**UAS Data Collection, Organization, Processing, and Analyzing**

David Sweeney (20 August, 2022)

The goal of this document is to guide team members both in the field and at the home office(s) through the necessary steps required/recommended for UAS data handling. This document will first touch on aspects of field data collection and organization that are best done during each day’s effort (see also the Mobile Demand Protocol). This document will then discuss recommendations for efficient data processing (e.g., pulling image stills for IDs and measurements, assigning field IDs to all whales within stills, etc.). Finally, this document will direct team members to preexisting help documentation on how to measure different aspects of each whale using the Whalength and Morphometrix applications and will then direct team members to widely used modeling techniques for photogrammetry.

Throughout all stages of this document, there will be references to code and other files found within the UAS team drive folder. If at any point you cannot find a given file, if a code script returns error messages during use, or if any other questions come up, please reach out to me (David; [dsweeney@marecotel.org](mailto:dsweeney@marecotel.org); 224-804-7754).

A large amount of this protocol involves the use of R scripts. If you have not already done so, please install R (<https://cran.r-project.org/bin/windows/base/>) and RStudio (<https://www.rstudio.com/products/rstudio/download/>) to be able to use these tools.

1. **Field Data Collection/Organization**
   1. **Folder Organization (to be prepped before each day’s effort)**
      1. At the start of each day of flights (or at the end of a day in preparation for the following day) copy the folder structure found at *G:\Shared drives\UAS\FieldDataDumpingFolderSetup* somewhere on your local drive and onto any/all external drives that will be used for data backup.
      2. Rename the “FieldDataDumpingFolderSetup” folder to the date you are flying the UAS and collecting data (date format doesn’t matter). Do not change the drone folder names (e.g., METRInspire2) within this “FieldDataDumpingFolderSetup” folder as they are important during data organizational steps that use R code scripts.
         1. This renamed day’s folder will be referenced later as the “daily effort folder”
      3. If at any point the drone you are going to fly is not included in the folder names, contact me (David) so that I can update the folder structure and associated organizational scripts to fit your field efforts. You are also welcomed to try and edit the “FieldData\_CleanUp.R” script found within the daily effort folder but be warned that edits made to the script may cause errors when trying to organize your data at the end of a day’s effort if coded incorrectly.
   2. **Mobile Demand Workflow During UAS Operations**
      1. Make sure you have read and understand the mobile demand protocol, as your ability to handle the mobile database quickly and correctly is essential for us to get useful data out of each flight.
      2. You will be the busiest person on the boat whenever the drone is out, bouncing between launching and catching the drone to recording all sorts of sighting information. Maintain communication with the pilot and be ready to grab the drone and go. I guarantee there will be times whales will surface before you are expecting, and you’ll need to launch the drone in a matter of seconds (safely).
      3. Pre-flight tips:
         1. Put on a helmet and safety gloves
            1. As uncomfortable as they may be, keep the gloves and helmet on during the flight as you may be needed on short notice to catch the drone as it returns to the boat
         2. If you have time before takeoff, create a new flight record from within the Flights Tab that specifies the pilot, photographer (if different from pilot), and drone being used. You can set the flight start time before taking off and the end time after landing as these times are just give a rough idea of when we were flying and are not mission critical.
            1. When creating a flight record, remember the flight number as this will later be used as the EventID within the sighting events to link videos with the appropriate flight number
      4. Mid-flight tips:
         1. Once whales have surfaced and the drone is in the air, go to the sightings tab and either create a new sighting if needed or find the appropriate sighting for the animals being flown over.
            1. Within the sightings tab, go to sighting events and prepare a “Video-Beg” event. Wait to capture a GPS fix/timestamp until the exact moment the pilot starts a video recording during approach of animals

I recommend doing a 3, 2, 1 countdown where you then hit the “Get GPS Fix” Sighting Event button for a “Video-Beg” event and the pilot hits the video record button on the flight controller at the same time

If for some reason you can’t create a sighting event at the time the pilot needs to start video recording, don’t panic, because you can still create a “Video-End” sighting event. Just make sure in these instances to coordinate the end of the video time precisely as you would for the start time

This weird GPS fix timing step is due to clock differences between the lidar data logger and DJI drones’ cameras, forcing us to use the mobile demands to help us link lidar data with the times of video recordings

* + - * 1. If you managed to create a flight log and obtain a new flight number prior to takeoff, enter the current flight number as the EventID in the current sighting event.

This will later help us link video recordings to the appropriate flight number so we know who was flying and what drone was used

* + - * 1. Whenever you have a pause in mobile data collection and are not needing to catch the drone, it can be very helpful for the pilot if you are following where the drone is in relation to the whales. This is especially helpful while the pilot is chasing after a group that just surfaced as it can be very difficult to see the animals in the screen
    1. Post-flight tips:
       1. Once you have helped catch the drone, finish whatever other data entry needs to be done and then help prep the drone for the next flight
          1. If you happened to create a sighting event but the pilot never started a video recording of the whales, you can simply put a comment under that sighting event that no video was taken. You can also delete the sighting event if convenient, but be careful to only delete the sighting event, not the actual sighting.
          2. If you flew overtop of animals and were the most impactful/only take of an animal during the encounter (i.e., no boats approached the animals, no tags were deployed, no biopsy darts shot), make sure to mark how many individuals were flown over and write “UAS” into the comments to declare it as a drone take.

A drone take is declared under our METR permit as the following: “During unmanned aircraft system (UAS) and manned aerial surveys flown at an altitude lower than 1,000 feet, count and report 1 take per cetacean or pinniped observed per day, regardless of the number of passes. If the UAS is launched during an approach by vessel, count only 1 take for all vessel and aerial activities as indicated at Condition B.5.c.”

* 1. **Drone Operations for the Pilot-in-Command**
     1. Pre-flight tips:
        1. Coordinate with the mobile demand handler/drone catcher about important phrases to be used during launch and recovery. When underneath the drone with the blades spinning, it can be loud, so clear communication is key to keep everyone safe
        2. Be aware of permit regulations controlling the minimum allowable altitude while flying with animals
           1. The altitude shown on the flight controller is zeroed to the altitude at takeoff, thus making the true altitude whatever you see on the screen plus how far above the water you were during launch
           2. METR’s US cetacean permit defines a take as flying overtop of an animal below an altitude of 1000ft and we are allowed to fly down to 25ft (7.6m) over small animals and 50ft (30.5m) over baleen and sperm whales
        3. Make sure you have read and understand all controls of the drone prior to flight. Drone manuals can be found on the team drive in the UAS folder
        4. Make sure lidar’s LiPo battery is connected to the data logger
           1. Lidar data logging should be working properly once you see a blinking light coming from the GPS and a blinking light coming from the data logger board. Both lights blink about once per second.
        5. Turn on drone and flight controller and make sure they connect.
        6. Look through flight settings and make sure everything is set as needed
           1. Make sure bottom sensors are disabled as these can make landing very challenging and dangerous by restricting the ability to shutoff the drone while in the hands of the catcher. If you forget to turn this off, the drone will try to pull out of the catcher’s hands and take flight again, so you will need to act quickly to turn it off before you can power down the drone.
        7. Make sure the DJI account used by the controller is Greg’s
           1. All devices should currently be set this way, but it never hurts to check
        8. If time allows, complete the pre-flight checklist on the airdata app on your controller. Make sure to specify yourself as the pilot-in-command. This will allow airdata to automatically upload the flight with you as the specified pilot.
        9. When about to launch DJI drones from the boat, top left bar is not green saying the drone has a good GPS signal but is instead red and says there is an IMU calibration error, simply restart the drone (you don’t need to restart the controller) and the problem should resolve itself
           1. The best I can gather is that this IMU error is caused by the rocking of the boat that messes up the IMU calibration prior to takeoff. I’ve noticed that the longer you wait before takeoff, the more likely this error is to pop up, so quick but safe launches work best
     2. Mid-flight tips:
        1. The safety of other team members is your responsibility whenever drones are out. Take it seriously and prioritize safety over data!
        2. When collecting photogrammetry videos/images:
           1. Whenever possible, approach animals with the glare behind the drone as this will make it easier to spot surfacing whales on the controller screen
           2. Make sure camera is tilted 90 degrees straight down while flying over top of animals
           3. Control the exposure (EV) and always error on the dark side (i.e., darker images are easier to measure and ID than washed out bright images)
           4. Always keep your altitude in mind, as flying too high can make it more difficult for the lidar to capture an accurate altitude measurement

I found between around 25-40m was a good altitude depending on if you want to fly over one animal or a group of animals at once

* + - * 1. Always maintain communication with the person entering data on the mobile demand to inform them of group size, coordinate video start times (see next tip), for helping tracking whales and your drone, and other important information
        2. Start video recording as soon as possible once you begin chasing down whales. The sooner you start the video, the more likely we can get group dynamics information within the video and the more time you will have to remember to hit the video record button.
        3. Due to clock differences between the lidar data logger and DJI drone cameras, make sure that you (the pilot) tell the mobile demand handler the exact time you are starting video recording so they can capture a GPS fix/timestamp on the mobile demand that will later be needed to combine data streams (this is super super important!!!!!)

I recommend doing a 3, 2, 1 countdown where you hit the video record on the controller, and they hit the sighting event’s video start (“Video-Beg”) GPS fix button at the same time

If for some reason you are forced to start video recording before the database handler is ready to get a GPS fix on a video start time within the sighting events, you can use a video end sighting event (“Video-End”).

* + - 1. Be careful about how much battery you have left so you don’t get the drone stuck 2km away from the boat without enough power to fly back and land. Try to make sure you are returning to the boat before you hit ~30% battery life to account for transit back and a safe landing.
         1. As you are getting comfortable with flying the first few days and as your catching person gets comfortable having spinning blades coming toward them, it is best to give yourself even more time to land as it may take several approaches before you land safely and smoothly
      2. When landing, make sure you have lowered the DJI Inspire’s legs to make it easier and safer to be caught
         1. Reminder that shutting down the motors mid flight during drone catching is pulling the left joystick down and in while simultaneously hitting the return-to-home button
    1. Post-flight tips:
       1. If you did not complete a pre-flight checklist, make sure to complete a post-flight checklist and specify yourself as the pilot-in-command. This will allow airdata to automatically upload the flight with you as the specified pilot.
          1. If you do not do this step, we will need to manually change the pilot within airdata after the trip and will rely on the mobile database’s records of who was flying at that time
       2. Following each successful flight during which videos, images, and/or Lidar data were collected, it is advised to upload the data from the lidar board’s memory card and from the drone’s images/videos memory card in case a subsequent flight results in a splash landing that destroys all stored data. I recommend the pilot do the following tasks to upload the data.
          1. Open the drone folder within the daily effort folder that corresponds to the drone from which you are uploading data.
          2. Create a new folder within the drone folder

Note: the name of this created folder does not matter, but you can name it according to the last flight number to enhance your data organization

* + - * 1. Copy all lidar data and UAS images/videos and paste them into this newly created flight folder

All data needs to be copied into a new, clean folder in this step because otherwise you will likely overwrite previous lidar data because of the generic lidar data naming scheme

* + - * 1. Backup all data onto external hard drives
        2. Confirm that all data has been successfully uploaded to your computer and to your external hard drives
        3. If desired, delete lidar data and UAS images/videos from memory cards and reinsert them back into the drone

This is only suggested so that if you are in a rush when uploading new data, you aren’t having to find the exact files from the most recent flight but can instead copy all and paste all without worry of creating multiple copies of videos and taking up memory space

* + - 1. If, when downloading lidar data off the drone, you realize there has been an issue with the data logger writing to the sd card, you will have to spend some time troubleshooting what is causing the issue. If there is not time to troubleshoot prior to the next flight, switch out the lidar system in question with a different system and troubleshoot the problems later
         1. From my experiences, the best thing to do when the lidar data isn’t writing to the sd card is check all soldered connections. This may require you to remove the glue around different soldering points. Make sure current is flowing between soldering points and that there are no touching wires that would mess up the circuits.

This is a trial-and-error process. My current best strategy is to keep poking stuff until it works. I’ve yet to find a consistent trend in the problem

If having to remove the glue from the soldering points, be very careful to not make matters worse by cutting wires

* + - * 1. If the there are no connectivity issues, check to see if the sd reader is firmly holding the sd card in place. I’ve had issues with one lidar system where the sd card wasn’t being firmly held and I believe this is what was causing the problems
        2. When changing out lidar systems, you may have to get creative to keep wires aware from blades and sensors, so just figure it out
      1. Keep an organized strategy where all batteries on the trip are being cycled through so we don’t overuse only a handful of batteries. This can be done however you’d like, but do not simply charge a set of batteries and then fly with then before using the other battery sets
  1. **End-of-Day Organization**
     1. Once you are done flying for the day and after you’ve uploaded the last flight’s data onto your computer and external hard drive(s), it is time to do some organizing to get your named files cleaned up and renamed. For this step, you will utilize the “FieldData\_CleanUp.R” script found in the daily effort folder. This code will essentially pull all the videos and images from the drone folders and rename them according to the approximate time the image/video was created (according to the drone camera’s internal clock) and the drone used.
        1. Open the “FieldData\_CleanUp.R” script and read the help documentation at the beginning of the file.
        2. Install any packages that are required and that you do not currently have installed.
        3. Find line 34 in the code immediately under “Manual Inputs” and change the file path to the daily effort folder
           1. R requires “/” instead of “\” when specifying file paths, so if you get any errors, check that you have use the correct slash direction
           2. This is the only line you should need to change for everything to work correctly.
        4. Run the entire script
        5. If you are getting errors, contact me (David) or see if you can troubleshoot things yourself
           1. This data organization step can always be done after the trip, so if you can’t figure out why you are getting errors or if you forget to do this stuff, don’t sweat it!
        6. Check the results
     2. Prepare for next day’s flights
        1. Follow the instructions found at the beginning of this protocol under 1.a to get ready for tomorrow’s data collection.
        2. Make sure all drone and lidar batteries are charged and ready for tomorrow
           1. Put fresh batteries on the drones, but do not connect the lidar battery to the data logger board as this will drain the LiPo battery overnight
        3. Place a copy of the mobile database containing all flight information into the daily effort folder as this data is needed to perform most of the future data processing steps
        4. If you have time and want to get a start on data processing while in the field, continue to section 2!

1. **UAS Data Processing**
   1. **Processing videos and images**
      1. Open a project within Adobe Premier Pro
         1. "G:\Shared drives\UAS\UAS\_VidStills.prproj"
      2. Open the PDT2UTC.R script found here: "G:\Shared drives\UAS\PDT2UTC.R"
      3. Open the compiled lidar log containing the lidar measurements (created from FieldData\_CleanUp.R) obtained during the day in which you recorded the video of interest
      4. Scan through the video in Premier Pro looking for good ID’able oblique views of each animal, cool photos of whatever they may be, and vertical stills of each individual that can be measured
         1. Good measurable images possess the following things:
            1. There is an associated lidar altitude at the time of the still

This is checked using the PDT2UTC.R script, which will give you the UTC time of the still that should then be searched for within the compiled lidar log to verify that a good lidar altitude was obtained

PDT2UTC.R uses the start time of the video (from mobile database) and the minutes, seconds, and partial seconds of the image still as see in Premier Pro to output the UTC time of the image still

If the lidar altitude says something like 13000 or similar, this means the lidar did not get a good altitude measurement.

Standard altitudes above whales are usually between 2000-6000

* + - * 1. The whale is at the surface and relatively parallel to the water’s surface
        2. The fluke is relatively flat
        3. The tip of the rostrum is not obscured by splashing water
        4. As much of the body is visible as possible and not obscured by water
      1. Once you have landed on a moment of the video you wish to capture a still of, click the camera symbol labelled “Export Frame” and save it to a folder within the daily effort folder.
         1. Once you have pulled all the still desired from the single video, create a subfolder within the folder where you have placed all the stills where you will then move all the stills that are measurable for body morphology
      2. Repeat this process for all videos within and across days of UAS effort
         1. Once all video stills and images are collected, open ACDSee and fill in the required information listed below:

Assign information on the photographer, project, and study area as done for all other field photos following the Photo Processing Manual

"G:\Shared drives\DigitalCatalogs\METR Photo Processing with ACDSee Pro10.docx"

* 1. **Matching whales to the photo-ID catalog**
     1. This process is easiest after the lateral images from the cameras on the boat have been already matched to the historical catalog. This way you can use the sighting numbers from the mobile databases to match sightings numbers and then easily find ID’d photos from a lateral perspective that can be matched to the aerial photos
        1. Open the mobile database(s) for the day when the drone videos were taken and determine the sighting of the whales flown over
        2. Open two windows of ACDSee
           1. Use one window to scan through the lateral views of the whales in each respective sighting

Title = Vessel-Sighting# (e.g. Azt-02)

Headline = Species (e.g. Zica)

Description = FieldID (e.g. 1 (B, mom), 2 (T, calf) from PAN; this would mean there are two whales, the bottom is ID 1 and is a mom and the top is ID 2 and is the calf, and these IDs were from panga sightings at Guadalupe)

This does not need to be in any exact format, just make it obvious which whale is which

Description Writer = image angle (e.g. V for vertical directly over whale or O for oblique angle while approaching whales)

EXIF: Model = WhaleID (e.g. 43 (R) 57 (L); this would be for two whales to the left and right of each other)

This is the most important

* 1. **Measuring animals**
     1. FYI: for the inspire2 drones, the lidar lense is 9cm above the Olympus camera lense when at 90 degrees pitch on the gimbal
     2. Installing Morphometrix, and Whalength
        1. To use Morphometrix, you will need to have downloaded python onto your computer. Use the most recent version available from <https://www.python.org/>.
           1. During the installation process, make sure to add Python to PATH, as shown in the image below:

**Graphical user interface, text, application

Description automatically generated**

* + - * 1. Once you have installed python, go to the following github repositories to download these applications:

<https://github.com/wingtorres/morphometrix>

Once on the github page, click the green “Code” drop down button, and then click “Download ZIP”

Once morphometrix is downloaded, unpack the .zip folder and move the entire folder to a memorable location.

If you have access to the METR google shared drive and the UAS folder, you can also find morphometrix here:

"G:\Shared drives\UAS\morphometrix-master"

* + - * 1. Next, open the Command Prompt on your computer and copy and paste the following line of code and then hit Enter

pip install PyQt6 PyQt6-WebEngine numpy scipy

* + - * 1. At this point, you should be ready to begin measurements using Morphometrix
      1. To use Whalength, you will need to have a Matlab license and have the Image Processing Toolbox
         1. METR has these software licenses, so if you are METR staff, contact David Sweeney to have the license transferred over to you while needing to perform measurements
         2. The Whalength code has been customized slightly to better fit the needs of our research and our data management systems. The modified code is found at "G:\Shared drives\UAS\Whalength"
    1. Using Morphometrix
       1. Type “cd ” into the Command Prompt (the space after cd is important) followed by the folder location of your morphometrix folder
          1. E.g. *cd C:\Users\marec\morphometrix-master*
       2. Now run the following last required Command Prompt line of code that will cause the morphometrix app to open:
          1. *python -m morphometrix*
       3. Once the application has opened, you can follow the instructions found on the bottom left panel of the application
       4. If measuring images from the METR DJI Inspires, input 25 for the focal length and 0.0045 for the pixel dimension in the upper right panel
       5. Use the following R script to calculate the altitude of the drone’s camera at each image timestamp:
          1. "G:\Shared drives\UAS\corrected\_image\_alt.R"
          2. This R script will also automatically build a csv file with information you are manually inputting into the morphometrix app to have a backup in case you mistype something (usable when later using Collatrix)
          3. Helpful information on how to use the correct\_image\_alt.R script is found at the top of the script once it is opened in RStudio
    2. Using Whalength
       1. Within the Whalength folder is an instruction manual on using the measuring tool: “Instructions for using Whalength v6”. Please read this over carefully, as it discusses data storage requirements and methods for performing different types of measurements. Not following these instructions exactly could cause data issues that are hard to catch or trace back.
       2. The folder structure we are using for our UAS data that has been described above is required by the Whalength application.
       3. Whalength requires an excel file with image names and lidar tilts and alititudes as you will read about in the instructions pdf. This input file can be made using the “Whalength\_excel\_file\_input\_prep.R” script
          1. To run this script, simply change the four lines found under where is says “Manual Inputs” and then run the entire scipt
       4. Note that you do not need to worry about overwriting datafiles if you have multiple sessions of measurements in the same day’s effort. I have modified to script to rename old measurement output files each time there is risk of overwriting.

1. **Morphology Analyses**
   1. Calculating Body Condition Metrics
      1. The Collatrix git hub repository is found here:
         1. <https://github.com/cbirdferrer/collatrix>
            1. Instructions for installing and using collatrix are found here:

<https://github.com/cbirdferrer/collatrix/wiki>