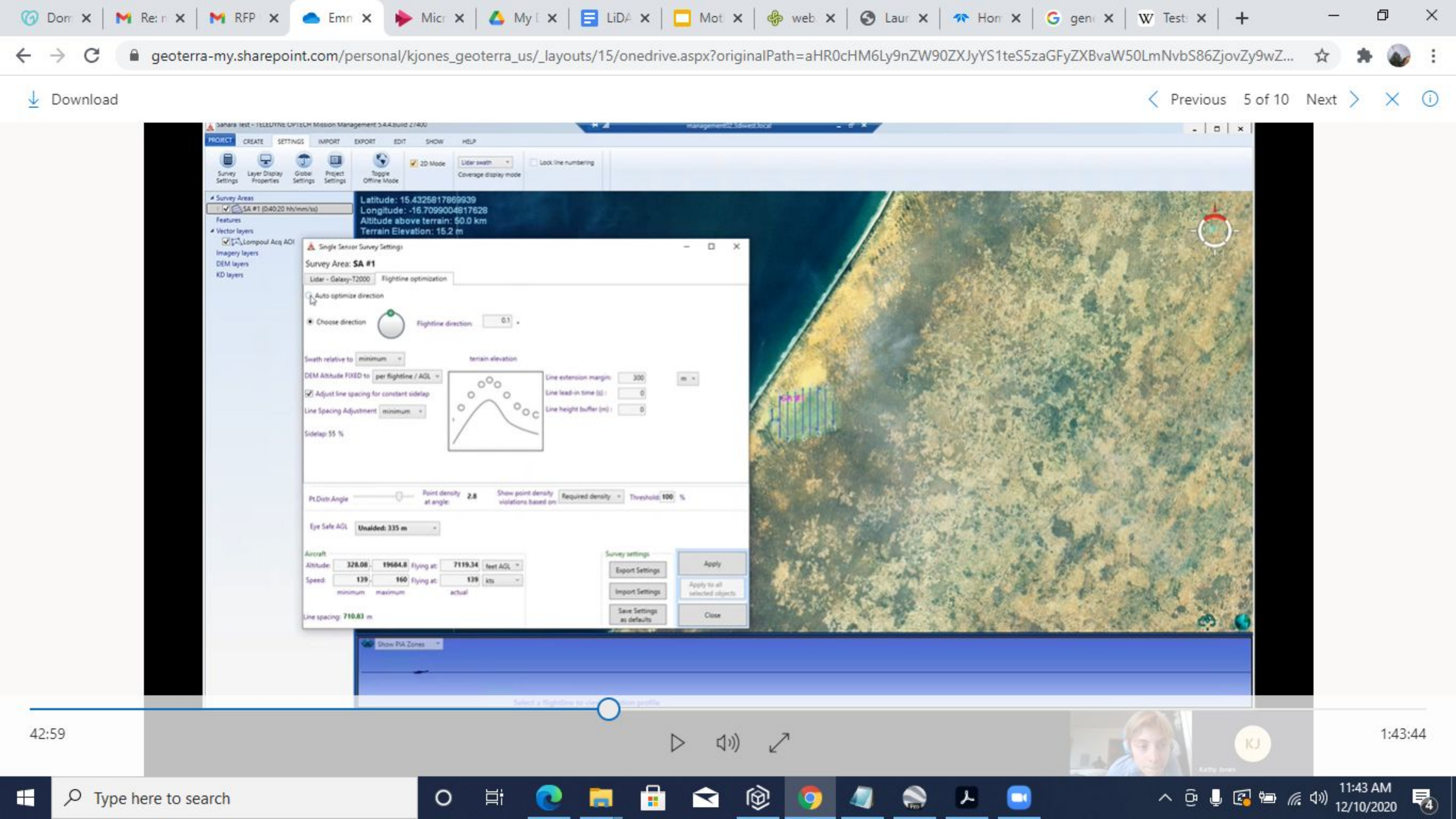
Number of Returns: 8 “bites” per beam

Sensor

The data shall be collected using a Galaxy T2000 sensor with SwathTrack. This sensor is particularly useful in traversing rugged terrain. Given the resources a better sensor to use for this project would be a sensor from Regal, which is particularly well-suited to collect data in flat terrains and over big expanses. Other options include Trimple Sensor.

Scanning Pattern

The scanning pattern shall be North-South. Flying parallel to the ocean will ensure consistency in flight speed both directions. Given the tendency for wind to blow West towards the shoreline, flying the plane in an East-West pattern may result in significant variation between flight directions, creating inconsistencies in the density of data collected.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Download
Previous
5 of 10
Next
PROJECT
CREATE
SETTINGS
IMPORT
EXPORT
EDIT
SHOW
HELP
Survey Settings
Layer Display Properties
Global Settings
Project Settings
Toggle Offline Mode
2D Mode
Lidar swath
Coverage display mode
Lock line numbering
Survey Areas
Features
Vector layers
Imagery layers
DEM layers
KD layers
Latitude: 15.4325817869939
Longitude: -16.7099004817628
Altitude above terrain: 50.0 km
Terrain Elevation: 15.2 m
Single Sensor Survey Settings
Survey Area: SA #1
Lidar - Galaxy-T2000
Flightline optimization
Auto optimize direction
Choose direction
Flightline direction
Swath relative to
minimum
terrain elevation
DEM Altitude FIXED to
per flightline / AGL
Adjust line spacing for constant sidelap
Line Spacing Adjustment
minimum
Sidelap: 55 %
Line extension margin
300
Line lead-in time (s)
0
Line height buffer (m)
0
Pt.Distr.Angle
Point density at angle
2.8
Show point density violations based on
Required density
Threshold
100
%
Eye Safe AGL
Unaided: 335 m
Aircraft
Altitude
328.08
19684.8
Flying at
7119.34
feet AGL
Speed
139
160
Flying at
139
kts
minimum
maximum
actual
Line spacing: 710.83 m
Survey settings
Export Settings
Import Settings
Save Settings as defaults
Apply
Apply to all selected objects
Close
Show PIA Zones
42:59
1:43:44
KJ
Type here to search
11:43 AM
12/10/2020

Scanning Angle

The Field of View (FOV) or aperture of the sensor lense will be 33 degrees, meaning that the will be 16.5 degrees on each side at nadir.

Footprint Diameter

With the specified scanning angle and flight altitude, the area that the LiDAR beam covers on the ground will be 1,800 m.

Footprint Diameter

With the specified scanning angle and flight altitude, the area that the LiDAR beam covers on the ground will be 1,800 m.

Pulse Density

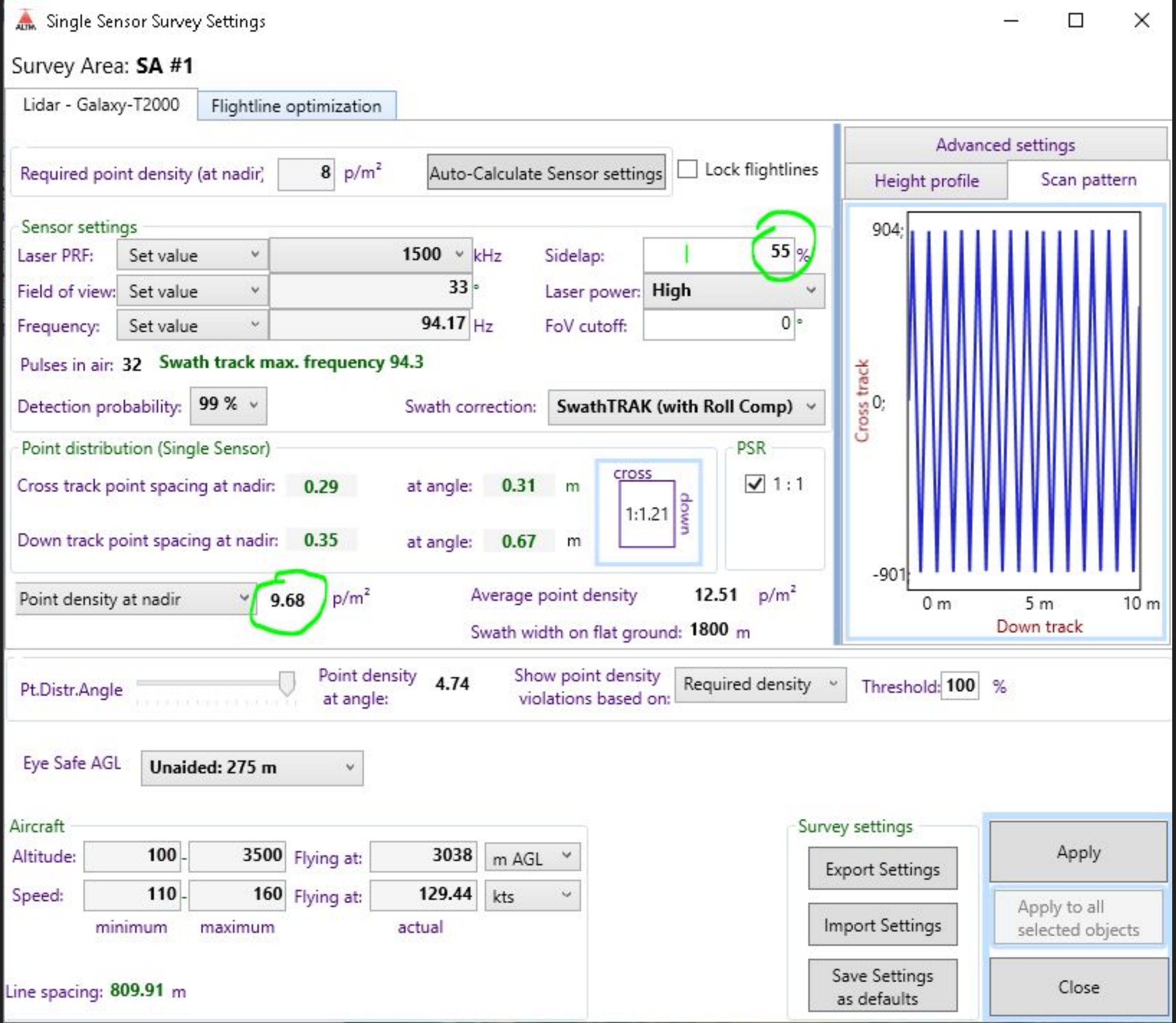
The product shall be rendered in 19 Points Per Meter (PPM). This density was selected because we are looking for the presence of features that may be unseen with the bare eye, therefore looking into soil, dust, and mineral patterns will be important.

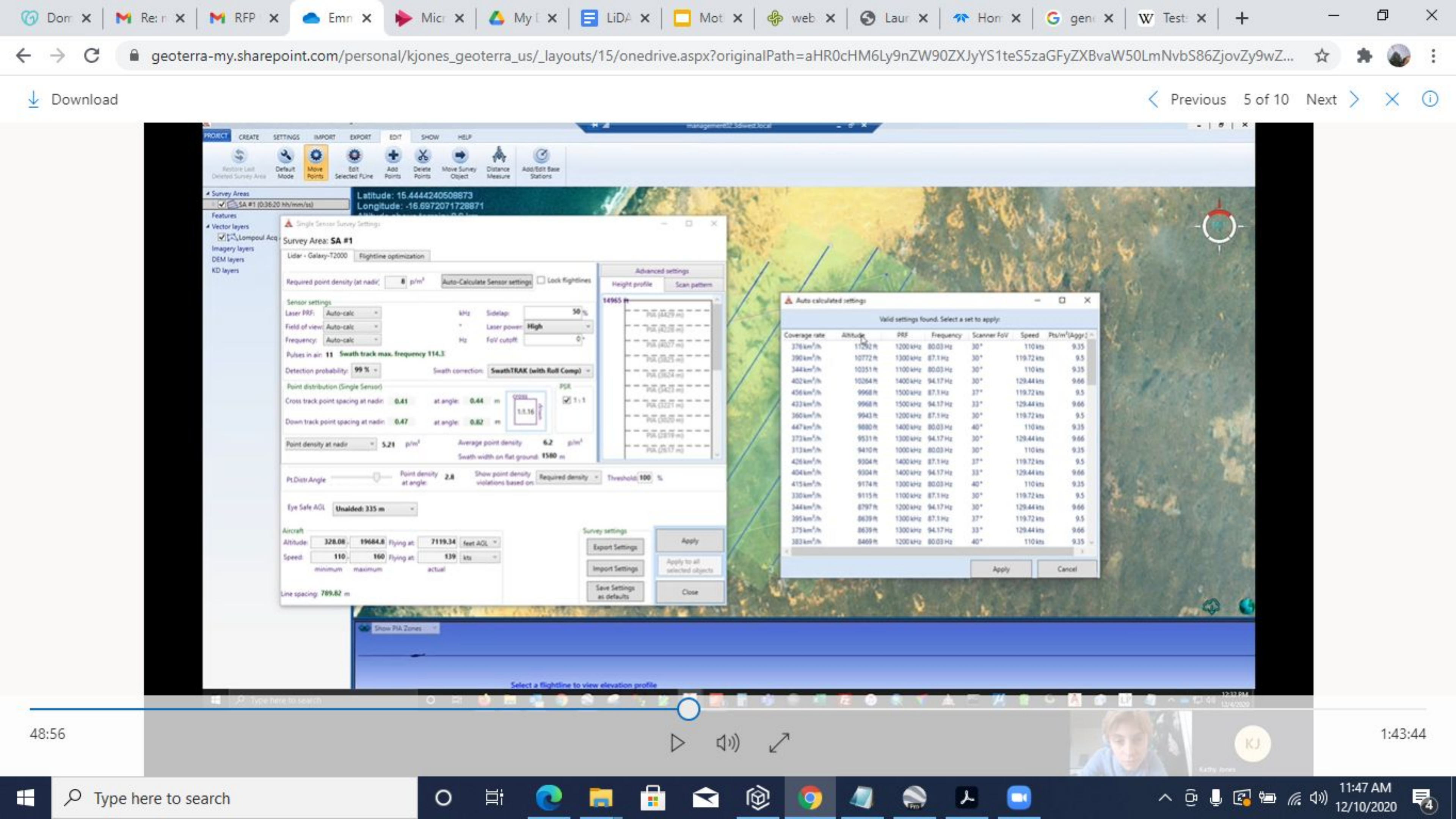
Sidelap

The product will be flown with 55% sidelap. This will ensure that each feature of the terrain will be covered with North AND South-facing beams.

Number of Returns

Each beam shall provide 8 points of data.


Single Sensor Survey Settings
Survey Area: SA #1
Lidar - Galaxy-T2000
Flightline optimization
Required point density (at nadir)
8
p/m²
Auto-Calculate Sensor settings
Lock flightlines
Advanced settings
Height profile
Scan pattern
Sensor settings
Laser PRF:
Set value
1500
kHz
Sidelap:
55
%
Field of view:
Set value
33
°
Laser power:
High
Frequency:
Set value
94.17
Hz
FoV cutoff:
0
°
Pulses in air: 32
Swath track max. frequency 94.3
Detection probability:
99 %
Swath correction:
SwathTRAK (with Roll Comp)
Point distribution (Single Sensor)
Cross track point spacing at nadir:
0.29
at angle:
0.31
m
Down track point spacing at nadir:
0.35
at angle:
0.67
m
cross
1:1.21
down
PSR
1 : 1
Point density at nadir
9.68
p/m²
Average point density
12.51
p/m²
Swath width on flat ground:
1800
m
904
0
-901
Cross track
0 m
5 m
10 m
Down track
Pt.Distr.Angle
Point density at angle:
4.74
Show point density violations based on:
Required density
Threshold:
100
%
Eye Safe AGL
Unaided: 275 m
Aircraft
Altitude:
100
3500
Flying at:
3038
m AGL
Speed:
110
160
Flying at:
129.44
kts
minimum
maximum
actual
Line spacing: 809.91 m
Survey settings
Export Settings
Import Settings
Save Settings as defaults
Apply
Apply to all selected objects
Close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Download
Previous
5 of 10
Next
Latitude: 15.4442240508873
Longitude: -16.6972071728871
Survey Area: SA #1
Auto-Calculate Sensor settings
Auto calculated settings
Valid settings found. Select a set to apply:
Apply
Cancel
Close
Select a flightline to view elevation profile
48:56
1:43:44
Type here to search
11:47 AM
12/10/2020

Flight Specifications

Altitude: 3038 meters Above Ground Level (AGL)

Speed: 129.44 nautical miles (kts)

Time of Day: 7 am - 2pm local time

Time of Year: March - May

Flight pattern and estimated time: 3 hours

Flight Altitude

The planes will fly at 3038 meters Above Ground Level (AGL)

Flight Speed

The plane will fly at a speed of 129.44 nautical miles (kts)

Ideal Flight Conditions

The flight shall be performed during the day to minimize the hazards and flying risks associated with operating a plane at night. Given that LiDAR uses a sensor that emits its own light source, the technology does not rely on capturing light waves reflected from an external light source such as the sun. As such, the LiDAR beams are actually better detected at night when light from the sun does not interfere with light emitted from the LiDAR sensor. However the risk of operating a plane at night is much greater than operating a plane during the day, and the potential hazards that night flying poses to the flight crew and equipment do not outweigh the depth of accuracy afforded by a night flight. For this reason the mission shall be performed during daytime hours, which fall between 7 am - 7 pm in the region.

In addition, flight scheduling will take place during the March-May quarter. This window avoids the heavy rains that happen during the rainy season (July - September) as well as the high heat/winds of October-November.

Terrain elevation will be considered and the flight pattern will be adjusted to accommodate any anticipated obscuration due to elevation increase. Given that this region is flat, no corrections to accommodate elevation are anticipated.

Flight Pattern: Airtime, fuel needs

The plane shall fly 30 kts one-way to project site and 30 miles back.

The plane shall fly 58 kts in lines

The plane shall fly 51 kts in turns

The plane can hold 4 hours of fuel, and with an estimated fly time of 3 hours (including travel to and from project site) we estimate that this project can be flown in one day.


Latitude: 15.47740339458
Longitude: -16.6798100583314
Altitude above terrain: 14.2 km
Terrain Elevation: NO DATA
DEM resolution (m): 92
EGM96 geoid offset: 30.2 m
Show PIA Zones
Select a flightline to view elevation profile

Data Analysis

After the LiDAR data is collected, a data analyst will process the data using the software Terrasolid. ENVI may also be used. First, the software will be used to calibrate the data, making sure that flightlines fit together correctly. Then the points will be classified to reveal a dataset of ground points. From there, a TIN model will be created and then a .TIFF file can be downloaded for use with any ArcGIS software.

During the data processing phase, several types of analysis are expected. Hydro flattening is a type analysis that is necessary for using and interpreting LiDAR datasets. Water creates data voids in LiDAR missions because water provides very little spectral reflectance in the NIR part of the electromagnetic spectrum. Since water absorbs wavelengths in the 750-1300 nanometer range, it does not reflect those wavelengths emitted by the lidar sensor back to the sensor to be recorded (most lidar sensors emit lasers in the 600-1000 nm range). Therefore LiDAR datasets have data voids in areas covered by water, and hydro-flattening is the process of adjusting for those datavoids, or removing TIN abstractions.

Fee Schedules

Project Consultation and Preparation: [ERROR: Future Undefined Currency, 2030 inflation]
Proposal and administration fee

LiDAR Collection: [ERROR: Future Undefined Currency, 2030 inflation]
Fuel, Pilot Daily Wage (1 day), LiDAR Technician daily wage (1 day), project insurance, instrument maintenance

Data Analysis: [ERROR: Future Undefined Currency, 2030 inflation]
Lead Analyst Daily Wage (4 days), Assistant Analyst Daily Wage (3 days); administration overhead

Thank Yous and Data Credits

Dr. Geoffrey Duh, Portland State University

Kathy Jones, GeoTerra, Inc and PSU Alum

Digital Terrain Analysis Fall 2020 Class Cohort

Full Abstract: *What is needed to fly LiDAR in the Sahel region of West Africa? How would such a mission fit into the existing landscape of remote sensing in the region, historically and today? In this term project I investigate these questions by drafting a mock Request For Proposal (RFP) from a fictitious branch of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). Then I answer that mock-RFP with a mock-proposal from Moth GeoMatics, a LiDAR company I invented for this project that flies LiDAR out of their fictitious headquarters in Dakar. The research I performed to ask and analyze these questions included an informational training session with a flight manager at GeoTerra, a company in the Pacific NorthWest that specializes in regional LiDAR acquisition and processing, in order to research the specific workflow and system requirements, and specifications for planning, flying, and analyzing LiDAR flights and data. Additionally, I advanced previous research into the current and historic scope of mapping in West Africa by focusing on the infrastructure for remote sensing and LiDAR in the region. This research is presented as a mock-RFP from UNESCO, a mock-proposal from a Moth GeoMatics (a fictional company that produces LiDAR products), and a script of an imagined presentation unveiling said proposal. Topics for resource analysis included: Use of Google Earth for LiDAR planning and analysis; Research into Teledyne and Galaxy T2000 instruments; Literature Review of available LiDAR RFPs; terrain and surface data sets such as soils and minerals, vegetation, rivers, urban development of the Dakar-St. Louis region of Senegal, West Africa.*

- Emma Rose Colburn