

Parts 1a and 2b

by Andrew Hurley

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UWTSD: Remote Sensing and Imaging

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Module: M6X00945

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Assignment Title: Part 1a – Remote Imaging and Sensing
Part 2b – QGIS & Map data

1 Contents

1	Contents.....	2
2	Introduction Parat 1a.....	3
3	Overview of Littoral Zones.....	3
3.1	Defining Characteristics	3
3.2	Challenges Posed	4
4	Current Data Acquisition Techniques	4
4.2	LIDAR.....	4
4.3	Aerial Photography	5
4.4	RADAR	6
4.5	Optimal Acquisition System	6
5	Raw Data Processing.....	6
5.2	Preprocessing of Remote Sensing Data:	6
5.3	Georeferencing to Ordnance Survey 1:1250 Scale Data.....	6
5.4	Digital Terrain Relief Model (DTM) Creation:	7
5.5	Data Output:	7
6	Part 2b.....	8
6.1	Landmine Data Poster.....	8
7	QGIS	8
7.1	Data Gathering.....	8
7.2	Data Limitations	8
7.3	QGIS Software	9
8	References	11
9	Table of Figures.....	13
10	Annex	13
10.1	Remote sensing and Imaging report – 2a	13

2 Introduction Parat 1a

- 2.1.1 Littoral Zones are the transitional areas between aquatic and terrestrial environments. They are critical ecosystems that support a diverse range of flora and fauna. Accurate mapping of these Zones is crucial for effective environmental management, though they pose several challenges when mapping due to their complex and dynamic nature.
- 2.1.2 Current data acquisition techniques vary in accuracy and efficiency and often have limitations that hinder the quality of the final mapping output. This paper provides an overview of coastal Zones, discusses current data acquisition techniques and their limitations, and recommends systems to use when mapping littoral Zones and how to process the data best gathered.

3 Overview of Littoral Zones

3.1 Defining Characteristics

- 3.1.1 The littoral zone, as the near-shore area of lakes and other bodies of fresh water, demonstrates a range of defining characteristics [1]. One of the most notable features of the littoral zone is its physical structure, various factors such as the surrounding geology and topography, and prevailing wind patterns [1]. This structural complexity supports a biodiverse variety of plants and animals uniquely adapted to this interface between terrestrial and aquatic ecosystems [2]. Rooted plants, for example, are a common sight in these zones, where they colonise the shallows and contribute to the overall productivity and stability of the habitat [3].
- 3.1.2 The penetration of sunlight to the bottom sediments is another defining characteristic, which facilitates photosynthesis and allows for a rich array of aquatic plant life that serves as food and shelter for various species [3]. Furthermore, the coastal zone's location in shallow waters close to the shore makes it an essential ecological bridge, as many organisms, including zooplankton and fish, rely on the resources found here for their survival, often moving between the coastal and terrestrial Zones in search of sustenance [1].
- 3.1.3

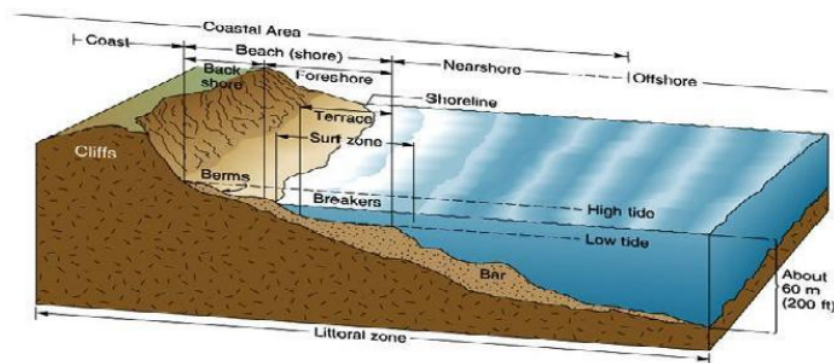


Figure 1 - Littoral Zone Illustration [4]

3.2 Challenges Posed

- 3.2.1 The complexity of mapping littoral Zones extends beyond merely charting the physical boundaries to understanding the biological intricacies housed within these environments. Littoral Zones consist of specialised floral and faunal populations that exhibit a symbiotic predator-prey relationship, which varies significantly among different littoral ecosystems [5]. Additionally, the geological diversity of littoral Zones presents a formidable challenge, as the physical characteristics of shorelines and nearshore bottoms range from sandy beaches to rugged cliff formations [5].
- 3.2.2 Consequently, accurately depicting the multifaceted nature of these coastal areas is a daunting endeavour that requires a tailored approach to each unique ecosystem, acknowledging that a one-size-fits-all methodology is impractical when faced with such geological and ecological diversity [5].

4 Current Data Acquisition Techniques

- 4.1.1 In the realm of data acquisition, a variety of techniques are currently being utilised.
- 4.1.2 In mapping littoral zones, three frequently employed techniques are RADAR (Radio Detection and Ranging), LIDAR (Light Detection and Ranging), and Aerial Photography. It is crucial to consider each method's distinct advantages and limitations, depending on the specific mapping requirements.

4.2 LIDAR

- 4.2.1 LIDAR possesses exceptional spatial resolution, making it capable of generating highly accurate elevation data, essential for detailed terrain modelling and analysis. Moreover, LIDAR can penetrate shallow water bodies, enabling the mapping and exploration of submerged features like near-shore bathymetry [6]. Additionally, LIDAR can be deployed from various platforms, including airborne, terrestrial, and mobile platforms, offering flexibility in data acquisition methods.
- 4.2.2 Nonetheless, the ability of LIDAR to effectively gather data is hindered by its inability to penetrate through dense vegetation, resulting in the attenuation of signals and the consequent loss of terrain information beneath foliage and other natural obstructions. [7]
- 4.2.3 Adverse weather conditions have a negative impact on the operations of LIDAR, rendering scanning impossible during inclement weather such as fog and rain. [8]

4.2.4

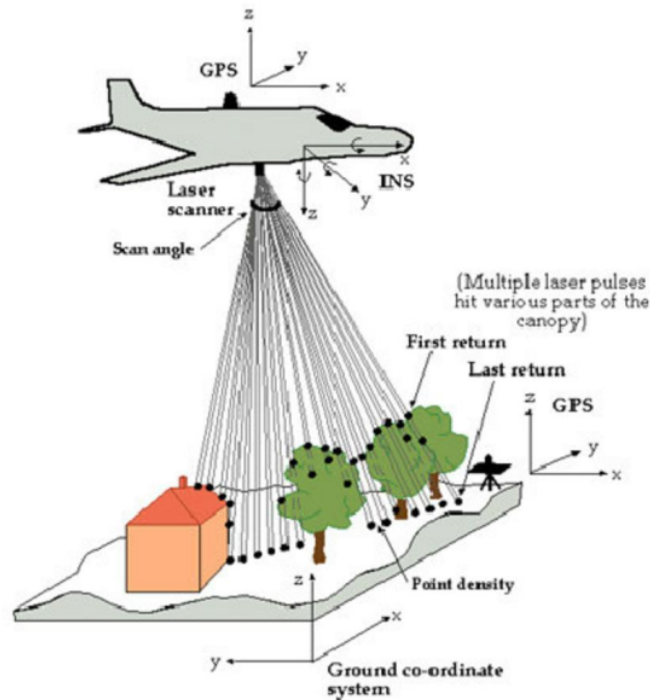


Figure 2 - Aerial LIDAR illustration [9]

4.3 Aerial Photography

- 4.3.1 aerial photography offers the advantage of obtaining images with exceptional resolution, enabling a meticulous examination of littoral characteristics. Additionally, it captures colour data, which is beneficial in the cartographic representation of vegetation types, land cover, and various surface features. [10]
Furthermore, collecting data at different time intervals makes it possible to compare and monitor alterations in the littoral zone, providing valuable insights for coastal management and environmental monitoring.
- 4.3.2 Nevertheless, the execution of aerial photography operations depends on weather conditions, as cloud cover and rain can obstruct the view. At the same time, strong winds can create an unstable platform or unsafe flying conditions. [10]
- 4.3.3 Another drawback to aerial photography is in capturing underwater characteristics and bathymetry, especially in environments with high turbidity or significant water depth, it is nearly impossible to gain any valuable data. [11]
- 4.3.4 Also, in some instances, the lack of historical photographs for comparison may restrict the usefulness of this method for long-term monitoring, depending on the specific area being mapped.

4.4 RADAR

- 4.4.1 RADAR can penetrate various atmospheric obstacles such as clouds, fog, and rain, ensuring reliable data acquisition even in unfavourable weather conditions. In the realm of large-scale mapping projects, RADAR systems prove to be highly efficient due to their ability to cover extensive areas in a relatively short duration. [12]
- 4.4.2 The ability of RADAR signals to penetrate through vegetation enables the collection of essential data regarding the hidden topography and features concealed beneath dense foliage. [12]
- 4.4.3 Opposing the above, RADAR falls short compared to LIDAR and aerial photography, limiting its suitability for detailed mapping applications. RADAR's accuracy is limited compared to LIDAR, primarily due to surface roughness and signal interference. Man-made structures can interfere with RADAR signals, resulting in potential inaccuracies in the collected data. [13]

4.5 Optimal Acquisition System

- 4.5.1 RADAR stands out for its ability to operate in any weather condition and cover large areas, although it may have limited resolution. On the other hand, LIDAR offers highly accurate elevation data and resolution, but it may face challenges in penetrating vegetation. Aerial photography, while providing detailed imagery and the ability to compare historical data, has limitations in capturing underwater features. The selection of the most suitable method depends on specific project requirements, such as resolution needs, budget limitations, and environmental conditions. In many cases, combining these methods can complement each other and ensure comprehensive mapping coverage of coastal zones.
- 4.5.2 CLARIS is currently used and combines LIDAR and RADAR technologies, emphasizing the above 4.5.1, creating a best-of-both-worlds dynamic [14].

5 Raw Data Processing

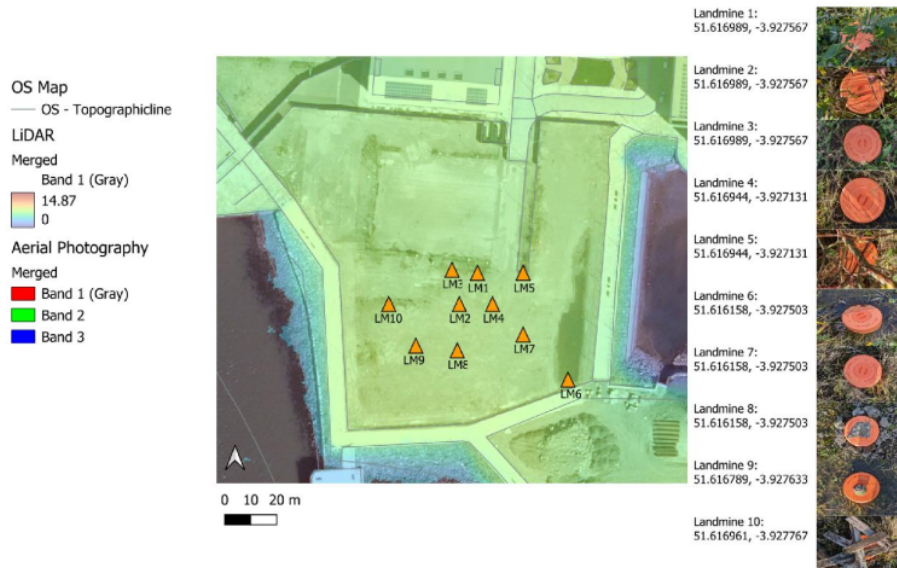
- 5.1.1 Several processing steps must occur to georeference the raw data to Ordnance Survey 1:1250 and create a digital terrain relief model (DTM) at the same scale.
- 5.2 Preprocessing of Remote Sensing Data:
 - 5.2.1 Initial data cleaning is required to remove any noise or artefacts, followed by radiometric calibration to ensure consistency in brightness and contrast.
 - 5.2.2 Geometric correction is then used to rectify distortions caused by sensor orientation, Earth curvature, and terrain relief.
- 5.3 Georeferencing to Ordnance Survey 1:1250 Scale Data
 - 5.3.1 Identify control points in the remote sensing and Ordnance Survey (OS) data. These control points should be identifiable features with known coordinates, such as road intersections, building corners, or prominent landmarks [15].
 - 5.3.2 Match control points between the remote sensing data and the OS data. This would be done manually or using automated image registration techniques. Followed by a transformation algorithm (e.g., polynomial transformation) to translate the remote sensing data to align with the OS data based on the control points.

- 5.3.3 The accuracy of the georeferencing would need to be validated by comparing additional points not used in the initial transformation [16].
- 5.4 Digital Terrain Relief Model (DTM) Creation:
 - 5.4.1 Utilize stereo pairs of remote sensing images to extract elevation information. This can be achieved using photogrammetric techniques or digital elevation models (DEMs) derived from the LiDAR [17].
 - 5.4.2 Process the stereo pairs to generate a point cloud representing the terrain surface. This will need to be cleaned, removing outliers and anomalies within the point cloud before interpolating to generate a continuous surface representing the terrain relief. Standard interpolation methods include TIN (Triangulated Irregular Network) or IDW (Inverse Distance Weighting) [18].
 - 5.4.3 Resample the resulting DTM to match the 1:1250 scale of the Ordnance Survey data, ensuring consistency in resolution and accuracy.
- 5.5 Data Output:
 - 5.5.1 The final georeferenced remote sensing data layers can be generated, and the DTM can be in a format compatible with Geographic Information System (GIS) software, such as GeoTIFF or ESRI shapefiles.
 - 5.5.2 It is essential to document the processing steps, metadata, and any assumptions made during the georeferencing and DTM creation process for future reference.

6 Part 2b

6.1 Landmine Data Poster

6.1.1



7 QGIS

7.1 Data gathering

7.1.1 Table of Data

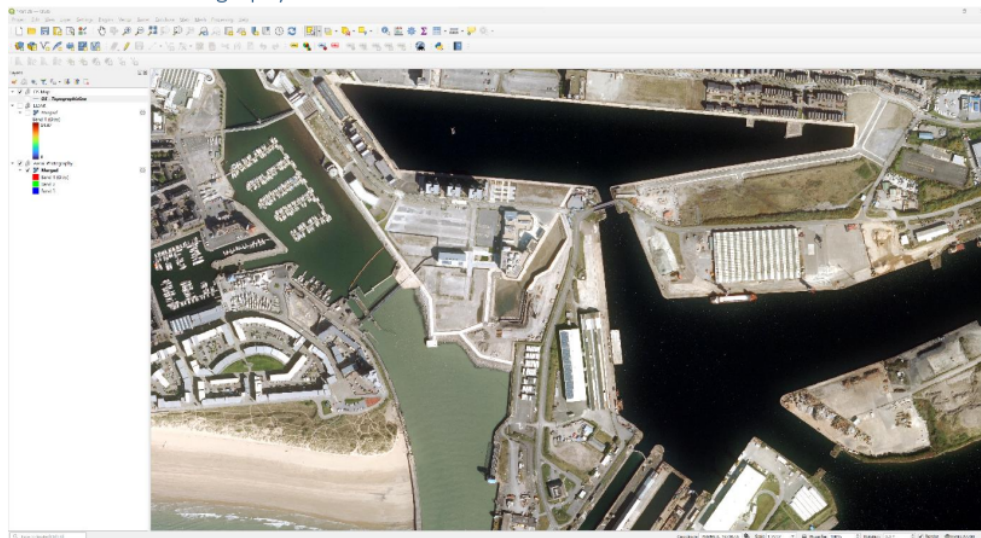
Data Type	Resolution	Date	Source
Aerial Photography	25cm	2020	Digimaps
LiDAR Wales	50cm	2015	Digimaps
OS Survey Map	1:2500	2023	Digimaps
Co-ordinates	N/A	2023	Google Pixel 7a geotags
Ground Photographs	4624x3472	2023	Google Pixel 7a

7.2 Data Limitations

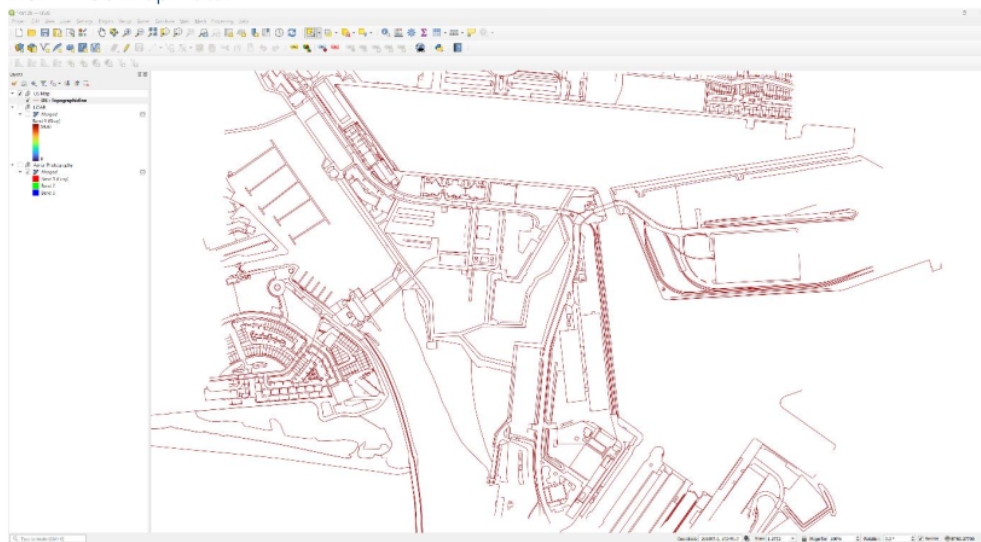
- 7.2.1 The date of the open-source Aerial Photography and LiDAR scans for south Wales has a significant impact on the accuracy of the map created as both of these sources are out of date by 36+ months in which time much could have changed, especially when considering the area of land is unkept and derelict.
- 7.2.2 The drone data received, as shown in Annex 9.1, can be compared against the data gathered in 2020 and 2015; however, it leaves a +/- three-year tolerance on when changes could have occurred.

7.3 QGIS Software

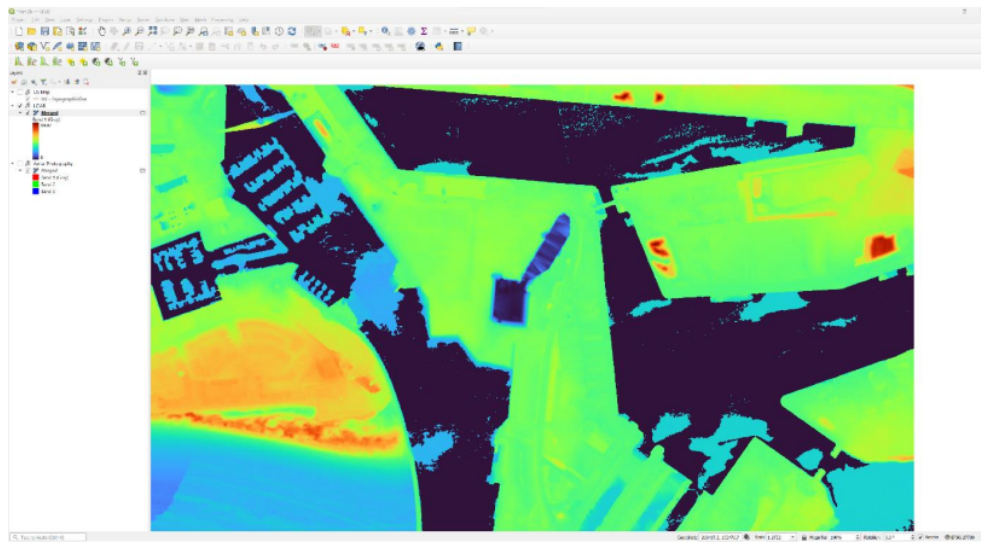
7.3.1 Aerial Photography:



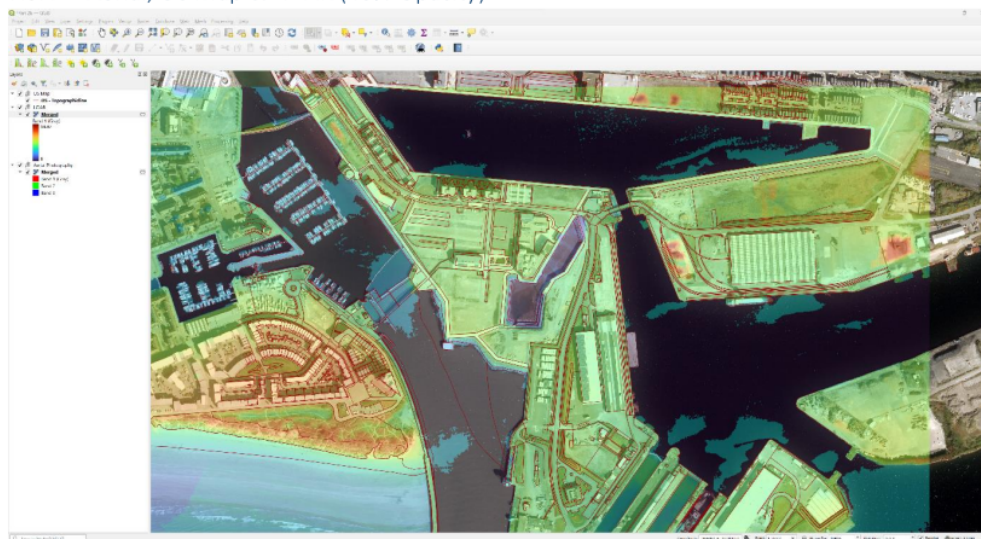
7.3.2 OS Map Data:



7.3.3 LiDAR Data:



7.3.4 Aerial, OS Map & LiDAR (40% Opacity)



8 References

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- [2] R. Gibson, "Intertidal Fishes," in *Encyclopedia of Ocean Sciences*, Oxford, Academic Press, 2001, pp. 280-285.
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- [17] K. K. & N. Pfeifer, "Advanced DTM Generation from LiDAR data," Institute of Photogrammetry and Remote Sensing, Vienna, 2001.
- [18] Z. B. G. a. B. D. hen, "State-of-the-Art: DTM Generation Using Airborne LIDAR Data," *Sensors*, vol. 17, no. 1, p. 150, 2017.

9 Table of Figures

Figure 1 - Littoral Zone Illustration [4] 3

Figure 2 - Aerial LIDAR illustration [9] 5

10 Annex

10.1 Remote sensing and Imaging report – 2a

UWTSD: Remote Sensing and Imaging

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Date: 15/12/2023

Module: M6X00945

Lecturer: Dr. Nik Whitehead

Assignment Title: Part 2a – Imaging and Sensing Notes

1 Contents

1 Contents 2

2 Introduction 3

2.1 Location 3

2.2 Ground and Soil 3

3 Equipment 3

3.1 Spot the dog 3

3.2 DJI Mavic 2 3

3.3 Google Pixel 7a 3

4 Task 3

4.1 Miniswapper 3

5 The area 4

5.1 Google maps 4

5.2 Pixel 7a Photos 5

6 Locating the mines 8

6.1 Mavic 2 8

6.2 Pixel 7a 13

7 Discussion 18

7.1 Mavic Drone 18

7.2 Spot the Dog 18

8 Conclusion 18

2

2	Introduction
2.1	Location
2.1.1	Located approximately 51°36'58.1"N 3°55'38.6"W, an unkempt, unmanaged privately owned section of land adjoins the UWTSO Swansea IQ campus. This land is coastal, protected by a sea wall [1] and rock armour [2] sea defences positioned predominantly southward toward an estuary.
2.2	Ground and Soil
2.2.1	Due to the derelict nature of this land, the ground has varied conditions, including patches of bare earth, compacted soil, scattered debris, and abandoned materials. Common soil types within the coastal Swansea areas are loamy and clay-based soils which retain moisture and nutrients better than the equally local sandy soils nearer to the shores.
2.2.2	During the scouting and imaging of the area multiple locations of standing water were noted visually along with long grass, short grass, common weeds, and small shrubs.
3	Equipment
3.1	Spot the dog
3.1.1	The Spot the Dog, a Quad-pedal operator-controlled robot (Boston Dynamics – MK IV), demonstrates the capability of self-correcting transit. It is equipped with a forward-mounted top arm and an Alt-mounted thermal IR camera fitted onto the top rail. Additionally, standard visual cameras are positioned both at the forward and aft of the robot, accessible through the operator's handset screen.
3.2	DJI Mavic 2
3.2.1	The DJI Mavic 2 functions as a compact drone operated via a controller and phone screen plugin for real-time visual output. It boasts an IR and AK camera, both mounted on a gimbal for remote operation in tandem with the drone's movement. Its operational range extends to long distances, up to 5 miles away from the operator, facilitated by an integrated auto-homing feature.
3.3	Google Pixel 7a
3.3.1	The Google Pixel 7a smartphone hosts three accessible cameras: a 64MP Quad Bayer wide camera, a 13MP Ultrawide camera, and a 13MP fixed-focus camera. Images captured using the Pixel 7a leverage GPS, GLONASS, Galileo, QZSS, and BeiDou satellite systems to embed coordinate data, date, and time information within each photo for precise location logging.
4	Task
4.1	Minesweeper
4.1.1	Mines planted in prior conflicts whether on land or in sea, pose a significant risk to civilian populations, military personnel and wildlife. With a potential to explode when disturbed, causing injury, death and damage to infrastructure, de-mining activities are vital to the continued safety for many all over the world.

3

4.1.2	Current methods for mine marking and mine clearance involves the use of manned expeditions to carefully find locations of minefields and mark up mines found via the use of metal detectors and animals trained on scent. These options involve risking harm on living beings and increased risk to exposing the environment to harmful chemicals.
4.1.3	To mitigate this risk, utilising the Mavic 2, Spot the dog and Pixel 7a, there is potential to image the area and mark potential hazard sites accurately without increased risk to human life and environment.
5	The area
5.1	Google maps
5.1.1	Figure 1. Screenshot of aerial imaging over "mined area"
	

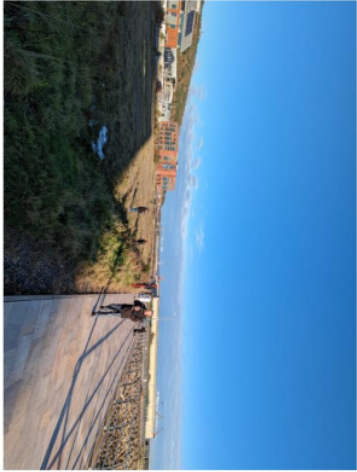
4

5.2 Pixel 7a Photos

5.2.1 Figure 2 – Panczana from ground platform

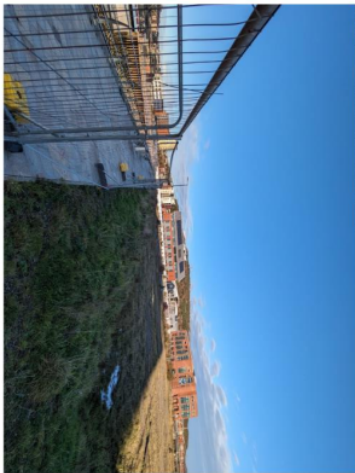


5.2.2 Figure 3 – Southwest corner, looking east

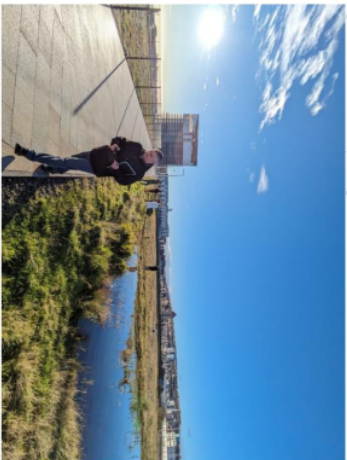


5

5.2.3 Figure 4 – Southwest corner, looking north



5.2.4 Figure 5 – Southeast corner, looking west

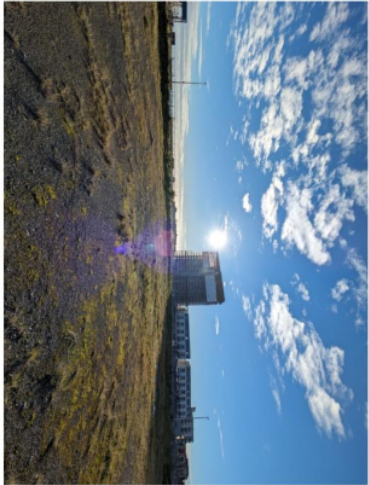


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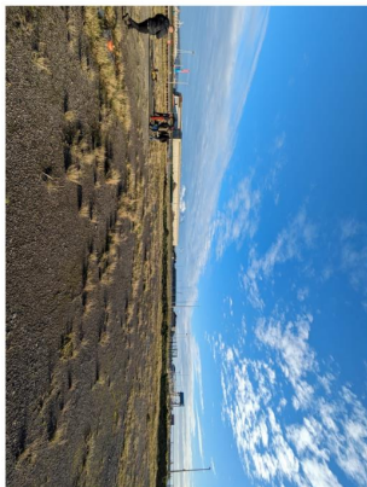
5.2.5 Figure 5 – Southeast corner, looking north



5.2.6 Figure 6 – Northeast corner, looking southwest



5.2.7 Figure 7 – Northwest corner, looking southeast

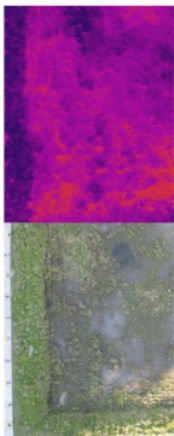


6 Locating the mines

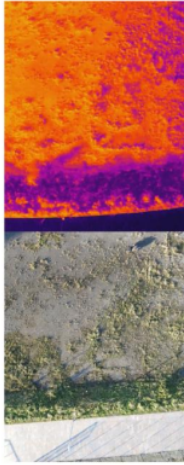
6.1 Mine 2

The Mine 2, equipped with thermal and visual cameras began with a perimeter path of the area taking 20meter resolution shots before then taking a grid-line path across the internal area. The visual camera should be able to be used to locate the orange landmines whilst the thermal should be able to be used to locate the could external diameter of the mine with the warmer internal pocket of the mine.

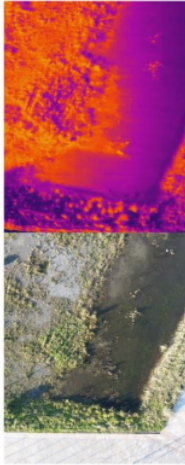
6.1.2 Figure 8 – Perimeter shot, Southwest corner (top is due east)



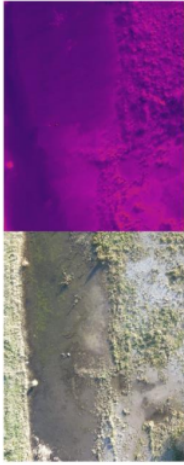
6.1.3 Figure 9 – Perimeter shot, South perimeter (top is due east)



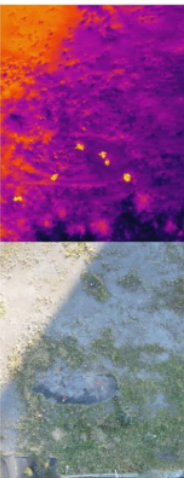
6.1.4 Figure 10 – Perimeter shot, Southeast corner, (top is due east)



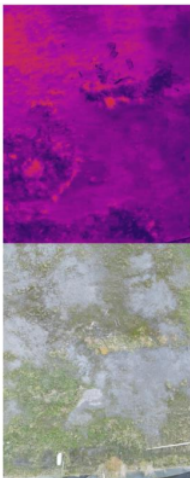
6.1.5 Figure 11 – Perimeter shot, East perimeter (top is due west)



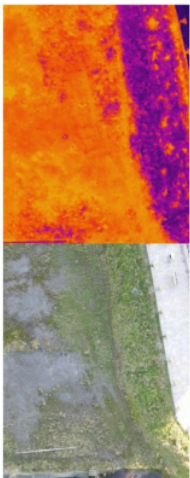
6.1.6 Figure 12 – Perimeter shot, Northeast corner (top is due west)



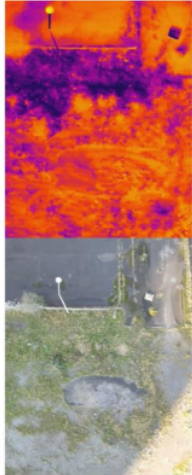
6.1.7 Figure 13 – Perimeter shot, North perimeter (top is due west)



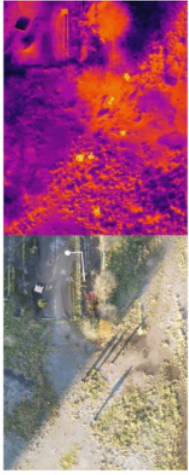
6.1.8 Figure 14 – Perimeter shot, Northwest corner (top is due west)



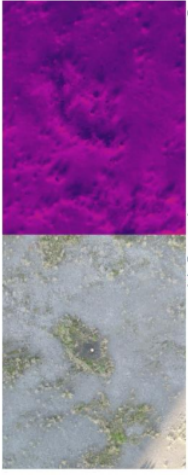
6.1.9 Figure 15 – Visual and Thermal infra spot image (1)



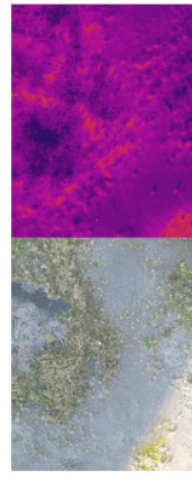
6.1.10 Figure 16 – Visual and Thermal infra spot image (2)



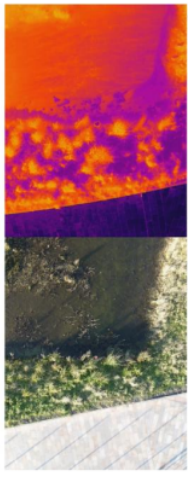
6.1.11 Figure 17 – Visual and Thermal infra spot image (3)



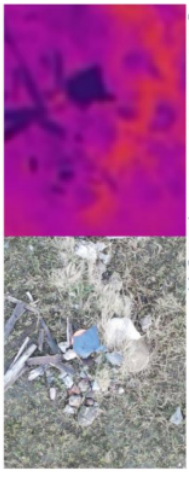
6.1.12 Figure 18 – Visual and Thermal infra spot image (4)



6.1.13 Figure 19 – Visual and Thermal infra spot image (5)



6.1.14 Figure 20 – Visual and Thermal infra spot image (6)



6.2 Pixel 7a

6.2.1

Using the current method of searching for mines, taking the area, and splitting into 5m wide lanes to walk down carefully, many mines were located purely visually and recorded via photograph with coordinates electronically attached to the image.

6.2.2

Figure 21 – Photograph of landmine (1) S1 616989, -3.927567



6.2.3

Figure 22 – Photograph of landmine (2) S1 616989, -3.927567



13

6.2.4 Figure 23 – Photograph of landmine (3) S1 616989, -3.927567



6.2.5 Figure 24 – Photograph of landmine (4) S1 616944, -3.927131



14

6.2.6 Figure 25 – Photograph of landmine (5) 51.616944, -3.927141



6.2.7 Figure 26 – Photograph of landmine (6) 51.616158, -3.927503



15

6.2.8 Figure 27 – Photograph of landmine (7) 51.616158, -3.927503



6.2.9 Figure 28 – Photograph of landmine (8) 51.616158, -3.927503



16

6.2.10 Figure 29 – Photograph of landmine (9) 51.616789, -3.927633



6.2.11 Figure 30 – Photograph of landmine (10) 51.616961, -3.927767



7 Discussion

7.1 Mavic Drone

7.1.1 Using both Visual and Thermal camera it was expected to easily spot the heat signatures of the hot core within the Landmine and the ambient exterior, however as seen within most figures in 6.1, the items are easier to spot on visual due to their being out in the open and bright in colour. This led to them often being spotted first on visual then later thermal imaging.

7.1.2 Of special note, figure 20 shows the importance of using more than one system as when covered with debris, there is zero imaging to show for the mine hidden beneath, this is where utilising the more specific search of spot the dog would be useful to unearth the mine or look for a better image angle.

7.1.3 In total there were 12 landmines to find, using all three systems only 10 were found on the first run, most through visual identification. However, figure 15 is representative to what would be the desired outcome as the thermal and visual cameras together provide locations for 4 landmines without the need to human intervention.

7.2 Spot the Dog

7.2.1 While having to data from Spot the Dog to place into the results at this time, there are some major issues that must be overcome before efficient use of Spot is possible.

7.2.2 The range of the dog from controller is only 20m this would require the handler to be in a hazardous environment to communicate with Spot.

7.2.3 Spot while autonomous in self-corrected motion, still required human intervention to right itself after falling, getting stuck and getting lost on more than one occasion. Spot would only be ideal in flat un-obstructed terrain such as the central area of the minefield as this did not have water, long grass, shrubs and hills to contend with.

7.2.4 Spots thermal imaging camera mounted to the rear, has a roll cage that completely obscures the camera when looking directly behind (180° line)

8 Conclusion

8.1.1 Not all 12 mines were located proving that the equipment provided was not perfected yet to acquire the location of thermal objects especially when hidden or left to cool.

8.1.2 There is promise with the use of the Mavic drone especially when in use with previous data to compare and look for changes to the environment.

8.1.3 Spot the dog is not yet ideal for mine locating or disposal. Greater controller range, improved roll-cage design and terrain control are needed at minimum to be a potential contender in the industry.

Parts 1a and 2b

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21