Handbook: Creating a Basic Image Velocimetry Site

How to construct and set-up the equipment you need

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Contents

Chapter 1 Introduction

There are numerous ways of creating a site intended for image velocimetry use, and each has their own advantages. Some work carried out with SEPA in and around Stirling saw two sites created, one using a Raspberry Pi unit (Linux OS), and one using a LattePanda (Windows OS) unit. Typically, people are not familiar with Linux OS, and that complicates the creation on new sites when using Raspberry Pi's. For this reason, it is being considered to move forward with Windows OS single board computers, similar to Raspberry Pi's. The familiarity with Windows OS will hopefully improve the accessibility of the sites for more people. The two sites constructed in Scotland have been of mixed results. With both being battery powered, the LattePanda that is used has seen issues with power consumption, while the Raspberry Pi has been consistent after both received bigger batteries. With that being said, any site that is mains powered will not have any of these issues, and is perhaps more favourable with the Windows OS single board for its accessibility. For the purpose of this handbook, we will be looking to use a smaller board, with only 2GB RAM compared to the 4GB boards used in Scotland. If successful, then the boards will be better used with battery operated sites that the original LattePanda that is currently used, simply for power reduction.

This handbook makes a couple of assumptions. Firstly, that this is not being used to set up the first site for the group. If it is, there are a couple of accounts that need to be created. The first account is an email account that is linked to all of the other accounts used to manage and monitor the sites. Secondly, an account with Amazons AWS S3 cloud storage is needed. This can be a free account to start with, but eventually with the creation of more sites, charges will start to occur depending on usage. Therefore, this account needs a card attached to it that can be charged monthly for usage. Thirdly, the email account will be needed to create an account for VNC Viewer/Server; used to remote access the sites and control them all from a single computer. This is also free for the first five sites, but will need upgrading as the site count grows. Other than that, the other software used such as the PTV/PIV software, the coding programs, and the code language, are all open source/free to use. This has been intentional so that costs are kept to a minimum while we learn what works/does not work effectively, and where we want to take the sites in the future depending on developments.

For this handbook, you will need all of the equipment listed in the equipment section, a personal computer/laptop, and enough space to download about 2GB of software. Your computer will need an Ethernet port, and you will need readily available WiFi.

Chapter 2 Equipment List

The equipment listed below is everything you need to get started with image velocimetry. There are many variations and alternatives you could go for, and each would vary on setting up, cost, and functionality. This set-up uses a Windows OS single board computer, but with only 2GB RAM, it should also be low power consumption. The camera is a cheaper model and has limited functionality compared to some others readily available, but is good for the start of velocimetry. Micro SD cards to extend storage is optional but advised. The links given below are optional also, if you want to find the same items or similar items from elsewhere, that should be fine, especially the cables.

Equipment Name	Available at:	General Price
LattePanda	RS Components	£150
HikVision Hi-Look Camera	CCTV Kits	£45
Mobile Dongle	Amazon	£40
Power Cable (Camera)	Amazon	£10
Power Cable (LattePanda)	Amazon	£10
Ethernet Cable (30m)	Amazon	£20
Camera Junction Box	CCTV Kits	£15
MicroSD Card (64GB) (2pack)	Amazon	£15
USB Extension (male to female)	Amazon	£5
Plastic Weatherproof Enclosure	RS Components	£25
HDMI Cable (needed once)	RS Components	£10

Chapter 3 Camera Set-up

The cameras that we tend to use will typically be HikVision cameras as they are cheap, reliable, and easy to operate. They usually do not come with their own power adapter, therefore, you need to ensure that you have a 12V, 2A (min) DC adapter (12 VDC ± 25%, 0.4 A, max. 5 W, Ø5.5 mm coaxial power plug).

1. When using a HikVision camera, we can use the HikVision software "SADP" to set up our camera. Go to: https://www.hikvision.com/en/support/tools/hitools/clea8b3e4ea7da90a9/ and download the tool.
2. Power up the camera and connect it to your PC via the ethernet cable.
3. Open up SADP, and you should be able to see the camera listed as 'inactive' if it's the first time being used. Click the tick box on the LHS of the screen to bring up its options. Set the password to password11, along with the security questions. If you change this password you have to change the password in the Code. Scroll down to where you can see "password11" in the code and change it to your new password. See figure 3.1.
4. Check the default settings are as follows, and check off the DHCP box at the top RHS. See figure 3.2
5. Next up, switch off your PC connection to the Wi-Fi, and open up the control panel. Go to the menu that says "View network status and tasks". Click on your ethernet connection, click on "properties", and find "internet protocol 4 (TCP/IPv4)", double click it. See figures 3.3 and 3.4.
6. Click on "Use the following IP address", and change the IP, subnet, and default gateway to 192.168.1.100, 255.255.255.0, 192.168.1.1 respectively. Click ok, and close the windows.
7. Open up your internet explorer, and type in the IP address of the camera (192.168.1.64), to bring up the set-up menu. Your username is "admin", and your password is what you previously entered in SADP (password11). See figure 3.5.
8. If you have another appliance on your Wi-Fi that shares the same IP address, you will not be able to access this menu with your Wi-Fi on, however, once logged in, you may notice that you cannot see the live view. The browser needs a plug-in to be able to live view the camera. At the top right of the screen, you should be able to see a "download plug-in" button, click on it, and the browser will fail because of a lack of Wi-Fi. Keep the failed URL open, turn your Wi-Fi back on, and refresh the page to start the download. Let the plug-in download, install it, and then turn your Wi-Fi back off.
9. Refresh the page that contains the live view, and you should now be able to connect to your camera and see what it sees. See figure 4.1
10. Click on configuration and work your way through the menus so you can see what is available to edit. I advise changing the camera name to the site it will be in, also checking the camera time is accurate. Go to Video/Audio and check the settings, notably, the frame rate. Change it to 20 or set it to what you want but be sure to remember what it is because we need to define this later on in the code. Finally, go to "Image" and go to "OSD Settings", change the settings to the following settings seen in figure 4.2
11. Once you are happy with the settings, close it all and turn your Wi-Fi back on. The camera should now be ready to use with the code.

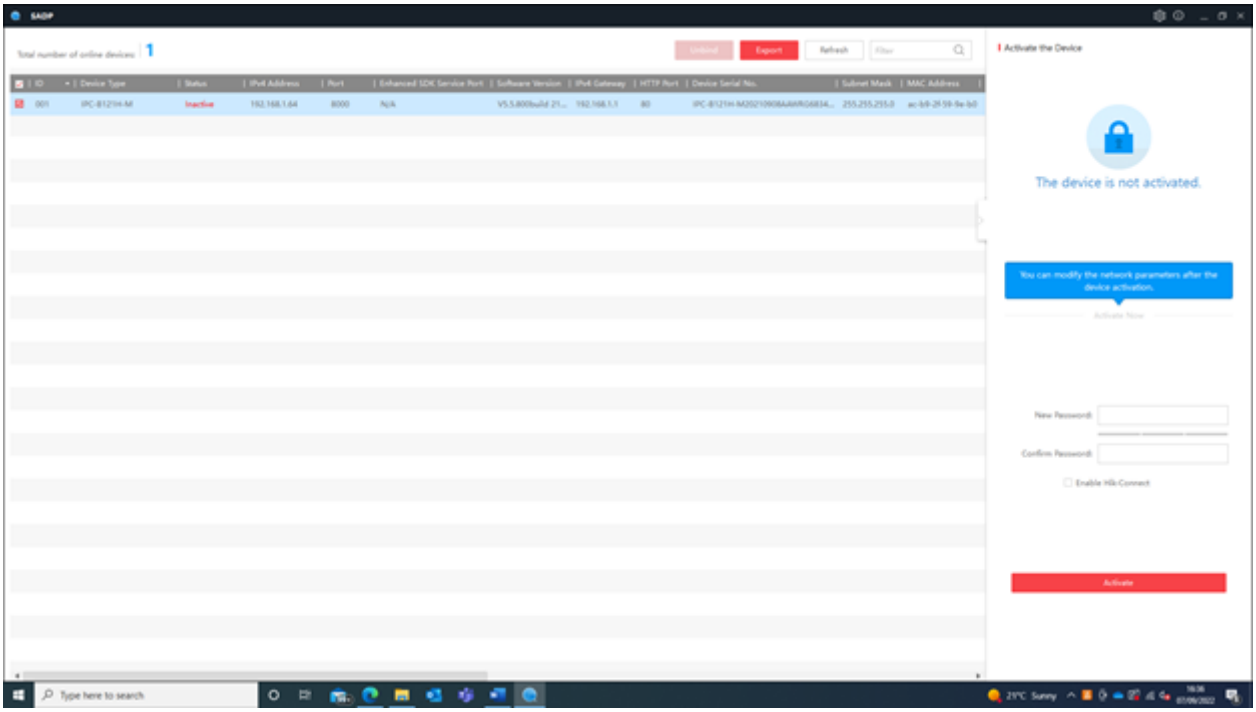


Figure 3.1: A look at SADP software. First time booting a camera requires you to insert a password, I advise password11 as this is what the code uses later on, and will need changing if you change the password here.

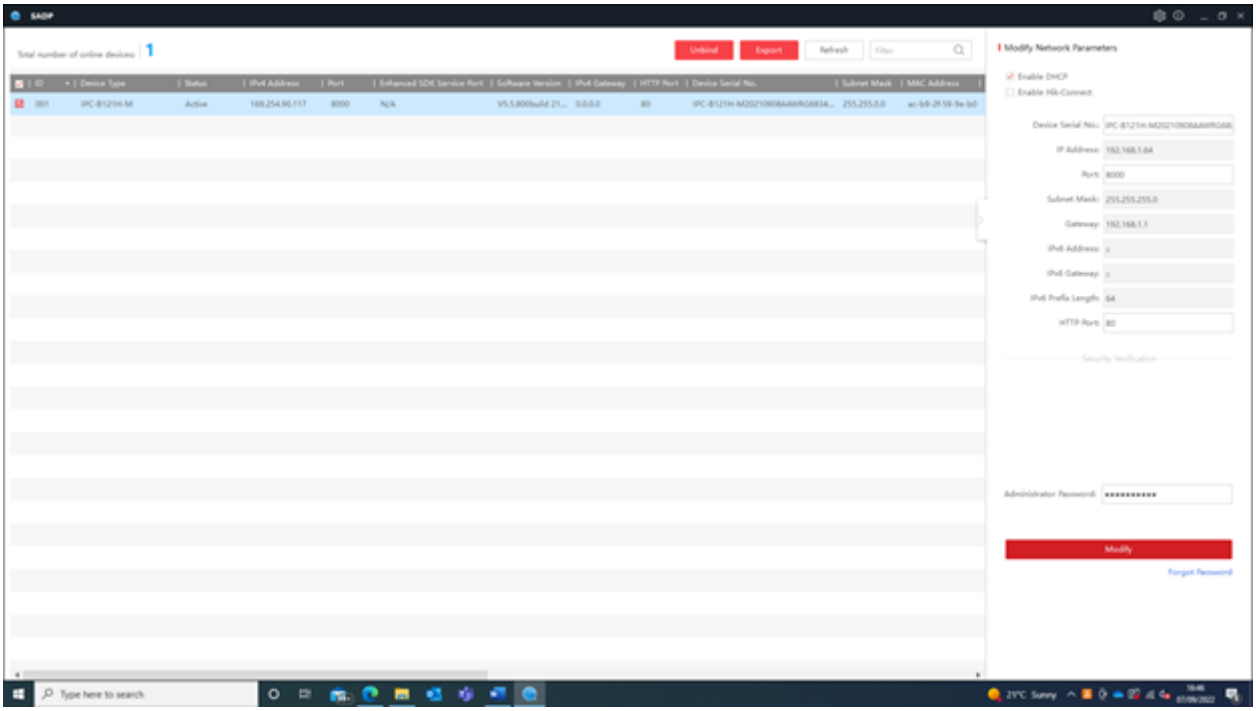


Figure 3.2: Initial camera settings including IP address's. Ensure DHCP is checked when you have changed the IP of the camera. Insert your password at the bottom and click 'modify' when done.

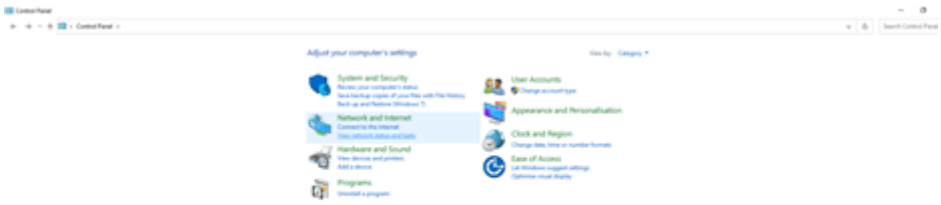


Figure 3.3: Go to your control panel and find networks.

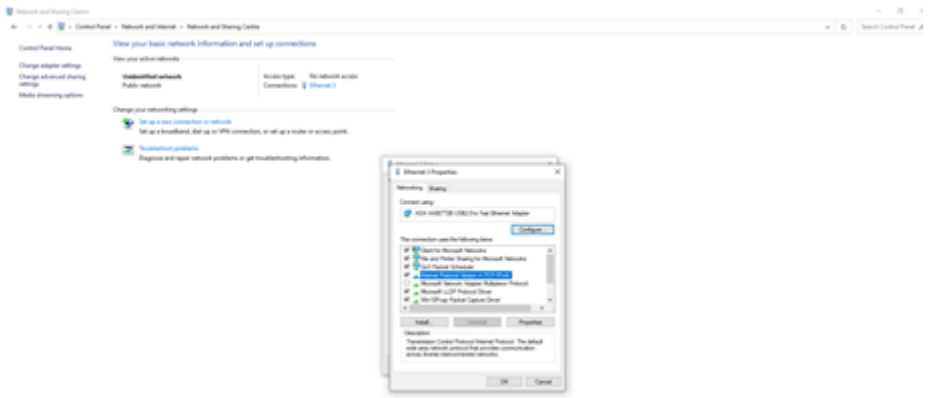


Figure 3.4: Click on your Ethernet connection, click on “properties”, and find “internet protocol 4 (TCP/IPv4)”, double click it.

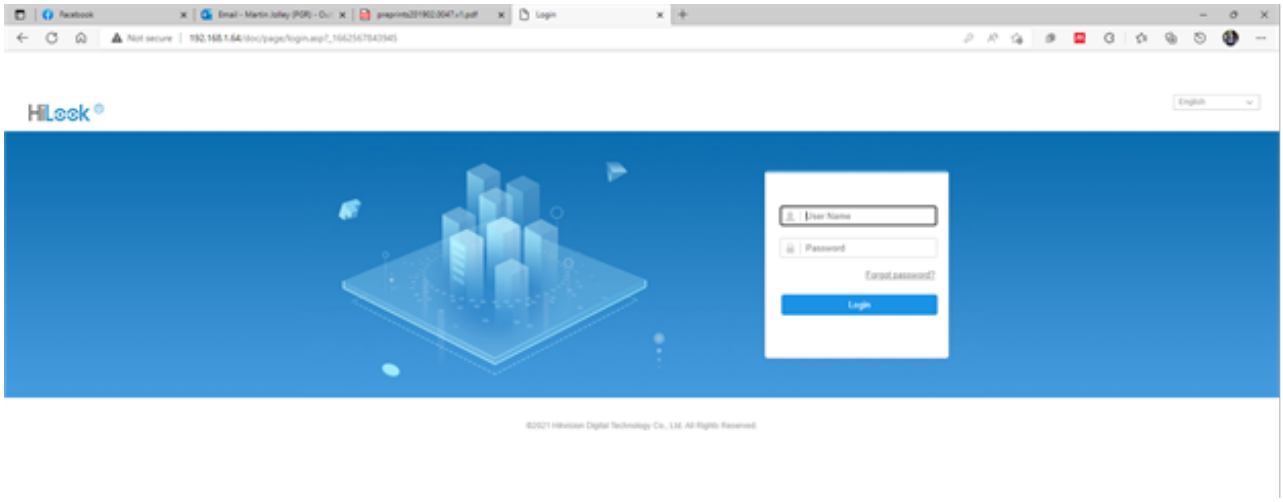


Figure 3.5: Open up your internet explorer, and type in the IP address of the camera (192.168.1.64), to bring up the camera settings.

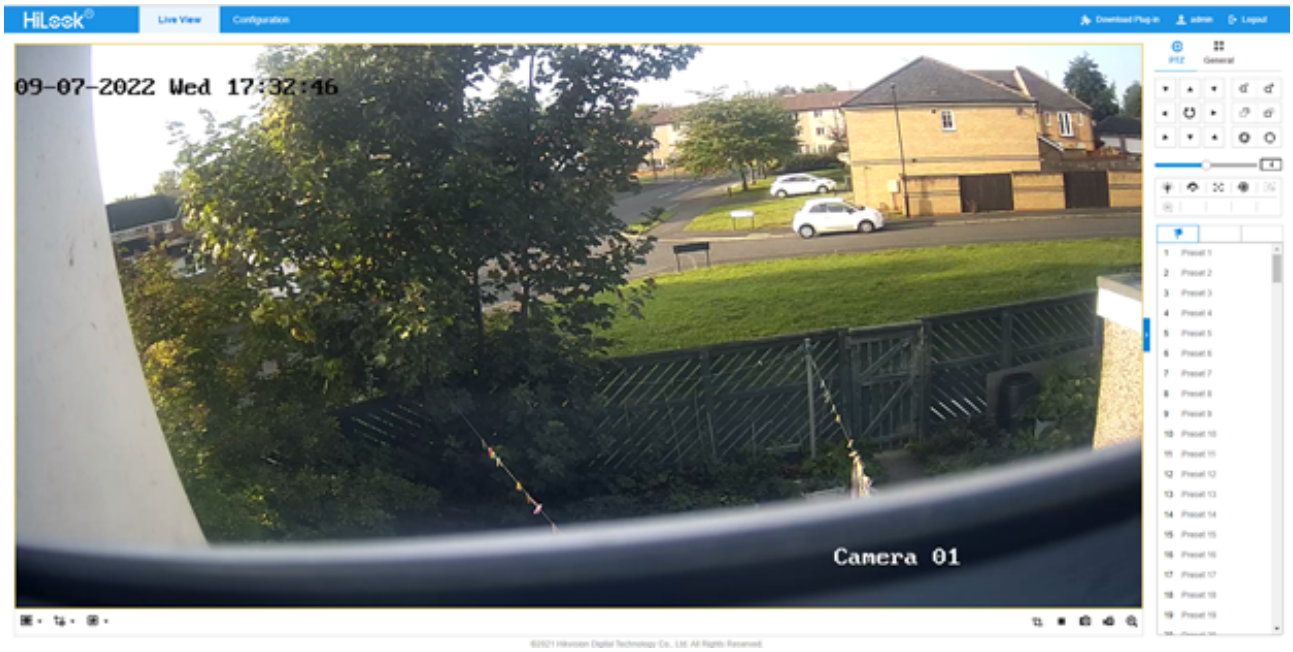


Figure 3.6: The browser needs a plug-in to be able to live view the camera. At the top right of the screen, you should be able to see a "download plug-in" button, click on it. After completing the download, you should get a live view of the camera.

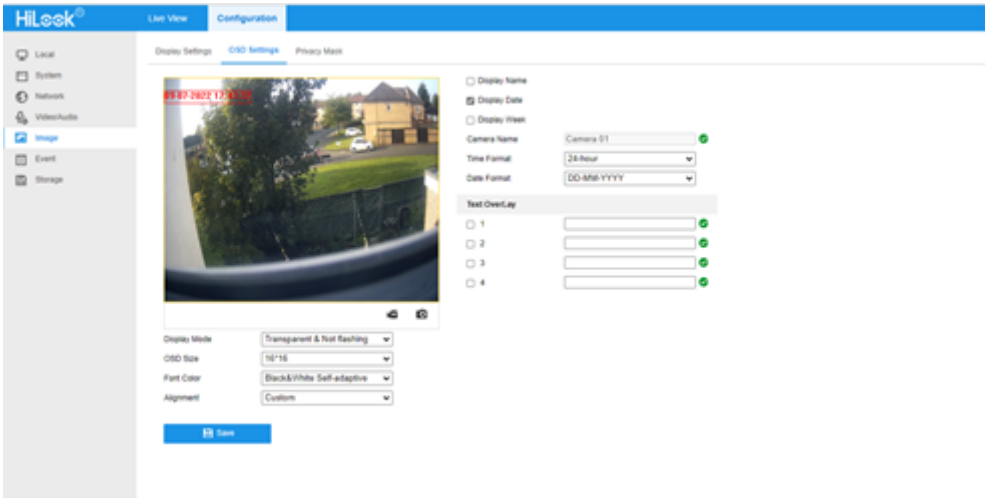


Figure 3.7: Click on configuration and work your way through the menus so you can see what is available to edit.

Chapter 4 LattePanda Set-up

The LattePanda we use here does not come with its own power cable, but can be powered with any 5V, 2A cable. These are usually readily available and power things like phones and other battery-operated systems.

1. Set up your LattePanda by connecting the antenna (this can be fiddly but stick with it), plugging it in, and connecting it via HDMI to a monitor and a keyboard and mouse. Insert your micro-SD card to the slot on the board.
2. Once powered on, it should automatically boot up and log in to the Windows start up desktop, where things may be out of resolution and enlarged. Simply go to settings, display, and change the resolution if you want to, but I find it slows it down a bit (its only a 2GB RAM board), as well as reducing the enlargement to 100. While on settings, be sure to set the time to the correct zone by going back to settings and going onto the "Time & Language" option.
3. Next-up, we want to connect to the Wi-Fi. If the antenna is connected properly, you should be able to click on the Wi-Fi icon bottom right and connect to your Wi-Fi. Enter your Wi-Fi password and connect.
4. Go to Windows settings, click on Time and Language, and go to Language, change it from US English to English (UK) by downloading the package. Then go back to settings home and search for "Advanced Keyboard Settings" and change the input language to English UK. The reason being, US keyboards have a different layout and its just easier to change it at the start than to guess it all later.
5. First off, download google chrome from here: https://www.google.co.uk/chrome/?brand=JJTC&gclid=EAIaIQobChMItNvtspqD-gIVGuvtCh3HpQCgEAAYASAAEgJQtPD_BwE&gclsrc=aw.ds
6. Next up, ensure to let the device update its windows version. This isn't vital, so you could skip this, but it is better to let it update. Simply go to settings, then update, and security. This could take a little while to complete, but we can do other things while it is doing it, just keep an eye on it to make sure it doesn't stop.
7. Next up, switch off your PC connection to the Wi-Fi, and open up the control panel. Go to the menu that says "View network status and tasks". Click on your ethernet connection, click on "properties", and find "internet protocol 4 (TCP/IPv4)", double click it. See figures 3.3 and 3.4.
8. Click on "Use the following IP address", and change the IP, subnet, and default gateway to 192.168.1.100, 255.255.255.0, 192.168.1.1 respectively. Click ok, and close the windows.
9. Now we want to make sure that the camera connects to the board and is viewable. So plug the Ethernet in and open up Chrome. Try initially with the Wi-Fi on, usually it is fine as there aren't any other registered IP addresses to the board. Type in your IP address of your camera (should be 192.168.1.64 by default), and bring up the log-in page. Log in with your admin account and once again, download the plug in as before. Refresh the page and you should be able to see the live feed of the camera.
10. Now we want to plant our code onto the card ready for use. Go to https://github.com/MJolley1/CamFeedCode and download "CodeV202.py" and "s3cmd.py". You can do this either on your personal computer and load it onto the SD card that is to be mounted in the single board, or you can download it straight onto the LattePanda.
11. To connect to the device remotely, we will want to download a VNC software: https://www.realvnc.com/en/connect/download/vnc/. From this website, we want to download "VNC SERVER" on to the board as that's the computer we want to control remotely. Later, we will download "VNC VIEWER" on our personal computer to control the board from. See figure 4.1

12. Install VNC server, and when asked to sign-in, use the general email for all other computers in the same group (ask team-leader for details). Give the computer a general password that is easy to remember and the same as any others on the network. Once logged in and it says its available, you should see the screen seen in figure 4.2.
13. This part is optional but good practice. On your personal computer, go to `https://www.realvnc.com/en/connect/download/viewer/` and download the VNC viewer. Log in with the same details as you logged in to VNC Server on the site board and see if you can connect to the desktop through it. You can now operate the site computer completely remotely whenever it is online. This is a little slower as it does have a slight lag depending on how good the internet connectivity is, but is so useful for updating things and checking status.
14. The code that runs on the computer is Python based and needs Python to be installed. Go to `https://www.python.org/downloads/` and download the latest version of python. Once downloaded, you should see the window seen in figure 4.3, be sure to CLICK ON “ADD TO PATH” and then install now.
15. Finally, go to settings, system, power and sleep, and turn both the settings there to ”Never” turn off.

Figure 4.1: To connect to the device remotely, we will want to download a VNC software.

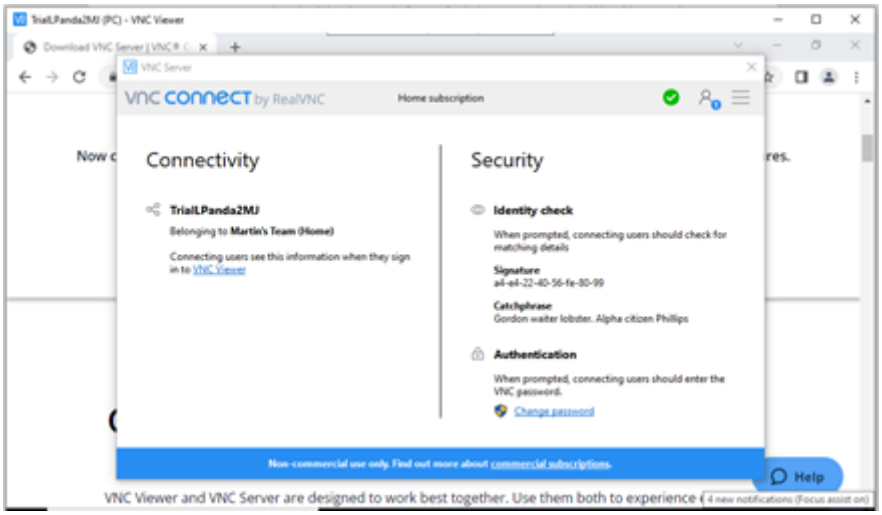


Figure 4.2: Once logged in and it says its available, you should see the screen seen here.

Figure 4.3: The code that runs on the computer is Python based and needs Python to be installed. Go to `https://www.python.org/downloads/` and download the latest version of python.

Chapter 5 Code Set-up

1. If you have already downloaded the two code files from the links found above, then move on. If not, now we want to plant our code onto the card ready for use. Go to https://github.com/MJolley1/CamFeedCode and download "CodeV203.py" and "s3cmd.py" (use any updated version if available).
2. From your download folder, cut and paste the two files to a new folder called "Code" to your SD card. Highlight both files, right click, cut, then go to "This PC" on the LHS, go to your SD storage device and double click. Right click in there and create a new folder and call it "Code". Open up that folder, right click and 'paste'.
3. You could download a python writing software if you wanted to, such as PyCharm (community), which was used to write the code and gives feedback on failures, but hopefully you do not need this. To edit the code, we simply need to right click on them, 'open with' and use Notepad. First off, lets edit the S3CMD.py file with notepad.
4. For this part, you will need your access key and private key from your AWS account. If this is not your first time setting up a site, you can find it on other copies of the S3CMD file on other computers. Once you have used a private key once, however, you are not able to view it again for security reasons on AWS, therefore, take a note of them and save them in a secure place. If its your first site, go on to your AWS account and go to "IAM dashboard". Click on "Manage access keys", and create a new one if you need to. Be sure to note them down somewhere safe for future use.
5. Within the S3CMD.py file, change the hashes to your security keys, for example:

```
    # Creating the low level functional client
client = boto3.client(
    's3',
 aws_access_key_id='FJDFSZN37ONYJ6MJS9JSDN'
 aws_secret_access_key='KJksjfawkuIJUIF6T3Ib2Z/jkh787h/smfbSHBFj,
    region_name='eu-west-2'
)
```

6. Now we need to edit the CodeV202.py file in Notepad. If it is your first time using this code, I advise you have a good read through of it first so you can read the comments on what everything does, so if there are any issues you may be able to see where it is and direct help to the root problem, also, to make sure nothing is missed that needs editing. Anything that starts with a "#", is a comment.
7. The section titled "User Input" is where we need to change a few things for each site. Please see figure 5.1. First of all:

```
saveDest = 'C:\\Users\\LattePanda\\Documents\\Code'
        # Where do you want to save the folders and files?
```

This needs to be changed to something like:

```
saveDest = 'D:\\Code'  # Where do you want to save the folders and files?
```

Depending on where you created your 'Code' folder. To find this location string, go to your code folder on file explorer and click on the string at the top, and copy this. It also depends on if you are using a

micro SD card as extended storage. I advise this because sometimes the video files fail to upload and can back log. As a fail-safe, keeping it on extended storage prevents the main device from being blocked up. See figure 5.2.

8. This next bit gets a little techy so I have tried to simplify as much as possible.
   (a). Open your windows cmd by searching on the start menu “cmd” and check to see if PIP is installed by typing:

   ```
   pip install --upgrade pip
   ```

   See figure 5.3.
   (b). Install OpenCV using the cmd window by typing:

   ```
   pip install opencv-python
   ```

   See figures 5.4 and 5.5
   (c). Now we need to install Boto3 which is what allows us to connect to our AWS account and upload our data. In your cmd window, enter the following:

   ```
   pip install boto3
   ```

   See figure 5.6
   (d). This should be everything we need to install via PIP and our cmd window. Close it up and now try and run CodeV202.py using python by double clicking the file.
9. Go to your CodeV202.py file, right click, and go to properties. On the general tab, find where it says “open with” and change it to Python so that it default opens with python. If Python does not come up straight away through the ”open with..” option, then right click on the file and open with ”choose another option..”, ”look for another app on this PC”. Go to ”C drive”, ”Windows”, scroll to the bottom and find ”py” and double click on that.
10. Once the code has been set up, we can place it into the windows OS start up folder so that when the module boots, the code automatically begins to run. This is needed for a multitude of reasons, but the most important being, if the power drops out then the module picks up where it left off without any interaction. To do this, select and copy the two files that you edited from before and navigate to the following path (if you do it manually you need to click on VIEW at the top, and on the right hand side, click ”Hidden Items” to show all these folders):

    ```
    C:\Users\"USER"\AppData\Roaming\Microsoft\Windows\Start Menu\Programs\Startup
    ```

    Paste the shortcut for CodeV202.py to this folder and it should boot with the computer.
11. Finally, go back to the file and right click. Go to properties, and where it says ”open with”, change it to Python by default.

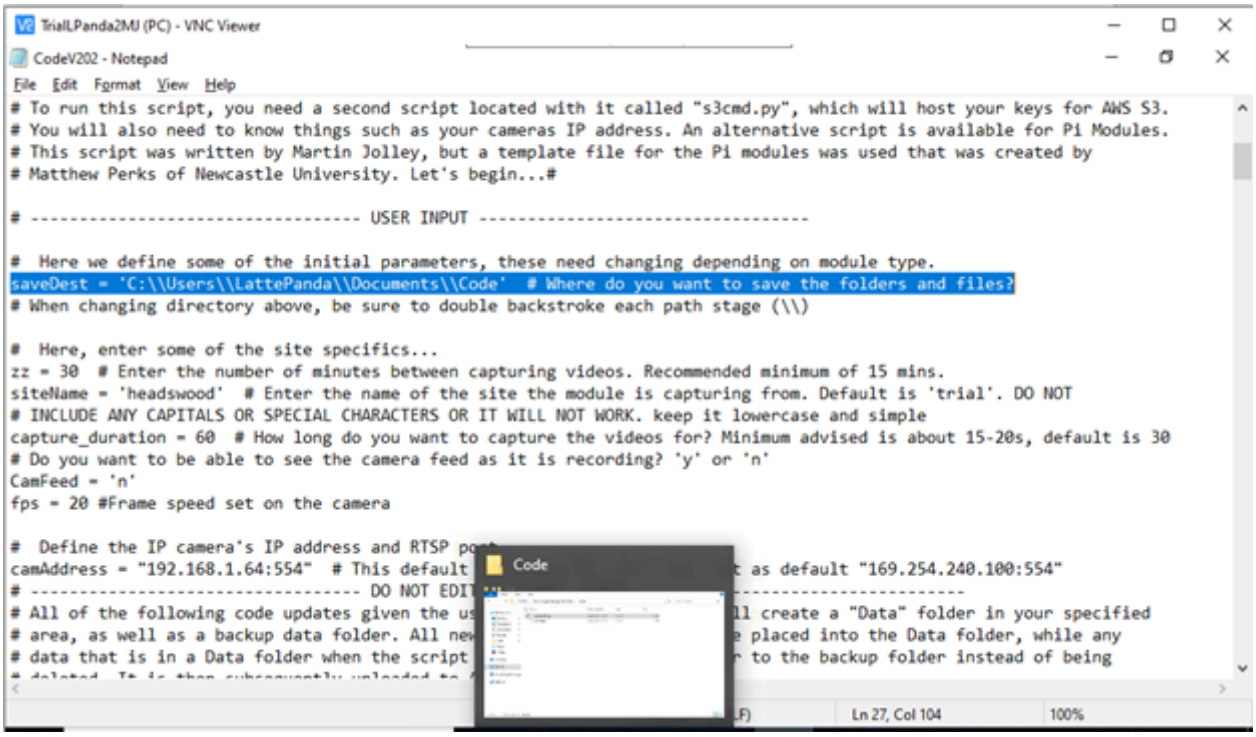


Figure 5.1: Change these settings here, especially the save destination to the folder you have the code located so that all of the data is in roughly the same place.

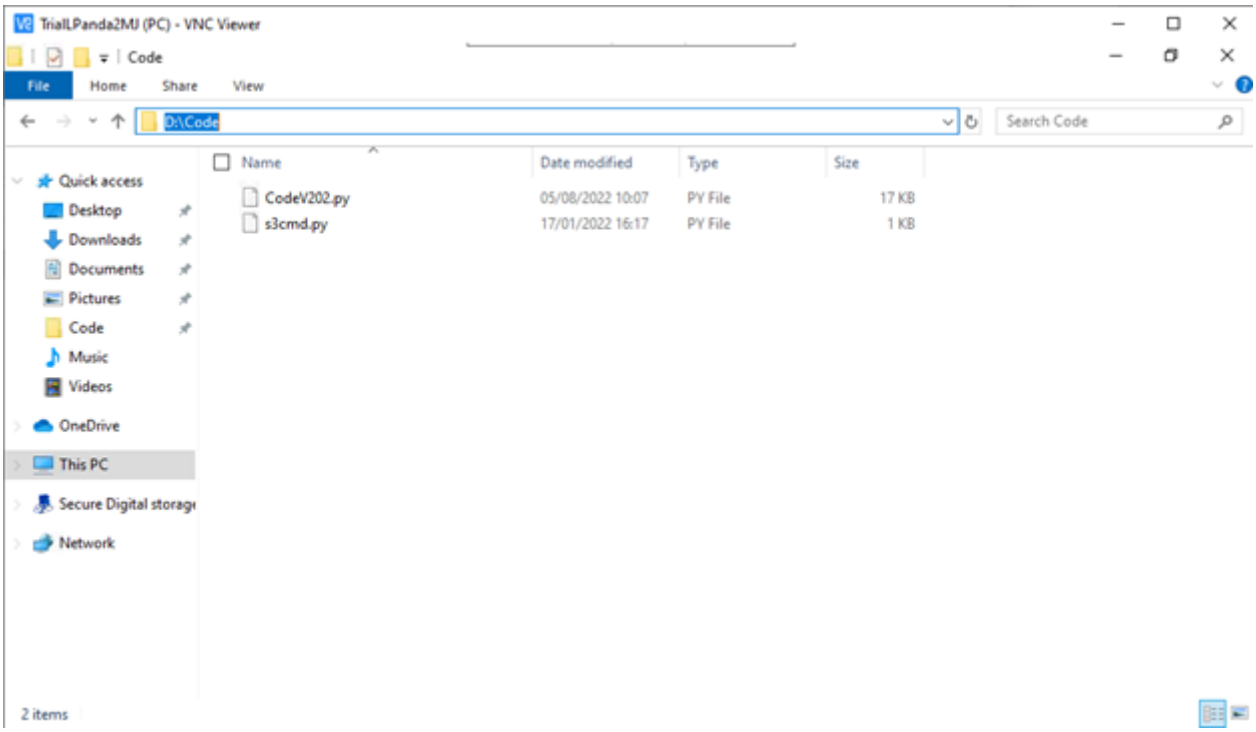


Figure 5.2: To find what to call the save destination, find it on file explorer and then click the string at the top and copy and paste that. Don't forget to double backslash the text in the code as it says in the notes.

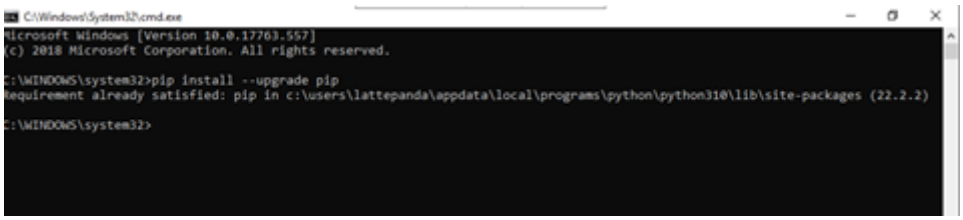


Figure 5.3: To find your command prompt, search ”cmd” in your windows search bar (bottom left).

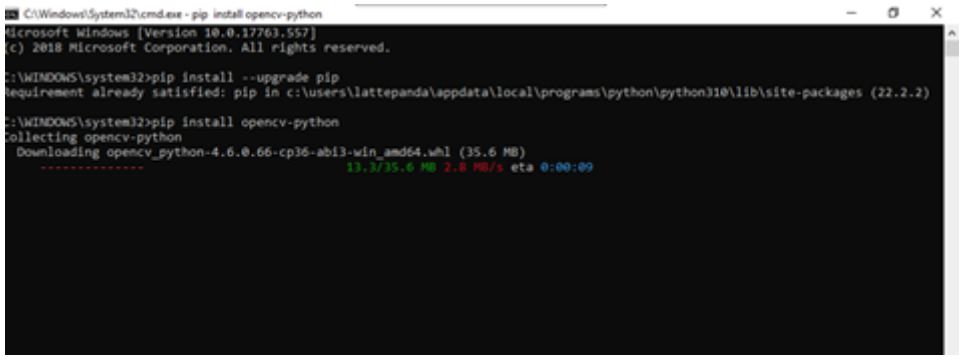
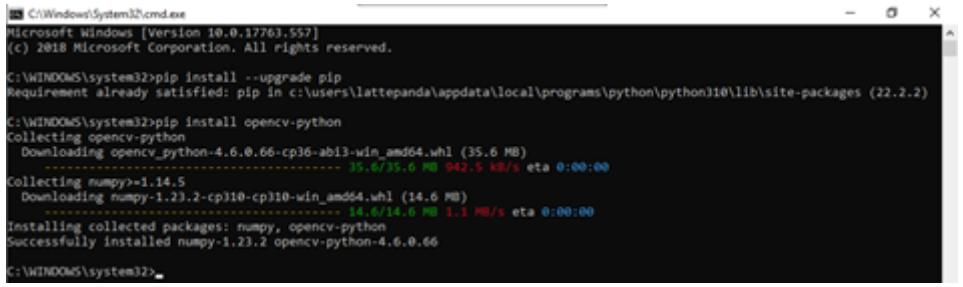


Figure 5.4: To save time, you can copy and paste the command in this document straight into the cmd prompt if you are VNC’ing into the LattePanda, or working directly on it. Install all of the prompt commands.



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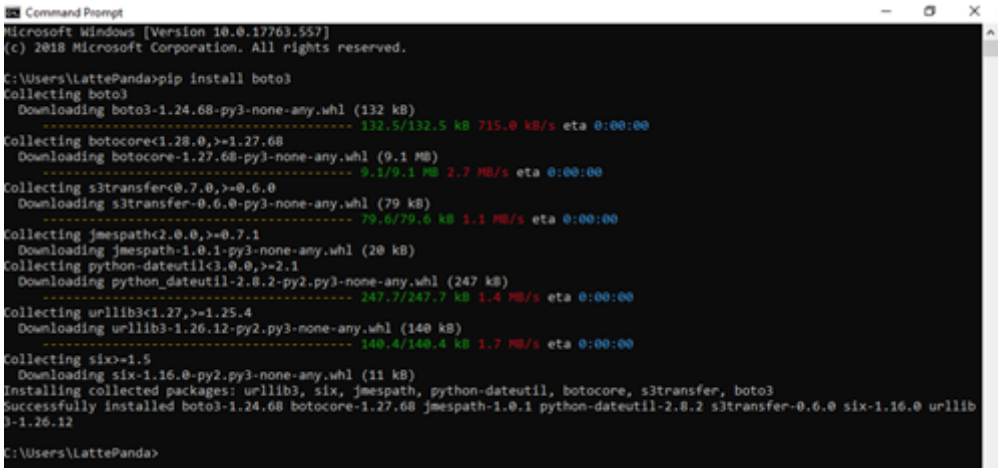

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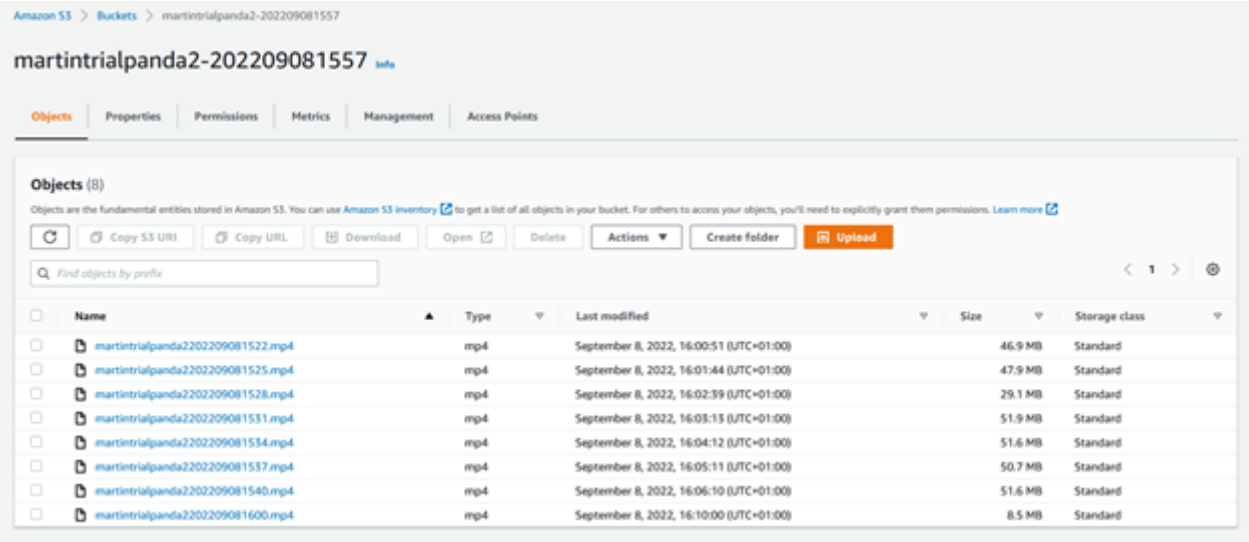

Figure 5.7: This is an example of what your AWS will look like after the script has captured and uploaded the data.

Chapter 6 Miscellaneous

6.1 Mobile Internet

This is pretty simple, using the dongle, insert your mobile sim into the dongle and plug it straight in to the USB. Click on my computer and open up the dongle, it might come up as a CD drive. Double click on auto run and set up the dongle. It should open up a browser and will allow you to connect with a valid sim card. See figure 6.1

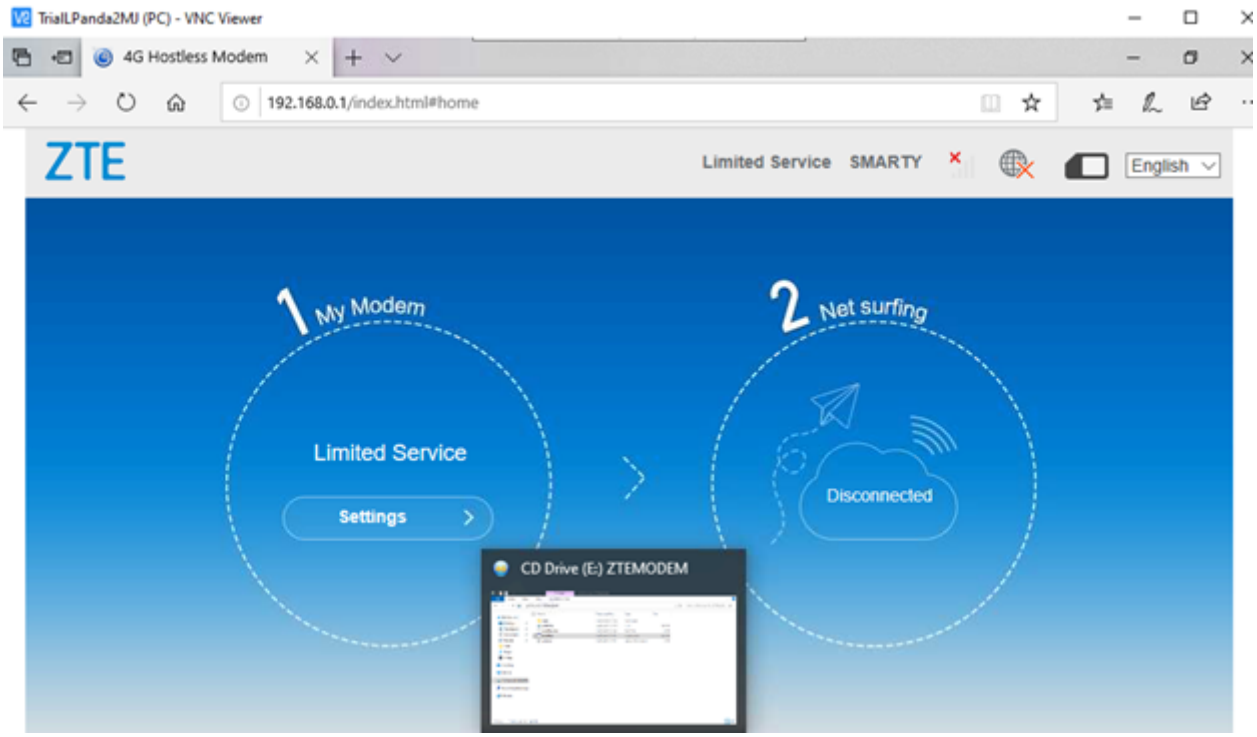

Figure 6.1: Dongle homepage may look different when a full working sim is inserted, but a lot of it is autonomous.

Chapter 7 Hardware Considerations

Some of the site set-up can be generic, but a lot of it has to be site specific (e.g. distance of camera from surface). Generic points to look for where possible are:

1. Camera as close to surface as possible while still capturing full cross-section AND able to cope with rising stages (bank to bank at full flow).
2. Camera angle as close to vertical (nadir) as possible.
3. GCPs easily distinguishable in camera view
4. Wherever the camera is to be mounted, make it easy for yourself regarding accessibility.
5. Where battery powered, ensure solar panels are efficiently used and away from vandalism.
6. Weatherproof boxing the Lattepanda is important, even if stationed inside. It keeps it away from dust, moisture, and keeps it warmer to avoid power loss from cold.
7. Mobile connectivity needs to be good. Some mobile dongles allow for an antenna to be added where needed.
8. Mains power is much more simple and reliable, but battery powered with these boards and camera should also be fine. Bigger the better regarding battery and solar size.
9. Be sure to wrap all connectors well with tape to ensure waterproofing, especially the Ethernet cable to the camera.
10. Some of the easier sites use scaffolding frame set-ups to allow easy maneuvering of the camera, and allow extension past where a ladder can go.
11. Where a viewpoint is too far away, if it is easier than moving the site completely, get a different camera that either has a variable mechanised lens, or a fixed larger lens.

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Chapter 8 GCPs

A GCP is a Ground Control Point that we use to locate points on an image so we can get relative distances. IV works by transferring distances on an image to real world distances, and measuring the distance that a point has travelled over a certain time (usually frame to frame). Put simply, GCPs need to be points that we survey in the field, but is also in view of the camera, so that later on, we can tell the software what the location of certain points are. For best practice, you need a minimum of EIGHT GCPs in the field of view. These can be naturally occurring and easy to locate, or you can place them artificially. Checkerboard stickers are ideal for this sort of thing, that you can stick to a surface and easily see the mid point on survey equipment, as well as on the camera.

1. Lay out a minimum of 8 GCPs or pick points that are clearly distinguishable on both a survey, and the cameras region of view. This can be the corner of buildings, joints in walls, bottoms of fence posts etc.
2. Double check that all your GCPs are clearly visible by the camera and will remain in the field of view while carrying out surveying.
3. Survey all the GCPs to a local coordinate system (can be global if wanted).
4. Be sure to survey the camera location too.
5. Take a note of the water level, and survey several points around the water level too. Later, we need to know the stages of the river in the videos, but in terms of our local coordinate system. I.e. If you measure the level on the day of the survey to be X,Y,Z (100,100,10), and the stage is at 2m, then a day that the stage is at 3m, the coordinates would be (100,100,11). We are only really interested in the Z coordinate here though.
6. Side note: If there is a stage board that you can get in view of the camera then sometimes they are really useful. But just be sure to note the stage at time of survey, and the stages Z coordinate in your local system too. Best thing to do is set the stage to match any other stage measurement you have for that site and use that benchmark zero to your local coordinate system zero.
7. The way it can sometimes be done effectively is to use a laser scanner to get a full 3d laser scan of the area so you have a selection of GCPs.
8. Once you have all your points, go to the handbook created previously to see how to edit them for input to software such as KLT-IV and RIVeR.