UFODAS

Unidentified Flying Object Data Acquisition System

Systems for the UFO Data Acquisition Project (UFODAP)

ufodap.com

User Guide

Revised 3-12-24 Version 1.24

RHOlch Systems

***** PRELIMINARY *****

Subject to change without notice

Disclaimer

This document is under active development and as such there may be mistakes and omissions — please watch out for these and report any you find to the developer at team.ufodap@gmail.com.

Contributions of material, suggestions and corrections are welcome.

CONTENTS

INTRODUCTION

This User Manual contains all essential information for the user to make full use of the Unidentified Flying Object Data Acquisition System (UFODAS). This manual includes a description of the system functions and capabilities, contingencies and alternate modes of operation, and step-by-step procedures for system access and use.

Refer to the Quick Start sections for an initial installation and introduction to the “look and feel” of the UFODAS system.

Questions and suggestions for improvements may be made by email to:

rholch@gmail.com

UFODAS systems are the basis for the data collection methodology of the UFO Data Acquisition Project (UFODAP). The UFODAP project is a result of collaboration between the UFO Camera Project and the work of engineer/computer scientist Ron Olch. Mr. Olch had independently developed the concepts of a low-cost optical tracking system beginning in 2014 as his personal research project as a member of the Los Angeles UFO Research Group. In 2016, Wayne Hollenbeck joined the LA group and expressed interest in the work he had accomplished, which was directly in line with the goals of the UFO Camera Project. Subsequently, MUFON OC, which had been funding the project for software development, shifted some of those funds as a research and development grant to Mr. Olch, who has continued the development work that has resulted in the UFO Data Acquisition System (UFODAS).

The technical focus of the UFODAP has been on resolving a portion of this issue by providing methods to recognize, track and photograph anomalous objects while simultaneously collecting data from multiple sensors. While this sort of capability has been investigated and other systems have been built, their design emphasis has not been on such low cost to make practical the kind of significant numbers to be deployed to have a practical impact on Ufology. By “low-cost” we assume a unit cost of perhaps $2500 or less. Thus, over the last eight years significant progress has been made on an Unidentified Flying Object Data Acquisition System (UFODAS) that attempts to address this issue such that hardware and software is available today for initial field trials.

Please see the following web site for more information:

www.ufodap.com

Contact us at:

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ABOUT THE DEVELOPER

UFODAS development was initiated in 2014 by **Ronald Olch** – MS Engineering and Computer Science, UCLA. His resume outlining his extensive background in electronics, software and system design may be found on LinkedIn:

http://www.linkedin.com/pub/ronald-olch/1/8a1/5b

Mr. Olch was a founding member of the Los Angeles UFO Research Group (LAUFORG) which began at UCLA in about 1973 and met every month until 2016. His research interest that motivated the development of UFODAS is scientific data collection to further understanding of UFO/UAP/AAP phenomena.

MISSION CONTROL SOFTWARE CHANGE LOG

V3.11 12 Mar 2024

1. **NEW** – Progress bar is displayed whenever MC is busy, such as during Mission configuration initialization or opening a video stream. This also enables movement of windows and option selections while a Mission is loading.
2. **NEW** – Since Weather, Aircraft and Data shared the Status text display, status messages prior to those displays were lost when returning to Status. Now, the last 50 scrollable status lines are preserved and redisplayed when Status is selected after any other display.
3. Includes MSDAU V3.13 with improvements to joystick user interface and displays. Bootup text now includes software version and IP address. Display changes to selected brightness immediately after selection. Setting brightness to 0 will display the level but display will turn off when selections are exited.
4. Revised internet availability warning to occur the first time connectivity is checked and again if the internet had become available and then was lost. Checking is repeated every five minutes.
5. Re-wrote portion of Aircraft data process for improved reliability and error processing.
6. Added a progress bar (indeterminate type) to indicate wait time for some processes.
7. MSDAU – Fixed joystick selections, disabled moving box display when in select.
8. Corrected function of Enable Test Mode in Setup. Allows computation and display of triangulation between two OTDAUs/cameras without actual target tracking. Used to visualize and test camera setup and triangulation prior to actual target acquisition. If the green direction lines cross, and the geolocation of the intersection is within bounds, and the system is in Run mode, then triangulation data will appear.
9. Various bug fixes and changes to enhance reliability, tolerance for error conditions and notifications.
10. **NOTE** – For OTDAU-MC addressing for pccam1, please use port 51200 instead of 51000 for improved reliability. Be sure to change the port number in the MC Sensors > OTDAU form as well as in any associated OTDAU System configuration.

V3.10 1 Jan 2024

11. TCP/IP Client bug fix for error conditions. Missions should load correctly for all combinations of DAUs.
12. Minor corrections for smoother openings of various combinations of Sensors.
13. Corrected bug that prevented video and data recording. Corrected recording termination indication after triggered recording ends.
14. Implemented logic so recording will be terminated when MC is Stopped, regardless of OTDAU/MSDAU trigger status.
15. After above corrections, verified recording during triangulation. **NOTE**: Trigger indications and triangulation calculations and display will occur with/without recording enabled. Recording is extended by two seconds beyond loss of tracking or triangulation for continuous recording through dropouts.
16. Corrected recording of tele frames – This option will record jpg frames at camera resolution except Tracking frames at their computed size. The source for the frames will be the selected Auxiliary Video Display selection.
17. Added fault messages for incorrect Mission display syntax or type of display not matching the type of DAU.
18. Corrected MSDAU data file writes and format. Added data sample write interval selection to limit data file size. Writes one sample of MSDAU data per this interval – Note that the rate that the MSDAU collects the data and sends it to the MC may be higher. This period applies to all MSDAU data including RF data.
19. Corrected composite trigger conditions for starting recording: Any condition will start recording (if recording enabled and system in Run); Recording stops when there is no trigger condition for more than two seconds. This allows continuity of recording through intermittent triggers.
20. Selecting the Aircraft display and map markers may not provide any data due to OpenSky Network overhauling their whole site front and backend in the next few months. It should work again once they have completed their changes. Selecting Aircraft provides a notification on the first line of the display if no data is available.

Prior release notes are listed in earlier versions of this document.

OTDAU SOFTWARE CHANGE LOG

V2.24 12 Mar 2024

1. **NEW** – The optical spectrum feature has been fully implemented. At present, you would need to provide your own blazed grating, mounted in front of a camera lens. The grating must be rotated such that the spectral line resulting from a point-like light source is horizontal and on the left of the point. The Spectrum selections have been relocated from the Setup menu to under the Analytics tab. For spectrum generation, go to the new Spectral Analysis menu, enable spectrum capture and select nanometers or angstroms for the wavelength unit display. Running the System configuration will cause continuous spectrum capture and plot generation. Select Spectrum for the Auxiliary Video Display to see spectrum plots. You can record both a video of that display as well as a CSV table of peak wavelength/intensity values via the Spectrum selection in the Recording Options menu. The time between recorded sets of peaks is governed by the Data Interval setting.
2. **NEW** – Progress bar is displayed whenever OTDAU is busy, such as during System configuration initialization or opening a video stream. This also enables movement of windows and option selections while a System configuration is loading.
3. **NEW** – Your LAN (router or gateway) address is detected and presented each time the Camera Configuration page is displayed. This value is helpful to check that the camera's IP address (if not port-forwarded) must be in the same LAN, that is, have the same first three octets. For example, 192.168.1.x.
4. Corrected Configuration Assistant type extension for fixed cameras.
5. Upon starting OTDAU, an initial C:\OTDAU\AnalyticsConfig.txt file is created with default data if it does not exist. Eliminated errors caused by initial file read without correct file.
6. Corrected behavior of AZ and El values for PTZ cameras when using Pan and Tilt offsets. Home position is set when Pan and Tilt offset enable is saved. Angle corrected for AZ below 0 degrees gives a value below 360 degrees. EL angle after setting offset goes to 0.0, increases up and decreases down to negative angles.
7. Correct operation of CCA for fixed cameras.
8. If OTDAU will not start and gets errors starting with "Traceback…" then you may not have the latest compatible version of Microsoft Visual C++ Redistributable for Visual Studio 2022. You can get the latest one here: https://learn.microsoft.com/en-us/cpp/windows/latest-supported-vc-redist?view=msvc-170 or

https://visualstudio.microsoft.com/downloads/#microsoft-visual-c-redistributable-for-visual-studio-2022

9. Updated PTZ camera pan search value in the CCA from 90 to 45 to allow for correct selection for some cameras, such as the older 50A230.
10. Revised zoom control during tracking to include proper check for maximum allowed zoom.
11. Corrected a bug that caused an error, stopping the code, when tracking begins within a circular bounding box.
12. Improved performance and verified operation for any of the three tracking options, whether using a rectangular or circular bounding box.
13. When using a fixed camera and a target is being tracked, it will continue to be so even when it leaves the area of the scene within the original bounding box.
14. Defaulted font size used for Path display to a minimum of 5 when selected font size is less than 5.
15. Due to the slow rate of acquisition of position status from IP PTZ cameras, pan and tilt values are computed (“smoothed”) by interpolation between the last and next actual values read from the camera. Corrected the computation of the increment value for pan resulting in smoother transitions between interpolated values.
16. Corrected a problem where a slaved camera would not stop continuous motion when the master did.
17. Revised so that all PTZ devices return to their last, saved home positions upon loading a System configuration.
18. Various bug fixes and changes to enhance reliability, tolerance for error conditions and notifications.
19. Revised the ONVIF driver and the CCA to accommodate cameras that do not fully support all ONVIF protocol such that they may still function for fixed-lens only use or because they have motorized zoom but not pan and tilt.

V2.23 1 Jan 2024

1. **NEW:** PTZ Camera Configuration Assistant – Allows the possible use of cameras that are not on the documented support list. To operate an ONVIF cameras with pan/tilt, OTDAU must convert degrees to a number between -1 and +1 for both position sensing and absolute position control. Since there is no ONVIF standard for these conversion equations, typically, they must be derived from testing using a sample camera. The new Configuration Assistant provides a means to determine the correct conversion equations for many cameras by a guided, semi-automatic procedure: Open an existing Camera Configuration or just a blank Configuration window. Enter the camera's IP, Port, User and Password. Click Assisted Configuration – the Assistant will open. Follow the Status message directions – For Step 1, Click Test ONVIF connectivity. If the camera is accessible and ONVIF-compliant, its RTSP URL, Manufacturer and other information will be discovered and shown. The URL will be used to open its video stream on the Aux display. Enter its maximum zoom value in Step 2 and then follow the directions in Step 3. You can click Next as many times as needed; repeating tests as required to find the 1 of 9 best control algorithm. When The camera video shows the correct position, click Accept. The Assistant now automatically tests each of 9 possible status algorithms and finds the correct one. Note that more than one combination of calcs may work. Then click Transfer to rename the Camera type in the opened Camera configuration to incorporate the discovered control and status equations. Now fill in the camera's maximum zoom (not discoverable) and then Save or Save As the completed configuration. The Camera configuration should now be usable in a System configuration. Note that prior Camera type names, such as "Dahua 42212" are also still usable and are converted to the new format via internal table lookup. The Assistant will work for PTZ, Z-only or non-PTZ cameras, indicating the type in the Motion control box.
2. **NEW:** Reduced PC CPU overhead, increased FPS rate and eliminated write frame dropouts at high resolutions and/or higher frame rates when playing and recording video files – For example, System config loaded but not running (using on i9 CPU):
   For ASC camera at 4000x3000: uses 20% CPU and can run at 21FPS with ASC set to 24PFS and no write frame dropouts.
   For N65CL5Z camera at 3072x1728: uses 15% CPU and can run at 25FPS with camera set to 25FPS and no write frame dropouts.
3. Corrected camera reservation process so that a PTZ camera is reserved when a System configuration is Run and returned to Available when Stopped.
4. Recommend use of the XVID codec, now supported, for avi files instead of MJPG. This codec is much faster and thus keeps up with higher frame rates at a given resolution much better in conjunction with the following item.

5. Corrected frame write process so that IP camera writes do not skip frames due to the write loop being slower than the frame rate. New frames are queued for writing. If the time it takes to write a frame to disk exceeds the frame rate, then the queue will eventually be full resulting in dropped frames. A new warning Status line indicates that condition. The write time is a function of the frame size and your computer's write speed. You can test for this problem by starting Manual recording (click on Ready to Record) and monitor the track queue messages to verify that the queue length does not keep increasing until it is exceeded. If so, reduce the camera frame rate or resolution. Be sure these are also changed in the Camera configuration. Some examples by camera of maximum frame rates for a given frame size and rate on my system (your results may vary) for no frame drops:
   NK8BR4, 4000x3000 (12MP) set to 25FPS: 21 FPS
   NK8BR4, 2880x2880 (8MP) set to 30FPS: 30 FPS
   N65CL5Z, 3072x1728 (5MP) set to 25FPS: 25 FPS
   42212, 1920x1080 (2MP) set to 30FPS: 30 FPS
6. To provide for the possibility of using IP cameras not previously tested with OTDAU, an internal table, referenced by the Camera type, is no longer used to calculate FOV and provide maximum zoom. Instead, those values, from the camera datasheet, should be manually entered into the Camera configuration.
7. Corrected a problem that sometimes prevented the tracking sound from playing following the initial detection sound.
8. Corrected process that reuses TCP/IP ports that were opened for prior use, during an OTDAU instance, for cameras with the same port number (51000, etc.).
9. An ASC camera is now identified by a horizontal FOV of 360 instead of calculation via an internal table. OTDAU uses this to correctly calculate target angles of ASC cameras and for Handoff control.
10. Found the problem that prevented connection to ONVIF cameras that cannot disable ONVIF Authentication or Authentication is enabled: This problem will not occur if the camera Time Zone and Current Time exactly match that of your PC (use Sync PC to set time). For Dahua cameras, go to System > General > Date & Time to set the Time Zone and Current Time. Correct connection will be made if the time is synchronized or Authentication is turned off.
11. Made System Options such as those in Setup Display operational as soon as they are Saved.
12. Expanded size of Password field in Validation to accommodate longer passwords.
13. Corrected recording indicator so that RECORDING will not display unless a System configuration has been opened and loaded.
14. Corrected bug in Validation that prevented changes to validation information when the IP field is 'USB'. Allows easier change to using an IP camera after initial validation for USB or Test.

15. Improved simulation tools: Linear option moves in a racetrack pattern. New option of small, central motion of the simulation dot, useful for checking operation of the Tracking Min time parameter. New slider to select the size of the simulator dot, useful for checking operation of the Tracking Min and Max size parameters. **TIP**: You can see how the Path color option works by setting Recording Aux Video to Path and using a narrow bounding box – This causes loss of tracking on the left and right sides of the box so that the target will be reacquired in the box resulting in a change of path color and number.
16. **TIP**: If you see a very large tracking box after initial target tracking, increase the Tracking Delta threshold to eliminate background noise and limit tracking to the desired target. Use the Aux Tracking display to visualize the effect.
17. Improved functionality of the Min time Tracking parameter. Internally, uses frame counts to determine tracking period to better deal with differences in frame rates. Should now more predictively filter out fast objects such as birds.
18. **TIP**: Small, jagged parts of the Path line may be due to short-term areas of the track with detectable contours. Increase the Tracking Delta threshold to reduce this effect.
19. **Audio recording** – All selections now function correctly. In addition to the Primary and Auxiliary Options, you can record audio during a tracking event (or manually). Recording may be from an IP camera with a microphone or from a USB mic or webcam mic. Recordings may be audio alone, resulting in a .mp4 file or combined with video resulting in an .avi file. Number of channels may be selected as well as the audio recording bit rate. Standard rates are: 8, 16, 24, 32, 40, 48, 64, 80, 96, 112, 128, 160, 192, 224, 256, or 320 (add a k after each to get that rate). Any value in this range will work but will be truncated to the closest 1KHz. With your particular computer, if you check the actual file bit rate (using file > Properties > Details) the maximum rate might lower, such as 48kbps even if a higher rate was selected. Note that AV (avi) files are about 3 seconds longer than the tracking period in order to record the full period audio.
20. Corrected operation of Maximum zoom in the System configuration – This value sets the maximum allowed zoom during tracking. Note that the Maximum zoom value in the Camera configuration is the camera's largest possible zoom position.
21. When in Handoff mode and tracking results in a handoff to the Tele camera, the PTZ position data and video frame sent to MC changes from Wide to the Tele camera data.
22. Revised emulated AZ and EL angles for fixed cameras for more useful representation in MC: AZ ranges from (360 – ½ horizontal FOV) to (1/2 horizontal FOV). EL ranges from vertical FOV at the top to 0.0 at the bottom. This is as if the camera was a PTZ type initially pointed North and ½ vertical FOV above the horizon.

23. TCP server configuration for each port is preserved after first use so that when any System configuration is Loaded, either a new server is started if its port had not been used or a previous one corresponding to the required port is reused. This ensures that when an MC Mission is waiting for a particular port, it connects to the correct instance of OTDAU.
24. Revised Analytics to always display the best composite confidence identification from those selected (YOLO, SSD or nighttime).

V2.22 2 Oct 2023

21. Corrected problem where system was not writing the updated config file, including the status of the Recording Enable selection, using Save from the Recording Options window.
22. Added support for Dahua 5A825GANR 4K 25x zoom camera.
23. Added colors and text to validation display button to provide more information on validation status. Increased startup speed due to faster method of Internet connection check.
24. Faster detection of ONVIF connection faults for disconnected or incorrectly addressed cameras.
25. Corrected Dark Mode not displaying when restarted. Reworked generation of C:\SystemOptions.txt – Every parameter in the Setup>Display and Setup>AutoStart menus is now saved in that file.
26. The C:\ConfigFiles folder is checked at startup – The first line is the software version number: If that version is not current, then the folder is emptied to allow for possible changes to config file formats.
27. Corrected camera sharing on-camera identification (‘Available’ or your name).

V2.21 19 Aug 2023

1. Corrected Setup>Display Save so that changes, e.g. to font size, occur immediately (as originally intended).
2. If a pre-detection time has been set and tracking stops and restarts during a run, then the second recording contained the start of the first and jumped to the second. Corrected this by resetting the circular buffer at the end of each recording.
3. Preliminary support for cameras: 'Hanwha PNM-9013', 'Hanwha PNM-9031', 'Hanwha XNP-9300', 'Hanwha XNP-8300' and 'Dahua SD4A425'. More work may be needed for full, correct operation.

V2.20 31 July 2023

4. **NEW**: USB camera video now revised to correctly support all available resolutions including 1920x1080 (if your camera supports that) at full available frame rate and reduced CPU overheard.
5. Corrected Touring files not opening.
6. Added a warning for IP cameras that, due to not being fully ONVIF-compliant, do not support focus status. The camera may work normally after the warning.
7. Corrected system slow-down or stop during IP audio recording when video is included.
8. Corrected Aux Display Telephoto view to retain the last tracked target image after tracking terminates.
9. Rewrote and improved Help menus.
10. Corrected Path generation so that a path is not generated unless there is a tracking event and a path does not arbitrarily start at the end of the last path.
11. Added test video “test-night-flashing-aircraft” to support same-named System configuration. **NOTE**: Difference when tracking by motion vs by motion/template matching.
12. Number of Tour positions reduced from 16 to 12 so that all of the Tour menu is visible when OTDAU is set for a lower resolution (HD) display.

NOTE: Tracking Settings for some provided System configurations may not reflect the best values for the current software. For any System configuration, if you have not already done so, set the Tracking Settings to the Default and adjust, as needed, from there.

V2.19 15 July 2023

1. **NEW**: Setup>Display provides for real-time wide video image rotation to any angle in degrees with a resolution of 0.1 degree. This is particularly helpful to orient an ASC camera image, in conjunction with enabling calibration marks so that the top of the displayed image is a view North. Adjust the image rotation at a time that some identified object (or the rising or setting sun) is viewable and adjusting rotation accordingly. This is helpful for setting up a PTZ camera for Handoff from an ASC – Orient the ASC image and then point the PTZ azimuth North and elevation at 0 degrees.
2. Corrected reading Camera configuration file from C:\OTDAU.
3. Changed folder renamed due to Analysis from Group folder to folder containing the Wide video file that was analyzed. Removed confidence when ID is 'UNKNOWN'.
4. Explain config files and home position…
5. PTZ camera home position no longer saved when Setup selections are saved.
6. Improved response timing accuracy Tracking Min time setting.
7. When a System configuration is selected and loaded the first time, the system will no longer automatically move the camera to a home position of pan=0, tilt=0, zoom=1, because no valid home position would have been established yet. The first time a System configuration is Loaded will set a valid home position. Each time that configuration is Run, a new home position will be saved and used subsequently for homing after Load and at the end of any Run process. Reopening a closed configuration restores the last saved home position. Any position offsets are retained through this process.
8. Improved timing performance and descriptions in Tracking Settings for Min time, Max time and Event interval. Simplified timing selections by eliminated Start interval as unnecessary.
9. Revised to write the composite path jpg file to the Group folder that contains the numbered folders for all tracking sequences for which paths were recorded.
10. Corrected the process that retains user-created configuration files. When OTDAU loads and if there is no C:\OTDAU\ConfigFiles folder, then it creates one and copies all of the System and Camera configuration files from C:\Program Files (x86)\OTDAU to C:\OTDAU\configurations and \cameras. If the ConfigFiles folder does exist, then the only files from Program Files that are copied are those with names that do not exist in C:\OTDAU\configurations and \cameras – In this way, new versions of OTDAU can add new configurations and cameras for anyone's use. Any subsequent loading and changing of System or Camera config files are made to those in the \OTDAU\configurations and \cameras folders. Thus, the user can make any modifications or additions desired and they

will be retained regardless of running OTDAU or new OTDAU version installations.

11. Revised to save the correct home position when Run starts for wide, tele and pan/tilt devices.
12. Corrected file reference for saving Setup options.
13. Made corrections so that the Pan/Tilt Unit feature is fully operational. Added fields to the Pan/Tilt menu to support this. This feature allows use of a pan/tilt head that is not part of a PTZ camera so that any directional sensor, such as an IR camera, radar or microphone could be pointed by an independent PTU. As an example, see the System configuration “usb0-800x600-onvifptu”. This configuration uses the P/T portion of a 42212 camera and a USB camera for video. It emulates a system wherein a USB camera is mounted on a P/T unit. To do this, the Wide and Tele cameras are set to usb0-800x600 and the Pan/Tilt Unit is set to onvif-108. The Pan/Tilt configuration “onvif-108” references an ONVIF-compatible P/T unit that happens to be part of a 42212 camera (the video from the 42212 not being used). Ordinarily, the Pan/Tilt type would refer to a manufacturer’s part number of a PTU so that OTDAU would know how to control it. The Pan/Tilt Driver selection indicates that this PTU can be controlled with ONVIF commands. Future versions may include drivers for other types of PTUs, such as Pelco-P/D. Removed the Enable P/T from System configuration as redundant with the enable in Pan/Tilt configuration.
14. Corrected file name extension during analytics to reflect the highest confidence level (and corresponding ID) found during the run.
15. Limited the number of rows of path indexes to 6 to limit obscuring of paths in display.
16. Added choice of simulated target color (black, white or yellow) to enhance target detection given various camera viewing conditions.
17. Corrected problem with dropped log file entries and added title in the file.
18. Increased the clutter limit to prevent early aborting of good tracks.
19. Improved response speed of manual focus control.
20. Dahua N65CL5Z maximum zoom corrected to 5.0.
21. Corrected AutoStart startup and messages process. Suggest testing using the test-aerobatics configuration.
22. Combined PTZ Control and Tracking Setup menu options to simplify finding desired option.
23. Modified method for initial move to target for more accurate predicted position. Also changed value used for crop increment to 2 times the entered value during the first three tracking events to better capture the target despite imprecise initial moves. Crop increment then returns to the entered value.

24. Improved look and scaling of calibration marks and suppressed other text on Wide display when marks are enabled.
25. Added 2 sec delay after end of tracking to recording termination to better see the last status message and where the target goes afterwards.
26. Any window can be open only once instead of showing multiple duplicate copies if selected again before closing.
27. OTDAU will now signal a triggered condition to MC whenever tracking is in progress, whether or not the OTDAU is recording.

V2.18 2 June 2023

1. **NEW**: You can now specify up to five seconds of camera video prior to a target event to be included in a recording. OTDAU continuously saves video frames in a circular buffer prior to an event. Shown as “Pre-detection recording time” in the Recording menu. This feature only applies to Auxiliary video selections.
2. **NEW**: Center of a Bounding Circle is now set when the left mouse button is depressed. As before, hold the button down while moving the mouse to set the circle size. Release the button and the bound will be saved and displayed.
3. **NEW**: Manual PTZ button to select which of the Wide, Tele or Pan/Tilt devices will be controlled by the PTZ direction, Zoom, Focus and Brightness controls. Makes it easier to setup camera directions when more than one PTZ camera is in use. All combinations of fixed cameras, PTZ cameras and a Pan/Tilt head are supported. (Pan/Tilt driver configurations are TBD.)
4. **NEW**: Alternate tracking method to support “star tracking” or similar targets. If a target is visible prior to Run, then it may be manually designated as the tracked target. In Setup > Tracking there are now three options: Target detection and tracking by motion (the original method), both detection and tracking by template matching and detection to set the template by motion detection but tracking by matching. To use template matching, draw a tight bounding box around the target of interest and then Run. OTDAU will capture the first frame after Run as a template and attempt to identify the same target in all subsequent frames. To use the first or third option, use a larger bounding box, a low value of Tracking > Min events to allow faster recognition of initial target motion and a Crop increment greater than 2. Bounding box, and target location indication are the same as in normal tracking mode. Use with Tracking Settings > Max time set to 0 for long-term tracking. Useful for targets of any speed but particularly for slow-moving such as celestial objects or satellites. See the ISS and jet-clouds test configurations for examples. **NOTE**: Template matching alone does not use any of the non-time Tracking parameters. It may lose lock due to target size and orientation changes. Does not function well if in Handoff mode due to non-specific initial frame crop area. Automatically terminates tracking if quality of match is significantly different than the last successful match.
5. **NEW**: When template matching is enabled, the Wide camera video display shows a thumbnail frame of the template with a SSID (deep learning) assessment of the object ID and, if not UNKNOWN, ID confidence below it. The resulting object class and confidence level are appended to the Wide video filename.
6. **NEW**: The Path display now includes numbers in the upper left corner that correspond to each path. If the Auxiliary Video Option is “Path of target hits” then

these numbers and the paths are randomly color-coded. If recording is enabled the path numbers also correspond to the folder number of each recorded tracking event. If when recording and the system is Stopped, then the last image of all of the overlaid paths is recorded as a …path...jpg file. The path display is cleared the next time that the system is Run. Each …path…avi file shows the path of the target recorded during that time interval preceded by the prior path for reference. **NOTE**: A path is indicated by a series of solid line segments. At the end of the sequence, the path is analyzed for angular divergences which may indicate non-natural target motion.

7. **NEW**: Track path analysis (initial method) – After each tracking sequence has finished, the path of the tracked target is analyzed for non-linear changes (Angular Path, divergence from a straight path). The point(s) of divergence is displayed and saved as a red circle on the track path. The Analytics option to modify the recording Group folder name to include analysis results will append "-AP" to the folder name to indicate any detected angularities. Try it on an example using the test-aerobatics configuration.
8. **NEW**: All data entry fields now provide a cut/copy/paste option – Left click on any field in OTDAU or in Windows, move the mouse to highlight the desired text and then release the button. Then right click on any field and select paste to place the text into the field. Similarly, cut, copy and paste between any OTDAU fields and any Windows text that is clipboard compatible.
9. **NEW**: To preserve user-modified or created configurations between new OTDAU revisions, the System, Camera and PT configuration files are now located in C:\OTDAU. After each installation, these files are copied/merged into the configurations, cameras and positioners folders in C:\OTDAU, updating any with the same name and retaining any with a name not provided in the new Installation. Thus, you no longer need to rename/save custom configurations between new software releases.
10. **NEW**: Option added to Setup for Dark Mode. Enabling this option changes areas on the GUI that are white to your selection of black, gray or red and displays white-on-color text in the Status area.
11. **NEW**: Option added to Setup to force the GUI resolution to a particular size or automatically scale to the computer monitor size.
12. **NEW**: Setup menu divided into four submenus due to their total length becoming too large for smaller screen size selections.
13. **NEW**: Video display text font size controlled by a slider in the Setup > Display menu. Set the slider from 0.0 to 10.0 for relative size control. If set to 0, no overlay text will be displayed. Click Save to immediately see the effect on video overlay text. Value is saved in the configuration file for the currently loaded configuration. All sliders can be adjusted by moving with the mouse or by clicking

on either side of the slider. Holding the mouse down will move the slider in the direction of the mouse.) **NOTE**: Take care not to eliminate text in recorded data that you may later want for identification and analysis.

14. **NEW**: Recording options now include Tele with and without overlay text. This does not affect the Auxiliary Video Display which is controlled by the buttons under the video and, for the Raw Video option, by the Setup > Display > Enable handoff option.
15. **NEW**: Procedure for handing off from an “All Sky Camera” (ASC) to a PTZ camera – Setup > Display > "Enable ASC handoff calibration marks" displays a 0-degree mark on the left center of a fixed camera, Wide image. It also enables the central crosshairs (CFOV) and tracking boxes on the Aux Raw Video display. To set up a PTZ camera for handoff from an ASC, identify an object on the horizon at the 0-degree azimuth mark. Use the Manual PTZ Controls to point the PTZ’s CFOV in the same direction as that object and the PTZ elevation to 0. Enable handoff mode and Run.
16. **NEW**: Definition of Tracking Min time parameter as a period of time instead of a detection count. Simplifies filtering out birds and other fast-moving objects. Tracking Settings now allow Min time of 0 for fast targets, Max time of 0 for no limit to tracking/recording time and Event interval of 0 for no timeout after target detection. Use these alone or in conjunction with the new template matching feature for long-duration tracking of non- or slow-moving targets. **NOTE**: Default settings have been adjusted for better initial testing – Try the defaults first before modification for your situation. Use the Aux Display Telephoto option to see what was rejected, e.g., still image captured of a bird.
17. **NEW**: Support for configuration of Amcrest IP8M-2899 8MP PTZ camera. NOTE: This camera has not been tested with OTDAU and thus is not known to be in full ONFIV compliance or meet environmental specs when mounted lens-up.
18. **NEW**: Support for electronic zoom-only (not pan/tilt) cameras such as the Dahua N65CL5Z. Set “PTZ capable” in the Camera configuration and “Enable Zoom” but not “Enable Pan/Tilt” in the System configuration. **NOTE**: The enable pan/tilt and enable zoom now determine if the system is allowed to operate those functions independently, both for manual control and for tracking.
19. **NEW**: System selection Close button – If the configuration is not running, closes the System configuration without having to use the System menu.
20. **NEW**: OTDAU now supports reading and streaming all of the following file types for A/V files: avi, mp4, mov, flv, wmv and mts (AVCHD).
21. **NEW**: Real-time analytics: Analytics options now available during Run time – Enable analysis and select the type(s) of identifiers desired. Selecting Enable modification of folder names will add the identification to the folder containing collected data each time a tracking sequence ends with Recording enabled. The

threshold, maximum frame and data path have no effect on real-time operation. A thumbnail of the analyzed image will appear in the upper right of the Wide Display along with the identification with the highest confidence. The Analytics option to modify the recording Group folder name to include analysis results will append the real-time results as it does for batch analysis.
NOTE: Using the YOLO identifier no longer requires internet access – The 237MB weights file is now built-in. Identifiers run in the background so that their lower-than-framerate speed does not interfere with tracking.

22. **NEW**: A log file is created in the Group folder when it is created. The file name format is “otdau-logfile-<date>_<time>.txt”. Various messages are written to the log during Run time that may be useful for debugging or data analysis. The file is closed at manual Stop. More types of messages may be added in the future.
23. **NEW**: Record enable options now has three choices – Disable, Enable until Quit and Enable until disabled. The first two, together, operate as before. Use the third option to retain record-enabled when OTDAU is closed and reopened.
24. **NEW**: Setup menus now include an AutoStart option – If AutoStart enabled and a System configuration is selected and saved, then when OTDAU first starts up, that configuration is Loaded and Run. Disable AutoStart to start up normally but retain the selected System configuration. Use with or without the Record until disabled option to automatically start, run and record during tracking just by running OTDAU. Use Windows Task Scheduler or another method of your choice to automatically start OTDAU during Windows startup.
25. **NEW**: All Analytics options are now saved in C:\OTDAU\AnalyticsOptions. Options are saved when the new “Save options” button is clicked and are read and displayed when Analytics is subsequently opened.
26. **NEW**: Target Simulator in Setup > Display options. Select Linear or Circular target path and the simulated target speed. Simulates a real target by adding a small, green dot to the Wide camera that appears to the system as an actual moving object in the camera view. Helpful for system testing, particularly for ASC handoff setup. Not saved with other Display options.
27. Improved menu definitions and operation of Tracking parameters.
28. Corrected Wide display – do not show crop box during handoff tracking.
29. Enhanced control functions with Status box indication of video source preparation shown while, e.g., an IP camera stream is opening.
30. Velocity-predicted target location for initial move shown as a yellow circle.
31. Corrected Telephoto display option to show image from Aux instead of Wide camera when Wide and Aux cameras are not the same.
32. Adjusted tracking response for proper action during initial target capture (predictive move) and abort due to moving into clutter.

33. Changed meaning of System config, Enable Pan/Tilt and Enable Zoom: Setting these allows pan, tilt or zooming during tracking but does not disable pan, tilt or zoom to manually set initial values prior to tracking if not enabled.
34. Corrected tracking process when zoom is greater than 1.0. Can track correctly whether or not P/T or Zoom is enabled in the System configuration.
35. Any changes to System or Camera configurations are now effective without having to close and reopen the configuration.
36. Camera home position is saved when Run is started. Camera moves back to Home position, with or without offsets enabled, when 1) A system configuration that uses it is Loaded, 2) When a tracking Run is started or 3) When tracking is restarted after a target is lost.
37. PID tracking has been further enhanced – proportional, integral and derivative portions all function. Parameters may need to be adjusted as before – try kp ~6.0, ki ~ 0.3, kd > 0 if it provides any improvement. Note that kp has the primary effect due to hardware latencies which vary by camera.
38. Due to low rate of camera position status reporting, OTDAU interpolates those values at a higher, emulated rate for more continuous AZ/EL data (esp. for triangulation). Revised this process for smoother data.
39. Corrected operation of Amcrest IP2M-841 camera and adjusted manual control rates. Note that this camera has no focus control. Brightness does work. It is difficult to use this camera for PTZ tracking due to its minimum P/T speed being too high.
40. Corrected host IP detection – prevented connection to MC.
41. Improved speeds of manual PTZ controls for more precise pre-positioning. Increased manual PTZ slew speed.
42. Corrected detection of clutter by compensating for current zoom value.
43. Improved display of wide and tele crop boxes and target designation for circular bounding boxes.
44. Improved frame rate accuracy based on reading FPS parameter from camera.
45. Simplified function of Load upon startup or after System configuration has been closed: 1) If no file has ever been selected, then prompt for initial selection, 2) If one config file exists, open that one, 3) If more than one config file exists, prompt to select which one desired.
46. System parameter “Zoom interval” removed as it was redundant to Camera parameter “Zoom time limit” and not used.
47. Corrected Home position and AZ/EL display during Handoff.
48. Corrected and enhanced Touring functions including correct pausing of Run during tour position changes and added on-screen status.
49. Verified functions of Master-Slave operation. NOTE: Slaves are assumed to be a PTZ camera as the Wide camera device.

50. Corrected Pan/Tilt offsets to not affect non-PTZ cameras.
51. Corrected operation of Master-Slave mode. Setup: 1) Load two or more copies of OTDAU, each with a PTZ camera. Each System configuration should have a different port number such as 51000 and 52000. 2) Run MC and Load a Mission with the corresponding OTDAU sensors, e.g., for the 51000 instance, use ptdau-pc-cam1 and for 52000 use otdau-pc-cam2. In this case, select mission-pccam1-pccam2. 3) For one of the OTDAUs, use Setup > PTZ Control to enable Slave mode. 4) Use manual controls to point the Master camera at a tracking starting point. 5) Use manual controls to point the Slave camera in the same direction as the Master. 6) Now test operation by moving the Master and note that the Slave makes the same move. Home, Zoom and Focus controls should also be mirrored as well as record start/stop.
52. Removed fault messages when a System or Camera file selection dialog is closed without selecting anything.
53. Email sharing option enhanced and includes the Log file as an attachment.
54. The Wide ASC camera view is no longer rectilinearized (flattened) to allow the handoff computation when the system is Run. The full circular view is preserved.

NOTE: Some cameras may provide better tracking performance by using noise reduction by using one of the Backlight Compensation modes, such as BLC, enabled. The 42212 camera, in particular, seems to benefit from this. For Dahua cameras that support this option, it is found in Camera > Conditions > Backlight.

NOTE: Some USB cameras, at some resolutions, may not provide expected frame rates. See your camera's documentation for what resolutions and frame rates are available.

NOTE: Setup for Handoff using a non-ASC fixed camera (or PTZ camera with PTZ disabled), in typical situations where the target is distant – Instead of aligning the crosshairs, use manual motion to initially point the tele camera in the same compass direction as the wide camera. That is, move the tele PTZ camera such that its pan and tilt angles match that of the wide camera. When using a fixed wide camera, move the tele PTZ camera so that its direction of view is parallel to that of the wide camera. Use a larger Crop increment and Event interval than normal.

Prior release notes are listed in earlier versions of this document.

MSDAU HARDWARE AND SOFTWARE CHANGE LOG

V3.1 24 May 2022

1. Supports 1750MHz, 6000MHz SDRs or none.
2. Enhanced data communications protocol with Mission Control.
3. Improved method of MC installing MSDAU firmware and rebooting the MSDAU.
4. The joystick may be used to select display brightness or OFF.
5. Automatically determines local LAN address and uses that with the selected unit address to form the unit IP address for communication with MC.

SYSTEM REQUIREMENTS

Minimum hardware and software required for implementation of an UFODAS system include:

- Windows 10 or 11 OS on a PC Computer with Core i5 processor, 16GB memory and 2GB free disk memory. A faster computer, e.g., an i7 or i9 or with higher speed ratings may provide higher analysis frame rates and thus better tracking of faster targets.

- The PC needs to have installed the current version of Visual C++ Redistributable installs for Microsoft C and C++ (MSVC) runtime libraries. See https://learn.microsoft.com/en-us/cpp/windows/latest-supported-vc-redist?view=msvc-170 to download and install the latest version for your computer.

- Alternatively, MAC OS using a Windows Virtual Machine as described below. Note that this option will provide somewhat slower operation than running on a native PC with a similar processor:

  https://www.howtogeek.com/187359/5-ways-to-run-windows-software-on-a-mac/

- At least one camera interfaced to the PC. The camera may be an internal webcam, external USB camera or any UFODAP supported external IP camera.

Currently supported IP camera manufacturers and model numbers include:

Dahua	DH-SD59A230TN-HNI, 50230UNI-A, 50232XANR, 50432XANR, NK8BR4, N51BD22, N53AB52, N53CB62, N65CL5Z, 49225TNI, 49425TNI, DH-IPC-EBW81242N, DH-SD6AL445XA-HNR-IR
Sony	SNC-RX570N, RZ25N
Hino	IPC7F12-AF, IPC7F12E-AF
Hikvision	DS-2DE4A425IW-DE
Amcrest	IP2M-841, IP8M-2899 (May not be in full ONVIF compliance)
Axis	M3025-VE
Trendnet	TV-IP450P (V1.1R)
Samsung	SNP-3750
Uniview	IPC868ER-VF18-B

Other cameras by the same manufacturers may also be used. Please contact the UFODAS developer to check compatibility or attempt to use any camera not listed. The

OTDAU software also provides a Camera Configuration Assistant feature to semi-automatically discover correct settings for other OVIF-compliant cameras.

Any camera that is certified ONVIF-compatible should work with the UFODAS software. ONVIF (Open Network Video Interface Forum) is an international organization established to promote standardized interfaces for effective interoperability of IP-based physical security products. Camera manufacturers who want to establish the ONVIF compliance of a particular product tests the product using an ONVIF test suite and file a report with ONVIF which then lists the product on its website. Some cameras claim to be ONVIF compliant but may not be if not listed on the ONVIF site:

https://www.onvif.org/conformant-products/

Cameras that are not ONVIF-compliant typically use a manufacturer-specific communication protocol, such as CGI (Common Gateway Interface) to communicate with hosts such as a UFODAS computer. Custom code must be added to UFODAS to support such a camera if not already in place. Currently supported cameras above that operate this method are the Sony and Samsung cameras. To enable the development of this custom code, any new camera proposed for UFODAS use must have available a comprehensive CGI document describing all of its commands. Some CGI command sets do not implement the minimum set of commands necessary for OTDAU control. Such compatibility will be determined during the custom development process.

Note that even cameras that claim to meet the ONVIF specification often do not or do so only partially. Even those that are compliant must be evaluated for correct operation by UFODAS OTDAU software. All of the cameras listed above have been fully qualified and OTDAU software has been designed to work correctly with them.

PURPOSE

It is apparent that timely collection of high-quality optical and electromagnetic scientific data related to UFO events has been difficult to obtain. Individuals who are in the position to potentially record such events often do not have the appropriate equipment at hand. Even MUFON Field Investigators may not have the means to wait for hours, days or longer to capture an event and, at that time, record all necessary data in a verifiable way.

Even when photos or videos are recorded, they often lack verifiable associated meta-data such as the exact location of the camera and sensors, the azimuth and elevation of the where the camera is pointing, time of day, associated electromagnetic and gravitational perturbations at that time and so on. Also, even if a single camera captured such data, the track of an object, its location on or above the Earth and its altitude, could not be ascertained without combining the data of at least two such systems, placed some distance from each other.

The focus of the UFODAS development has been on resolving a portion of this issue by providing methods to recognize, track and photograph anomalous objects while simultaneously collecting data from multiple sensors. While this sort of capability has been investigated and other systems have been built, their design emphasis has not been on such low cost to make practical the kind of significant numbers to be deployed to have a practical impact on Ufology. By “low-cost” we assume a unit cost of perhaps $2000 or less. Thus, over the last five years significant progress has been made on an Unidentified Flying Object Data Acquisition System (UFODAS) that attempts to address this issue.

UFODAS consists of a Windows operating system-based personal computer and options of one or two cameras and other clusters of sensors. In addition, there is software to pull data and video, locally or over the internet, from multiple sensor locations and triangulate target objects. The system supports a wide range of supported cameras including USB webcams up to sophisticated all-weather IP cameras with pan and tilt as well as optical zoom. The software architecture is designed to adapt to most any camera or Pan-Tilt-Zoom (PTZ) mechanism in the future by addition of a single software element, without modification to the main UFODAS software. In dual camera applications, one camera may be a non-PTZ type that views a wide field of interest including all-sky cameras. The second camera would be a PTZ camera directed to point at the object based upon its relative location in the field of view of the wide-angle camera. The PTZ camera then independently tracks the object. Whether using one camera or two, the processor samples frames from the wide-field camera and through some sophisticated image analysis, detects qualified moving objects. It then directs the pan-tilt head to point the telephoto camera at the object and collects images from it. The software can acquire an object of interest and smoothly tracking and zooming a moving object even with a single camera. Maintaining track while moving the camera, which causes the background to also move, was a significant part of the development effort.

The software architecture employed enables support for additional cameras, whether simple or sophisticated, including those with fast PTZ operation, higher resolution or non-visible spectrum devices.

Triangulation of a sighted target object requires accurate azimuth and elevation of the tracking camera. The optional MultiSensor Unit (MSDAU) is an embedded hardware and software subsystem that provides camera GPS coordinates and precise time as well as 3DOF magnetometer and DC accelerometer. The same sensors may be used to sense perturbations in those fields and include that data with a camera-based event or provide the initial trigger for subsequent data collection.

The software also provides several related functions which include:

- When a qualified event is detected, sends an email to a designated address with data that includes attached photos, GPS coordinates of the camera and object azimuth and elevation.
- Saves automatically named photos and videos to folders it creates in local memory.
- A sophisticated Graphical User Interface (GUI) for user-friendly operation.
- Real-time track correlation with data from FlightAware to distinguish unknowns from aircraft.
- Real-time weather conditions local to deployed DAUs.

Ongoing development work includes:

- Additional methods to eliminate false alarms such as birds and aircraft including the use of deep learning methods.
- MSDAU interface for acoustic sensors.
- MSDAU interface for radar data.
- Use of an optical gradient filter to determine target spectrum
- Differential magnetometry to determine target magnetic field strength and direction
- Support for pan-tilt-zoom heads that provide mounts for various cameras or other sensors.
- Support for other types of cameras such as those operating in the Long Wave Infrared (LWIR) portion of the spectrum.
- Support for DSLR camera shutter control.

The UFODAS system architecture provides for an extremely broad set of configuration options to meet the goal of providing systems for every budget and type of case. UFODAS architectural components consist of:

- Mission Control (MC) GUI-controlled software. MC interfaces with other elements via the Internet to bring together, in one location, data from up to six Data Acquisition Units (DAUs). DAUs may be any combination of OTDAUs or MSDAUs.

- Optical Tracking Data Acquisition Unit (OTDAU). An OTDAU includes a GUI-controlled software element that provides an interface to many types of cameras for optical target acquisition, tracking and video storage. An OTDAU can either stand-alone or work with MC. Two OTDAUs and an MC form a comprehensive solution to tracking with triangulation and both OTDAU and MC local data storage.

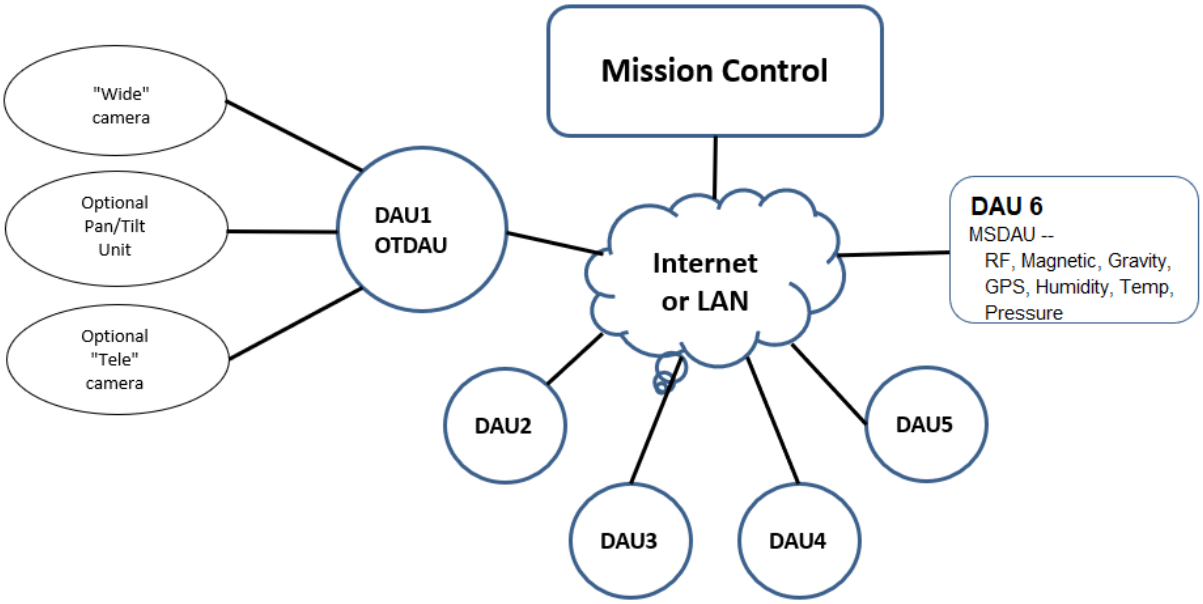
- MultiSensor Data Acquisition Unit (MSDAU). An MSDAU consists of an all-environment enclosure with an embedded Raspberry Pi computer interfaced to nine different sensors including GPS, magnetometer, DC accelerometer, AC accelerometer, temperature and pressure. An MSDAU communicates with an MC over the Internet to provide all of this data in real-time. An MSDAU may also transmit data from other USB-interfaced sensors such as a Trifield meter.

- All cameras and the MSDAU may be either tripod or wall/poll mounted. Each unit is powered by and communicates data via a single Ethernet. An MC may be configured to use a co-located MSDAU data to locate the camera and collect multi-sensor data simultaneous with tracking events.

All collected data is initially stored on the computer running OTDAU or MC software. The MSDAU does not store any data. All MSDAU data is stored on the computer running the MC software that is communicating with the MSDAU. All data is available to the user to store or send by any common method such as uploads to cloud data storage, email attachment or remote access via remote PC control software.

UFODAS cameras, the MSDAU, OTDAU and MC software as well as numerous installation and support options are available via the UFPDAP website. Several cameras are offered, each with unique capabilities and price levels ranging from a fixed lens, wide-angle unit, an All-Sky 360-degree camera to 12x and 32x PTZ models. OTDAU software allows the use of each type alone or in combination.

The figure below illustrates a high-level view of the UFODAS architecture. A DAU is either an OTDAU with one or two cameras or an MSDAU.



OTDAU also supports various motorized Pan/Tilt units which can carry sensors that have no PT capability on their own such as an IR or thermal camera, directional microphone or a radar antenna.

OTDAU and MC software may be run on a computer local to cameras and MSDAUs, connecting to them directly or via a router. In this case, the computer, camera(s) and MSDAU(s) each connect to the same router. All of these devices would be on the same Local Area Network (LAN).

Alternatively, any instance of OTDAU and/or MC could run on a computer remote from any connected camera(s) or MSDAU(s) and communicate with it via the Internet. Typically, the computer would be connected to a router that has an Internet connection. Each camera and MSDAU would gain access to the Internet by a wired or wireless connection to some other router. In this way, the computer(s) would access the cameras and MSDAUs via the Wide Area Network (WAN).

Any combinations of local and remote connections, working together for the same system are feasible. In addition, for systems that use more than one camera, such as for triangulation, each instance of OTDAU software (one per camera) may run on the same computer or separate computers. MC software may run on the same computer as OTDAU or on a different computer. How many computers are used for a particular application will be a matter of convenience and speed which, in turn, depends on connection speeds and camera resolutions and frame rates.

FUNCTIONAL DESCRIPTION

As shown in the configuration diagrams, a UFODAS system can take several forms, from simple to more complex, depending on available resources and data collection requirements.

In its simplest form, such a system may consist of a single PC with a fixed-lens USB camera pointed at a portion of the sky of interest. An object moving into the fixed field of view would be acquired, tracked and recorded. When a moving object enters the portion of the field defined by a bounding box (to reduce false identifications of motion in the background, such as foliage), the bounding box is reduced in size to surround the object and recording begins. The bounding box is made smaller to reduce the likelihood that, as the object moves past structures and foliage, it is less likely that the system will move its attention away from the object first acquired. When the object leaves the field of view, the system stops recording, returns the bounding box to its original location and size and waits again for another moving object. At the end of recording, several factors are used to determine if the object was truly of interest. These factors include the length of the capture sequence (very short may be due to birds, for instance) and image recognition of the object, such as an aircraft.

In a more capable configuration, a Pan/Tilt/Zoom (PTZ) IP camera is used. In this case, a similar acquisition sequence occurs except the system attempts to move the camera to keep the detected object in the center of the field of view (CFOV) so that zooming into the image will not send it out of frame. Zooming is incremental with a timeout between zooms to allow the system to bring the error distance from the object position to CFOV to below a set value. Again, the object will be continuously tracked and possibly zoomed into for as long as it remains visible.

At the end of each tracking sequence, data may optionally be sent via an email to up to three designated email addresses indicating that an event occurred, basic meta-data including time, location and system configuration as well as attached video or still frames of the event.

Triangulation is accomplished by combining the azimuth and elevation from two cameras tracking the same object. For this to be reasonably accurate, the location of each camera must be known. The system can determine the geolocation of each DAU from a street address entered as part of its configuration. Alternately, an MSDAU can provide GPS location and accurate time. All that data is combined with the camera video and meta-data and included in the recording/upload. The magnetometer and accelerometer data can also be monitored for unusual disturbances prior to or during a video recording sequence. Such a disturbance may result in recording independent of or combined with camera data if a moving object is detected at the same time.

All functionality is set up and controlled by the MC and OTDAU Graphical User Interfaces (GUIs). These user interfaces are detailed in the following sections of this Guide.

A UFODAS system can take many forms to suit a particular user's needs. As illustrated below, it may consist of just the OTDAU software with one or two cameras. It may also include an MC communicating with any combination of up to six OTDAUs and MSDAUs. IP cameras and MSDAUs may be combined or separate and communicate with either a local computer on a LAN at the same location or to distant computers over the Internet.

Thus, a field investigator may only be responsible for installing a camera and/or MSDAU with power and an internet connection while the data those devices provide may be sampled by a computer at a distant researcher site.

Alternately, all the data acquisition equipment as well as the computer(s) running the OTDAU and MC software may be at the same site, communicating via a LAN on a single router.

Given the nature of IP connected devices, more than one computer can simultaneously monitor a video stream from one camera. Thus, a system may be constructed wherein a camera obtains PTZ control and data storage on one computer while several others monitor its video stream via OTDAU or another application such as Internet Explorer browser or the VLC video display software.

HARDWARE CONFIGURATION OPTIONS

The UFODAS system architecture allows for many combinations of hardware and software to meet various data collection requirements and user budgets. Some of these configurations are illustrated in the diagrams below.

The most basic system would be just a PC computer running the OTDAU software with input from a USB webcam or a low-cost home-monitoring type of pan-tilt or PTZ camera. The camera may communicate with the computer via hardwire connection to the user's router or by WiFi.

A somewhat more sophisticated system might upgrade the camera to a security system quality PTZ camera with or without optical zoom. A hardwired Ethernet interface to a router is typical in this case. Camera power may be provided by an AC power supply or by a Power over Ethernet (PoE) Injector.

Note that, in contrast with other object recording systems that depend on higher-resolution cameras to detect object details, the OTDAU utilizes the combination of continuous tracking and optical zooming to optimize the number of sensor pixels used to image an object. Thus, for example, an object might occupy 100x100 pixels in a 4000x3000 pixel fixed-field image using a high-cost camera. The same object could be recorded in approximately 1400x1080 pixels in a typical 1080P (1920x1080) image. The UFODAS/OTDAU concept thus greatly improves on image quality as well as lowering system cost.

A single OTDAU computer may also use two cameras. One might be, for example, a USB fixed-field camera and the other a PTZ camera. In this configuration, an object detected with the fixed-field camera is used to direct the PTZ camera to point at in the general direction of the object. The PTZ camera then begins its own search for the object, detects it and then continuously tracks and zooms. In another mode, the PTZ camera's direction is continuously updated according to the object location in the FOV of the fixed camera These two-camera modes are particularly effective when the fixed-field camera has an especially wide field of view, such as one with 360-degree optics (also known as a panoramic or "all-sky" camera).

The next stage of UFODAS system implementation may utilize two of the above OTDAU/camera systems and add the Mission Control (MC) software. In this configuration, one can monitor both OTDAUs and, when they both signal acquisition of a tracked target, continuously compute and record the triangulated geographic position and altitude of that target as it moves with respect to both camera systems.

The MC software can monitor and record data from up to six Data Acquisition Units (DAUs). DAUs may be OTDAUs for optical tracking but may also be MultiSensor DAUs (MSDAUs). Any combination of OTDAUs and MSDAUs may be locally (via LAN) or remotely (via the WAN or Internet) monitored and recorded by an MC.

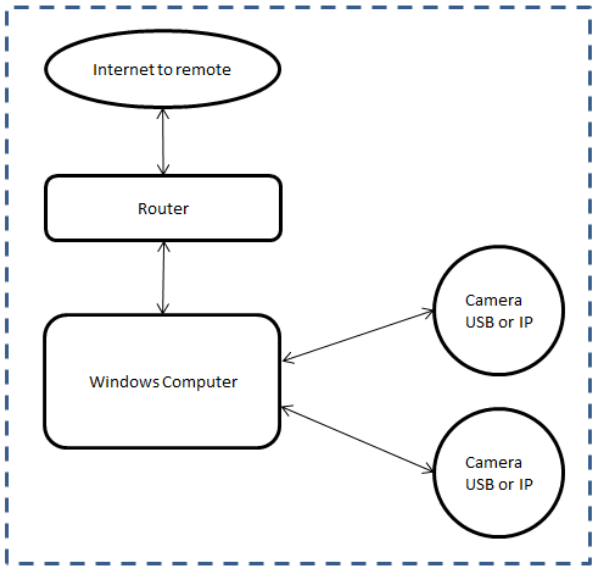
Physical mounting of PTZ cameras may be accomplished in several ways depending on the available installation environment. A camera may be mounted by means of standard hardware provided by the camera manufacturer to a wall or pole. If the installation must be temporary or its position often changed, then an environmentally protected tripod mount for such a camera is available. The MSDAU alone may be tripod mounted or use Dahua standard mounting hardware for wall or pole mounting. The same mounting options are available for an MSDAU that includes a camera collocated on the same mounting adapter plate assembly.

Note that when configuring a data collection system, one can run more than one copy of OTDAU on a single computer and/or combine one or more OTDAUs with MC on a single computer. The limit to this is a function of the speed and memory of the PC, the number of such processes and the video resolution of the configured cameras. Some individual experimentation may be required to determine if the processing power of a particular combination will be sufficient for a user's application.

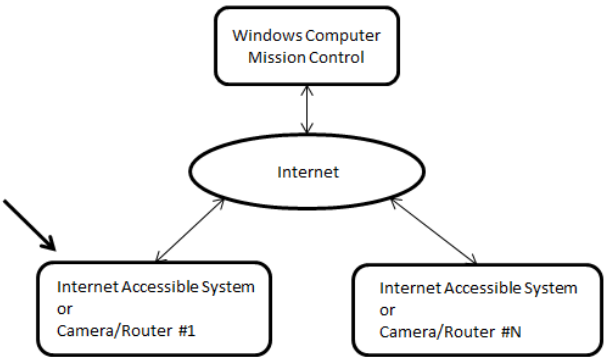
Please see the ufodap.com website for the latest hardware, options and systems offered on the UFODAP Shop, accessed via the home page. The R&D section of ufodap.com also provides a look at what capabilities may be offered in the future.

Internet Accessible, single (or dual) camera

Triangulation feasible if cameras widely spaced

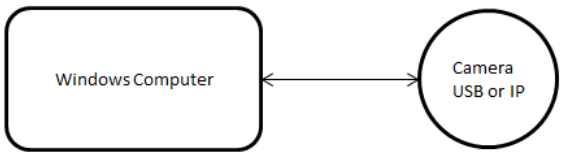


Wide-Area system suitable for triangulation and data analysis

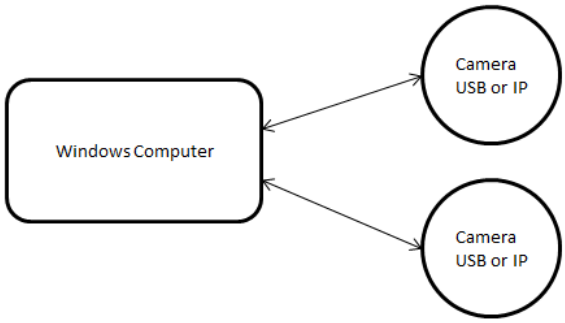


NOTE: "Camera USB or IP" may also include a Multi-Sensor Unit combined on a single Ethernet cable.

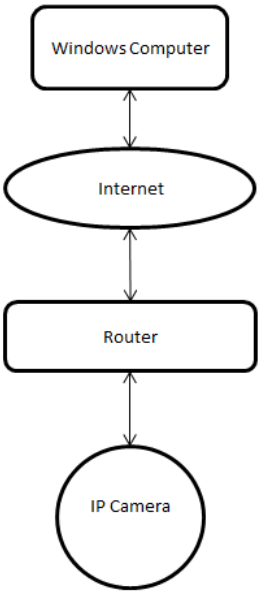
Standalone data collection



Standalone, dual cameras (e.g., wide-angle fixed + telephoto)



Direct connect to internet, remote computation



NOTE: "Camera USB or IP" may also include a Multi-Sensor Unit combined on a single Ethernet cable.
Cameras could be fixed, wide-angel, IP-PTZ, USB or USB from converted composite video, e.g., an all-sky camera

MISSION CONTROL (MC)

INTRODUCTION

The Mission Control (MC) software provides a means to draw together, in one location, data from up to six remote DAUs. If two of those DAUs are OTDAUs then MC can triangulate the location, azimuth and elevation data acquired from those DAUs to provide a real-time view of the geolocation, altitude, size and velocity of an object both DAUs are tracking.

Each DAU could be, in any combination:

- An OTDAU with one or two cameras
- An MSDAU with optional external USB and WiFi connected sensors
- Other types of DAUs which would consist of a version of the Raspberry Pi with its OS and firmware plus internal or external specialized sensors such as radar or acoustic devices.

The MC displays on a single main screen data from all the connected DAUs along with thumbnails of the video from any OTDAUs. It also provides a real-time updated Google Map showing the locations of all DAUs, with camera bearings and triangulation results. Alternately, a real-time, full frame-rate video stream from an OTDAU tracking camera, moving graph of MSDAU data or an MSDAU RF spectrum may be selected to replace the map display. The user can rapidly switch between any of these data sources. Controls are provided to move the center of the map and zoom the map in or out for detailed location analysis.

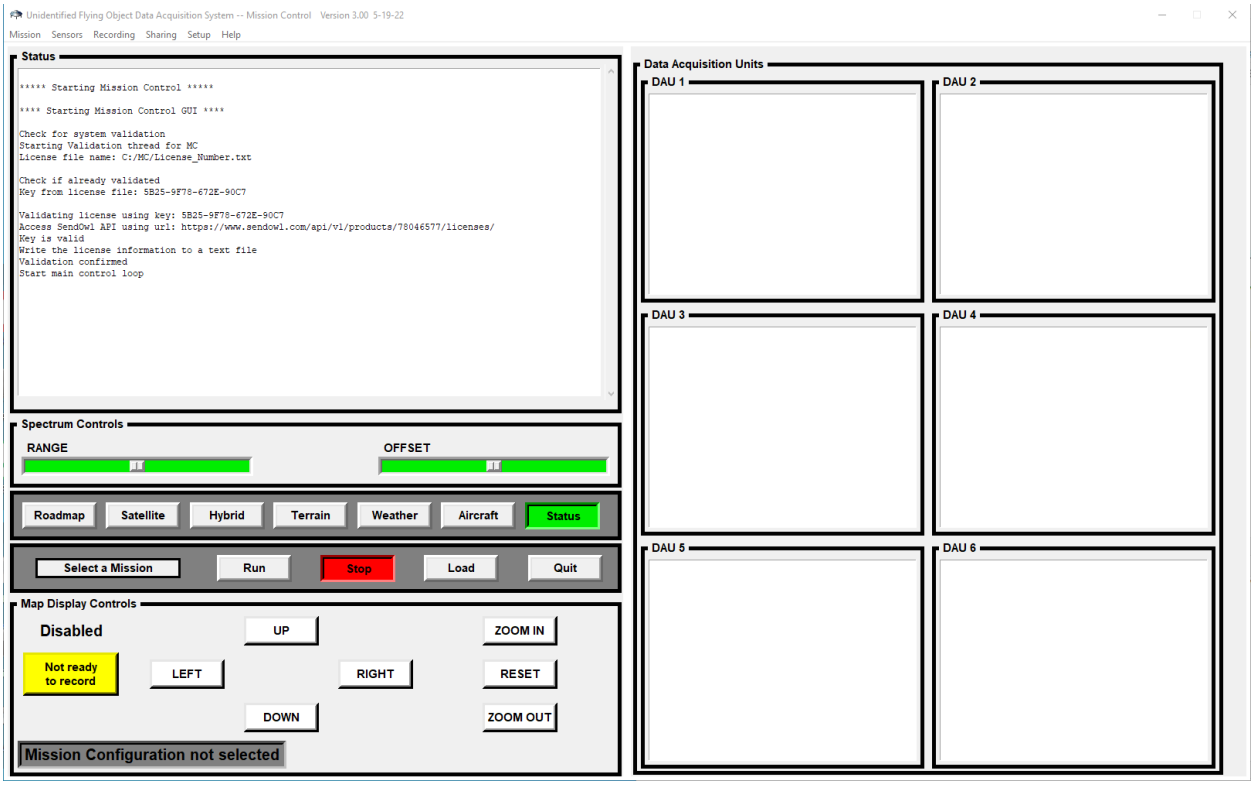
MC also can record to a local disk file all of the continuously collected OTDAU and MSDAU data, the map image and up to two camera feeds. Camera video is saved as avi files while other data is saved as CSV files suitable for input to Excel for analysis.

MC QUICK START GUIDE

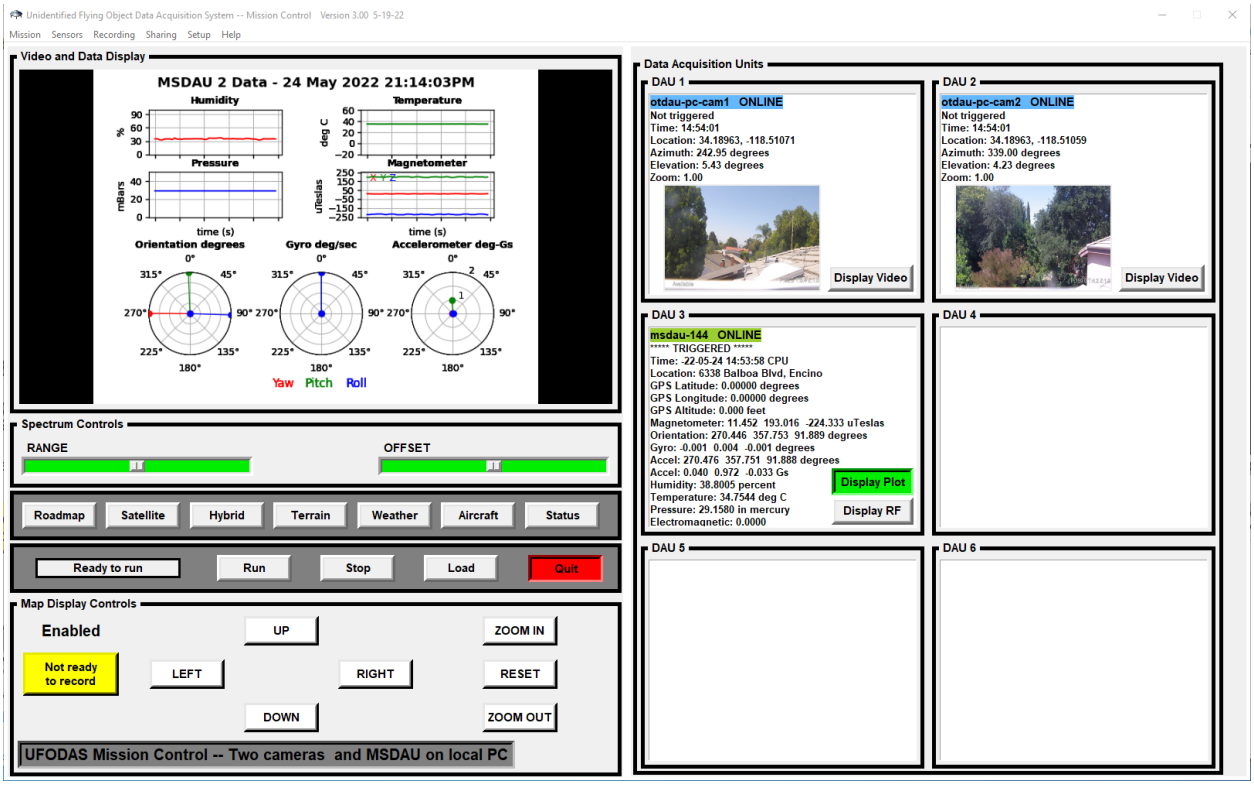
Perform the following steps to setup an MC for a simple mission:

- Open MC by double-clicking on the MC icon on your desktop.
- Click Mission. This will bring up the Mission Configuration form.
- Click on Open to select a previously configured mission.
- Double-click on the desired mission file name, “mission-ms1.json” for example, for a mission with a single MSDAU. The main display status box should now show “Ready to load”.
- Click Close Window. To the right of the status box, click the Load button. Data from the selected DAUs will appear in the Data Acquisition Units display windows. The status box will show “Ready to run”, the Stop button will illuminate. A Google map will appear which shows the location of the DAU.
- Click the Display Plot button to see real-time MSDAU data or click Display RF to see a real-time RF spectrum plot.
- Recording options may be selected at any time after opening the mission configuration file.
- Clicking the Run button would enable any recording options selected if the DAU(s) became triggered.

After initial load:



After selecting Display Plot:

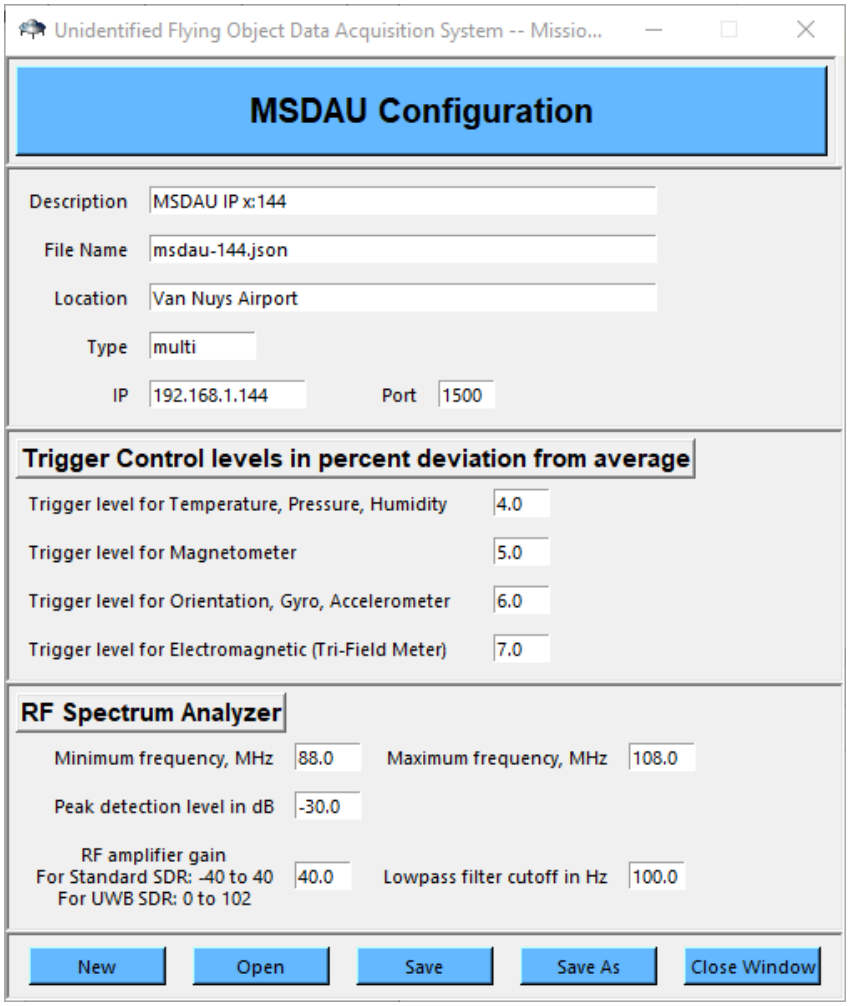


The plot is continuously updated with the following data from the MSDAU:

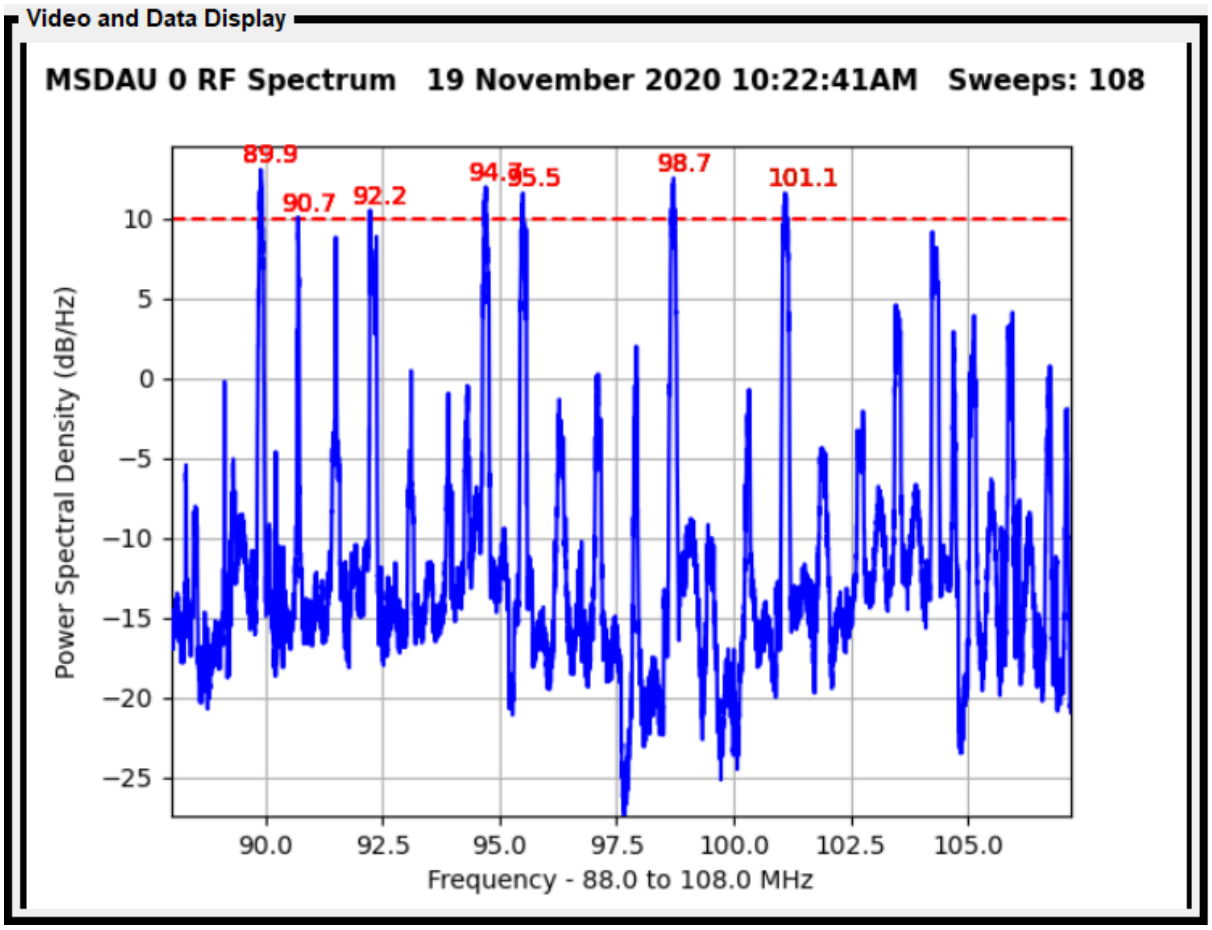
- Relative humidity in %
- Temperature in degrees C – NOTE: This is the internal temperature of the MSDAU useful as a measure of its hardware status and longevity. It is not the outside environmental temperature.
- Pressure in milliBars
- Magnetometer in microTeslas for each of the X, Y and Z directions
- Orientation in degrees of the MSDAU for each axis -- yaw, pitch and roll
- Gyro (AC accelerometer) in degrees/second for each axis -- yaw, pitch and roll
- Accelerometer (DC) in degrees for each axis of yaw, pitch and roll. The length of each of the axis lines indicates acceleration in Gs

After selecting Display RF:

The minimum and maximum frequencies to be swept and the peak detection level are selected in the MSDAU Configuration, as shown below.

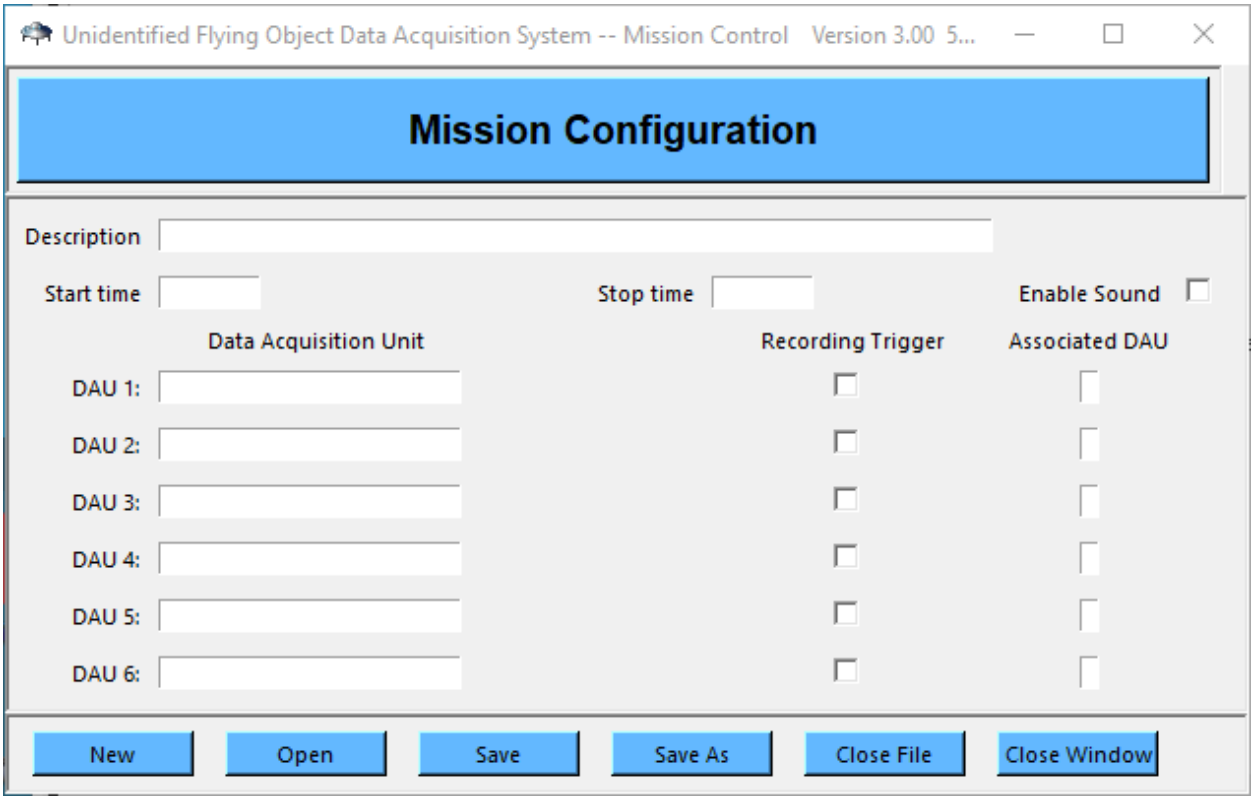


Display with trigger level of -30 dB and anomalous peaks for fmin and fmax that encompasses the entire FM broadcast band:



The peak detection level is a value in dB which is displayed as a dashed red line. Initially, the system makes a number of measurements of the specified RF band and retains that as a background level. Subsequently, if any energy is detected that exceeds that level, then those peak values are highlighted with their specific values displayed in red, as shown above.

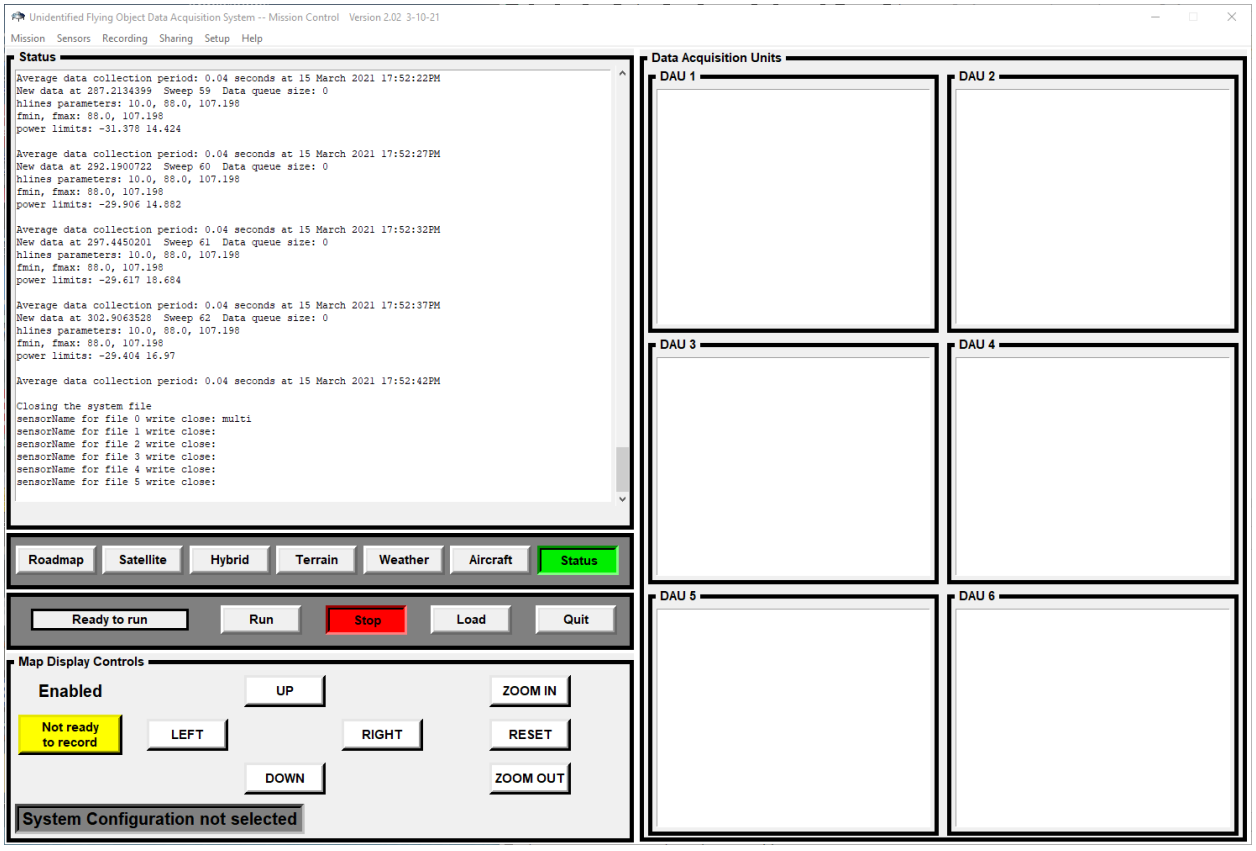
A trigger condition results from any frequency values exceeding the selected peak level during a Run. If an MSDAU is selected to be a Recording Trigger then this trigger condition, as well as for any sensor value above the percent increase selection, causes the system to begin recording all of the data selected to be recorded, as shown in the Mission Configuration below.



MISSION CONTROL MENUS AND DISPLAYS

Operating the Mission Control application requires the user to set up several mission configurations. These configurations are entered from forms selected by the following titles found at the top of the MC main window:

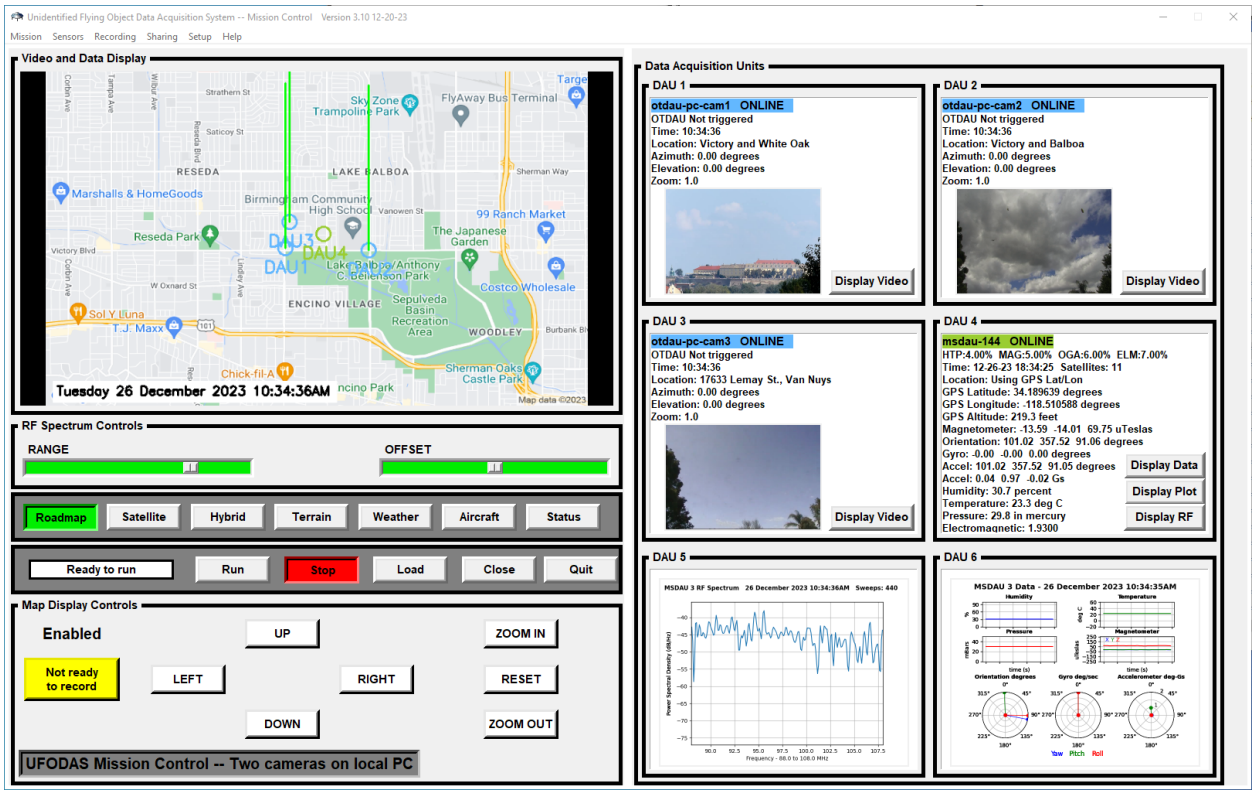
- Mission
- Sensors
- Recording
- Sharing
- Setup
- Help



Mission Control application GUI prior to mission configuration selection.

A default (CGI UFO) photo is shown when the system has not been configured and thus there is nothing to display.

Up to six sensors or Data Acquisition Units (DAUs) are supported per mission configuration.



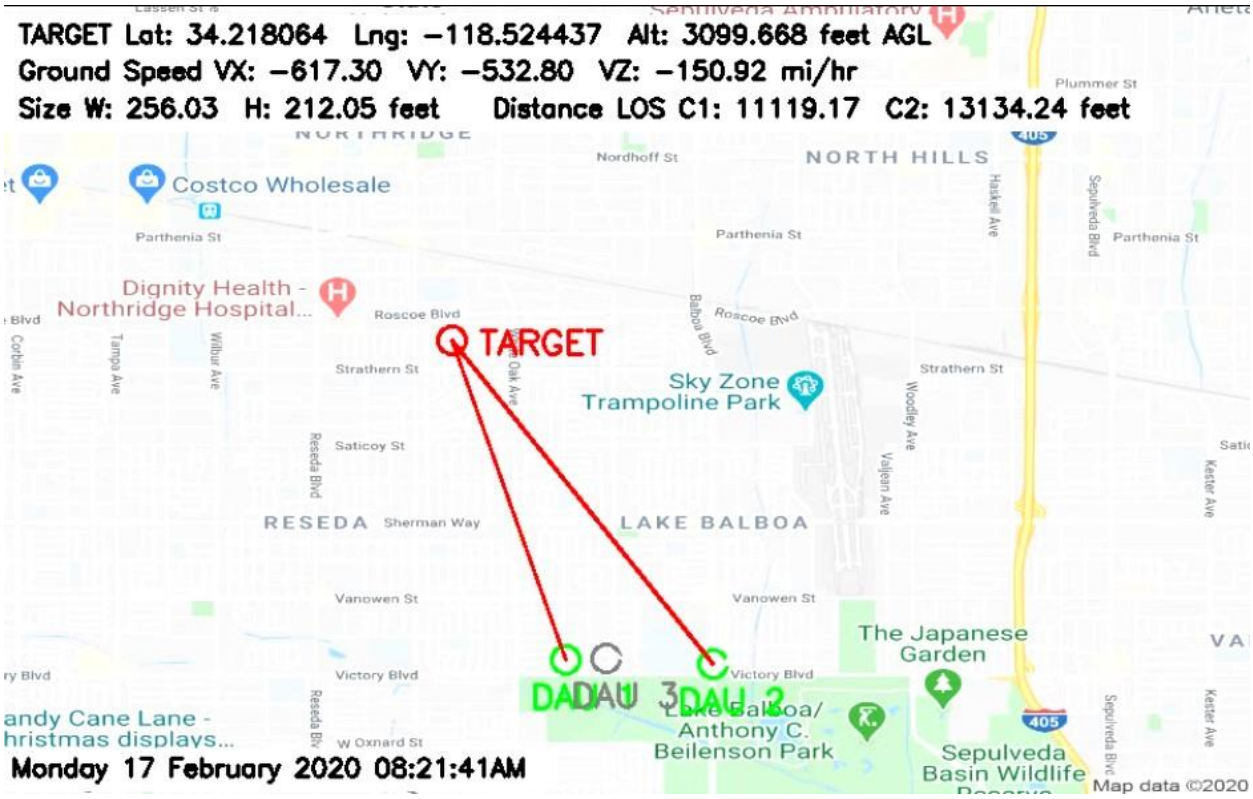
MC after configuration with three PTZ cameras, MSDAU and corresponding Sensor Units with optional additional data displays in unused DAU positions.

Pins on the Google Map are color coded to the associated sensor and show the Sensor number.

The MSDAU is located by GPS because it has sufficient satellites for a fix. Since the Mission configuration did not specify that the location of the cameras (each instance of OTDAU), was not Associated with the the location of the MSDAU. The location of each camera is shown at itsr default location, specified manually in the Sensor > OTDAU window for each.

Both cameras are pointing in the same direction as shown by the green bearing paths.

The location shown of an MSDAU will be its longitude/latitude as derived from its internal GPS receiver if the receiver has achieved a fix on at least four satellites. Otherwise, the location will be that entered as the Location in the MSDAU configuration.



MC with Google roadmap after a target has been acquired by both cameras and triangulated. The target latitude, longitude and altitude are now displayed.

Real-time recording of the map, both camera video streams and all the digital meta-data from all four sensors would start recording, if selected.

When the target can no longer be triangulated, the system may optionally send a status email with map frames and other data to up to three email addresses.

SYSTEM STATUS CONTROLS

The contents of the System Status box are controlled by a group of six buttons below it.

The Roadmap, Satellite, Hybrid and Terrain buttons govern what kind of map display is shown.

The Status button, the initial default, selects ongoing MC program status messages. Prior messages no longer in the window may be viewed when MC has been Stopped. Messages may be scrolled by using your mouse wheel or the slider on the right side of the Status display.

WEATHER DATA COLLECTION

The Weather button displays a list of weather conditions at each DAU location, as shown below.

Atmospheric Data per DAU — UFODAP Mission Control — 15 March 2021 18:15:26PM

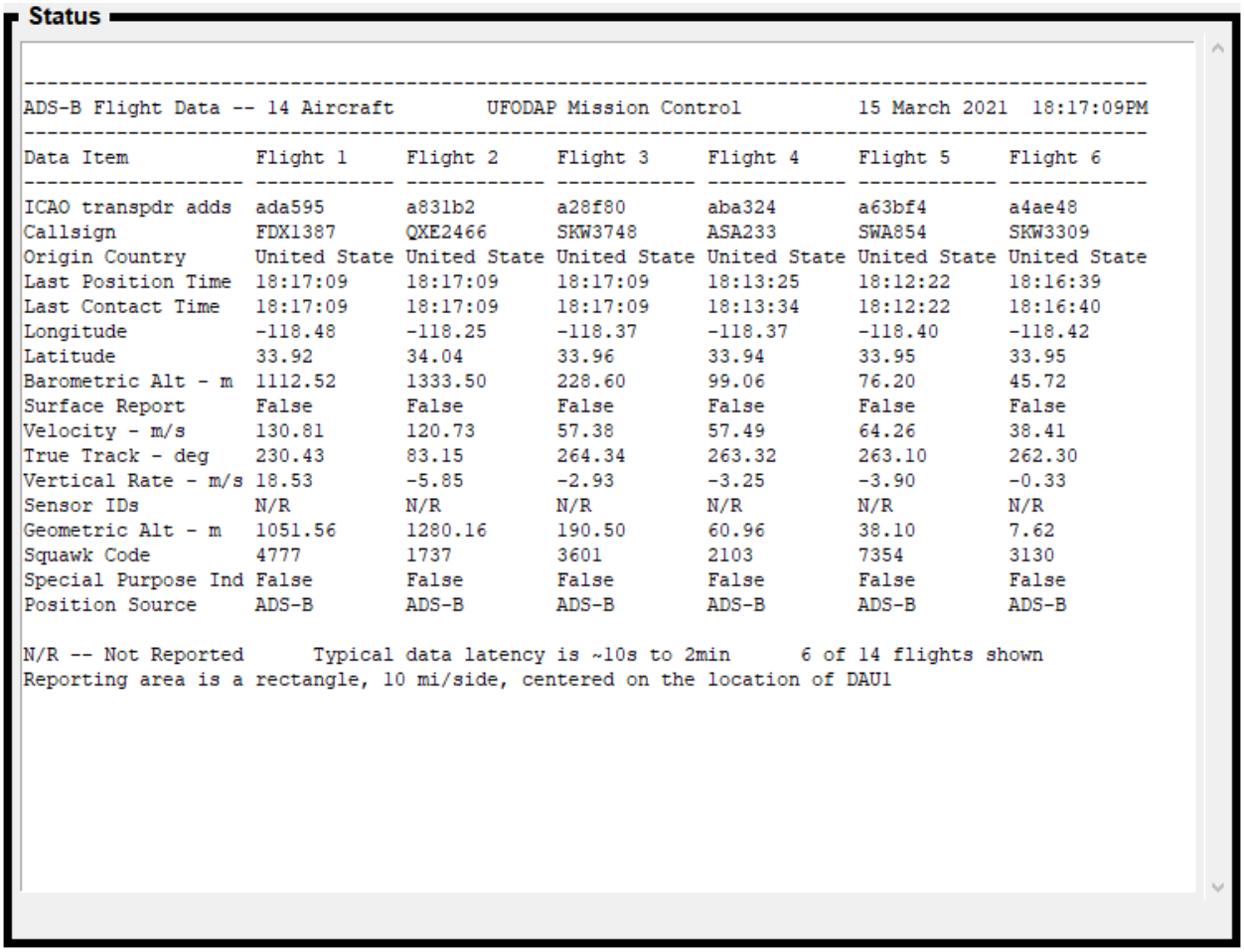
Data Item	DAU1	DAU2	DAU3	DAU4	DAU5	DAU6
City	N/R	New York	Toronto	Portland	Hooper	Houston
State	Colorado	New York	Ontario	Oregon	Colorado	Texas
Time of calculation	18:15:25	18:15:26	18:15:00	18:13:46	18:15:28	18:12:28
Local Time	19:15:23	21:15:23	21:15:24	18:15:25	19:15:25	20:15:26
Sunrise Time	06:14:04	04:07:12	04:29:20	07:22:38	06:14:10	05:30:59
Sunset Time	18:10:28	16:02:21	16:23:30	19:16:28	18:10:33	17:29:43
Status	few clouds	clear sky	overcast clo	overcast clo	clear sky	few clouds
Wind Speed - m/s	5.66	3.60	3.67	2.06	8.75	4.12
Wind Speed - mi/hr	12.66	8.05	8.21	4.61	19.57	9.22
Wind Gust - m/s	12.86	7.72	5.20	N/R	11.32	N/R
Wind Gust - mi/hr	28.77	17.27	11.63	N/R	25.32	N/R
Wind Dir - deg	270.00	300.00	116.00	300.00	240.00	150.00
Humidity - %	49.00	17.00	43.00	49.00	42.00	83.00
Temperature - C	5.08	1.41	-2.82	6.14	5.07	23.23
Temperature - F	41.14	34.54	26.92	43.05	41.13	73.81
Pressure - hPa	1009.00	1027.00	1028.00	1022.00	1009.00	1011.00
Pressure - inHg	29.80	30.33	30.36	30.18	29.80	29.85
Visibility - m	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00
Rain - mm/hr	N/R	N/R	N/R	N/R	N/R	N/R
Snow - mm/hr	N/R	N/R	N/R	N/R	N/R	N/R
Clouds - %	20.00	1.00	100.00	90.00	1.00	20.00

N/R -- Not Reported New data is available every two hours or less

Weather data may be saved to a CSV format file by selecting the associated Recording Option. This saves all weather parameters at the time a trigger condition occurs, which starts all recording options.

AIRCRAFT FLIGHT DATA COLLECTION

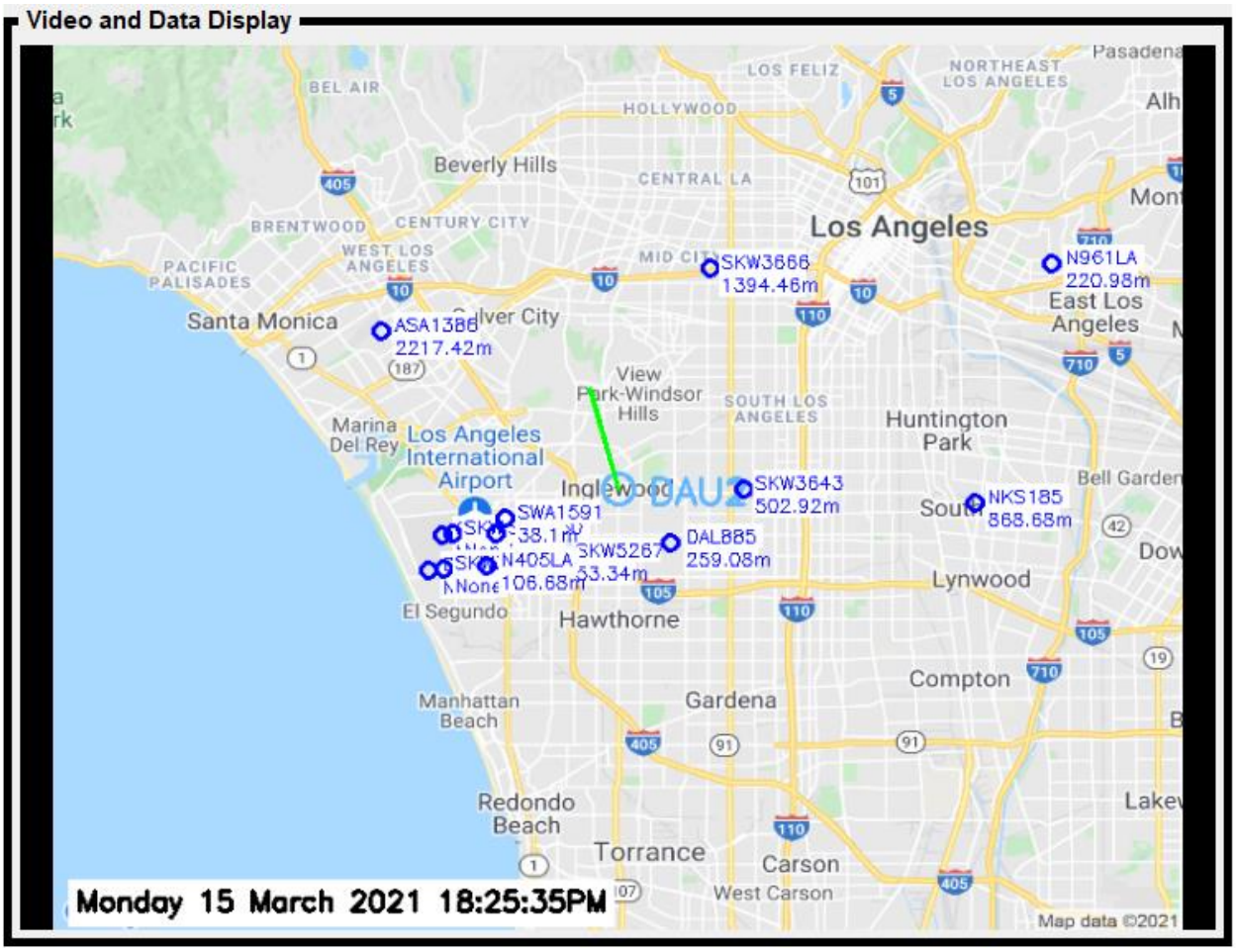
The Aircraft button displays a list of aircraft information for all flights within a 10 mile on-a-side area surrounding DAU1.



Aircraft flight information is listed for the first six flights of the total flight data available. Flight data includes each aircraft's call sign, time of last position measurement, whether it is on the ground or in the air (Surface Report), absolute (Geometric) altitude, etc. The position source is typically from Automatic Dependent Surveillance–Broadcast (ADS-B) receivers but may also be derived from Multilateration (MLAT) or All Purpose Structured Eurocontrol Surveillance Information Exchange (ASTERIX) data.

Detailed information about how flight data is collected and what aircraft may or may not be displayed is available at:

https://www.opensky-network.org

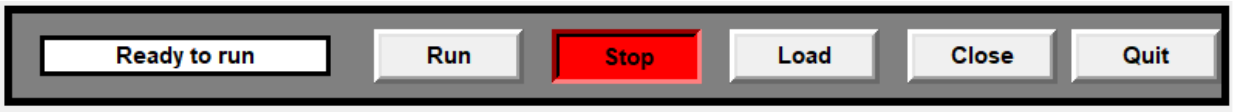


The call sign and geometric altitude are also geolocated and displayed on the map. Each such indicator moves whenever the data is updated, typically every 10 seconds.

Aircraft flight data may be saved to a CSV format file by selecting the associated Recording Option. This saves flight parameters for all aircraft at the time a trigger condition occurs, which starts all recording options.

OPERATING CONTROLS

A status box and four buttons are located below the System Status controls.



From left to right these are:

Status Box – Displays a message indicating the current MC operational state. These messages include:

Stopped (as shown above)

Ready to load

Waiting for DAUs

Ready to run

Running

*** TARGET ACQUIRED ***

*** Recording ***

Recording stopped

Run – Click this button to start monitoring DAUs for triggered state(s) and updating the map display.

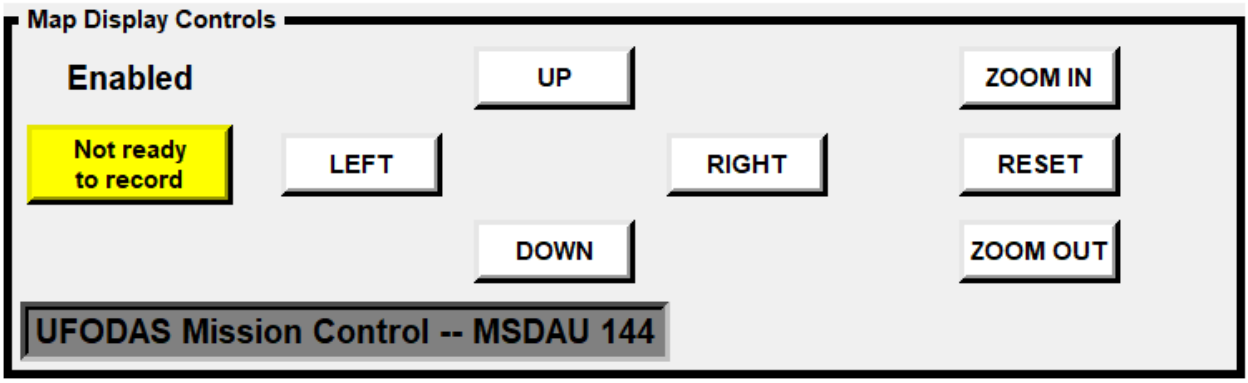
Load – Click to load the selected Mission configuration, update the DAU displays and get ready to Run.

Close – Close the current Mission.

Quit – Terminate MC program execution.

MAP CONTROLS

The Map Controls portion of the display is enabled for user control when the system has been loaded with a Mission Configuration but is not in the Run state. Whether these controls are Enabled or Disabled is indicated under the Map Controls title.



When Map Controls are enabled, the user may move the portion of the displayed map up, down, left or right by clicking on the corresponding buttons. Holding down the left mouse button while over a direction allows continuous movement in that direction.

The map may also be zoomed in or out by clicking on or click and hold the zoom in or zoom out buttons.

Clicking on Reset will return the map to the original size and location prior to any direction or zoom command.

The contents of the box in the lower left corner reflects the Mission Description entered in the Mission Configuration window.

MISSION SETUP

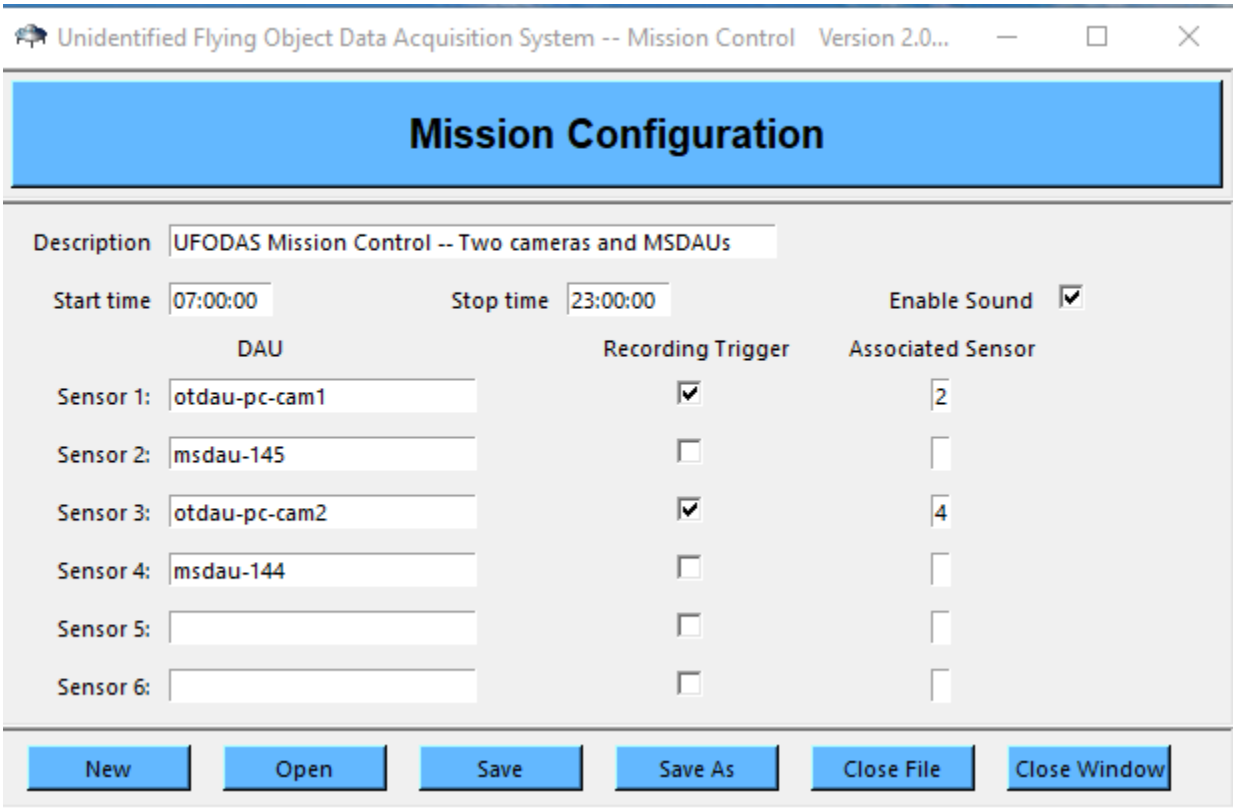
Setting up an MC for a particular mission involves the following steps:

1. Determine which DAUs will be used for the mission.
2. Verify or setup those DAUs as Sensors in Sensor Configurations.
3. For each OTDAU computer, calibrate the camera position. This is accomplished by manually moving the camera via the PTZ controls to set the pan angle (azimuth) due North and the tilt angle (elevation) at the horizon. Then in the OTDAU Setup menu, click on “Set Pan and Tilt offsets” and then Save. This will create an offset to the actual camera pan/tilt angles, zeroing them out at this initial position.
4. For each OTDAU computer, set the initial Home position of the camera to the field of interest and any other necessary parameters and then Run the tracking process.
5. On the MC, select or configure a Mission configuration that uses the needed DAUs. Be sure to set the Recording and Sharing options as required before Runing. If MSDAUs are used, adjust the triggering sensitivity by changing the Trigger level percent in the Setup Options menu.
6. Run the Mission and verify via the right-side displays that data and video is streaming to the MC from the DAUs and that the MSDAU trigger level is not too low (creating false triggers). Use the MSDAU Display Data button to review trigger levels and current background “noise”. Stop the Mission and adjust as necessary.

Note that the function of Run is to enable recording and enable triangulation. Data can be checked for any DAU prior to Run.

All the MC parameters and menus are described below.

MISSION CONFIGURATION



An MC is configured for operation for a particular application by setting several parameters via the System Configuration window. This window is accessed by clicking on the System tab at the top of the main window.

This window shows all the available system configurations. To select one, click it once and then click on Open or double click your selection.

A different configuration may be selected by clicking on Close File, then Open and selecting a different configuration.

It is often convenient to create a new configuration by opening an existing one, modifying it, and then clicking on Save As. The same file list will appear but the file name, at the bottom will be highlighted and contain just ".json". Add the rest of the desired name before the ".", for example, "mission-mycam-ms1.json" might be used to describe a configuration with two DAUs – mycam referencing an instance of OTDAU and ms1 referring to an MSDAU.

After selecting a system configuration, all of its parameters are available for inspection or modification via the System, Cameras, Tracking, Recording, Sharing and Setup menus. Particular DAUs selected for Sensors 1 thru 6 have configurations accessed via the Sensors tab.

System Configuration form entries are:

Description -- User-provided description of the configuration.

Start time – The time in 24-hour format at which the system will start to run if enabled to Run. Start time and Stop time are particularly useful when, for example, a sensor may false trigger or a camera used is such that the image will start to pixelate under low-light conditions causing false motion triggering.

Stop time – The time in 24-hour format at which the system will stop running.

Enable Sound -- Enable a system sound when a recording triggering condition occurs.

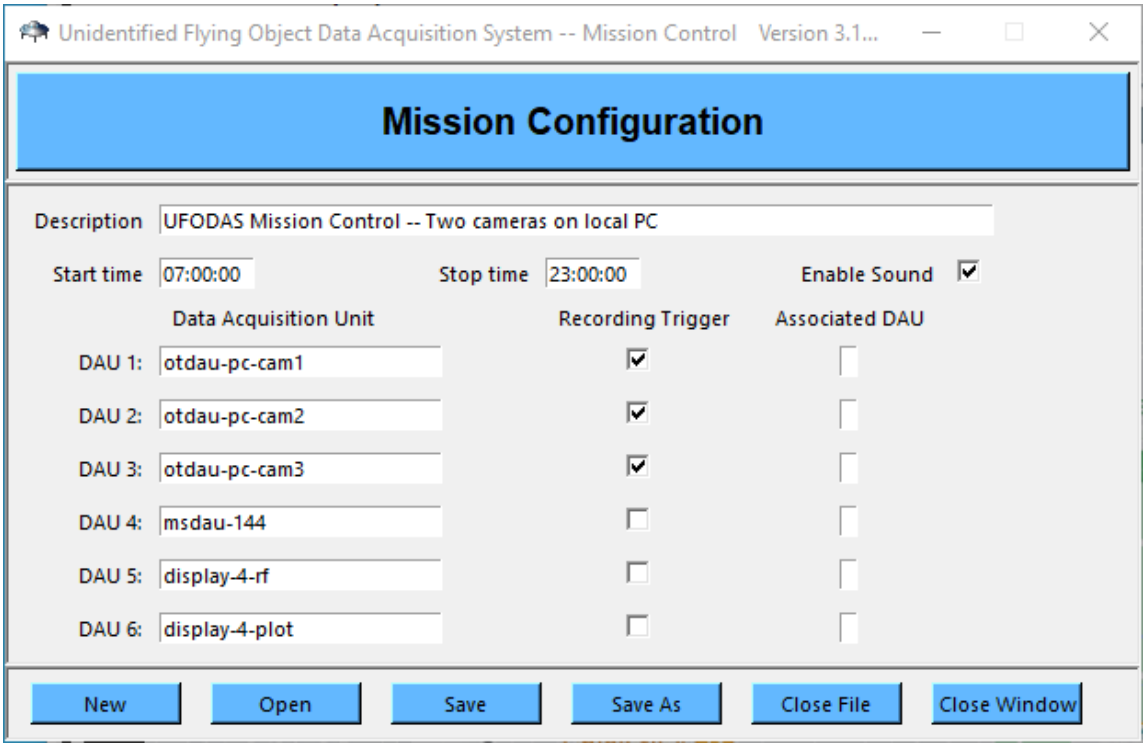
DAU – Up to six DAUs of any type may be specified. During Run time, each DAU will be monitored and its data displayed in the right panel. Unused DAU display boxes may also be used for additional data displays, as described below.

Recording Trigger – Enables the system to start recording if the associated DAU sends MC a trigger signal. Recording is stopped if all such DAU are no longer triggered for two seconds. This delay prevents intermittent trigger conditions from creating too many recorded folders.

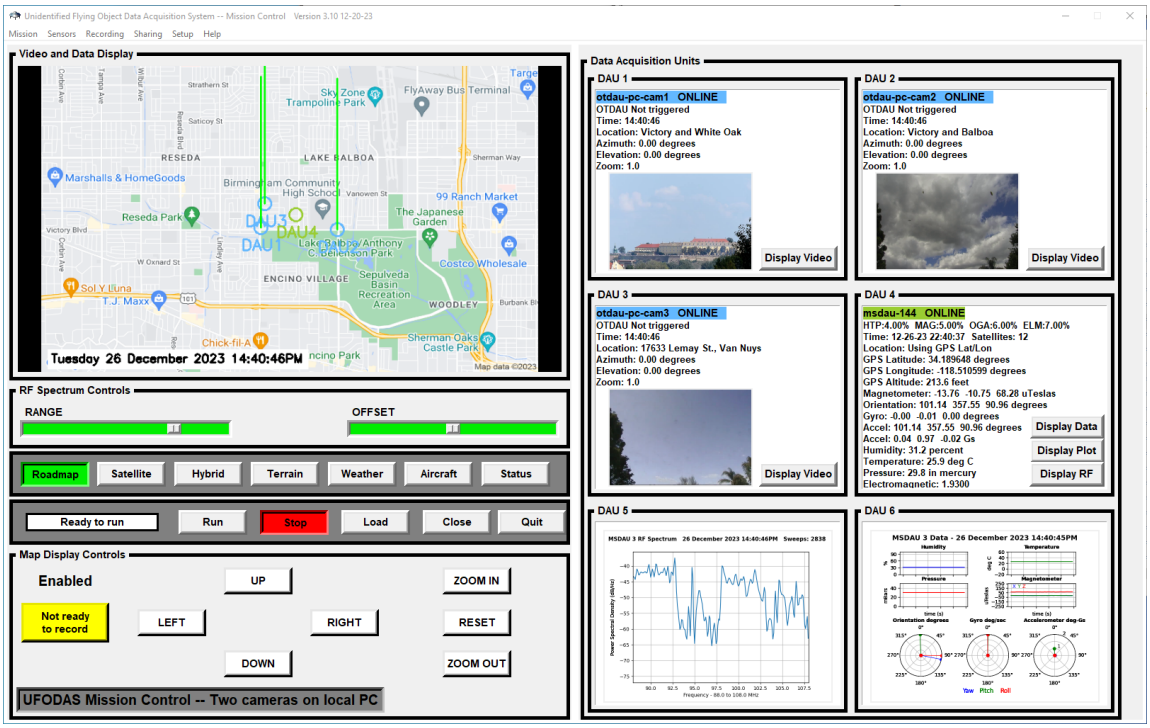
Associated DAU – Tells MC to use the location of the Associated DAU (1 to 6) as the location of the DAU rather than use the geolocated position of the DAU derived from the location entered in the DAU sensor configuration, typically a street address. This option may be used to locate a camera based on the GPS location of an MSDAU.

You can also use DAU 1-6 display areas for other data displays. In a Mission configuration, in an otherwise unused DAU entry, enter the text “display-n-type” where n is the DAU which is the source for the data and type is the keyword “map”, “video”, “plot” or “rf”. For example, to display the RF Spectrum from DAU 2 in position DAU5 enter “display-2-rf” in the DAU2 line of the list of Data Acquisition Units in the Mission Configuration window. Typos or references to a DAU which cannot be the data source will be ignored or generate an error message. When using “map”, n can be any valid number.

For example, this Mission Configuration –

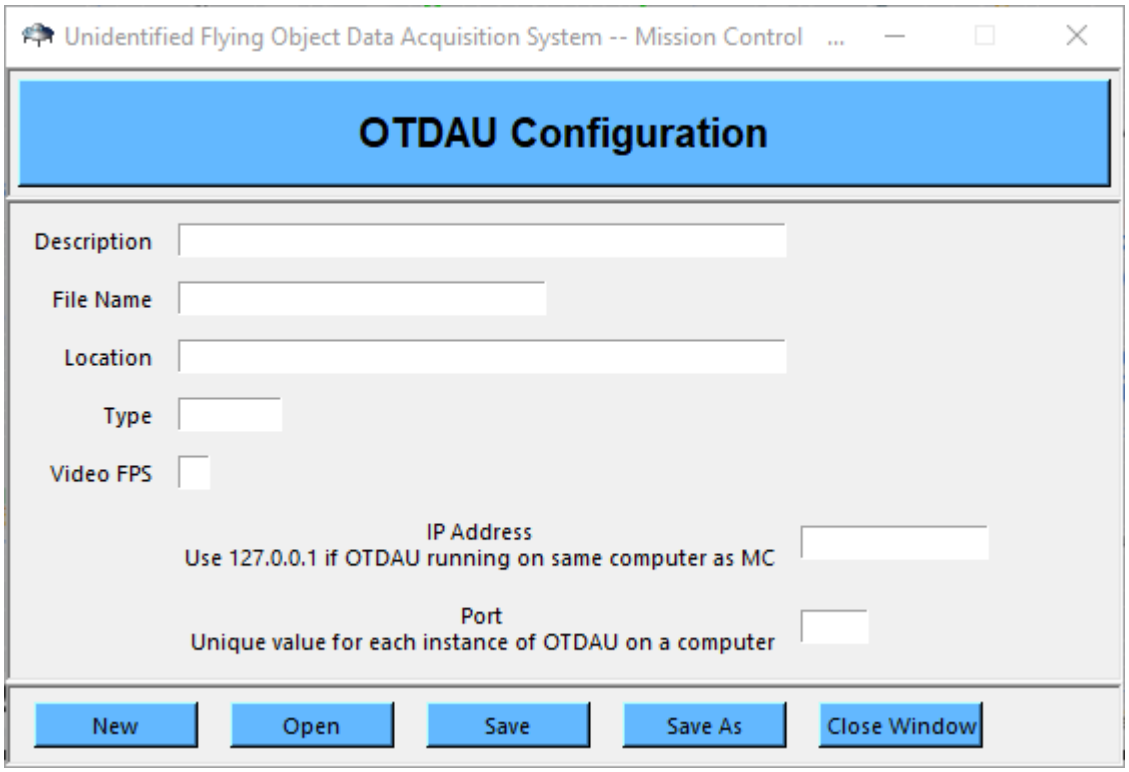


Results in the following set of displays:



SENSOR OTDAU CONFIGURATION

Clicking the Sensor tab and then OTDAU Configurations brings up the OTDAU Configuration window



Description -- User-provided description of the configuration.

File Name – The name of the file in which this configuration is stored. Not user editable.

Location – The physical location of the DAU. Used to geolocated the DAU on Google Maps. May be in any form acceptable to Google Maps such as a street address, intersection or longitude/latitude.

Type – The type of DAU. Must be either “track” if an OTDAU or “sensor” if an MSDAU.

Video FPS – The frame rate of the camera used by the referenced OTDAU.

IP – The IP address of the computer running the referenced copy of OTDAU. For instances of OTDAU running on the same computer that is running MC, use 127.0.0.1. If OTDAU is running on a different computer (on the same LAN or port-forwarded from a different LAN), use that computer’s static address. For example, 192.168.1.37. This

number would have been entered on the OTDAU host computer as a static IPv4 address. See below +for how to give your computer a static IP address instead of using DHCP.

Port – The port number representing the particular instance of OTDAU running on this computer. For example – 51000, 52000, 53000… This is the port number entered in the System Configuration, Computer port field of the configuration running on the desired OTDAU. Note that one computer can run multiple copies of OTDAU, each with its own camera(s). In that case, each OTDAU configuration should have a different Computer Port number, but the IP address would be the same.

NOTE: The TCP server configuration for each port is preserved after first use so that when any System configuration is Loaded, either a new server is started if its port had not been used or a previous one corresponding to the required port is reused. This ensures that when an MC Mission is waiting for a particular port, it connects to the correct instance of OTDAU.

Control buttons

New –Opens a file selection window but has no other effect. Not used in this version release. Use Save As instead to create a new configuration.

Open configuration – Opens a window into the System configuration file folder. Select a configuration by either double clicking on an entry or clicking one once and then click on Open. The selected configuration must be Loaded prior to use after Opening it. Note that the Load button may be used before or after the System Configuration window is closed by the Close Window button. See the Load button, below.

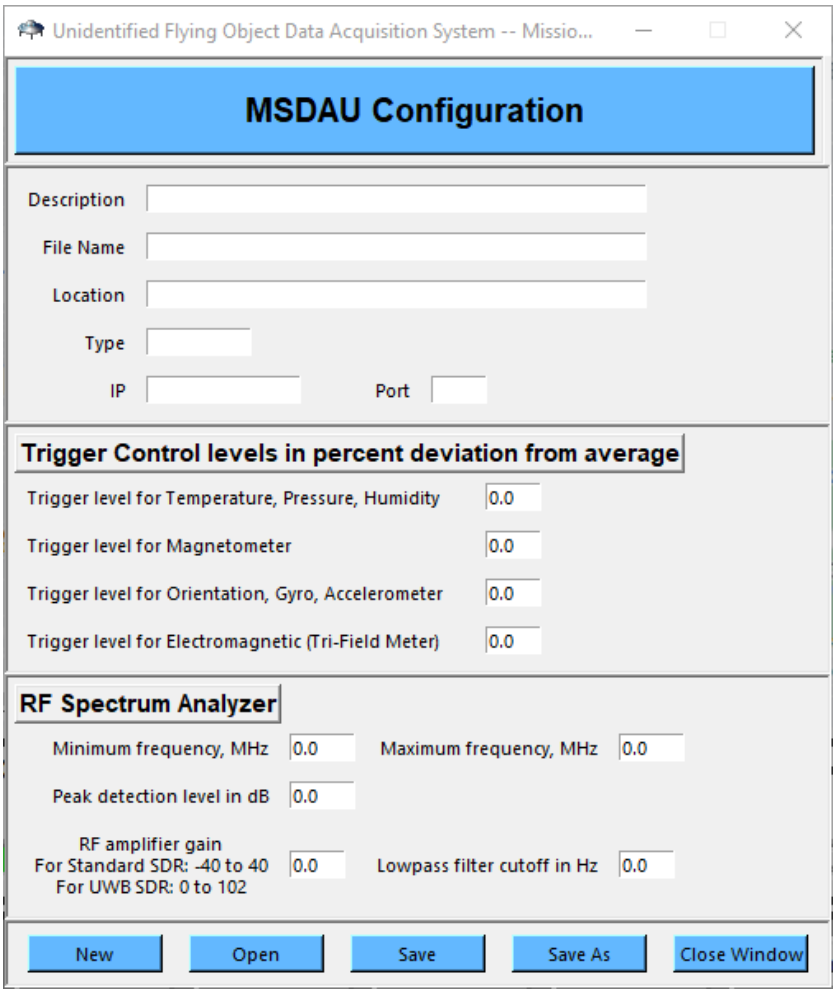
Save – Saves the current settings as part of the currently loaded System configuration.

Save As – Opens a window into the System configuration file folder. Saves the current settings as the System configuration but with a new name selected in this window. It is very useful to Open an existing configuration, modify its values, and then Save As with a new name to create a new configuration.

Close Window – Closes the configuration window.

SENSORS MSDAU CONFIGURATION

Clicking the Sensor tab and then MSDAU Configurations brings up the MSDAU Configuration window:



The Description and other fields in the top box are the same as described for an OTDAU, above.

Trigger level percent – Percent change from nominal baseline value that will cause a trigger condition. The same level is applied to all MSDAU sensors.

Due to different background noise levels and absolute magnitudes of different classes (groups) of sensors, there are four trigger levels instead of one. Trigger level may be specified for Humidity/Temperature/Pressure/ (HTP), Magnetometer (MAG), Orientation/Gyro/Accelerometer (OGA) and Electromagnetic (ELM – the external USB interface for a Tri-Field meter). The group abbreviations and their values are shown on

the second line of each MSDAU data display. A single trigger condition from each MSDAU occurs if any group is in a triggered state or there is an RF trigger condition due to an RF spectrum peak(s) exceeding the Peak detection level. For each data group, a trigger will occur if the absolute value of the difference between the currently sampled value of any value in that group and its running average (10 samples) exceeds a trigger level. The trigger level for each value is a percentage of the full-scale range of data for that value. The full-scale range for each group is: HTP – H:100, T:50, P:31, MAG and OGA – 360 (except accel raw is 2) and ELM – 100. Setting too low a trigger level will cause continuous triggering due to background noise. A sensor group will never trigger if the associated level is set too high. Using the MSDAU Display Data selection, set each level based on observation of nominal, settled conditions and select a value above that.

RF Spectrum minimum frequency – Starting frequency for RF spectrum sweeps.

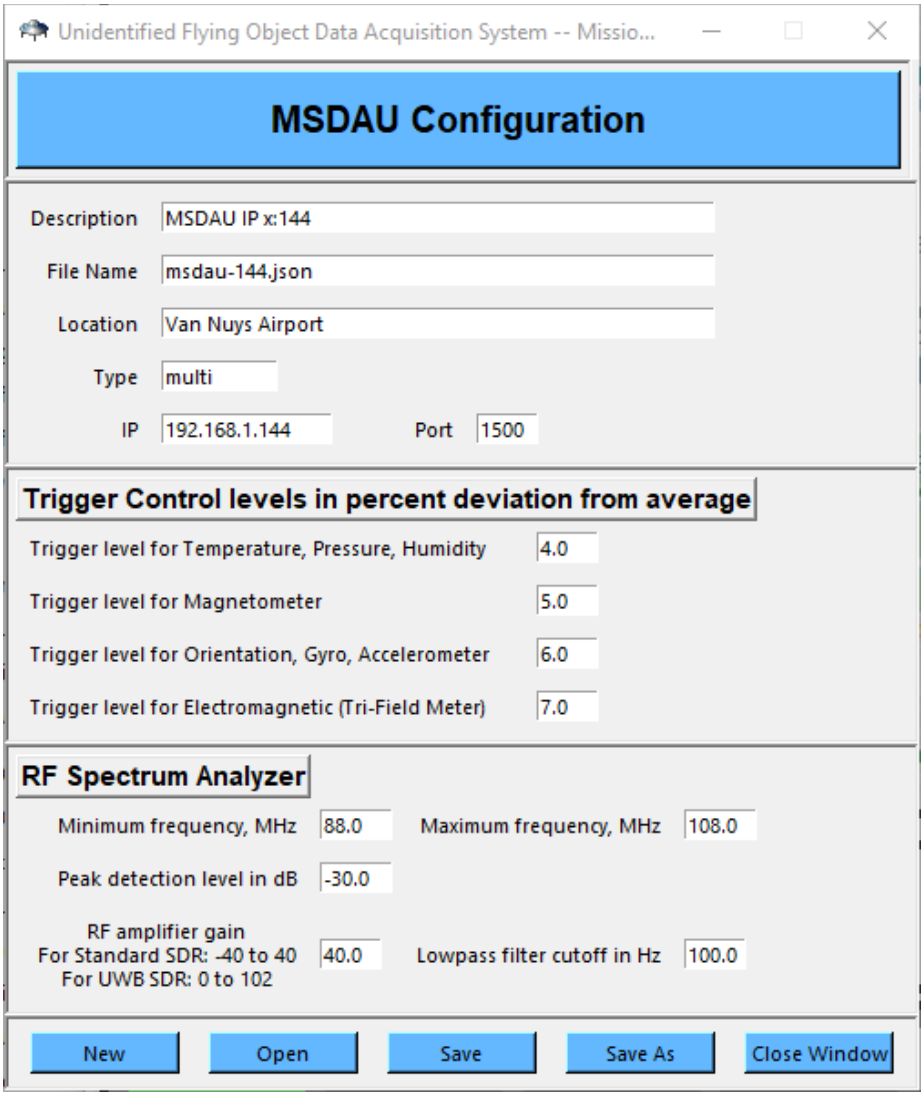
RF Spectrum maximum frequency – Ending frequency for RF spectrum sweeps.

RF Spectrum peak detection level in dB – After an initial baseline sampling period, any RF energy above this level will cause a trigger condition.

Control buttons

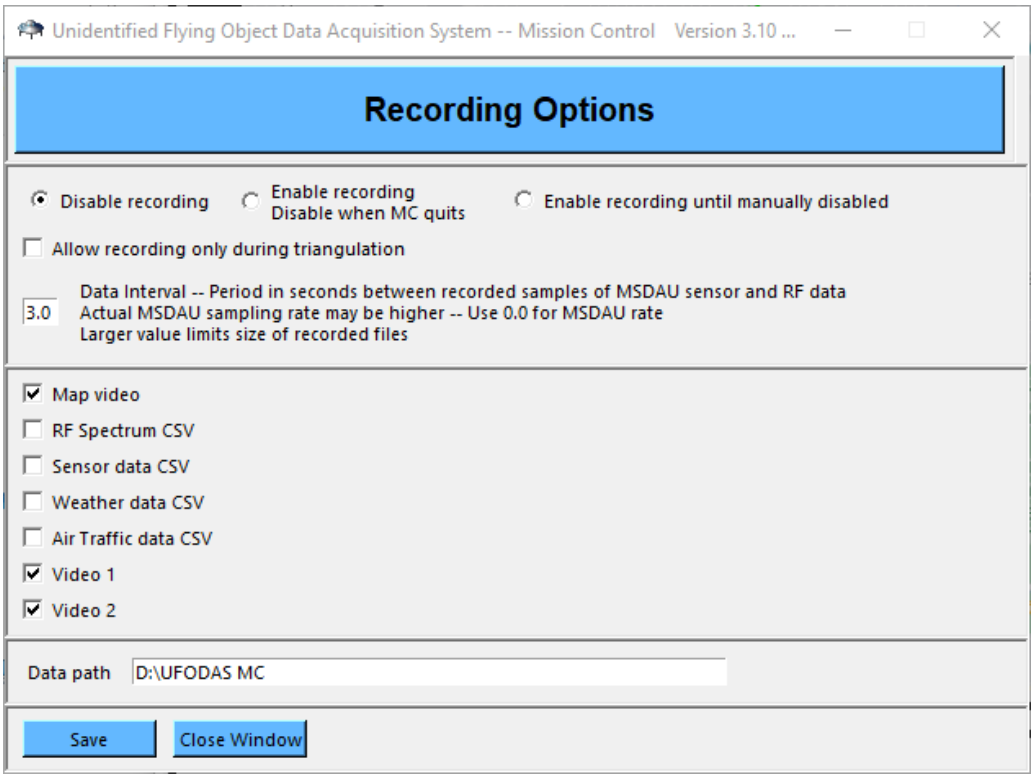
See OTDAU description, above.

For example:



The RF spectrum portion of this configuration will result in the collected RF data as shown in the example, above.

RECORDING OPTIONS



Disable recording – Disables recording enabled by either of the following two selections.

Enable recording – Disable when OTDAU quits – Enables the following selections to control data recording if checked. Defaults to disabled when the system is started to prevent accidental recording during the typical system startup. Startup may involve testing data acquisition, parameter tuning such as MSDAU settings followed by test Runs. This setting is retained through all changes to configurations or Run/Stop until OTDAU is shut down (Quit).

Enable recording until manually disabled – Enables recording but does not automatically disable when OTDAU quits. Recording is automatically reenabled whenever OTDAU starts. This option may be used with the AutoStart option to automatically reenable recording when OTDAU restarts.

Allow recording only during triangulation – If recording is enabled, start recording only when triangulation begins, namely, when two data from two cameras results in triangulation of a target.

Data Interval -- Data sample write interval selection to limit data file size. Writes one sample of MSDAU data per interval – Note that the rate that the MSDAU collects the data and sends it to the MC may be higher. This period applies to all MSDAU data including RF data.

Map – Record the Google Map display as a continuously changing video.

RF Spectrum – Record the spectrum received from all configured MSDAUs

Sensor Data – Record data from any configured MSDAUs.

Video 1 – Record video from the first active camera. An active camera is one associated with a configured OTDAU.

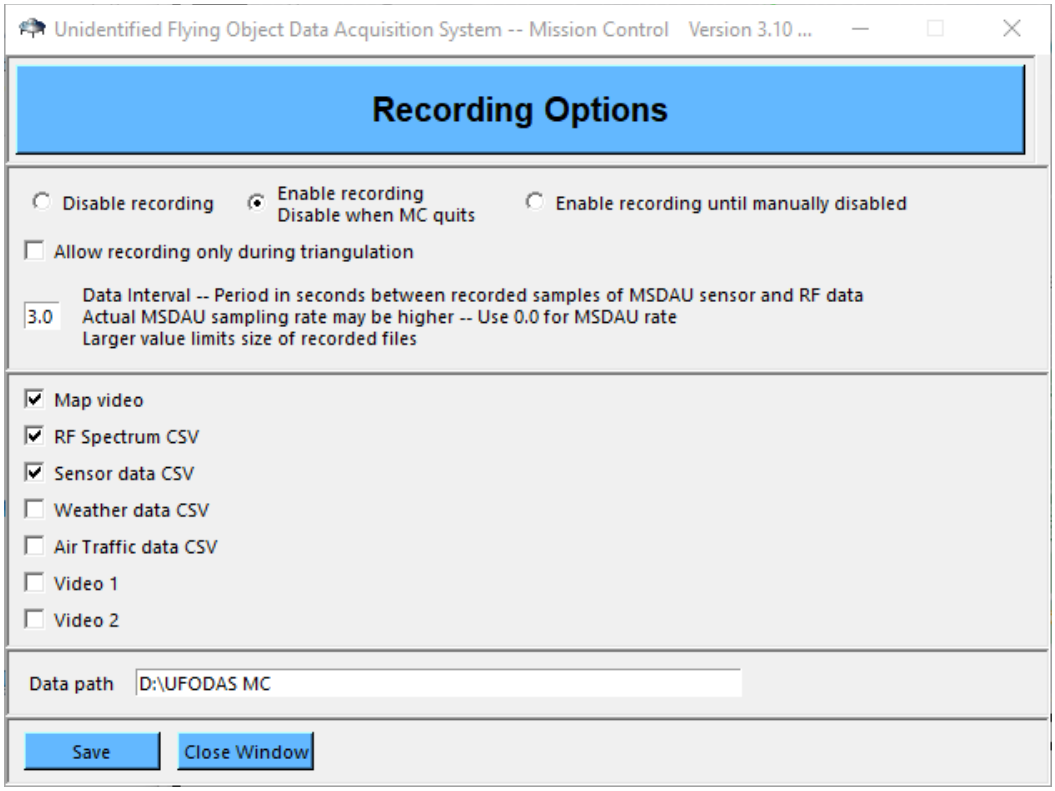
Video 2 – Record video from the second active camera.

Data path – The disk drive path where the system will create a folder that will contain any video or image files collected during run time, as selected above. The folder will be created if it does not already exist.

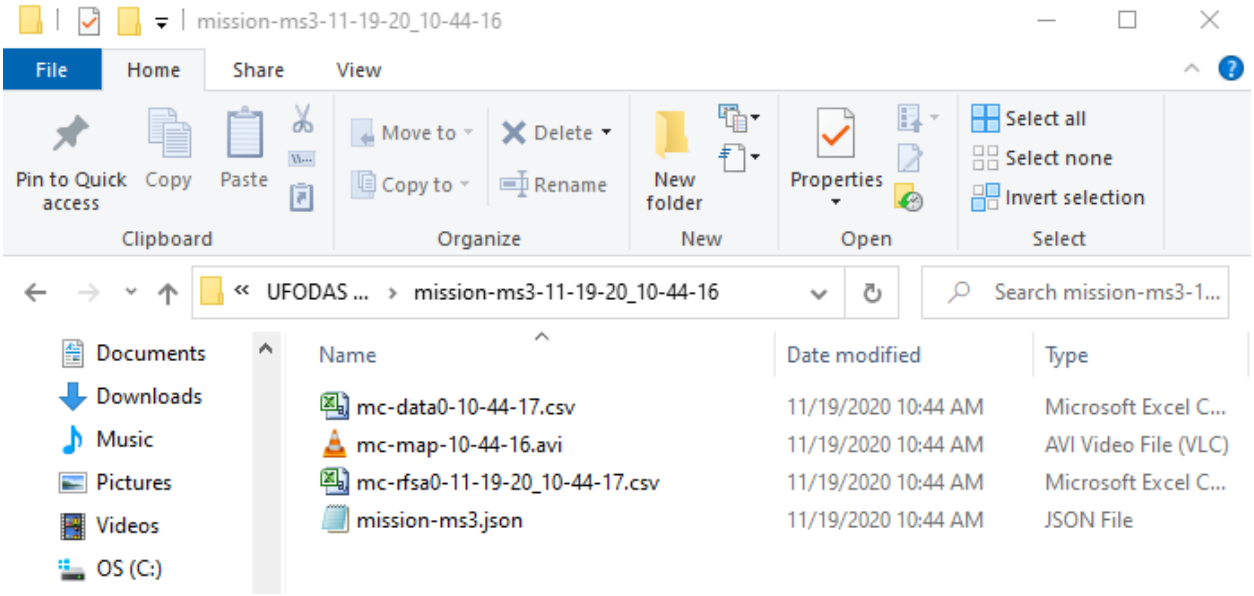
NOTE: Recording will be terminated when MC is Stopped, regardless of OTDAU/MSDAU trigger status. Recording during triangulation.

NOTE: Trigger indications and triangulation calculations and display will occur with/without recording enabled. Recording is extended by two seconds beyond loss of tracking or triangulation for continuous recording through dropouts.

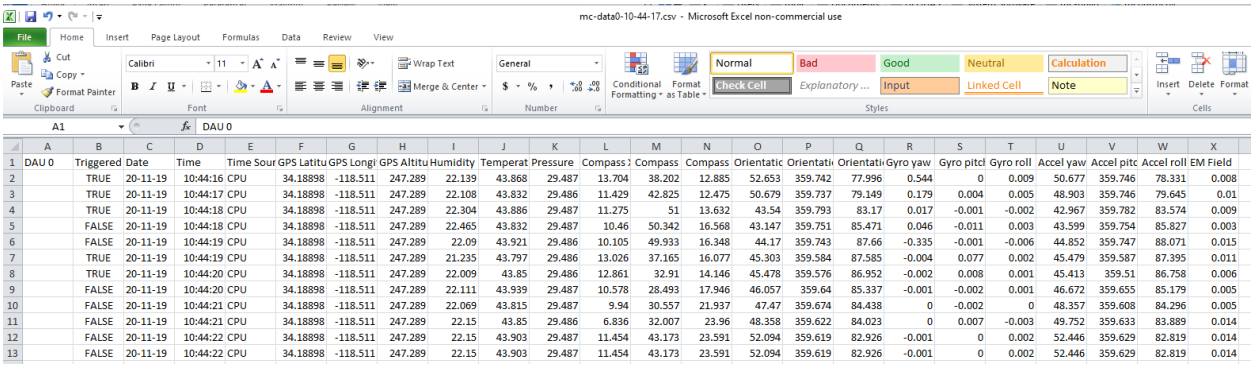
For example, with Recording Options set as shown below:



After an MSDAU trigger condition occurred, the following files will be written:



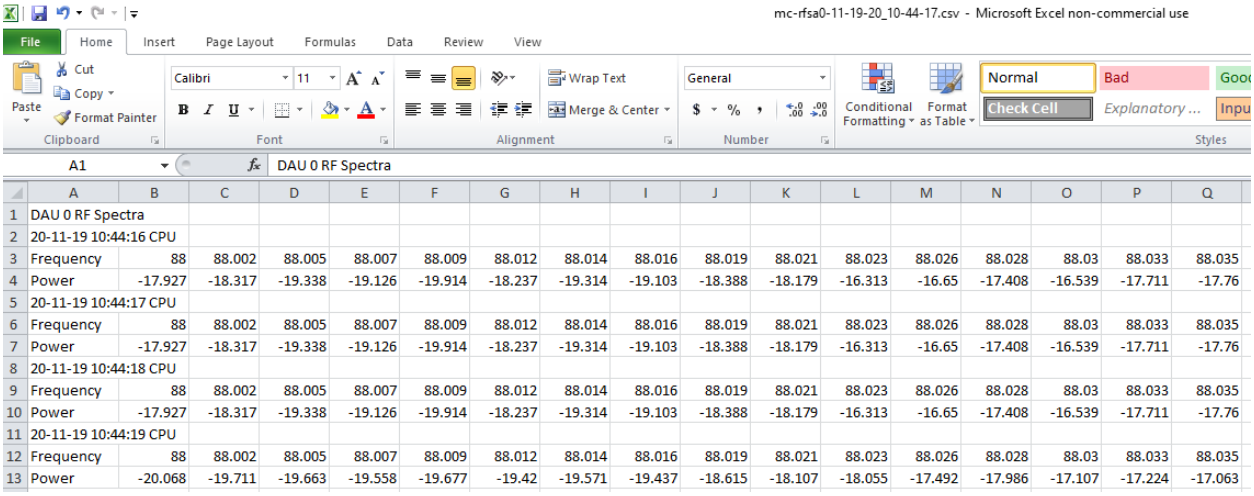
The MSDAU data CSV file contents looks like:



mc-data0-10-44-17.csv - Microsoft Excel non-commercial use

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	DAU 0	Triggered	Date	Time	Time Sour	GPS Latitu	GPS Longi	GPS Altitu	Humidity	Temperat	Pressure	Compass	Compass	Compass	Orientatic	Orientati	Orientati	Gyro yaw	Gyro pitcl	Gyro roll	Accel yaw	Accel pitc	Accel roll	EM Field
2		TRUE	20-11-19	10:44:16	CPU	34.18898	-118.511	247.289	22.139	43.868	29.487	13.704	38.202	12.885	52.653	359.742	77.996	0.544	0	0.009	50.677	359.746	78.331	0.008
3		TRUE	20-11-19	10:44:17	CPU	34.18898	-118.511	247.289	22.108	43.832	29.486	11.429	42.825	12.475	50.679	359.737	79.149	0.179	0.004	0.005	48.903	359.746	79.645	0.01
4		TRUE	20-11-19	10:44:18	CPU	34.18898	-118.511	247.289	22.304	43.886	29.487	11.275	51	13.632	43.54	359.793	83.17	0.017	-0.001	-0.002	42.967	359.782	83.574	0.009
5		FALSE	20-11-19	10:44:18	CPU	34.18898	-118.511	247.289	22.465	43.832	29.487	10.46	50.342	16.568	43.147	359.751	85.471	0.046	-0.011	0.003	43.599	359.754	85.827	0.003
6		FALSE	20-11-19	10:44:19	CPU	34.18898	-118.511	247.289	22.09	43.921	29.486	10.105	49.933	16.348	44.17	359.743	87.66	-0.335	-0.001	-0.006	44.852	359.747	88.071	0.015
7		TRUE	20-11-19	10:44:19	CPU	34.18898	-118.511	247.289	21.235	43.797	29.486	13.026	37.165	16.077	45.303	359.584	87.585	-0.004	0.077	0.002	45.479	359.587	87.395	0.011
8		TRUE	20-11-19	10:44:20	CPU	34.18898	-118.511	247.289	22.009	43.85	29.486	12.861	32.91	14.146	45.478	359.576	86.952	-0.002	0.008	0.001	45.413	359.51	86.758	0.006
9		FALSE	20-11-19	10:44:20	CPU	34.18898	-118.511	247.289	22.111	43.939	29.487	10.578	28.493	17.946	46.057	359.64	85.337	-0.001	-0.002	0.001	46.672	359.655	85.179	0.005
10		FALSE	20-11-19	10:44:21	CPU	34.18898	-118.511	247.289	22.069	43.815	29.487	9.94	30.557	21.937	47.47	359.674	84.438	0	-0.002	0	48.357	359.608	84.296	0.005
11		FALSE	20-11-19	10:44:21	CPU	34.18898	-118.511	247.289	22.15	43.85	29.486	6.836	32.007	23.96	48.358	359.622	84.023	0	0.007	-0.003	49.752	359.633	83.889	0.014
12		FALSE	20-11-19	10:44:22	CPU	34.18898	-118.511	247.289	22.15	43.903	29.487	11.454	43.173	23.591	52.094	359.619	82.926	-0.001	0	0.002	52.446	359.629	82.819	0.014
13		FALSE	20-11-19	10:44:22	CPU	34.18898	-118.511	247.289	22.15	43.903	29.487	11.454	43.173	23.591	52.094	359.619	82.926	-0.001	0	0.002	52.446	359.629	82.819	0.014

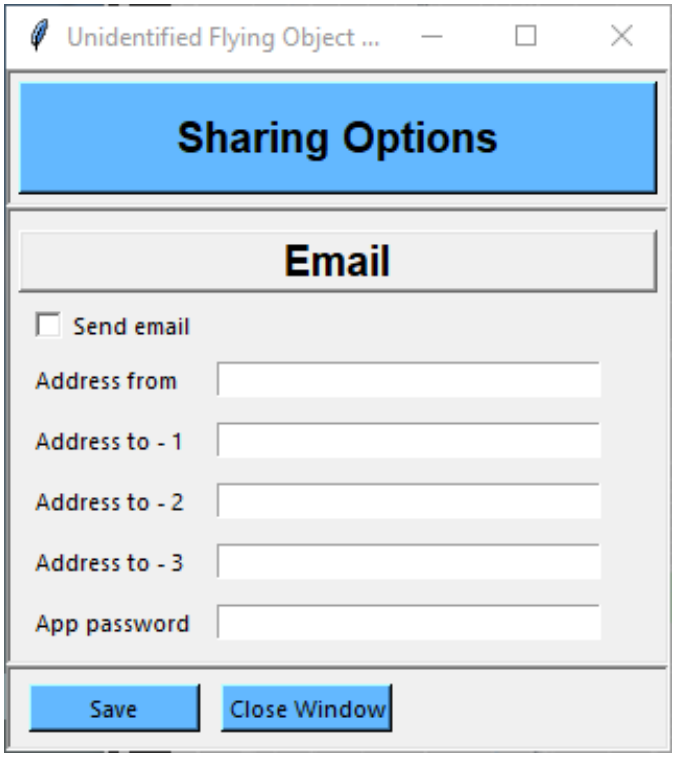
The MSDAU RF spectrum CSV file (partial) looks like:



mc-rfsa0-11-19-20_10-44-17.csv - Microsoft Excel non-commercial use

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	DAU 0 RF Spectra																
2	20-11-19 10:44:16 CPU																
3	Frequency	88	88.002	88.005	88.007	88.009	88.012	88.014	88.016	88.019	88.021	88.023	88.026	88.028	88.03	88.033	88.035
4	Power	-17.927	-18.317	-19.338	-19.126	-19.914	-18.237	-19.314	-19.103	-18.388	-18.179	-16.313	-16.65	-17.408	-16.539	-17.711	-17.76
5	20-11-19 10:44:17 CPU																
6	Frequency	88	88.002	88.005	88.007	88.009	88.012	88.014	88.016	88.019	88.021	88.023	88.026	88.028	88.03	88.033	88.035
7	Power	-17.927	-18.317	-19.338	-19.126	-19.914	-18.237	-19.314	-19.103	-18.388	-18.179	-16.313	-16.65	-17.408	-16.539	-17.711	-17.76
8	20-11-19 10:44:18 CPU																
9	Frequency	88	88.002	88.005	88.007	88.009	88.012	88.014	88.016	88.019	88.021	88.023	88.026	88.028	88.03	88.033	88.035
10	Power	-17.927	-18.317	-19.338	-19.126	-19.914	-18.237	-19.314	-19.103	-18.388	-18.179	-16.313	-16.65	-17.408	-16.539	-17.711	-17.76
11	20-11-19 10:44:19 CPU																
12	Frequency	88	88.002	88.005	88.007	88.009	88.012	88.014	88.016	88.019	88.021	88.023	88.026	88.028	88.03	88.033	88.035
13	Power	-20.068	-19.711	-19.663	-19.558	-19.677	-19.42	-19.571	-19.437	-18.615	-18.107	-18.055	-17.492	-17.986	-17.107	-17.224	-17.063

SHARING OPTIONS



EMAIL SETUP

Checking the **Send Email** checkbox will cause the system to send an email including all recorded video and still frame files as well as the current System configuration JSON file for reference.

'**Address from**' – Your email address such as johndoe@gmail.com.

'**Address to – 1, 2, 3**' -- Up to three email addresses that you would like the system to send emails to. A copy of the same email will be sent to each address.

'**App password**' -- The application-specific password associated with the named Gmail account. This is not your Gmail password you use for access to emails via gmail.com.

You can generate an app password by the following process:

https://support.google.com/accounts/answer/185833?hl=en

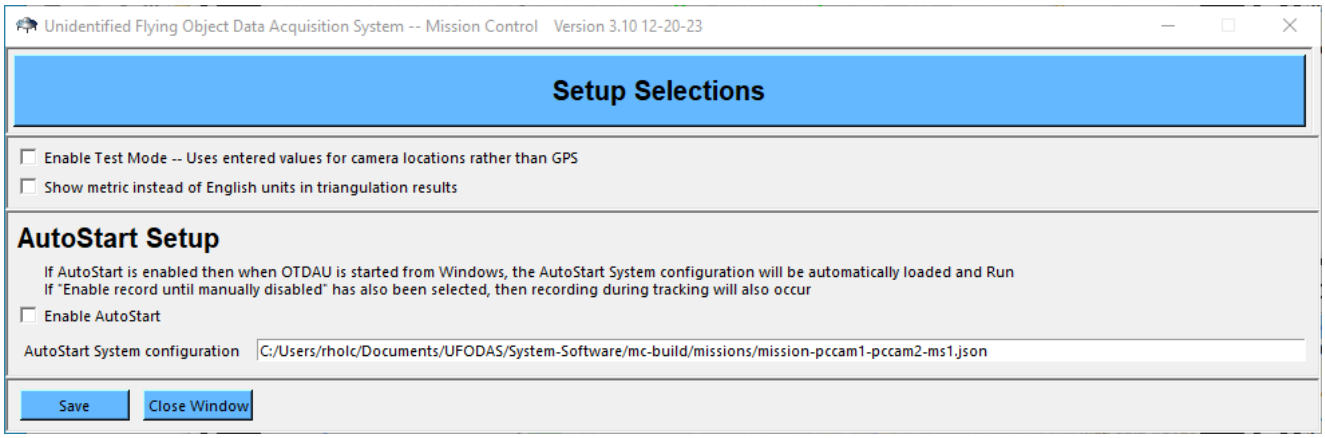
Start by navigating to your Google Account via the hyperlink in the above page. Follow the steps shown under Create & use app passwords. When asked to select an app, enter OTDAU and then click GENERATE. Type this 16 character, lower-case password into the Email password field and click Save.

If the Send email box is checked, an email will be sent just prior to the system has returning to the camera Home position if the following conditions are met:

- After each data collection sequence is complete and data is saved
- After a target object has been identified and tracked until lost to view

The system accepts the tracking sequence (e.g., it was long enough) and just prior to the system returning to the camera Home position.

SETUP SELECTIONS



Enable Test Mode – Enables a mode in which the MC will triangulate data from two cameras regardless of their actual trigger condition. This allows testing of system triangulation calculations when the cameras, via their respective OTDAU software, are manually positioned to simulate common target acquisition, even though the OTDAUs have not detected motion. Manually set the location of each camera via their Sensors > OTDAU Location settings and do not enter a value for their Associated DAU to prevent override of their entered locations by MSDAU/GPS values.

Show Metric units – Select presentation and recording of data in metric units rather than English units.

MC can automatically Load and Run any System configuration when started from Windows. This may be useful for situations where system power may not be reliable – when power drops out and then returns, and the computer reboots, OTDAU can restart, running, with the same options enabled as when power went down.

AutoStart may also simply be used to manually startup MC in a Run mode in the least time.

If AutoStart is enabled and a System configuration is selected and saved, then when MC first starts up, that configuration is Loaded and Run. Disable AutoStart to start up normally but retain the selected System configuration. AutoStart may be used with or without the Record until disabled option to automatically start, run and record during tracking just by running OTDAU.

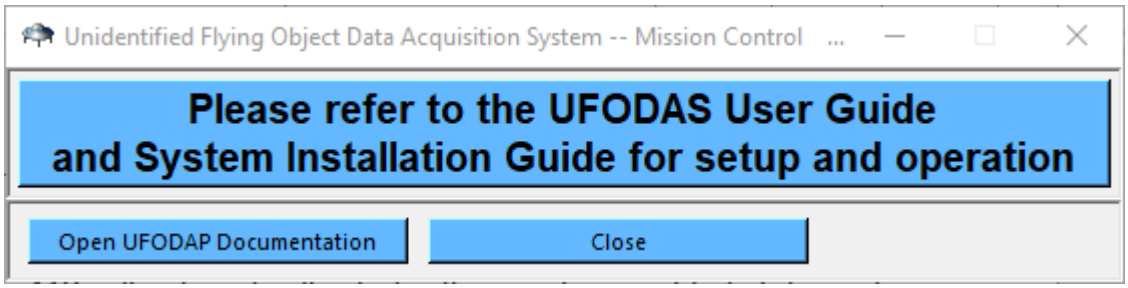
Use Windows Task Scheduler or another method of your choice to automatically start MC during Windows startup.

Enable AutoStart – Enables automatic Load and Run the next time OTDAU is started.

AutoStart System configuration – Clicking in this field will open a list of System configurations. Selecting one of those will populate this field with the selected configuration.

HELP

Help > Documentation –

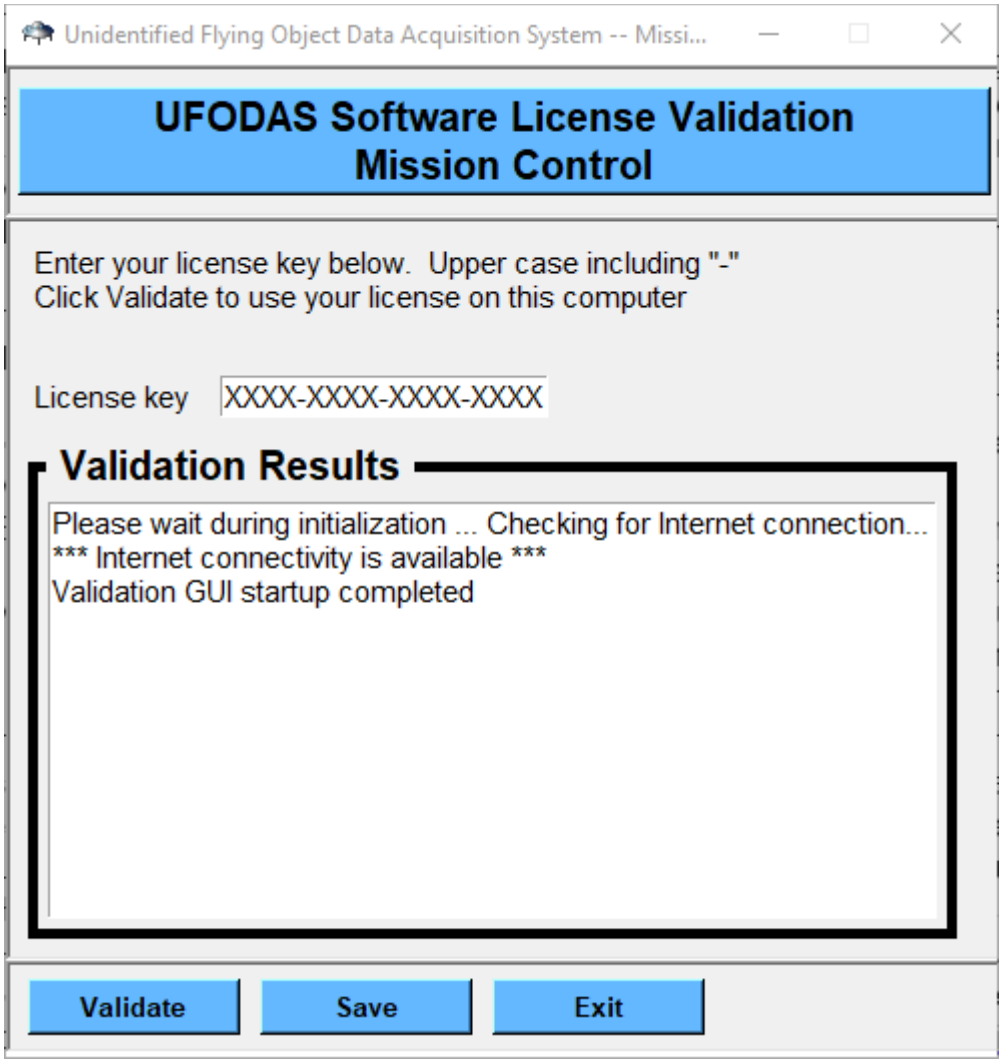


Clicking on “Open UFODAP Documentation” will open the part of ufodap.com providing various documents as pdfs in a browser window. You can then leave any document open for reference.

Help > About –

This window shows the current version of MC software. The version is also shown at the top of the main display.

Help > Manage License –

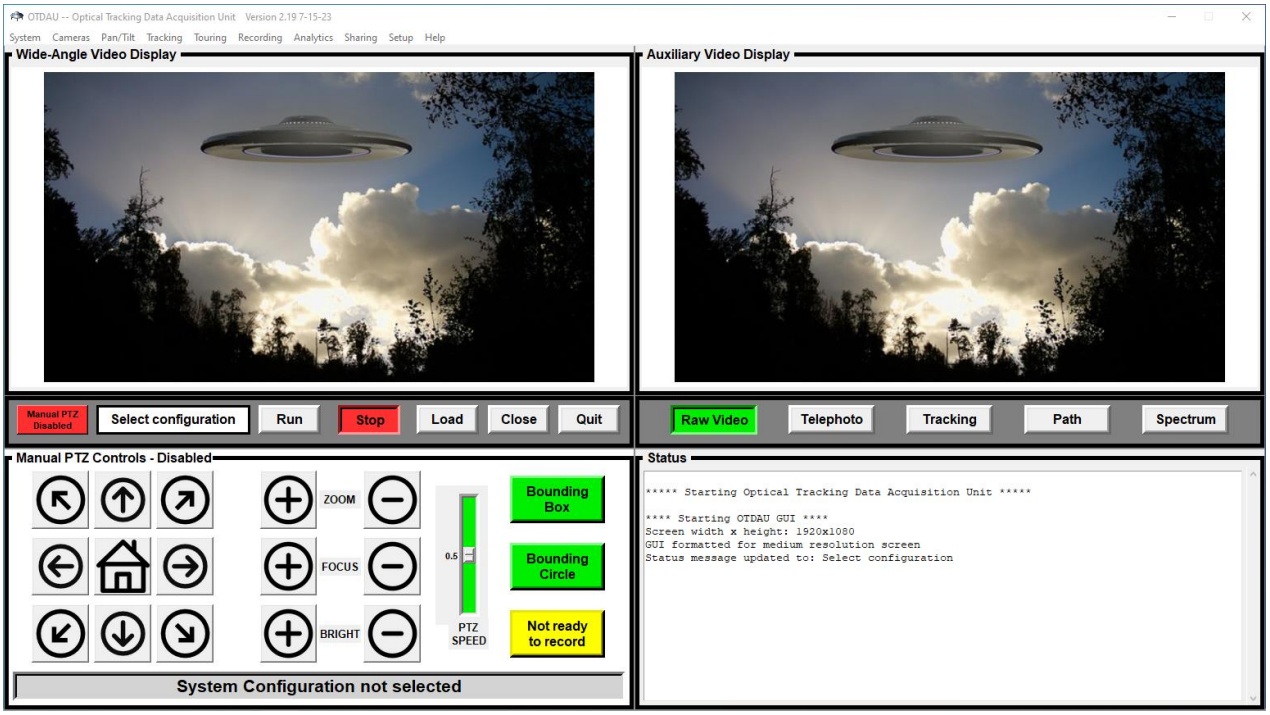


Check the validity of your license key by entering it and clicking Validate.

If the key is correct, then “License key validated” will be displayed. Clicking Exit will return to the MC software.

If the key is incorrect, it will display “Invalid key”. Exiting will close the MC software. To run MC, restarting it will display the Validation screen. Correct the key and click Exit.

OPTICAL TRACKING DATA ACQUISITION UNIT (OTDAU)



INTRODUCTION

The UFODAS system architecture supports a variety of Data Acquisition Units (DAUs). One type of DAU performs optical acquisition, tracking and recording of objects in motion within its Field of View (FOV). This type of DAU is thus an Optical Tracking DAU or OTDAU.

An OTDAU may be set up to use one or two cameras. The system supports a wide range of supported cameras including USB webcams up to sophisticated all-weather IP cameras with pan and tilt as well as optical zoom. The software architecture is designed to adapt to most any camera or Pan-Tilt-Zoom (PTZ) mechanism in the future by addition of a single software element, without modification to the main UFODAS software.

In dual camera applications, one camera may be a non-PTZ type that views a wide field of interest including all-sky cameras. The second camera would be a PTZ camera directed to point at the object based upon its relative location in the field of view of the wide-angle camera. The PTZ camera then independently tracks the object.

Whether using one camera or two, the processor samples frames from the wide-field camera and through some sophisticated image analysis, detects qualified moving objects. It then directs the pan-tilt head to point the telephoto camera at the object and collects images from it. The software can acquire an object of interest and smoothly tracking and zooming to a moving object even with a single camera. Maintaining track

while moving the camera, which causes the background to also move, was a significant part of the development effort of the OTDAU software.

OTDAU QUICK START GUIDE

The OTDAU Graphical User Interface (GUI) provides typical Windows-style menus, such as File, Open to select a camera(s) and data collection process, PTZ controls for initial positioning of a camera to a field of interest, video displays and system status.

The basic process of using OTDAU includes:

1. Select a System configuration. This defines which cameras are to be used, start and stop times and other items (defined below)
2. Manually move the camera (if it is a PTZ type) and select an appropriate bounding box
3. Load the configuration
4. Select any options for Recording, Email or those in Setup
5. Make any necessary changes to Tracking options.
6. Run the configuration

Clicking the Run button starts scanning for moving objects and thus, all the actions which occur if one is detected. The video sources are displayed along with embedded meta-data text overlay and a blue bounding-box. The user can select the size and location of the bounding-box to avoid initial false detection due to object proximity to foliage, for example. Also, the right-hand, multi-function Auxiliary Video display can show the telephoto camera stream with its meta-data overlay, the Raw, non-annotated stream, indications of tracking accuracy or the tracked object path.

What you need:

- UFODAS software installed to the standard Windows Program Files (X86) folder.
- At least one camera. It may be a USB camera or an IP camera, with or without PTZ capabilities. Any combination of these cameras may also be used if the Wide camera is different from the Telephoto camera.

Setup:

- If your laptop computer has a built-in webcam, it is USB-0.

- If using an external USB camera, plug it directly into your PC. If you also have a built-in webcam, then the external camera will be USB-1. A second external camera would be USB-2.
- If using an IP camera, connect its Ethernet cable to a PoE injector. Connect the injector's LAN connection to your router. No additional connection to your PC is required assuming that it already communicates to the internet via that same router. If the IP camera is connected to your router, then its IP address will be its local (non-forwarded) address, typically 192.168.1.x. If you want to use a remote IP camera on some other router, you must use its port-forwarded IP address obtained from the owner of the router. Refer to the Setup Guide for more information on camera setup and testing.
- Click on the OTDAU UFO icon to run the OTDAU program.

Operation:

- Click on System > Open configuration and double-click on a System file to select an OTDAU configuration. For example: usb0-800x600 or dahua-50230-108-80-1920x1080. The term local in the file name indicates a camera directly connected to the user's Local Area Network (LAN), that is, to his router either by cable or by WiFi. (All of the configuration file names are simply examples – you can create/rename such a file to any Windows-compatible name.) Thus, the names of such files are arbitrary, but the dot extension must be "json". Click Close Window after configuration selection.
- Click Load. The system should initialize and display the selected camera image.
- Notice the scroll of messages in the lower right panel. When it stops, the system is Ready to Run, as indicated by the Status box next to the Run button. You should also see a video display from the selected camera(s) in the left and right video panes which replace the default flying saucer images.
- The PTZ Controls are Enabled for use when the system is in Stop mode. At this time, you can move the camera (if it is PTZ-capable) to a preferred position. Use the SPEED control slider to adjust the speed of PTZ actions controlled by the UP/DOWN/LEFT/RIGHT and WIDE/TELE buttons. This will be the position that the camera will automatically return to after a tracking run.
- Click on System > Recording and select what type of data you would like to record when there is an event. Set the Data path to a disk location you want to

use to save the recordings, such as “D:\OTDAU data”. Click Save if you made any changes, then Close.

- Explore the other menus under System, Camera, Analysis, Sharing and Setup to see if there are other changes you would like. Note that all parameters in these various menus are saved in the System json file you opened except those under Cameras. The Cameras Wide and Tele Configuration selections refer to the cameras selected by the System file. If the camera is PTZ-capable, and motion is desired, be sure that the PTZ box in the System menu is checked.
- Press Run to start scanning for moving objects. The Status box will indicate what state the system is in and the System Status pane on the lower right will be a fairly continuous scroll of operations in progress. You will probably not need to pay attention to these unless reporting the state of the system if a fault occurs.
- You can press Stop at any time to end frame acquisition and data analysis. Stop will return a PTZ camera to its Home position. You can press Run again to restart. For example, you may want to re-position the camera at a better Home position by pressing Stop, using the PTZ controls and then click Run.

Data Analysis:

- If enabled, any data collected will be saved in a folder in the specified Data path, identified by the System folder name you entered under which it was collected and the date/time. This folder will contain all video files, individual still frames, Path jpg, log file and PTZ data files.
- Video files have an extension of .avi and are best played by the VLC Media Player. Still frame files have extensions of .jpg and may be viewed like any other photo (e.g., just double-click them). PTZ data files use the extension .csv. The json file you selected that defines the System configuration and its referenced Camera configuration files are also saved.

Camera Options

As noted above, the UFODAS is designed to use a wide variety of cameras. The camera selection for a particular application would be based on the following criteria:

- Cost
- Need for triangulation of data from two cameras
- Size and ease of deployment
- Image resolution
- Anticipated target speed

Smaller, lower-cost cameras, such as USB “webcams” may be useful in situations where the investigator does not have access to the larger UFODAS configurations and/or can purchase the camera or already owns one. It is also the most portable. In this case, the entire installation may consist of just the user’s computer and such a camera. This system can, unattended, collect video and still frames with meta-data including time of day.

The Dahua cameras have the PTZ speed required for most situations, as do most of the others, but have superior imaging capabilities. This contrasts with an older Sony camera with low resolution and poor response in dark conditions (thermal noise). An Amcrest camera is very low cost (~$100), has good image quality but lacks optical zoom. Dahua cameras are rated for IP66 or IP67, outdoor use. Many other cameras were evaluated but did not provide features better than the Dahua for their cost and often presented programmability issues.

A mid-range system (the focus of the recommended initial development and test) would use a good-quality PTZ camera with 1080P resolution and at least 20x optical zoom, such as the Dahua 50230XANR. As mentioned above, this camera was selected as one of several recommended for typical UFODAS applications after extensive research and test of alternatives due to its high performance including PTZ speed and image resolution, all-weather rating, good technical support and relatively low cost. It was found that other cameras, regardless of nominal specifications, could not be used because they either did not provide an adequate PTZ software interface or did not adhere to their own specifications. UFODAP camera data sheets are available on ufodap.com. More detailed information may be obtained from the Dahua website:

https://us.dahuasecurity.com/

The architecture of the UFODAS software also provides for adding new types of cameras. This feature will provide for the use of higher-end cameras that cover different portions of the spectrum such as the MWIR (3.0-5.0 um) FLIR RS6700 used with a high-speed Pan/Tilt head such as the FLIR PTU-D48 E Series.

This type of camera can provide up to 1344 x 784 pixel Medium Wave Infrared (MWIR) images using an internally cooled indium antimonide (InSb) detector with up to 10x

zoom. One trade-off in using such a camera is its relatively narrow wide-angle field-of-view (FOV). The RS8300, for example, has a maximum FOV of only 8.97 degrees compared to 67.8 degrees of the Dahua camera. In applications where the location of the object of interest is well known, this is not a problem. However, in our application, we need to cover as much of the sky as possible while scanning for initial object acquisition. Thus, the use of an IR camera may need to be coupled to the need for a second, wide-angle EO camera on the same pan-tilt mechanism. As mentioned previously, the UFODAS is designed to accommodate that sort of configuration by making the initial target recognition with a fixed-field, wide-angle camera such as the Dahua NK8ZBR4 and then handing off tracking to a second, PTZ camera.

Other products also provide a combination of very capable Electro-Optical (EO) and Infrared (IR) imagers on a single PTZ mechanism. For example, Infiniti Electro-Optics makes a variety of such systems. See 0.

Note that the greater the zoom the more difficult it is to maintain the target in the field of view. Thus, greater zoom is useful for targets that may be initially captured while moving when the camera is zoomed out but remain in a steady position when zoomed into. These target features may or may not fit the characteristics of the UFO to be captured, so the full capabilities of some high-end cameras may rarely come into use. Nevertheless, these capabilities may have value as they are held in reserve for unknown situations that arise.

A mid-range system (the focus of the recommended initial development and test) would use a good-quality PTZ camera with 1080P resolution and at least 30x optical zoom, such as the Dahua 50230UNI-A. This camera was selected as the recommended unit for typical UFODAS applications after extensive research and test of alternatives due to its high performance including PTZ speed and image resolution, all-weather rating, good technical support and relatively low cost. It was found that other cameras, regardless of nominal specifications, could not be used because they either did not provide an adequate PTZ software interface, did not adhere to their own specifications, or did not offer any performance advantage for higher cost. An alternative, the Dahua 4A425DBNR, has very similar specifications but trades off a somewhat lower cost for only 12x zoom.

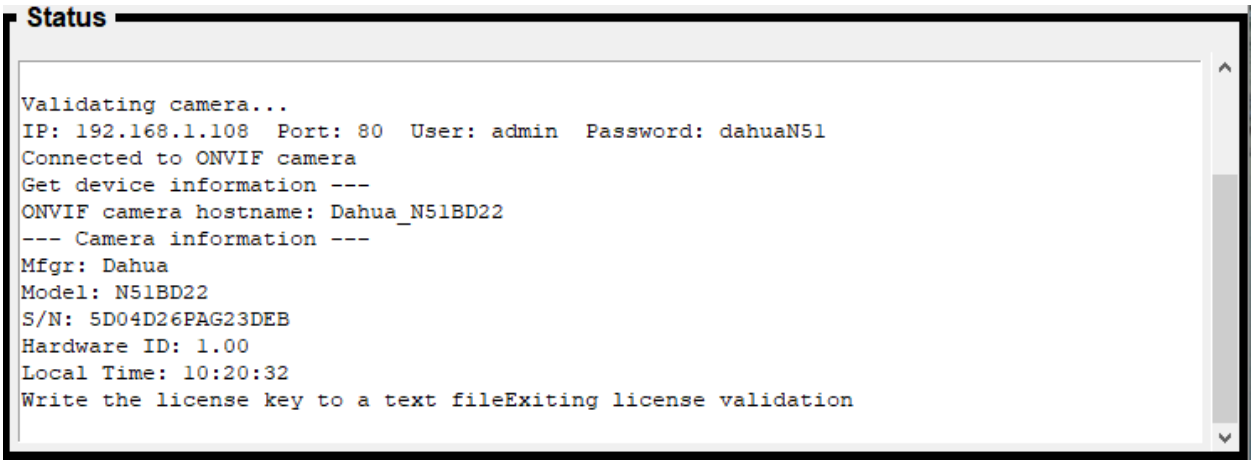
SYSTEM CONFIGURATION AND OPERATION

OTDAU configuration for operation is implemented by creating or using existing fill-in-the-blanks forms. The forms are accessed by clicking on one of the following tabs at the top of the OTDAU main window, shown below:

- System
- Cameras
- Tracking
- Touring
- Recording
- Analytics
- Sharing
- Setup
- Help

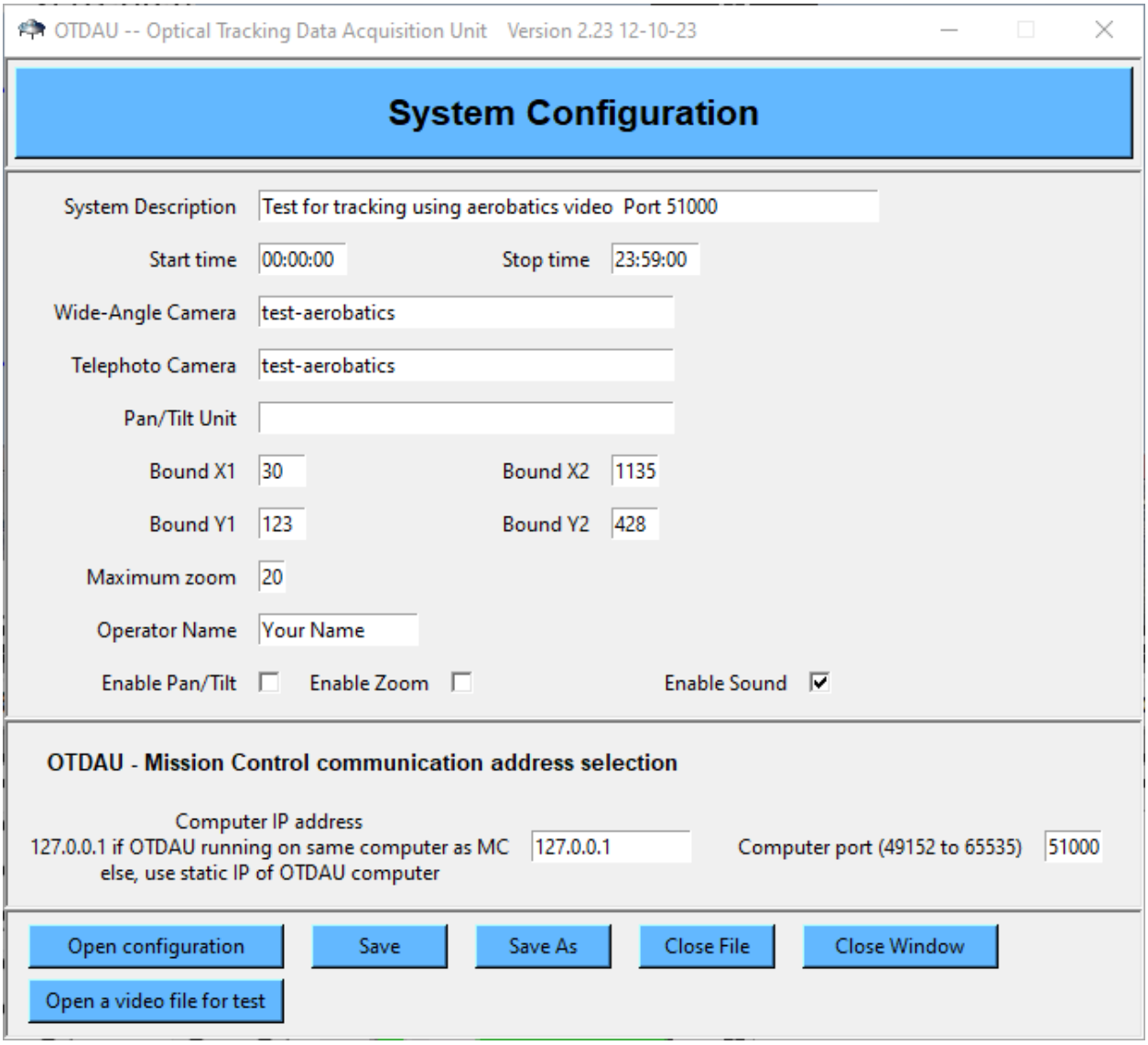
An OTDAU is configured for operation for a particular application by setting several parameters via the System configuration window. This window is accessed by clicking on the System tab at the top of the main window.

The Status display in the lower right of the main window provides a running list of messages related to what OTDAU is currently doing and its status. Prior messages no longer in the window may be viewed when OTDAU is Stopped. Messages may be scrolled through using your mouse wheel or the slider on the right side of the Status display.



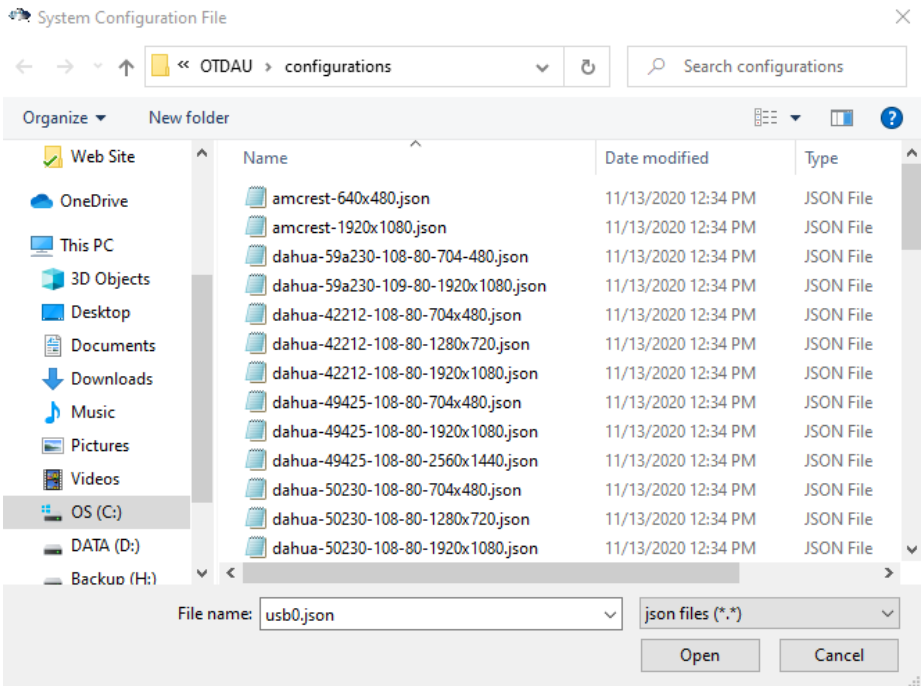
Typical uses of this information would be to see values of system variables to tune tracking or error messages to share with the system developer to solve problems.

SYSTEM CONFIGURATION



After opening the System tab in the main window, click the Open button. A file selection window will open as shown below.

NOTE: All data entry fields in OTDAU menus provide a cut/copy/paste option – Left click on any field in OTDAU or in Windows, move the mouse to highlight the desired text and then release the button. Then right click on any field and select paste to place the text into the field. Similarly, you can cut, copy and paste between any OTDAU fields and any Windows text that is clipboard compatible.



This window shows all the available system configurations. To select one, double click it or click it once and then click on Open or your selection. Note that local-usb0 is the default selection, so simply clicking Open will select the configuration that uses the USB0 device for both Wide and Telephoto camera.

A different configuration may be selected by clicking Close File, then Open and select a different configuration.

It is often convenient to create a new configuration by opening an existing one, modifying it, and then clicking on Save As. The same file list will appear but the file name, at the bottom will be highlighted and contain just ".json". Add the rest of the desired name before the ".", for example, "home-sony-1500.json".

After selecting a system configuration, all of its parameters are available for inspection or modification via the System, Cameras, Tracking, Recording, Sharing and Setup menus. Cameras selected for the Wide-Angle and Telephoto devices are shown in the Configuration menu. The unique aspects of a camera type are shown in the Cameras menu although camera specific parameters are stored in the cameras folder and modified via the Cameras menu.

To preserve user-modified or created configurations between new OTDAU revisions, the System, Camera and PT configuration files are now located in C:\OTDAU. After each installation, these files are copied/merged into the configurations, cameras and positioners folders in C:\OTDAU, updating any with the same name and retaining any

with a name not provided in the new Installation. Thus, users do not need to rename or save custom configurations between new software releases.

System Configuration form entries are:

System Description -- User-provided description of the configuration

Operator Name -- This entry should be the name of the user or other information that would clearly identify the user to others who may want to share a camera. This name will be inserted onto the Wide-Angle camera On Screen Display when the configuration is Run thereby allowing other potential users of that camera to know who is currently using it.

Start time – The time in 24-hour format at which the system will start to run if enabled to Run. Start time and Stop time are particularly useful when, for example, the sensor of the camera used is such that the image will start to pixelate under low-light conditions causing false motion triggering. Another typical use is to avoid capturing bird movements at the beginning and end of the day.

Stop time – The time in 24-hour format at which the system will stop running. It will automatically restart at the next Start time.

Wide-Angle Camera – Camera configuration selected to be the wide-angle camera.

Telephoto Camera -- Camera configuration selected to be the telephoto camera. Required but may be the same as the Wide-Angle Camera. If the selected camera is PTZ-capable, then it may be used with some type of Wide camera in the Handoff mode.

Pan/Tilt unit – Selected configuration of a Pan/Tilt unit. A PTU is a device providing a motorized mount with pan and tilt motion, for any type of load such as a video camera, DSLR camera or radar antenna. Click on this field to open a folder of available PTU device drivers. If you are not using a Pan/Tilt unit, then leave this field blank.

Crop X1 -- Pixel number of the left side of the bounding box. Numbering in the x direction is from 0 to the camera's horizontal resolution, left to right. All four crop values are automatically filled in when using the Bounding Box feature.

Crop X2 -- Pixel number of the right side of the bounding box.

Crop y1 -- Pixel number of the top of the bounding box. Numbering in the y direction is from 0 to the camera's vertical resolution, top to bottom.

Crop Y2 -- Pixel number of the bottom of the bounding box.

Maximum zoom -- Maximum optical zoom allowed for the tracking session. Should be less than or equal to the maximum the camera is capable of.

Enable Pan/Tilt -- Enable pan and tilt operations for cameras so equipped.

Enable Zoom -- Enable zoom for cameras so equipped.

Enable Sound' -- Enable bell sound when a potential target motion is recognized and a different system sound when it is qualified and acquired.

For OTDAU <-> Mission Control communication:

Computer IP Address – The IP address of the computer running the instance of OTDAU for a particular camera(s). If the computer is the same as will be running Mission Control (MC) software, then this address should be 127.0.0.1. If the OTDAU computer is different, then this address should be a static address assigned to that computer or the WAN address of the computer if it is remote from the LAN running MC.

Port -- A unique port number assigned by the user to distinguish the computer from other devices on the LAN, such as port-forwarded cameras. The value should be in the range 49152 to 65535. This port should be different for each instance of OTDAU on the computer – For example: 51000, 52000, 53000.

Control buttons

Open configuration – Opens a window into the System configuration file folder. Select a configuration by either double clicking on an entry or clicking one once and then click on Open. The selected configuration must be Loaded prior to use after Opening it. Note that the Load button may be used before or after the System Configuration window is closed by the Close Window button. See the Load button, below.

Save – Saves the current settings as part of the currently loaded System configuration.

Save As – Opens a window into the System configuration file folder. Saves the current settings as the System configuration but with a new name selected in this window. It is

very useful to Open an existing configuration, modify its values, and then Save As with a new name to create a new configuration.

Close File – Terminates use of the last selected configuration. The related cameras views on the Wide-Angle and Auxiliary displays will revert to the default image. If the system is in Run mode, it must be Stopped before Close File is selected.

Close window – Closes the System Configuration window. If the window is closed before any changes to settings are Saved, then those changes are lost.

Open a video file for test – A special type of open for configuration files which operates the same as opening a pre-configured test file (such as test-jet-cloud) except the user can select any avi file, anywhere on the computer, for the test. You may navigate to any folder on your system and then select any avi file in that folder. When opened, the first frame of that file will display. You can then click Run to emulate tracking of that pre-recorded file instead of using a camera. This is very helpful to analyze existing files and to adjust tracking parameters for similar future recordings using a live camera.

TIP: To optimize Tracking settings for a particular type of target and environment:

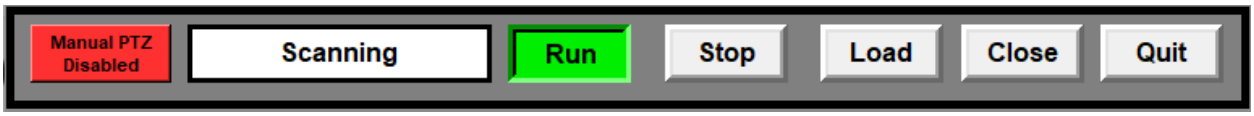
1. Set up the camera to point in the desired direction at a typical time/environment
2. Turn off any PTZ settings, using the camera as a fixed lens unit
3. Set recording options including Tele video without text
4. Click Ready to Record to start/stop manual recording when a representative object, such as an aircraft moves through the image.
5. Load the resulting file using the above test option
6. You can now play the test video as many times as needed while making adjustments to various Tracking options

A System configuration may be selected in two ways:

- Click on the System tab and then Open to see all available configurations. After selecting a System Configuration, click on the Load button located below the Wide-Angle Video Display area.

- Click on the Load button without using System. This will bring up a shortcut list of any configurations that have been loaded using the System menu previously. If no configuration had ever been loaded, then you will be prompted to select one. If only one such configuration had previously been used, then that configuration is immediately loaded.

The status box on the left, also below that display area will indicate load progress ("Initializing video…") and, when the load has been completed, it will display "Ready to Run". When the system is Running, "Scanning" is displayed.



When a PTZ (or Zoom-only) camera is loaded, the Manual control indicator on the left will turn green and show the initial camera that the PTZ control will affect. Clicking on this button will change the affected camera from Wide to Aux if that camera is PTZ capable. The button will again turn red during Run. Being able to select which camera the Manual controls apply to make it easier to setup camera directions when more than one PTZ camera is in use. All combinations of fixed cameras, PTZ cameras and a Pan/Tilt head are supported. Cameras such as the Dahua N65CL5Z that have a motorized zoom function but not Pan/Tilt are also supported.

The Close button closes the currently selected System configuration. Click it prior to using the Load button or the System menu to select a new configuration.

The Load button is used in two ways –

- To initialize a new configuration after it has been selected via the System menu.

- To select a new configuration immediately after starting OTDAU or after Closing the last configuration. OTDAU provides a list of past configurations to choose from. If only one configuration was ever selected, then clicking Load immediately loads that configuration.

The Wide-angle display at the top left of the main window displays the video stream from the selected Wide camera.

The Auxiliary Video Display, at the top right of the main window, will display a still frame or motion video depending on which of four buttons are clicked:

- Raw Video -- Default selection that displays the Wide-Angle camera video stream without any meta-data overlay.
- Telephoto -- Video from the configured Telephoto camera or from the Wide-Angle camera if the Telephoto camera is the same as the Wide-Angle camera. This display will include an overlay of meta-data including camera type and date and time on the bottom as well as camera position, field size and PTZ motion indicators if the camera was defined to be PTZ-capable. Displays a digitally-zoomed image of the tracked object if the Wide camera is not PTZ.
- Tracking -- Displays video from the tracking process to aid in tracking-related parameter settings. If Feature Tracking is not enabled then this display shows a black and white representation of frame-to-frame differences. If Feature Tracking is enabled, then this display shows the Raw video with the tracked object surrounded by a green box. This display is helpful to verify what the system is tracking and if it loses track.
- Path -- Displays an accumulation of lines indicating each time a target was recognized by the tracker during run-time. Particularly when the Wide-Angle camera is not PTZ, this is a convenient method to determine the track or motion profile of a tracked target.

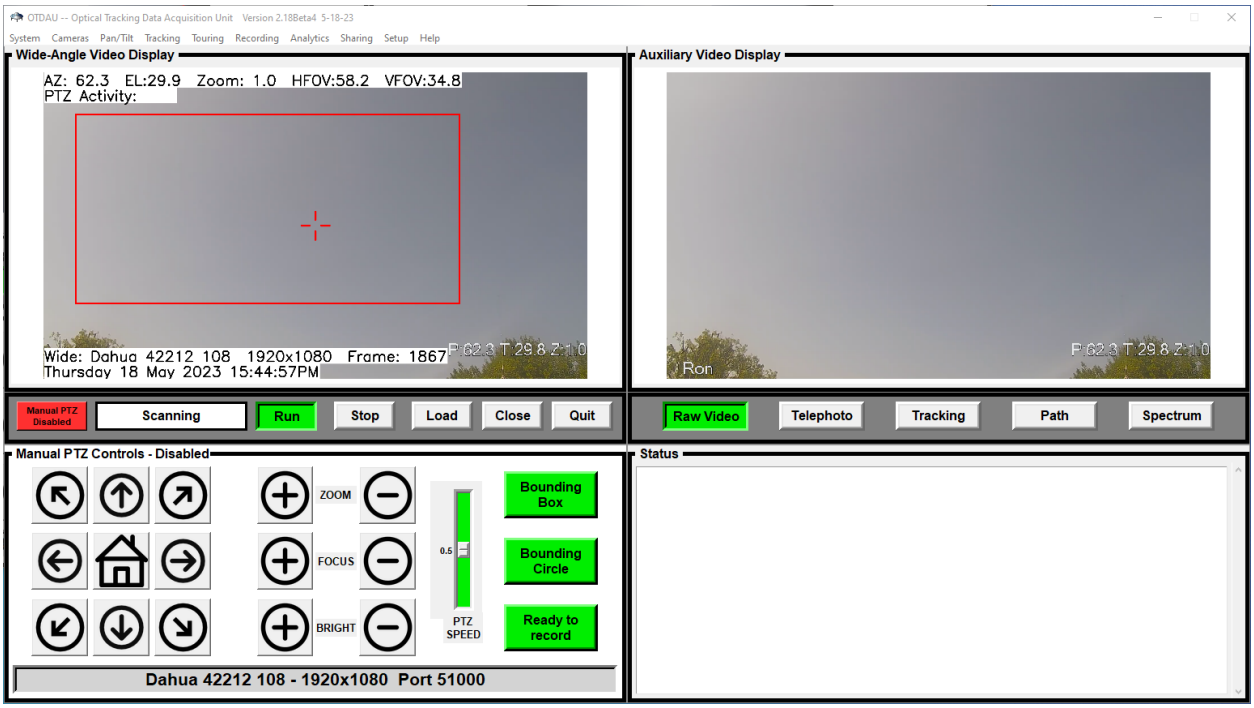
  The Path display includes numbers in upper left corner that correspond to each path. If the Auxiliary Video Option is “Path of target hits” then these numbers and the paths are randomly color-coded. If recording is enabled the path numbers also correspond to the folder number of each recorded tracking event. If Recording options do not include Paths, then the path display shows each path in green.

  Track path analysis – After each tracking sequence has finished, the path of the tracked target is analyzed for non-linear changes (divergence from a straight path). The point(s) of divergence is displayed and saved as a red circle on the track path.

  When recording and the system is Stopped, the accumulated paths are saved as a single .jpg file in the Group folder for the run.

- Spectrum – Displays a real-time optical spectrum if the Wide camera is equipped with an appropriate grating. (HARDWARE FOR THIS IS IN DEVELOPMENT).

The complete main window, with Raw Video selected, will now appear as follows:



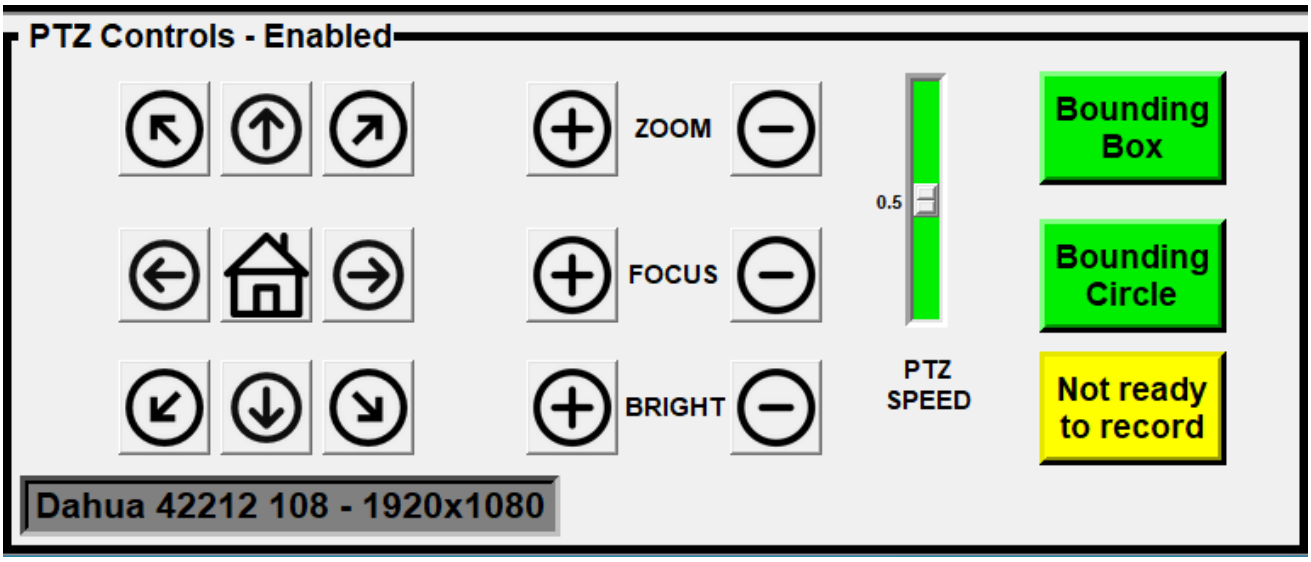
The scrolling text in the Status window, on the lower right, provides an indication of what the system is always doing. It may be used to confirm what files and cameras are in use, error conditions and other operational status. Status messages that have scrolled out of view can be viewed by moving the slider on the right or clicking into the Status window and using your mouse scroll wheel.

Note that manual pan and tilt adjustments are only operational if the System Configuration Enable Pan/Tilt box is checked. Likewise, Zoom adjustments are only available if the Enable Zoom button is checked. The Focus and Brightness controls will not function for cameras that do not support ONVIF control of those properties.

During tracking using a fixed camera, the AZ and EL values are emulated in software. These angles are computed for useful representation when displayed by Mission Control: AZ ranges from (360 – ½ horizontal FOV) to (1/2 horizontal FOV). EL ranges from vertical FOV at the top to 0.0 at the bottom. This is as if the camera was a PTZ type initially pointed North and ½ vertical FOV above the horizon.

At this point, if the Wide or Telephoto camera is a PTZ unit, then the pan/tilt/zoom controls in the PTZ Controls area are enabled. The PTZ Controls, in the lower left of the main screen, are shown below.

D



The label next to “PTZ Controls” indicates whether these controls are ready for use or not as Enabled or Disabled.

AUTOMATIC CAMERA HOMING FUNCTIONS

OTDAU detects the home or initial position of a pan/tilt/zoom camera and saves it in the associated configuration whenever a System configuration starts to Run. When during the run the system is reset, e.g., due to a timeout or clutter, the camera is returned to the last set home position.

OTDAU also moves a camera(s) that are part of a configuration to its home position as soon as that configuration has been Loaded. It does that so the user can set up camera pan/tilt/zoom values for a particular situation, as reflected in the System configuration and the camera(s) automatically return to that position.

If a configuration had never been loaded such that no home position exists, OTDAU will not move the camera(s). The user may then manually move a camera to the desired starting position. When the configuration is then Run, an initial home position is saved.

POSITIONING A PTZ CAMERA

The PTZ Controls, when Enabled, are used to move the camera into the Home or initial position, ready to begin scanning for moving targets. This is accomplished via the LEFT, RIGHT, UP, DOWN, ZOOM WIDE and ZOOM TELE buttons. Moving the PTZ SPEED slider up or down will set the relative speed of any of those controls. The last position of a PTZ camera prior to starting Run will be the position the camera returns to at the end of each tracking process.

The Focus control will continuously adjust camera focus in or out while + or – is held on with the left mouse button.

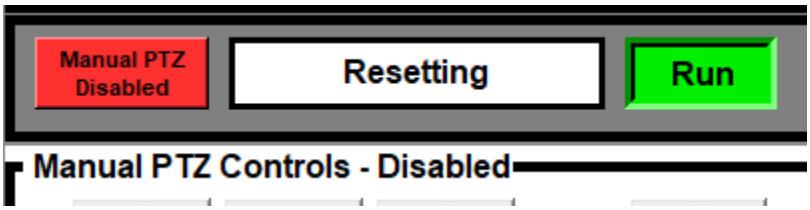
The Brightness control incrementally adjusts camera image brightness up or down when + or – is repeatedly clicked.

Manual PTZ button to select which of the Wide, Tele or Pan/Tilt devices will be controlled by the PTZ direction, Zoom, Focus and Brightness controls. This makes it easier to set up camera directions when more than one PTZ camera is in use. All combinations of fixed cameras, PTZ cameras and a Pan/Tilt head are supported.

Manual controls are disabled when:

- Pan/Tilt and Zoom are not enabled in the System configuration
- PTZ capable is not enabled in the Camera configuration
- The system is in Run mode

For example, PTZ functions are disabled as shown in the fragment of displays, below:



SETTING A BOUNDING BOX

OTDAU allows the user to select the area of the Wide camera view that the system will scan for motion, ignoring the area outside of this bounding box. This is valuable to avoid triggering tracking on moving parts of the background, such as foliage. The Wide-Angle Video Display shows the bounding box in blue when the system is not running and in red when it is.

Start by clicking on either the Bounding Box or the Bounding Circle buttons. Either type will work for any camera or test video. The circle is particularly useful with panoramic, All-Sky Cameras that have a circular optical view.

To set a bounding box:

- Click on System after a System configuration has been selected. Manually change the values of the entries for Crop X1, Crop X2, Crop Y1 and Crop Y2. These are the left, right, top and bottom extents of the bounding box. Clicking on Save will save these values to the configuration and update the display to show the new region. You may modify these values again and re-save until the box is satisfactory. Click Close Window when done.

- With a System configuration loaded, click the green Bounding Box button. The button will change color to yellow. Hover the mouse over the Wide-Angle Video Display window. Move the cursor to one corner of the desired bounding box and, while holding down the left mouse button, drag the cursor to the opposite corner of the desired box, which will be displayed as you do this. Release the mouse button to see the full box – the coordinates of this box will be saved in the currently opened configuration and displayed. You can redraw the box, starting at any corner, as many times as needed by clicking the Bounding Box button and redrawing the box. The box coordinates are automatically saved to the open configuration when the mouse button is released.

To set a bounding circle:

- With a System configuration loaded, click the green Bounding Circle button. Move the mouse to point to where you want to place the center of the circle. Hold the left mouse button down and move the mouse to define the size of the circle. Release the button to set the circular bounding box. The circle data is saved in the System Crop values as center X in Bound X1, center Y in Bound X2, radius in Bound Y1. Bound Y2 is always 0.

When the Run button is clicked, the system will begin to scan for moving objects in the bounding box within the field of view of the Wide-Angle camera.

Note: When operating OTDAU without Pan/Tilt enabled, a target will only be tracked when it is within the bounding box. When using a PTZ camera with Pan/Tilt enabled, a target object will be tracked for as long as it remains in view.

ENABLING PAN, TILT AND ZOOM

The Enable Pan/Tilt and Enable Zoom check boxes may be used to enable those functions for a PTZ camera. If the Wide camera is not PTZ-capable, then Enable Pan/Tilt is ignored. However, enabling zoom will cause the Telephoto view to use digital zoom. In this mode, the telephoto view displays the portion of the Wide camera frame within the current bounding box, resulting in a digital zoom effect.

The Wide and Telephoto camera selections can be the same Camera Configuration but could be any combination of two cameras. For example, the Wide camera might be a 360-degree (“All-Sky”) type and the Telephoto camera may be a PTZ type. In that case, the location of a detected moving object in the field of view of the Wide camera is used to continuously direct the view of the Telephoto camera to the same object.

If the System Configuration Wide camera is not PTZ capable, such as a USB type, and the Telephoto camera is PTZ-capable, then the PTZ Controls will apply to manual moves of the Telephoto camera.

MANUAL RECORDING

The Recording button allows the user to continuously record the Wide-Angle camera view without on-screen metadata. The button is initially green and is labeled “Recording stopped”. Any time after a System Configuration has been Loaded, and recording has been enabled via the Recording options, the user may click on this button to record the Wide-Angle view. When clicked, the button changes to red and displays “RECORDING”. Click it again to stop the recording.

The recorded .avi file is written to the same folder as other recordings, as selected in the Recording menu. Each manually initiated recording opens a new folder named for the System Configuration with the date and time appended. Under that folder will be a video .avi file named “otdau-wide-manual-date.avi” such as, for example:

otdau-wide-manual-12-52-17.avi

OTDAU will continue to record wide camera frames to this file until the Recording button is clicked again, the configuration is closed or the OTDAU software is closed.

Normal triggered recording, as enabled by the “Enable recording” check box in the Recording menu, also causes the Record button to change color and label when an event causes recording to start or stop. Both triggered and manual recording states affect the color/label of the Recording button independently. The user may start or stop manual recording regardless of any triggered recording functions in progress.

CAMERA CONFIGURATION

UFODAS supports inputs from and displays of either one or two simultaneous camera video streams. These are displayed on the left Wide-Angle Video pane and the right Auxiliary (Aux) Video pane. It also supports Pan-Tilt-Zoom operation of cameras capable of such motions via their CGI command set or via internationally standardized ONVIF commands.

Supported combinations of cameras and displays are as follows:

One camera: Selected in a System configuration File as both the Wide-Angle and the Telephoto camera. In this case there are several operational possibilities, depending on camera type:

1. The camera is not PTZ-capable, such as a USB camera or it is an IP camera with PTZ disabled. The camera image will be displayed on the Wide-Angle pane including textual meta-data superimposed on the image. On the Aux pane, there are four selectable display sources:

    - Raw Video: The video image without any superimposed text.
    - Telephoto: The video image with abbreviated text. The image will be the portion of the Wide-Angle image that is within the Bounding Box, which simulates digital zoom.
    - Tracking: The wide-angle video image as processed by the tracking algorithm showing what contours the system is using to identify a target. This display may be helpful when setting analysis parameters to improve target identification and tracking. White areas may display intermittently showing where the system sees a potential target that may or may not be accepted.
    - Path: The Wide image overlaid with green boxes indicating each time the tracker identifies the moving object and its relative size. This is very useful in determining the track or motion of an object that may be too fast or small to know otherwise.
    - Spectrum: A line spectrum resulting from use of an optical grating in front of a camera lens is automatically detected and converted to a graph of power vs wavelength, displayed. This option will be usable after a suitable grating

assembly and any further software additions are made available after completion of development.

2. The camera is PTZ-capable and PTZ is enabled. This case is similar to 1 except that the Telephoto display is the full video of the Wide-Angle camera, and the superimposed text includes azimuth, elevation and zoom values.

Two cameras: Selected in a Configuration file, either static or PTZ-enabled. Typically, in this case, the Wide-Angle camera is a fixed camera (or a PTZ camera is used without PTZ enabled) to focus attention on an area of interest. The relative location of a target on this camera is used to direct the Telephoto camera to point at the target. The Aux pane thus displays the target as close to the center Field of View (FOV) and as zoomed in as the system is capable of tracking given the target dynamics. This case includes the application of either a fixed or an “All-Sky” type of camera and a PTZ camera with 360-degree pan capability.

To set up a two-camera system where the second camera is PTZ-capable, prior to running, start by enabling FOV calibration marks in the Setup > Display Options. Then move the initial position of the PTZ camera so that its Center Field of View (CFOV, as indicated by the red crosshairs) is aligned with the CFOV of the fixed camera. A laser pointer may be helpful to establish a common point of reference for both cameras. Verify that a test object moving left-right and up-down near the CFOV of the fixed camera moves in the same direction in the Telephoto view of the PTZ camera. If not, rotate either camera to achieve this alignment.

Another two-camera configuration is used for triangulation. In this case, both cameras may be fixed or PTZ-enabled and are operated by two separately running copies of OTDAU. Both cameras independently identify and track moving objects and their data is combined by the Mission Control software to provide a true position estimate of the target. Note that any combination of the OTDAU instances and MC could run on the same or different computers if the addresses and port numbers are set correctly in the OTDAU System configuration and corresponding MC Sensors configurations.

USB CAMERA SETUP

Most USB cameras and other USB-interfaced video sources require a driver to be installed prior to use. The driver would be provided by the camera manufacturer.

Use a utility provided as part of the manufacturer's software to determine or modify the camera's operating settings. For example, change the horizontal and vertical resolutions. Values for resolution and frame rate must match those entered in the camera's Camera Configuration. The current version of OTDAU software automatically configures USB cameras to the resolution specified in the Camera configuration, if possible. An error message will appear if the camera does not support the selected resolution.

Any USB camera will work with OTDAU. Just be sure to select a resolution that the camera can produce. A camera that only provides a composite analog video output can be interfaced to OTDAU via an analog to USB interface device. One such device that works well for this purpose is the USB-Live 2 Analog Video Digitizer from Hauppauge.

OTDAU attempts to set the resolution of a USB camera to the values entered in its Camera configuration.

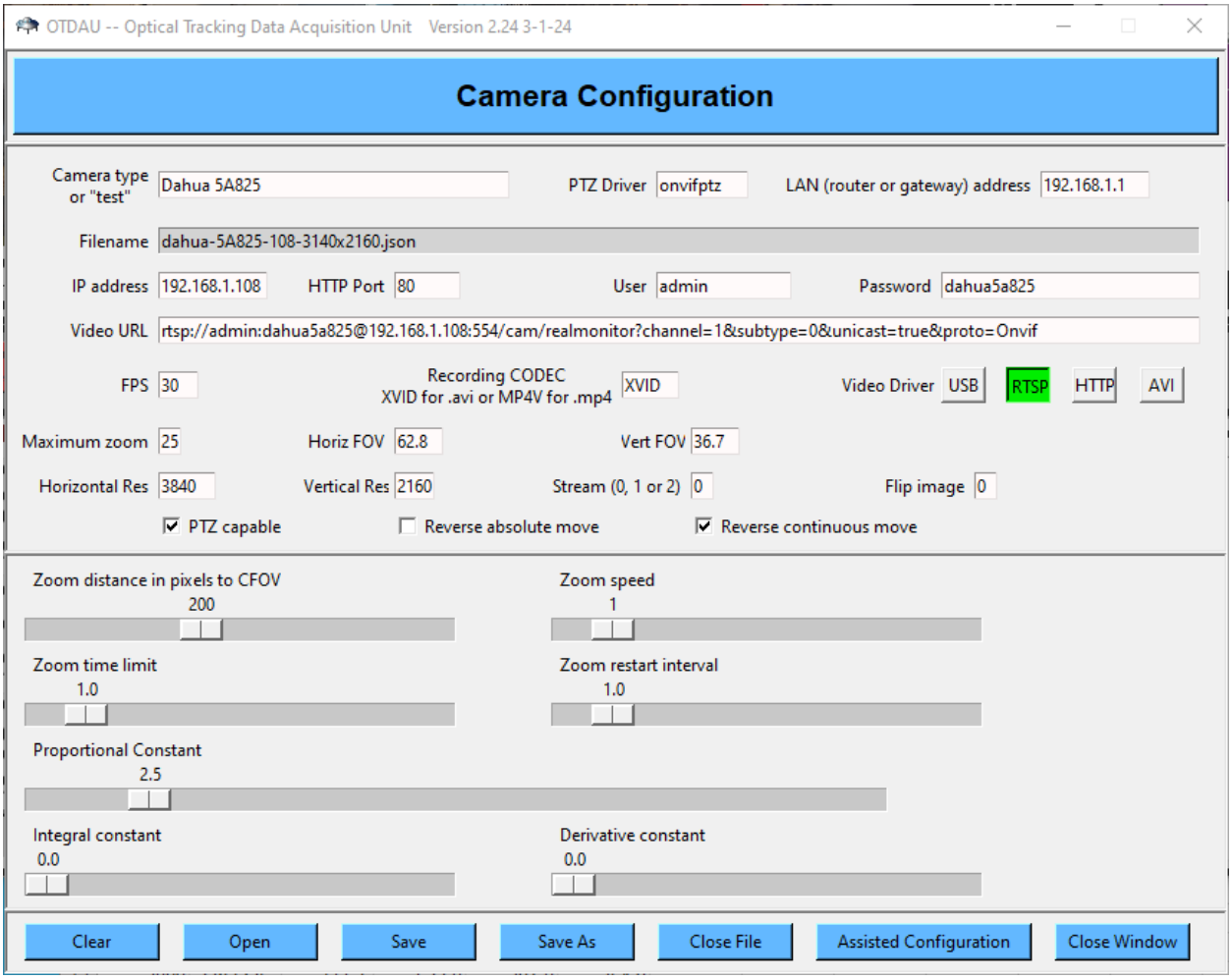
If you have difficulty acquiring an image from a USB camera (or analog-to-USB converter), try connecting via a program other than OTDAU. Three helpful resources are:

- VLC Media Player – connect via its Media > Open Capture Device feature to stream video from a camera.
- WebcamViewer – Automatically shows connected USB devices to select from. Just select the resolution and click Connect. You can find this free tool at:

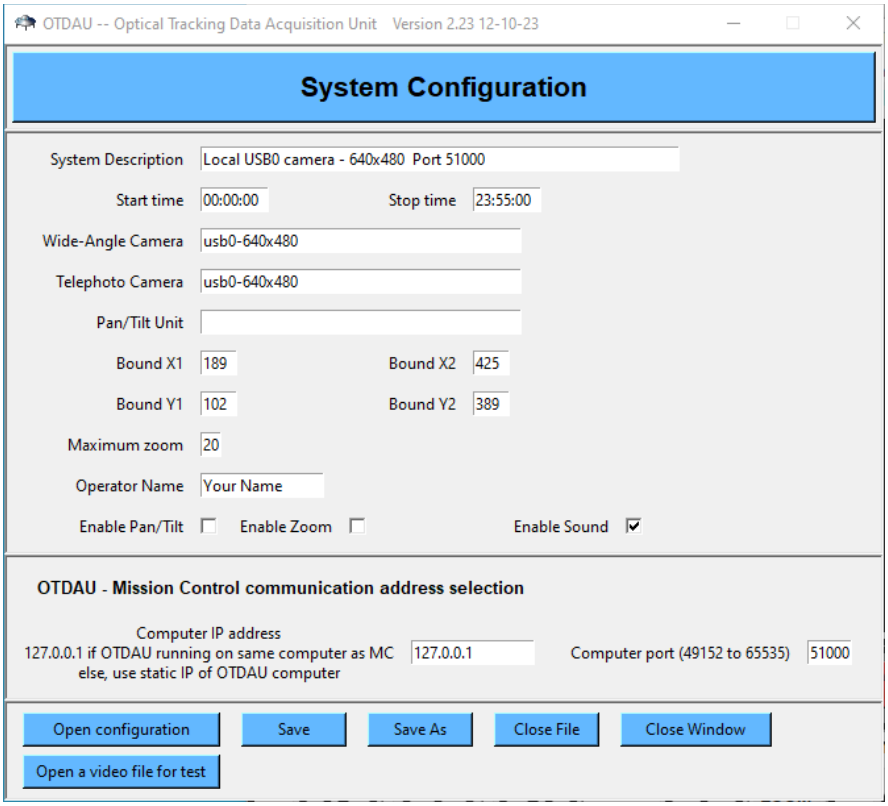
  www.bustatech.com

- Webcamtests.com – Just select the video input (corresponding to a camera USB port) and click "Test my cam". This online test will display the video stream as well as list all the specs/characteristics of the camera selected.

After verifying that the camera functions on the computer running OTDAU, proceed to create a Camera Configuration for it or use one of the USB0, USB1 or USB2 configurations provided with OTDAU, as shown below.


OTDAU -- Optical Tracking Data Acquisition Unit Version 2.24 3-1-24
Camera Configuration
Camera type or "test"
Dahua 5A825
PTZ Driver
onvifptz
LAN (router or gateway) address
192.168.1.1
Filename
dahua-5A825-108-3140x2160.json
IP address
192.168.1.108
HTTP Port
80
User
admin
Password
dahua5a825
Video URL
rtsp://admin:dahua5a825@192.168.1.108:554/cam/realmonitor?channel=1&subtype=0&unicast=true&proto=Onvif
FPS
30
Recording CODEC
XVID for .avi or MP4V for .mp4
XVID
Video Driver
USB
RTSP
HTTP
AVI
Maximum zoom
25
Horiz FOV
62.8
Vert FOV
36.7
Horizontal Res
3840
Vertical Res
2160
Stream (0, 1 or 2)
0
Flip image
0
PTZ capable
Reverse absolute move
Reverse continuous move
Zoom distance in pixels to CFOV
200
Zoom speed
1
Zoom time limit
1.0
Zoom restart interval
1.0
Proportional Constant
2.5
Integral constant
0.0
Derivative constant
0.0
Clear
Open
Save
Save As
Close File
Assisted Configuration
Close Window

A System configuration that uses this USB camera might look like:

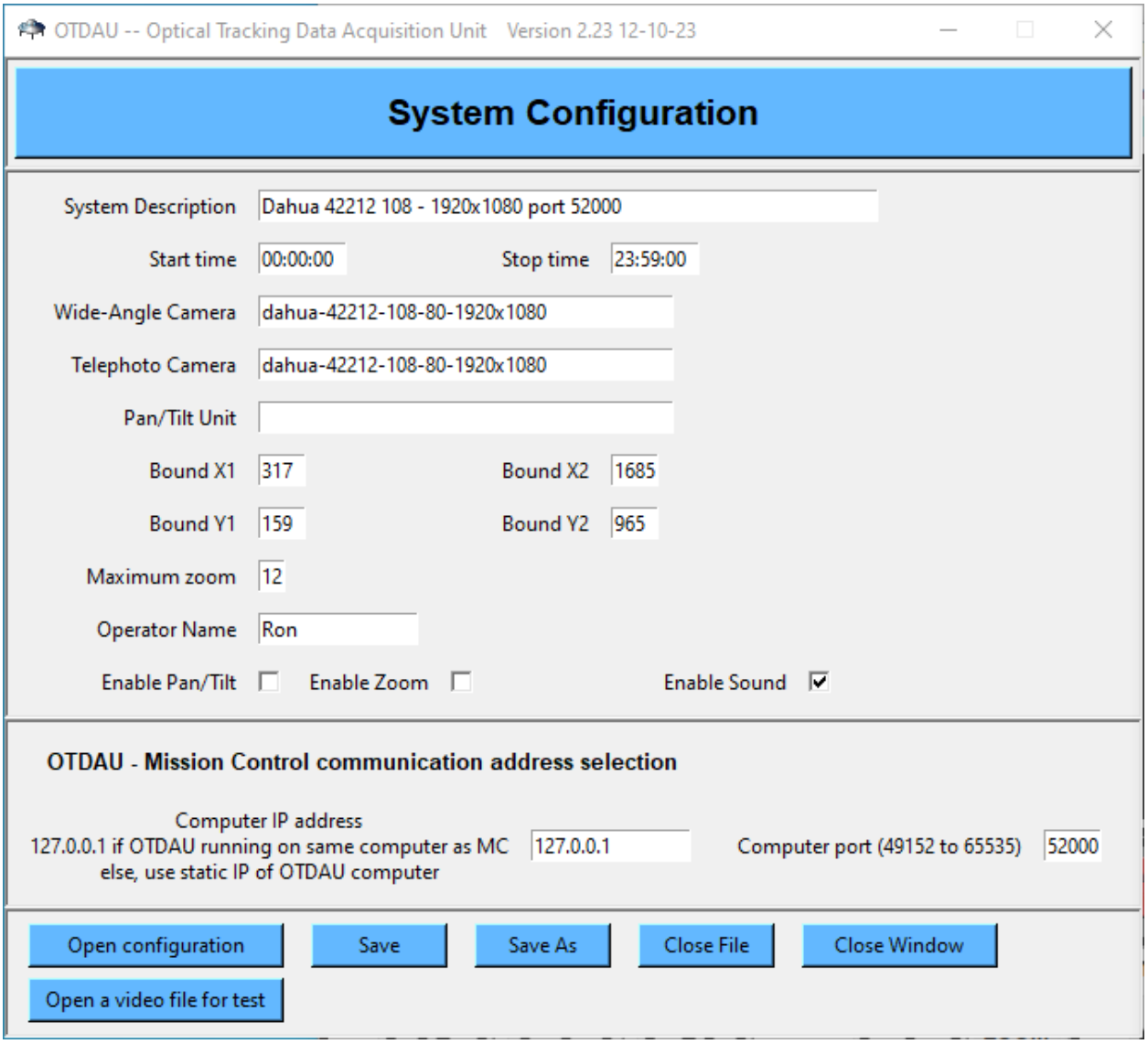


IP CAMERA SETUP

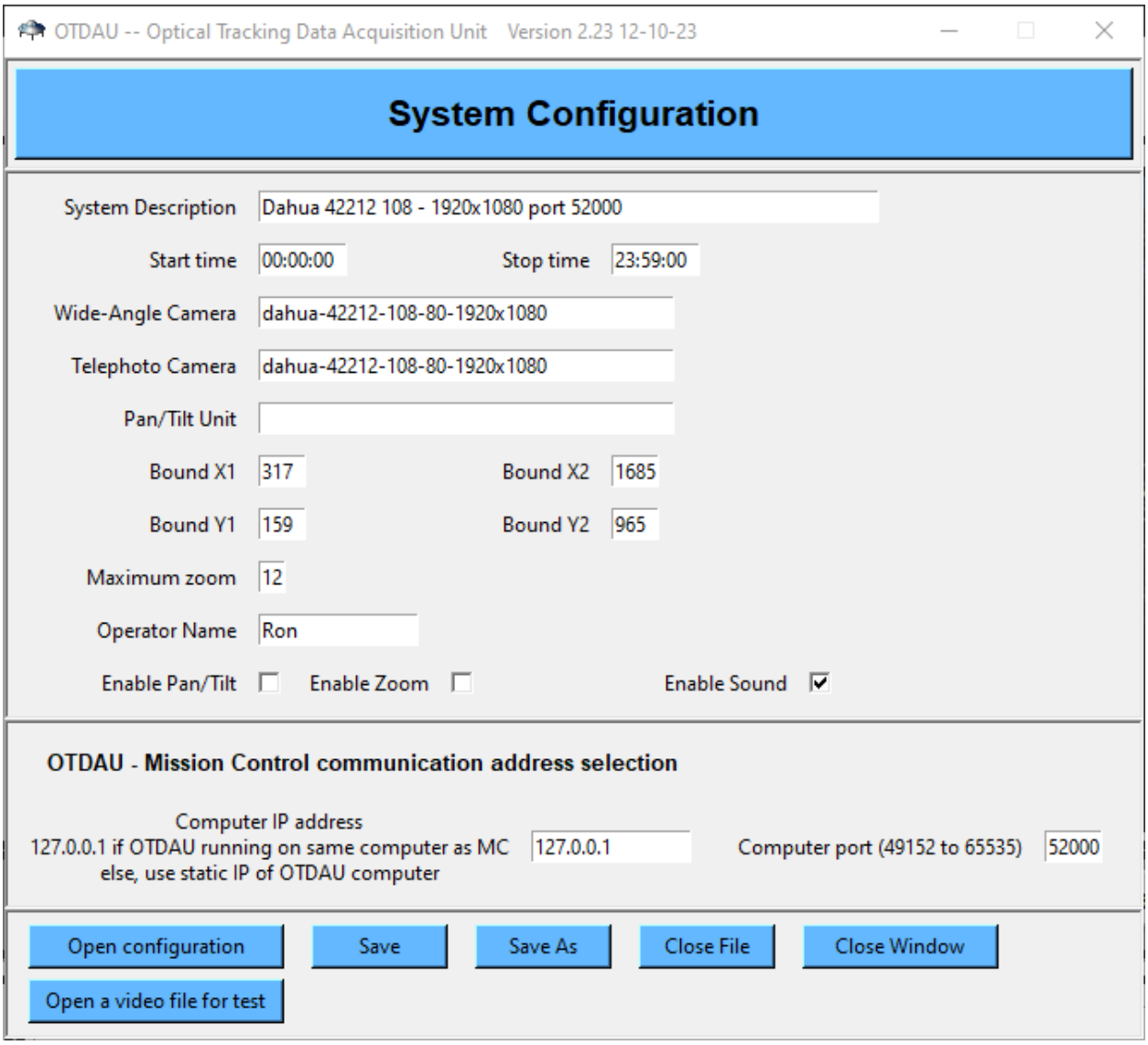
Setting up an IP camera for use with OTDAU involves several steps that, if done carefully and in order, will make it a reasonably simple process.

Please see the UFODAS System Installation Guide for IP camera hardware setup and configuration.

After verifying camera connectivity and operation it may be used with OTDAU by creating a camera configuration, for example, as shown below for a Dahua 42212 camera set to a resolution of 1920x1080.



A System configuration that uses this Camera configuration might look like:



Since this camera supports pan/tilt/zoom functions, the Pan/Tilt and/or the Zoom choices could be enabled and Saved prior to Run to allow those functions to be used for manual or automatic tracking purposes.

IP CAMERA SETUP PROBLEMS

Some typical problems with IP camera setup and OTDAU configuration include:

- The camera IP address and port are set to values that are not the same as those in the camera's configuration file.
- The camera's IP address conflicts with another device on the same LAN. Use the Dahua ConfigTool to check for this – it will highlight two conflicting cameras in red if they have the same IP address. A typical problem is that the range of DHCP addresses that the router uses to automatically assign IP addresses to non-Static devices overlaps your camera's IP address and the router used that address. If this is the case, modify the DHCP range to, for instance, 1 to 99 so that your camera's IP, such as 108, is not within that range.
- If port-forwarding via the router, the port number selected in the camera is not available to be forwarded in the router.
- The video resolution selected in the camera's setup does not match the camera's OTDAU configuration.
- The camera's codec is not set to XVID, MPEG4 or MJPEG, but rather JPG or H.264 for example.
- The video stream HTTP string entered as the Video URL in the camera configuration has an incorrect user, password, IP or port number. It may also not comply with the particular URL format required by the manufacturer for that camera.
- If the PTZ camera will not initially acquire a target image, but instead makes an initial movement away from the target position, verify that the value of the Absolute move direction check box in the PTZ camera configuration is correct. Reverse it and try again, preferably with a test object or the laser-on-the-wall method.
- If the PTZ camera makes uncontrolled continuous movements after target acquisition, check the setting of the Continuous move direction check box in the camera configuration. Also check that the Proportional velocity setting is not too large. The correct setting will cause the camera to smoothly track a moving object and, when the object slows or stops, moves it to the CFOV. An incorrectly large setting will result in "hunting" or constant back-and-forth movement of the camera CFOV about a static target location. If it is sufficiently larger than this stabile setting, then the camera will move away from the target location, possibly

encountering other background objects which cause additional triggers and even more loss of control.

- If the image tends to defocus (and loose track) during zooming, then it may be that the camera's autofocus function is not adequate for OTDAU zooming or is too slow or does not focus properly in low-light conditions. Prior to use, it is usually best to set the cameras zoom option to Manual and then set focus as follows:

    1. In daytime lighting, center the camera FOV on an object with sharp edges or writing.
    2. Zoom to maximum, moving pan or tilt to keep the object in the center of the frame.
    3. Operate the +/- focus control to bring the object into as sharp focus as possible. Iterate between steps 2 and 3 to get the best focus.
    4. Notice that now the object and other parts of the view will stay in focus regardless of zoom level.

- Problem connecting to ONVIF cameras that cannot disable ONVIF Authentication or Authentication is enabled: This problem may not occur if the camera Time Zone and Current Time exactly match that of your PC (use Sync PC to set time). For Dahua cameras, go to System > General > Date & Time to set the Time Zone and Current Time. Correct connection will be made if the time is synchronized or Authentication is turned off.

- If when opening a System configuration, you get a message such as: 'Could not connect to ONVIF camera -- check IP, port, username or password' and error information that the connection is not authorized, then your camera may not have an ONVIF user set up. Go to the System account section of your camera's webpage and look for a place to add an ONVIF user. Use the same username and password to set up an ONVIF user as you use for the camera.

-

COMMON IP CAMERA CONFIGURATION PROBLEMS

If OTDAU will not recognize your camera after configuration and Load or if you get the error message ‘Could not open wide RTSP camera’, then it you may want to check for the following camera and system configuration problems:

- IP address in the Camera configuration in either the IP or Video URL entry or both does not match the IP address of the camera.
- The User and/or Password entries are incorrect.
- The IP, Port, User and Password are correct, but they were changed and then the Camera Configuration was not saved.
- The port number entered in the Camera configuration does not match the camera’s HTTP port number or the camera’s port was not set to the expected port number in the camera’s setup menus, accessed via IE.
- If the camera is accessed remotely via the Internet by port-forwarding, then verify that the IP address used in the Camera configuration is the camera’s WAN address, not its LAN address (192.168.1.x). Verify that the camera has been properly port-forwarded using its correct IP address and port number in the router which is local to the camera (which it is directly connected to by wire or WiFi).
- The Camera type in the Camera Configuration is not one recognized by OTDAU.

If the computer running OTDAU is connected to the same local router as the camera (they are on the same LAN), then verify that the IP address used for the camera is its local (LAN) address, i.e., 192.168.1.x.

The Camera Configuration Assistant function of OTDAU has been provided to help resolve such issues and automatically identify the correct RTSP URL and ONVIF control and status functions.

SETUP FOR ALL-SKY (PANORAMIC) CAMERA

OTDAU supports IP and analog cameras with ultra-wide-angle lenses, also known as All-Sky Cameras (ASC) or panoramic cameras. An ASC may be used alone or in combination as the Wide camera with a second Tele camera.

If the tele camera is PTZ-capable, then it will operate in one of two modes – slaved or handoff. With the Setup Handoff option disabled, the PTZ camera pan and tilt angles will be slaved or incrementally moved to match the calculated approximate direction of the target based on its location in the Wide camera FOV.

If Handoff is enabled, then the initial calculated target position is used to move the PTZ camera to those pan/tilt angles and then hands-off subsequent tracking to the PTZ camera. At handoff, the PTZ camera is moved such that its FOV is approximately centered on an estimated target position. The PTZ camera then begins its own target detection resulting in a second absolute move of the target to its CFOV, this time more accurately. It then continues to track the target in a continuous, velocity feedback mode.

Because the handoff position is more of an estimate than when a PTZ camera would have made the initial recognition, the Crop increment value in Tracking Settings should be set larger than usual. For example, set it to 10.0 instead of 5.0. The system will automatically reduce the crop or bounding box around the target after the PTZ camera locks onto the target itself.

When using an ASC you may notice that some smaller objects you can see visually do not seem to appear on the ASC Wide-Angle display. This is possibly because so much of the visual field is imaged by the ASC that objects visually observed near the horizon occupy too few pixels on the image. On an ASC, the closer to the horizon (its worst case), the more the field is compressed.

This website provides a size/distance/angle relationship:

http://www.astro.ex.ac.uk/people/hatchell/rinr/sizeangle.pdf

Which is x = r a pi/180 where x is the size of the object, r is the distance to it and a is the angle subtended by the object to an observer.

As an example, for a small aircraft, x might be 20'. Say the distance from the observing area to an aircraft is about 4000'. So, the angle the aircraft subtends would be 0.28 degree. Assume that the ASC was set to resolution 2048x1536. That would result in about 2000 pixels per 360 degrees. The aircraft would then cover only 1.5 pixels and thus would not be visible. In contrast, a non-ASC camera with a horizontal FOV of 60

degrees, at resolution 1280x720 would provide 1280 pixels per 60 degrees. This would result in the aircraft covering nearly 6 pixels and thus probably be visible on the display and detectable by OTDAU. Note that these calculations are for the worst-case condition of an object near the horizon. The closer an object gets to the CFOV of the ASC, the less reduction in size/pixels will occur. Thus, a particular ASC may be rated for 180/360-degree coverage but not all that area may be useful. Additional calculations or experimentation may be required to determine how much of the FOV of an ASC would be useful.

SETUP FOR DUAL CAMERAS

OTDAU can be configured so that the wide-angle and telephoto cameras are not the same. Each one can be any type of camera OTDAU supports. Typically, the same camera configuration is used for both, example, USB0 or a PTZ camera.

If the single camera is USB, then that camera's video will appear on both the Wide-Angle Video Display and the Auxiliary Video Display regardless of the sources selected. All tracking functions will work but, of course, no PTZ action is possible.

If the single camera is a PTZ-capable unit, then its video stream will also be used on both displays. However, the Auxiliary on-screen data will vary depending on the source selected. Raw video may be selected to eliminate all on-screen data, for example.

If different cameras are used for the wide and tele configurations, then the wide camera stream will be used for all displays except the Telephoto source selection. Note that these same four selections are available for recording.

A particularly useful System configuration consists of two cameras where the Wide camera has very wide-angle fixed optics and the tele camera is a PTZ unit. In this configuration, OTDAU will use the relative position of a tracked object on the wide camera to direct the pointing angles of the PTZ camera at the same object. As tracking progresses, the PTZ camera will incrementally zoom in the same manner as for a single PTZ camera configuration. If Handoff is enabled, then the Tele camera will perform its own object identification and then continue to track as if it were the only camera. If Handoff is not enabled, then the Tele camera will make a series of incremental moves to each x, y coordinate provided by the Wide camera as it tracks the object. In this case, the Tele camera is slaved to the Wide camera instead of controlling itself.

In the case where the wide camera is a panoramic or "all-sky camera" (ASC with up to 360-degree optical FOV), some special setup steps are required to align the PTZ camera FOV with that of the wide camera. For the ASC to provide the PTZ camera with the correct estimated pan/tilt values, the system must be calibrated prior to use. The initial position of the PTZ camera must be related to the ASC by the following process:

1. Try to mount the two cameras so that their lenses are as close together and at the same height as possible. However, given the typically long distances to a target object, a difference of a foot or two is not very consequential.

2. Enable handoff calibration marks in the Setup > Display menu.

3. Load OTDAU with the dual-camera configuration and set the Auxiliary source to Telephoto. Verify that you can see the views from both cameras. Set the

Auxiliary Video Display to Raw Video. Use Flip = 0 for the ASC camera configuration.

4. Rotate the wide camera so that the horizon is parallel to the lower part of its FOV.
5. Using the PTZ Controls, move the tele camera down and rotate so that it displays the wide camera's view centered in its FOV. Use the Setup > Enable FOV calibration marks to help align the marks of both cameras. Using the PTZ Controls, move the PTZ camera so that tilt is 0 degrees (horizon) and pan is such that it is aligned with the bottom of the ASC view direction.
6. Use the Pan control to manually move the PTZ camera so that its Center Field of View (CFOV) crosshairs are over the same view as that of the Wide camera.
7. Optionally, Enable Handoff in the Setup menu. If enabled, when a target is detected in the Wide camera, the Tele camera will be pointed in the same direction and begin its own detect/track process. Both camera's video will be recorded, if enabled. If Handoff is not enabled, then the Tele camera is "slaved" to the target location in the Wide camera FOV. It will incrementally move as the target moves in the Wide camera FOV.

The system is now ready to Run.

SETTING FOCUS FOR NIGHT SKY TRACKING

When setting up a PTZ camera for use in night conditions, it is particularly important to verify that the image will stay in focus during zoom-in to the tracked object. Otherwise, as the camera incrementally zooms into the object, it may become unfocused and possibly lose tracking lock.

One method to avoid this problem is to setup the camera so that it retains focus at any zoom level using the following procedure:

1. Open the camera's web page using a browser such as IE via the Dahua ConfigTool. (See the UFODAS System Installation Guide for how to do this.)
2. Select Setting, Camera, Conditions and then Focus & Zoom
3. Set Digital Zoom to Off, Zoom Speed to 100, Mode and Focus Limit to Auto, Sensitivity to Default and PFA to On
4. Using the pan-tilt control arrows in the lower left corner, move the camera so that there is some identifiable object, such as a tree, in the center of the field of view.
5. Use the -/+ Zoom buttons to zoom into the object to the maximum zoom telephoto zoom level. If the object gets too out of focus during zoom, adjust focus with the -/+ Focus buttons.
6. Adjust the image for best focus at maximum zoom (for example, x12 or x30 depending on the camera.)
7. Zoom back to x1 and verify that the image stays in focus throughout the zoom range.
8. Click Lens Init in IE to verify that the camera will retain a sharp image after resetting its focus and zoom.

DATA INTERPRETATION AND ADJUSTMENTS

OTDAU accomplishes tracking by means of a two-phase process:

1. **Detect** motion of an object that moves with respect to the background. Reject detections from objects that move too fast or are outside of size limits. Reduce the bounding box to an area that only surrounds the detected target object.

2. **Track** the target by rapid re-detections only in the smaller detection bounding box until no further detections occur for a set time period.

In the optical environment of an OTDAU there will inevitably be many sources of false positive tracking events. The source of those events includes:

- Foliage such as trees moving in the wind.
- Significant dirt spots on the camera lens or on a window if the camera is used inside a structure.
- Certain geometric shapes in clouds.
- Significant movement of water or reflections off a body of water.
- Birds and large or close insects.

Of course, aircraft and helicopters moving through the field of view will also be tracked. In this case, such events may be of some value as they may be associated with another unknown event collected close in time. Tracking aircraft is particularly useful for calibrating the system and verifying that to some extent, the system is set up appropriately for the ambient conditions.

Higher frame rates are valuable in terms of the fastest object motion that can be captured.

However, the highest practical frame rate does not need to be higher than the rate at which the OTDAU software can process those frames -- otherwise the extra frames are redundant.

The processing frame rate is a function of the speed of the computer and communications paths between it and the camera. This means that there is no fixed answer to determining camera resolution and frame rate without considering the other factors.

However, you may find that it is practical to operate a camera at 20 FPS, sometimes trading that off against a lower resolution such as 704x480. The key issue to bear in mind is that OTDAU uses zoom to effectively increase the number of pixels to image an object rather than depending on the camera's imager resolution alone. The value of an

imaging chip with a higher resolution, larger size and more sensitivity is improved ability to make the initial target recognition when an object is smaller (i.e., some combination of farther and smaller) and in dimmer light if the target is not self-illuminated.

Note: You can start a scanning run at a zoom level other than x1. Whenever OTDAU goes into the Run mode, it captures the current pan, tilt and zoom levels as the Home position. It returns to that position after each tracking event. The zoom level can start at any value the camera provides. If zoom is selected in the System Configuration, then zoom is incrementally increased until the selected maximum value. It will not decrease until the event is over when it returns to the Home value.

Due to lag in camera motion, a moving object will not be at the initially detected position by the time the camera moves its center FOV to that position. Simply expanding the crop (Tracking, crop increment) may be adequate but would often catch surrounding clutter close to the object instead of the desired target. OTDAU makes the initial move to the future predicted location of the object. It does this by sampling object motion just after detection and calculating its velocity and direction of motion.

When using a PTZ camera, the first move after target detection is a rapid absolute move to try to place the target at the CFOV, as described above. For every other target detection thereafter, during tracking, the system controls the PTZ velocity in a closed loop to move the CFOV toward the target, minimizing the difference between the target's location in the image and the CFOV. However, the speed of the target may be sufficient so that the CFOV always trails the target. At every frame, OTDAU measures the total non-contiguous size of moving areas of within the bounding box. If that total is below the Min area or exceeds the Max area, there is no detection. At the same time, if the total area exceeds 10x the Max area, then tracking is aborted due to clutter.

The Auxiliary Video Display, Telephoto selection displays a 100x100 pixel digital zoom of the center of the camera frame when scanning or a digital zoom of the crop around a tracked object. This helps identify transient objects that fly by but do not trigger tracking as well as tracked objects. Since the last frame of the triggering event is retained on the display after the sequence ends, this feature helps identify what caused the system to detect the event. This feature may be used along with higher values of the Min events Tracking parameter to reduce false triggers.

See the discussion of Tracking settings for further information.

Testing otdau setup and tracking

In addition to trying the various “test-x” System configurations, using a laser to test tracking is a very effective way to simulate actual targets and see how OTDAU responds.

However, the problem is the following:

-- OTDAU uses a process of predictive location to determine where to make the initial absolute move upon detection (the PID loop continuous velocity control is used after that).

-- The predicted position is derived from measuring the vector velocity of a potential target during the number of frames specified by the Tracking, "Min events" parameter. After that number of detections are measured, it uses the estimated lag time of the software/camera to derive what the target location will be in the future and move to that point.

-- Thus, while the system sees the laser, if you make some quick motions (high velocity), then it predicts what may seem to be odd future locations some distance from the laser spot.

-- Thus, to do that kind of testing requires a very steady hand. Another method is to sit in a swivel chair, point the laser at the wall outside of the bounding box and then turn in the chair so that the laser spot emulates a moving object in the FOV. That method tends to eliminate the dithering problem.

The purpose of the resolution entry is to tell the system what the camera is set to. You cannot use it to set the camera's resolution.

You may also want to reduce the initial zoom speed, for example, from 2.0 to 1.0.

Generally, the process to validate system operation is to:

1. Check operation with P/T and Zoom disabled and use the Default settings. Look for proper detection and tracking and adjust settings such as Crop, Blur, Delta, Min and Max areas if necessary.

2. Enable only P/T and check again. Look for proper detection, initial move and continuous tracking of the sort of targets that were detectable in step 1. Adjust camera Proportional constant larger if there is no hunting (unstable motion), then back it down a bit.

3. If that works, then enable Zoom. Look for the largest number of zoom-in increments without losing the target.

It would be best to try all this on daytime aircraft as test targets. At night, you may find that you want to make the Min area a bit larger to avoid triggering on twinkling stars.

For technical support feedback, the best sort of files to provide are just a Wide video plus a screenshot of your Wide and Camera configurations.

Note the following:

-- The configured FPS should match whatever the camera is set to, which has various options depending on resolution.

If they don't match that will affect two things: Displayed frame rates will be inaccurate; The length of recordings will not match actual times. It should not affect tracking.

-- Pan/Tilt values are actual when a camera is a PTZ type. If not, then the P/T values are emulations based on the location of a detected target in the frame. Thus, if no target has been detected, then there are no PT values to change until then.

-- Performance of the various Dahua cameras varies a bit depending on optical sensor sensitivity, P/T rate, etc.

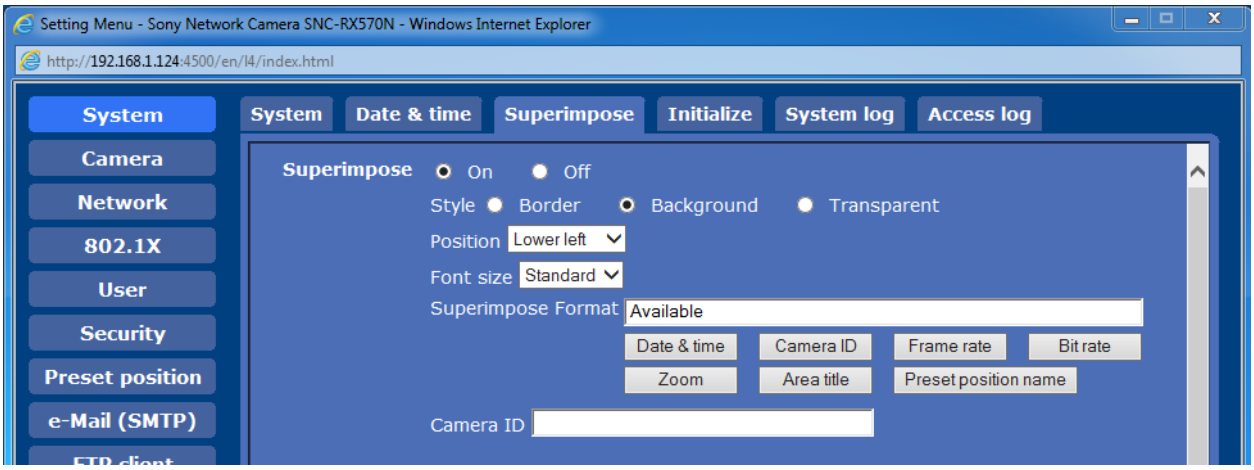
CAMERA SHARING

One IP camera may be used simultaneously by more than one copy of OTDAU. However, if more than one OTDAU attempts to send PTZ motion commands to that camera then both OTDAUs will react to motions created by any of them.

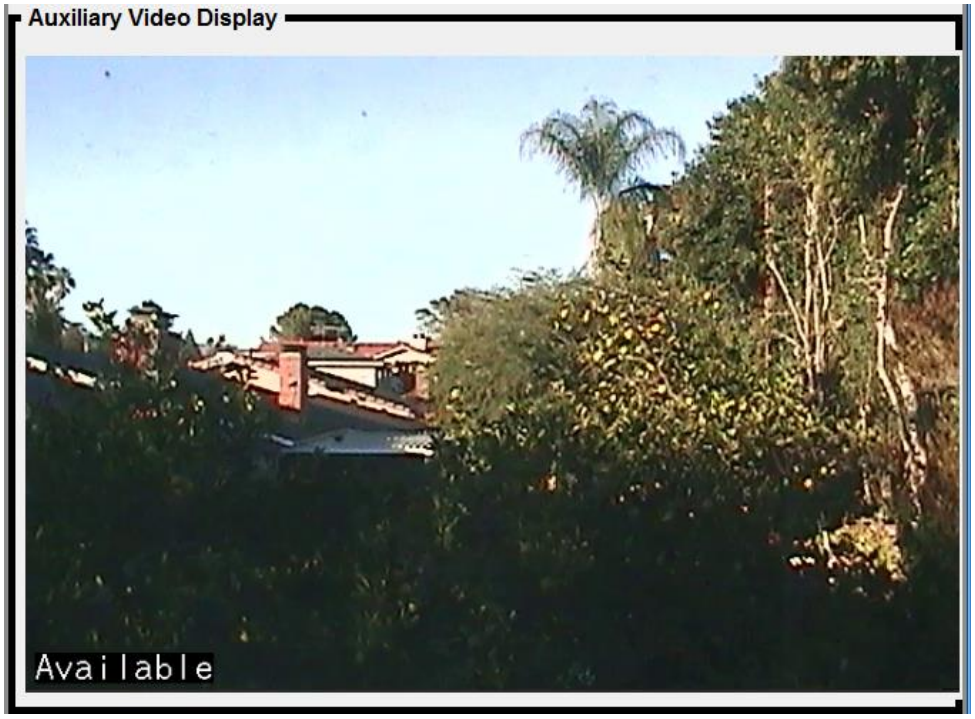
OTDAU provides a feature that prevents more than one copy of the software from controlling a particular IP camera. It does this by setting and reading a particular string of characters to the camera's On-Screen Display (OSD). This text is initially "Available". If it was "" (blank) then OTDAU will initialize it to the Operator Name of the first PC that uses it. When a PC running OTDAU is set to the Run state, it reads and checks this text. If the text is "Available" or "" then it will set the text to its Operator Name. If the text is otherwise indicating that the camera is already in use, then it will perform all normal OTDAU functions for that configuration except for PTZ controls, if enabled. The position of this text on the video frame is preferred to be in the lower left so that in the Wide-Angle Display it is covered by text generated by OTDAU. It will be visible in the same position on the Auxiliary Video Display if that display is set to Raw Video.

A camera is initially set up for OTDAU sharing by setting the camera's OSD as shown in the following screen displays.

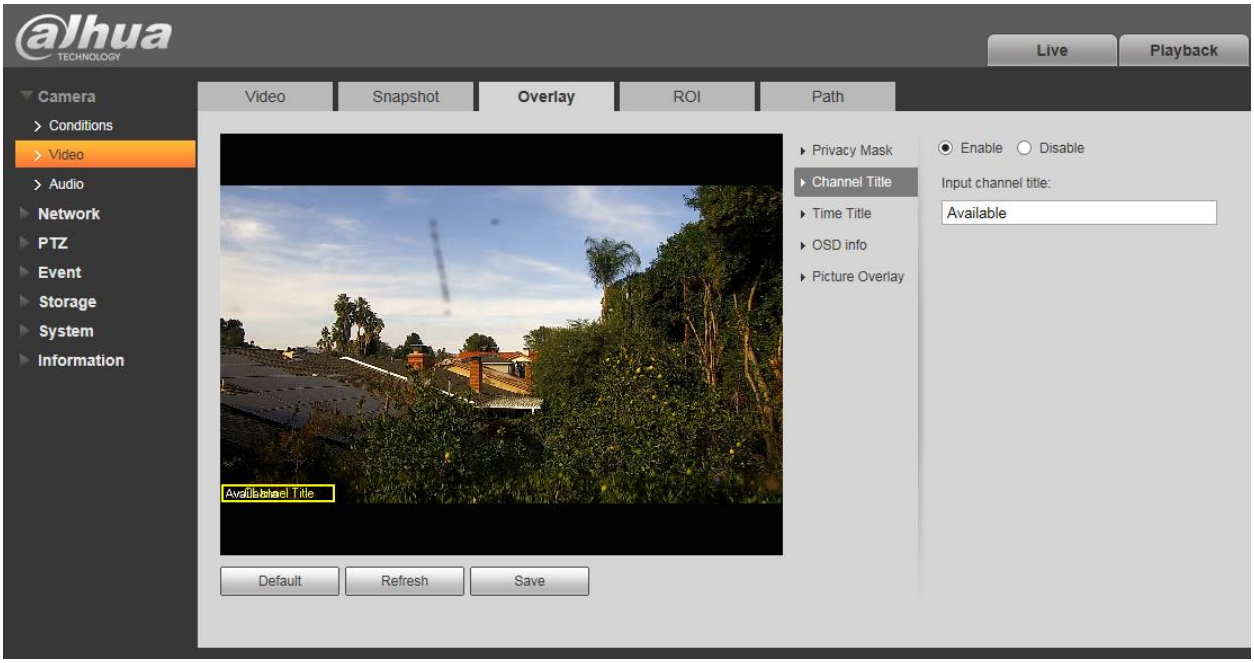
For a Sony camera, turn on Superimpose and edit its settings as shown below



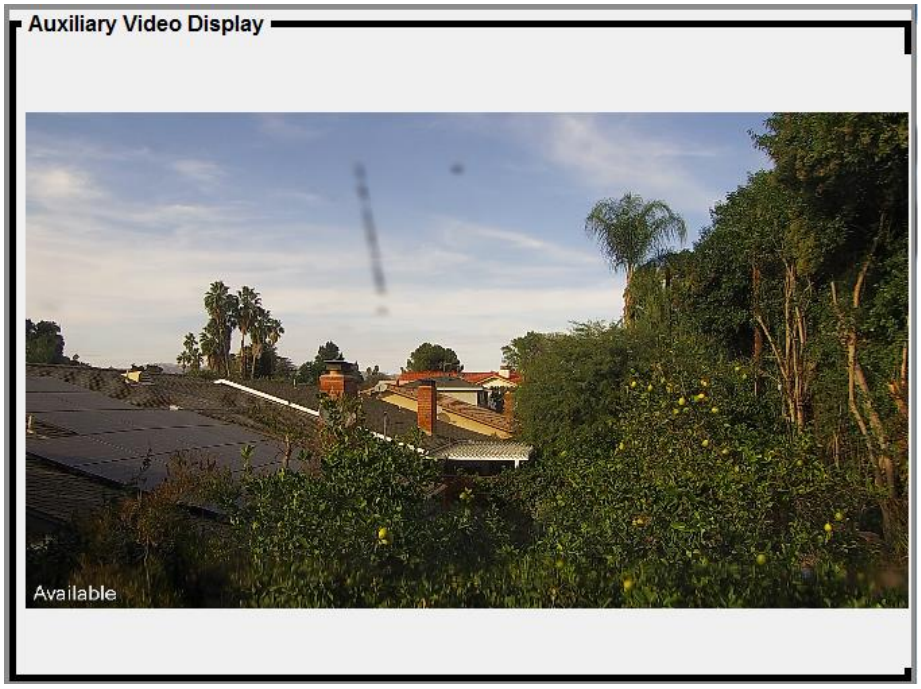
The resulting display will appear as follows:



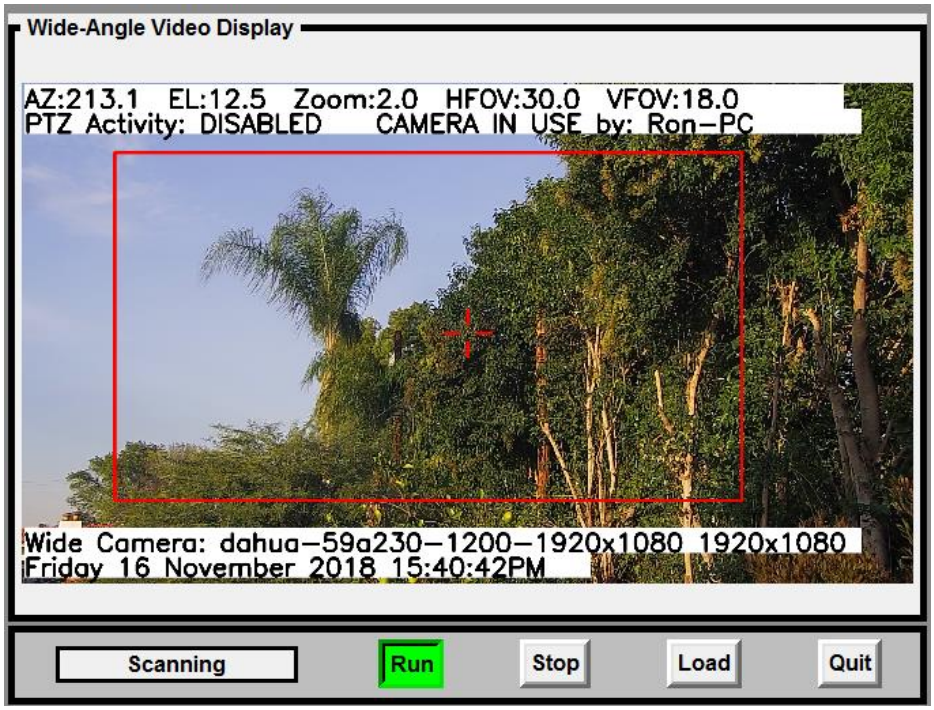
Initially set a Dahua camera as shown below.



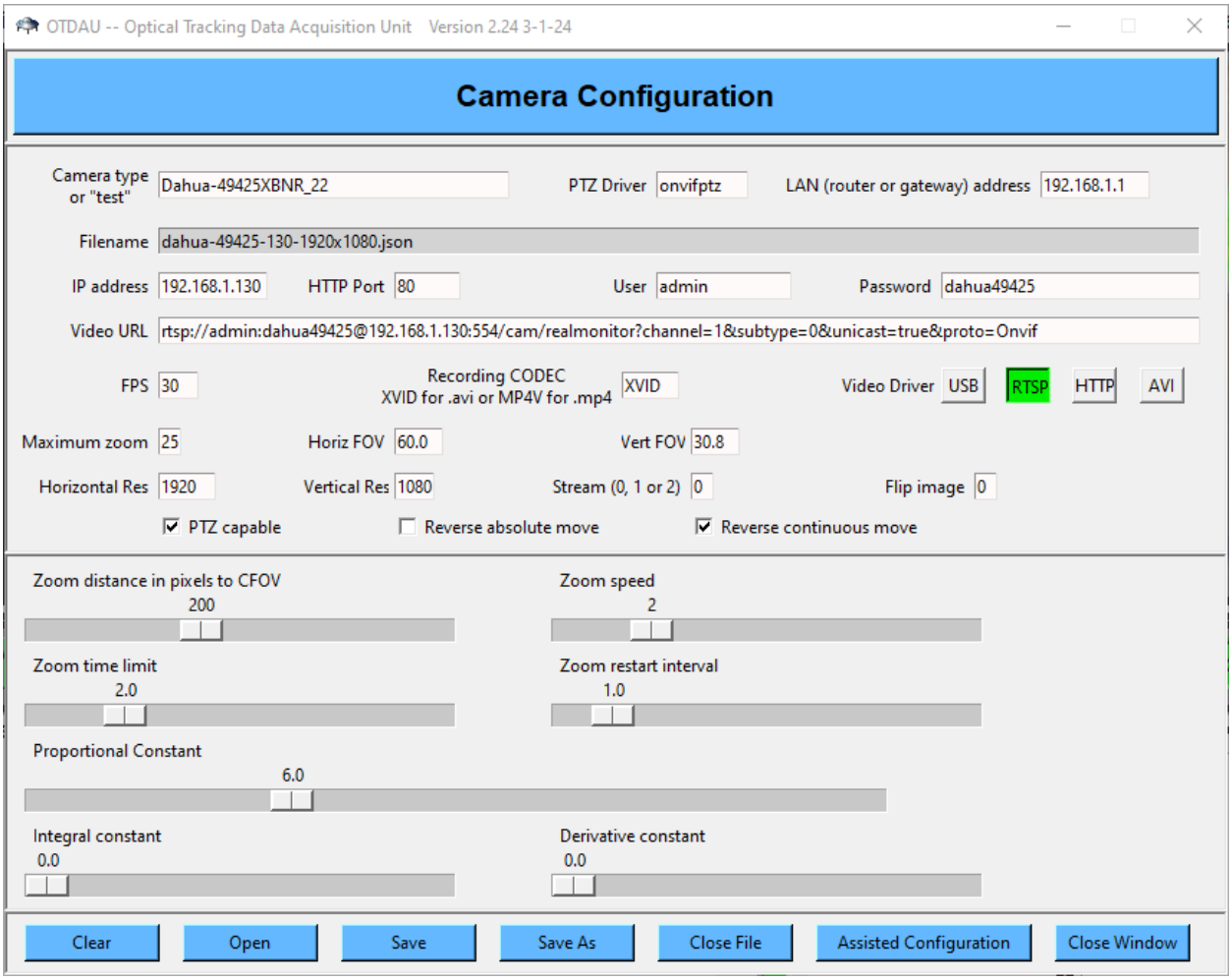
The resulting display will appear as shown below.



When a copy of OTDAU attempts to use a camera that is already in use by another copy of the software, then the second row of text on the Wide-Angle Display will indicate that the camera is in use and by what Operator (for example, Ron-PC), as illustrated below.



CAMERA CONFIGURATION OPTIONS



The following is a list of all system configuration parameters found in each configuration file.

Camera type or "test" – Must be one of the following unique supported camera model identifiers, entered exactly as shown:

- "Dahua SD50A230"
- "Dahua SD6AI445"
- "Dahua 49225"
- "Dahua 49425"
- "Dahua 50230"
- "Dahua 50232"
- "Dahua 50432"
- 'Dahua 5A825"
- "Dahua 42212"
- "Dahua 4A425"
- "Dahua NK8BR4"
- "Dahua ASC"
- "Dahua N51BD22"
- "Dahua N53AB52"
- "Dahua N53CB62"
- "Dahua N65CL5Z"
- "Hino IPC7F12"
- "Hanwha PNM-9013"
- "Hanwha PNM-9031
- "Hanwha XNP-9300"
- 'Hanwha XNP-8300"
- "Hikvision 4A425"
- "Amcrest IP2M-841"
- "Axis M3025"
- "Samsung SNP-3370"
- "Samsung SNP-3750"
- "Sony RZ25N"
- "Sony SNC-RX570N"
- "Uniview IPC868ER"
- "USB x" where x is 0, 1, 2 or 3

“Dahua ASC” may be used for any 360/180 degree camera including the NK8BR4.

These types may also be names created by the Camera Configuration Assistant (CCA). See below for a full description.

Entering a Camera type that does not conform to any of the above values will result in an error displayed when the configuration is Loaded.

Filename -- Not user modifiable. Shows the filename for this configuration.

IP – The LAN IP address of the wide-angle camera as x.x.x.x. For example: 192.168.1.108.

HTTP Port – The HTTP Port number of the camera, a two to four-digit number, typically 80. **Note:** This is not the RTSP port, which typically has a value of 554 and is used for video streaming. Rather, this is the camera’s HTTP port which is used for camera setup and motion commands.

User – Username to access the camera. Typically, ‘admin’ but could be whatever user name has been assigned to the camera.

Password – Password to access the camera. The default will be provided by the camera manufacturer. It is changed to match Camera configurations provided with the OTDAU software when the camera is purchased but could be changed by the user via access to camera settings.

Video URL – The full URL required to stream video from this camera. Such URLs vary by camera and manufacturer. However, it can be manually modified and saved.

PTZ Driver -- The name of the driver software provided with OTDAU or a customized version for a particular camera with controls that do not conform to existing drivers. Any camera that conforms to the ONVIF standard should use “onvifptz”. Current values may be:

- amcrest
- usb
- sony
- samsung
- onvifptz
- dahua
- testdriver

LAN (router or gateway) address – OTDAU finds and displays the base address of your Local Area Network (LAN), also known as your router or Gateway address. This may be helpful to verify that the address used as the Camera IP address is correct, since the first three parts (octets) of that address must match that of the LAN address. (This is not the case when the camera is port-forwarded.)

FPS -- Camera Frames Per Second. Should match the camera's setting.

Recording CODEC – XVID for .avi or MPV4 for.mp4 – The desired CODEC to be used to encode the video stream for recording. Should match the type of file to be created during recording – avi or mp4.

Video Driver -- One of four choices, depending on type of video stream supported:

- USB -- for any USB camera
- RTSP -- for most IP cameras
- HTTP -- for IP cameras that do not support RTSP
- AVI -- for running simulated camera test files. Also used for MP4 files

Maximum zoom – The maximum zoom value of the camera. The camera will stop zooming after this value is reached.

Horizontal Resolution -- Must match the camera's horizontal resolution.

Vertical Resolution -- Must match the camera's vertical resolution.

Stream (0, 1 or 2) – IP cameras can typically support more than one simultaneous output stream, each with a different resolution and other parameters as selected in their Settings menu. These are the Main Stream (0) and Sub Streams (1 or 2). It is convenient to set the camera's streams to different values that may be of use and create (or use the provided) System/Camera configurations that correspond to those. Thus, alternate System configuration may be used with a camera without changing any camera Settings.

Absolute move direction -- Checked or unchecked depending on how the camera responds to absolute move commands. OTDAU issues an absolute move command upon confirming an initial target detection event. If a camera moves in the wrong direction upon testing detection, then reverse this setting.

Continuous move direction -- Checked or unchecked depending on how the camera responds to continuous move commands. OTDAU issues continuous (velocity) move commands after the absolute move stemming from an initial target

detection event. If a camera moves in the wrong direction upon testing detection, then reverse this setting.

Horizontal FOV -- The fully zoomed-out horizontal field of view of the camera optics in degrees.

Vertical FOV -- The fully zoomed-out vertical field of view of the camera optics in degrees.

PTZ capable -- Set if the camera is pan-tilt-zoom or just zoom capable.

Flip -- Set if camera video frames need to be inverted horizontally or vertically due to mounting orientation. Use 0 for no change, 1 for flip vertical, 2 for flip horizontal and 3 to flip both vertical and horizontal.

Zoom distance in pixels to CFOV -- The maximum distance from the target image from the CFOV to allow the start of zooming in pixels. For example, if the zoom distance is set to 200 then zooming will start when the CFOV is brought within 200 pixels from the target.

Zoom speed -- The relative speed of zoom command sent to the camera when zooming is allowed.

Zoom time limit -- The period in seconds that the camera is allowed to zoom at the zoom speed each time zooming is allowed.

Zoom restart interval -- The minimum time in seconds that must elapse from the end of the zoom time limit until the next time zooming is allowed.

These four zoom parameters govern how effective zoom can be used by the system when zoom is enabled by the System configuration. The amount of zoom (the telephoto multiplier, x1 to x32 for example) will be higher if these parameters are more optimally set and how fast the target object moves and how long it loiters in a limited area.

Less optimal operation may occur if, for example, the zoom speed is too high or the time limit is too long. In those cases, the offset of the target from the CFOV will more rapidly affect the distance of the object from the CFOV, causing the target to move away from view, possibly causing loss of tracking.

Proportional, Integral and Derivative constants – Controls for the PID loop that attempts to minimize the error between the position of the target in the image and the center of the field of view. Typically, only Proportional is set to a value above 0. Tune PID operation by starting with a low number, about 4 and try tracking with pan enabled. If the CFOV always lags the target location, then slowly increase this value, and try

again. If the CFOV overshoots the target or moves back and forth over the target in ever larger distances until the target is lost, then reduce this value. An optimal value is indicated by the CFOV staying close to the target object and moving on top of the target if it stops.

Control buttons

Open – Opens a window into the Camera configuration file folder. Select a configuration by either double clicking on an entry or clicking an entry once and then click Open.

Save – Saves the current settings as part of the currently loaded Camera configuration.

Save As – Opens a window into the Camera configuration file folder. Saves the current settings as the Camera configuration but with a new name selected in this window. It is very useful to Open an existing configuration, modify its values, and then Save As with a new name to create a new configuration.

Close File – Terminates view of the last selected configuration and clears all entries. This has no effect on any cameras used in the currently open System configuration.

Assisted Configuration – Runs the ONVIF Camera Configuration Assistant, described below.

Close window – Closes the Camera Configuration window. If the window is closed before any changes to settings are Saved, then those changes are lost.

ONVIF CAMERA CONFIGURATION ASSISTANT

Assisted Configuration – Opens the ONVIF Camera Configuration Assistant (CCA)

This feature makes possible the use of cameras that are not on the documented support list. To operate an ONVIF cameras with pan/tilt, OTDAU must convert degrees to a number between -1 and +1 for both position sensing and absolute position control. Since there is no ONVIF standard for these conversion equations, typically, they must be derived from testing using a sample camera. The new Configuration Assistant provides a means to determine the correct conversion equations for many cameras by a guided, semi-automatic procedure:

1. Open an existing Camera Configuration or just a blank Configuration window.
2. Enter the camera's IP, Port, User and Password.
3. Click Assisted Configuration – the Assistant will open. Follow the Status message directions – For Step 1, Click Test ONVIF connectivity. If the camera is accessible and ONVIF-compliant, its RTSP URL, Manufacturer and other information will be discovered and shown. The URL will be used to open its video stream on the Aux display.
4. Enter its maximum zoom value (from its datasheet) in Step 2 and then follow the directions in Step 3. You can click Next as many times as needed; repeating tests as required to find the 1 of 9 best control algorithm.
5. When The camera video shows the correct position, click Accept. The Assistant now automatically tests each of 9 possible status calculations and finds the correct one. Note that more than one combination of calculations may work.
6. Click Transfer to rename the Camera type in the opened Camera configuration to incorporate the discovered control and status calculation.
7. Fill in the camera's horizontal and vertical FOV from its datasheet (they are not discoverable)
8. Save or Save As the completed configuration.

The Camera configuration should now be usable in a System configuration. Note that prior Camera type names, such as “Dahua 42212” are also still usable and are converted to the new format via internal table lookup. The Assistant will work for PTZ, Z-only or non-PTZ cameras, indicating the type in the Motion control box.

The Camera type generated by this procedure is in the form:

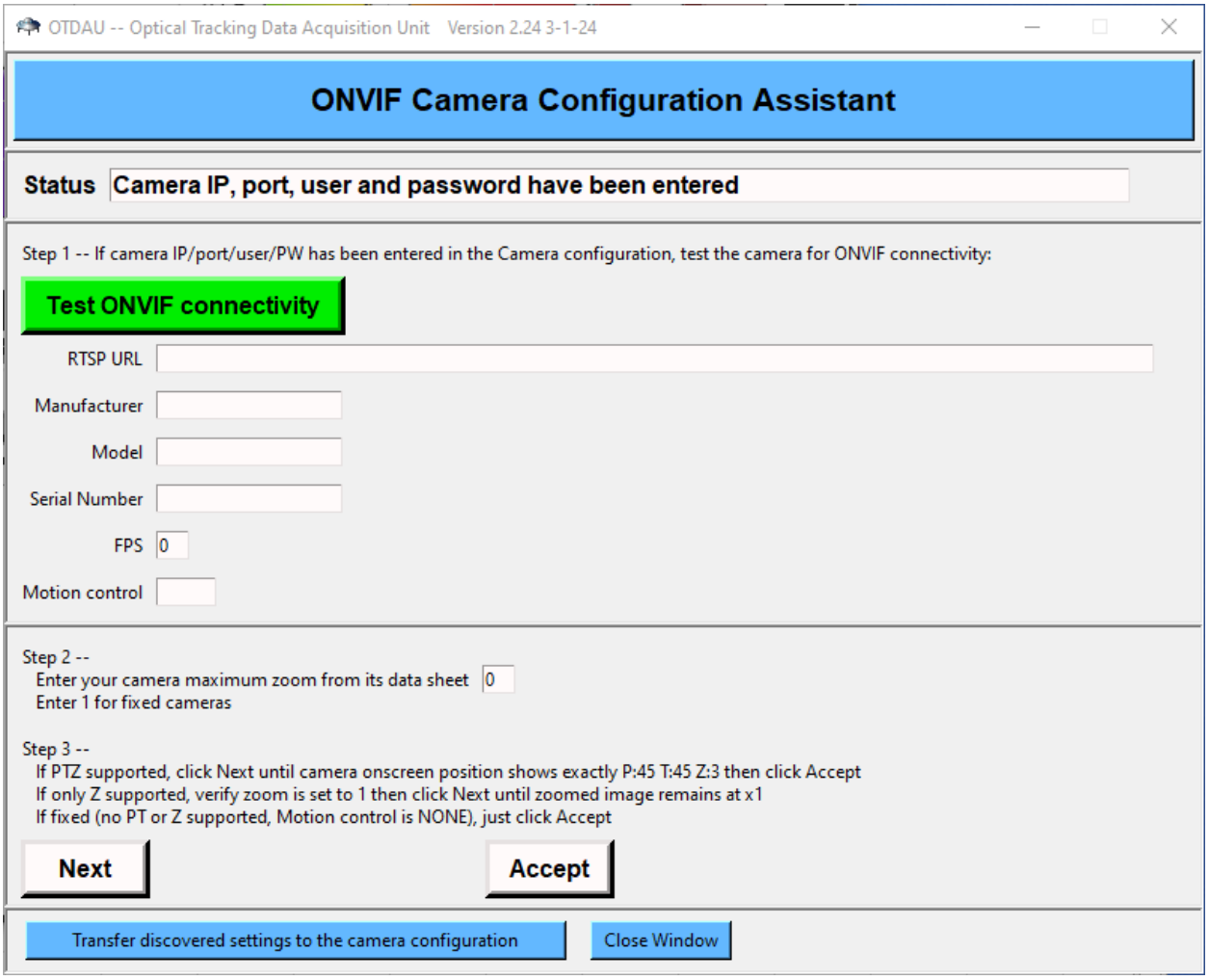
“<manufacturer>-<model>_<control calculation><status calculation>”

For example, the type for a 42212 camera can be the original “Dahua42212” or, using the CCA, “Dahua-42212TNI_11”.

“Test ONVIF connectivity” may be started any number of times prior to Steps 2 and 3.

If a non-existent IP, port, user or password are entered, then an error message will be generated when the connectivity Test is started.

For example, after loading the Camera configuration of a 42212 camera, running Assisted Configuration and clicking Test ONVIF connectivity:


OTDAU -- Optical Tracking Data Acquisition Unit Version 2.24 3-1-24
ONVIF Camera Configuration Assistant
Status
Camera IP, port, user and password have been entered
Step 1 -- If camera IP/port/user/PW has been entered in the Camera configuration, test the camera for ONVIF connectivity:
Test ONVIF connectivity
RTSP URL
Manufacturer
Model
Serial Number
FPS
0
Motion control
Step 2 --
Enter your camera maximum zoom from its data sheet
0
Enter 1 for fixed cameras
Step 3 --
If PTZ supported, click Next until camera onscreen position shows exactly P:45 T:45 Z:3 then click Accept
If only Z supported, verify zoom is set to 1 then click Next until zoomed image remains at x1
If fixed (no PT or Z supported, Motion control is NONE), just click Accept
Next
Accept
Transfer discovered settings to the camera configuration
Close Window

TRACK AND ZOOM TUNING

After identifying an object for tracking, the OTDAU attempts to continuously move a PTZ camera such that the object is in the camera's CFOV. When the object image is within the Zoom distance (listed above) from the CFOV, both horizontally and vertically, then an increment of zoom is performed at the Zoom speed, for the Zoom time limit.

The method used to center the image is by means of a Proportional, Integral, Derivative (PID) feedback loop. The parameters used to tune this loop are listed above. Typically, one may only need to adjust the Proportional constant, leaving the other two at zero. If this constant is too large, then the system will move the object back and forth across the CFOV (assuming, just as a test case, that the object has very little movement). If the value to too low, then tracking will lag behind the target object movement such that the target will not be tracked at all. If the PID constants are not appropriately set, then zooming will also not provide acceptable results.

The best sequence to make these adjustments is as follows:

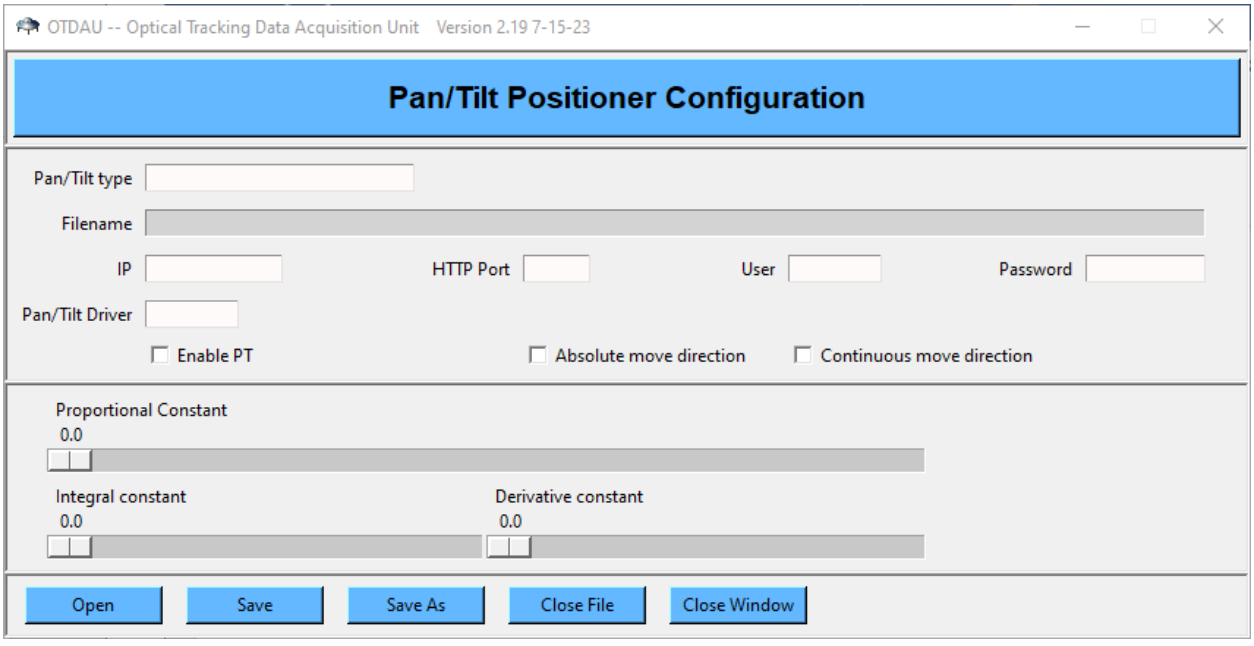
1. Disable Pan/Tilt and Zoom in your System configuration.
2. Provide for tracking test targets. One way to do this is to use aircraft in your vicinity. Another more convenient method is to point the camera at a flat, light surface, such as an indoor wall, and use a laser pointer to simulate moving objects.
3. Select Run and verify that the system detects target motion. Setting the Auxiliary Display to Tracks helps visualize the rate and number of detections. Adjust the values of the Blur parameter and the Delta threshold to provide the highest rate of detections without false detections from background items.
4. Enable Pan/Tilt and repeat the tests and note the system response to moving test targets. Adjust the value of the Proportional constant iteratively until smooth tracking is achieved up to moderate target speeds.
5. Enable Zoom and adjusting the zoom-related constants so that a moving target is periodically and progressively zoomed into and not lost to tracking in the process.
6. If you were not using aircraft as test targets, set up your camera to do that and run the system to verify that tracking and zooming are operating as expected.

PAN/TILT POSITIONER CONFIGURATION OPTIONS

OTDAU supports the use of remotely controlled Pan/Tilt heads that, unlike PTZ cameras, are independent of any specific payload. This feature allows use of a pan/tilt head that is not part of a PTZ camera so that any directional sensor, such as an IR camera, radar antenna or microphone could be pointed by an independent PTU.

As an example, see the System configuration “usb0-800x600-onvifptu”. This configuration uses the P/T portion of a 42212 camera and a USB camera for video. It emulates a system wherein a USB camera is mounted on a P/T unit. To do this, the Wide and Tele cameras are set to usb0-800x600 and the Pan/Tilt Unit is set to onvif-108. The Pan/Tilt configuration “onvif-108” references an ONVIF-compatible P/T unit that happens to be part of a 42212 camera (the video from the 42212 not being used). Ordinarily, the Pan/Tilt type would refer to a manufacturer’s part number of a PTU so that OTDAU would know how to control it. The Pan/Tilt Driver selection indicates that this PTU can be controlled with ONVIF commands. Future versions may include drivers for other types of PTUs, such as Pelco-P/D.

Entry and selection of data to setup an optional Pan/Tilt head is as shown below.



Pan/Tilt type – Description of the P/T configuration

Filename – (Display only) Shows the currently open filename.

IP, HTTP Port, User, Password – Data that defines the LAN connection to be used to communicate with this P/T head. Typically defined by data entered in the P/T head's manufacturer-provided interface.

Pan/Tilt Driver – The software interface needed to communicate with this particular P/T head. **To be defined in subsequent releases of OTDAU and might include Pelco-D and references to manufacturer-specific APIs.**

Enable PT – Enables use of this positioner.

Absolute move direction -- Checked or unchecked depending on how the camera responds to absolute move commands. OTDAU issues an absolute move command upon confirming an initial target detection event. If a camera moves in the wrong direction upon testing detection, then reverse this setting.

Continuous move direction -- Checked or unchecked depending on how the camera responds to continuous move commands. OTDAU issues an continuous (velocity) move commands after the absolute move stemming from an initial target detection event. If a camera moves in the wrong direction upon testing detection, then reverse this setting.

Proportional, Integral and Derivative constants – Controls for the PID loop that attempts to minimize the error between the position of the target in the image and the center of the field of view.

Control buttons

Open – Opens a window into the Pan/Tilt configuration file folder. Select a configuration by either double clicking on an entry or clicking an entry once and then click Open.

Save – Saves the current settings as part of the currently loaded Pan/Tilt configuration.

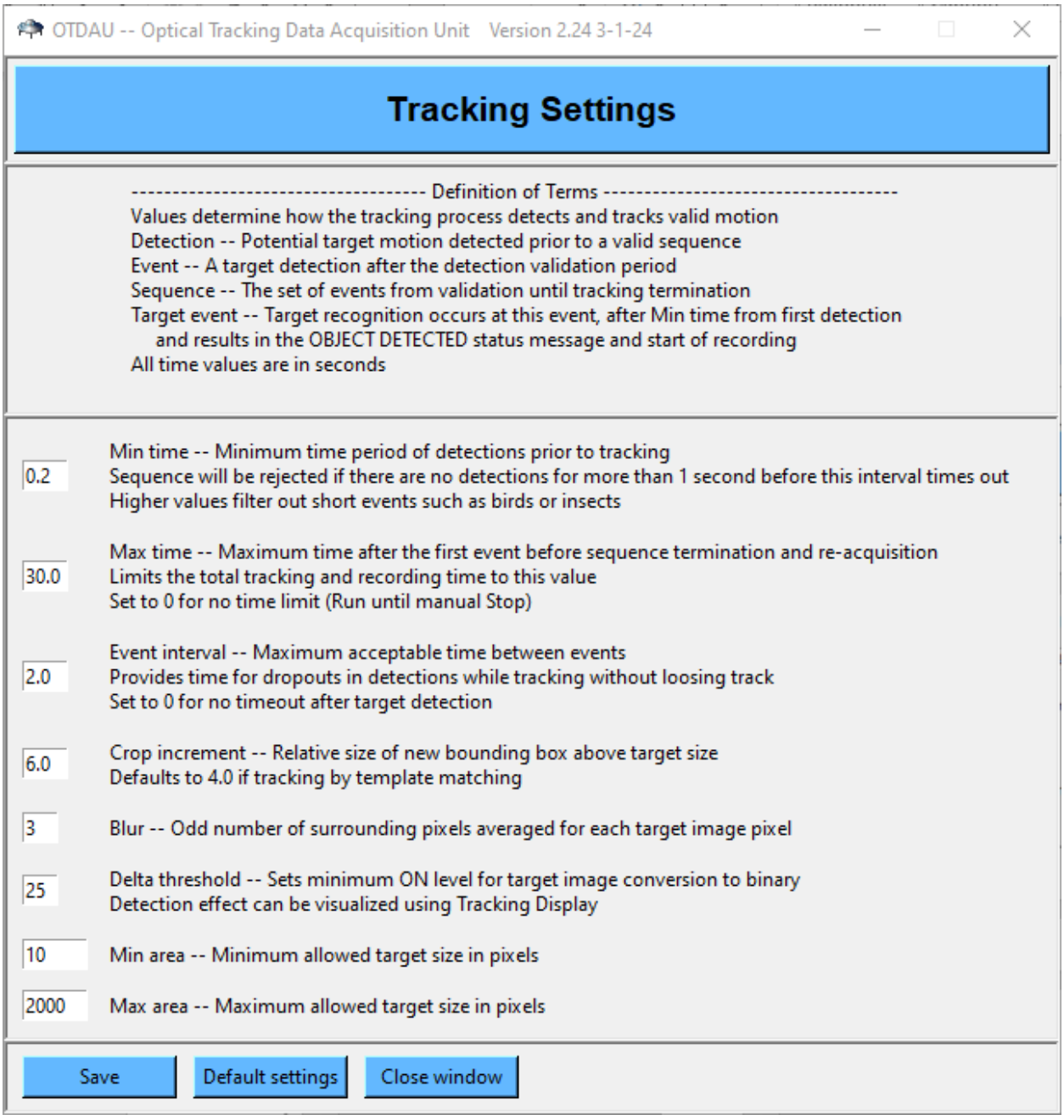
Save As – Opens a window into the Pan/Tilt configuration file folder. Saves the current settings as the Pan/Tilt configuration but with a new name selected in this window. It is very useful to Open an existing configuration, modify its values, and then Save As with a new name to create a new configuration.

Close File – Terminates view of the last selected configuration and clears all entries. This has no effect on any P/T units used in the currently open System configuration.

Close window – Closes the Camera Configuration window. If the window is closed before any changes to settings are Saved, then those changes are lost.

TRACKING OPTIONS

Select Tracking to adjust tracking settings. The values of the Default settings are shown below.



Note the distinction between potential target detections vs events. In OTDAU, a detection means that some motion was detected in a single video frame. An event is initiated when the characteristics of a series of detections indicates that a target of interest may be in view.

Units for time values are in seconds and Blur is in pixels. Delta is grayscale value, from 0-255 (black to white) that is compared to each gray-scaled pixel of an image that is a frame-to-frame difference. Max and Min areas are square pixels. All time values are in seconds.

Minimum time – The minimum time period of target detections to allow tracking of the sequence to begin.

Target tracking begins if motion is recognized after at least this period of time starting at the first detection. This filtering out birds and other fast-moving objects. Tracking Settings allow Min time of 0 for fast targets, Max time of 0 for no limit to tracking/recording time and Event interval of 0 for no timeout after target detection. Use these alone or in conjunction with template matching feature for long-duration tracking of non- or slow-moving targets. **NOTE**: Default settings have been adjusted for better initial testing – Try the defaults first before modification for your situation. Use the Aux Display Telephoto option to see what was rejected, e.g., a still image captured of a bird.

Maximum time – The maximum clock time in seconds for a tracking event until the system returns to the Home position and restarts scanning for motion. It may be useful to limit this time if known obstructions may be encountered by a target, assuming its flight trajectory. It would make sense to increase this time to an estimated maximum event time.

The system uses the Minimum and Maximum area parameters (square pixels) to reduce some false positives by rejecting initial motion detections that are too small or too large.

After getting five such detections that are less than the Start Interval apart, It averages the size of each detection and then computes new max/min sizes to be used for the subsequent detections.

The new max/min values are the average +/- a value that is based on the video frame width and zoom value.

When the event sequence is over, the max/min reverts to the user-selected defaults.

Event interval – Maximum time in seconds between motion detections to declare the start of an event sequence. Adjust to filter infrequent detections, such as birds.

Crop increment – Relative number governing the amount that the crop or bounding box is reduced after initial target identification. This reduction is provided to reduce the possibility of distraction from trees, etc. as the object moves across the landscape. The larger initial bounding box is needed for initial capture over a wide FOV but is undesirable thereafter. The value reflects the size of the box above the size of the object during tracking. A typical initial value is 4.0 to 6.0. A larger value makes it easier for the tracker to capture a faster object given the latency of PT motion to move the object to CFOV after the initial motion recognition. Too large a value, however, will result in loss-of-lock for a larger distance from the object as it flys past background distractions. This value is automatically doubled for the first three events to better capture a target despite an inaccurate initial move. **Note** that the nominal value of this parameter should be set to 2.0 when Feature Tracking is enabled and a larger value when Handoff is used in dual camera configurations.

Blur – Must be a positive odd number. If an even number n is entered, then n+1 is used. Filters background noise by averaging the surrounding n pixels around the central pixel. Larger numbers cause more filtering but lower resolution. For example, some cameras with low light sensitivity may show pixilated images in night conditions. If this parameter is too low, the camera will generate a lot of detections of the thermal noise in the video rather than actual objects. Increasing this parameter may allow such a camera to still be useful as it may ignore the noise but still recognize multi-pixel lights such as aircraft strobes. Thus, a larger number helps ignore video “noise”, clouds, etc. This is also helpful to allow use of cameras with poor low-light response that display thermal noise in low light conditions – noise is ignored and sufficiently large objects are still detected with a blur value of 5 or more. Setting this parameter too high will filter out valid objects.

Delta threshold – Threshold for moving object recognition with respect to a static background. Lower numbers increase sensitivity. Threshold for valid targets based on the difference from the prior frame average. Smaller numbers will allow smaller but perhaps less qualified images to be detected as targets. Nominal value is about 20 for typical uses. **TIP**: If you see a very large tracking box after initial target tracking, increase the Tracking Delta threshold to eliminate background noise and limit tracking to the desired target. Use the Aux Tracking display to visualize the effect.

Min area – The motion detection algorithm measures the contours of any “objects” sufficiently different from frame to frame. The area within these contours is tested to verify if it is too small to qualify as a valid target. If the system is triggering on what seems like noise or objects that are smaller than what you expect to capture, such as cloud features, then increase this value. Use the Tracking option of the Auxiliary Video

Display to visualize small differences that may be occurring, but the system is not triggering, as desired.

Max area – Maximum area of a contour allowed for a valid target. Decrease to reject objects that are too large, such as buildings or masses of dense foliage.

Control buttons

Save – Saves the current settings as part of the currently loaded System configuration.

Default settings – Changes all settings values to recommended default values. Those values are shown in Tracking Settings view above.

Close window – Closes the Tracking Settings window. If the window is closed before any changes to settings are Saved, then those changes are lost.

Tip: Use the test System configurations, such as “test-aerobatics.json” to see what effect various combinations of Tracking parameters have on tracking performance.

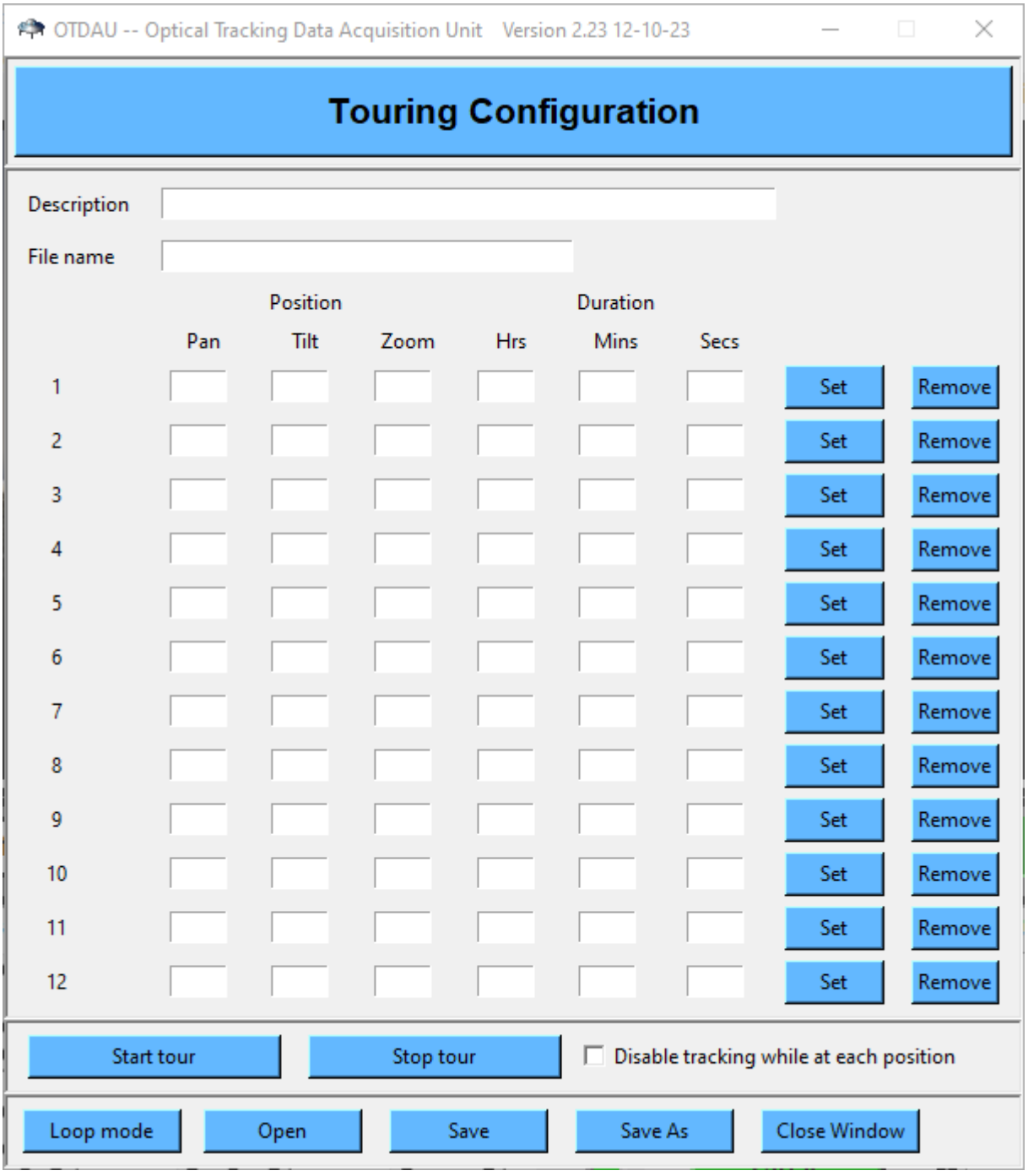
You can also test a camera by pointing it at a blank wall and using a laser pointer to simulate a moving object.

Similarly, you can simulate various types of objects using the Setup > Display target simulator. The simulator adds a moving dot of selectable size color and speed to any video image. Thus, it works with both fixed and PTZ cameras and any other test videos.

Another way to find the best Tracking settings for a particular viewing environment is to use Manual recording to capture a typical target object, such as an aircraft, moving across the FOV. The resulting avi file can then be loaded via the System configuration “Open a video file for test” and played back as many times as needed. The resulting Tracking settings should then be a good starting point for actual live camera tracking.

TOURING CONFIGURATION

OTDAU has the capability to move a PTZ camera between up to 16 pan/tilt/zoom positions, in order, during a Run. The dwell time or duration of each stop can be set in hours, minutes, and seconds. Tracking object identification is suspended during moves between tour stops to prevent triggering on tour movement.



Description – User-supplied description of the tour for reference.

File name – Desired folder and file name for saving a tour.

Start tour – Click to start running the tour if one has been loaded. This will have no effect if the camera is not a PTZ type or P/T is not enabled.

Stop tour – Stops running the tour and returns the camera to its home position.

Disable tracking while at each position -- PTZ enabled in System configuration is required to use Touring. Check this Disable tracking option to disable motion when tracking begins so that the PTZ camera can operate in a fast-tracking, fixed camera mode at each touring position.

Loop mode – Click ON / Click OFF: When enabled, the camera is moved to each defined position and then starts again at position 1.

Open – Opens a window to select a previously defined tour.

Save – Saves the tour values to the previously loaded named file.

Save As – Opens a window to select a new name for the tour configuration and saves it.

Close Window – Close the Tour Configuration window.

To setup a tour:

Open a System configuration for the desired camera.

For each of up to twelve positions –

1. Move the camera to the desired position and zoom value.
2. Click Set to save those values into one of the positions.
3. Repeat move and Set for any other positions.
4. Enter the Duration for each position.
5. If different values are needed for a position, click Remove and set new values or leave blank – that position will not be used during the tour.

Click Save or Save As to save the tour position values.

Test the tour by clicking Start tour.

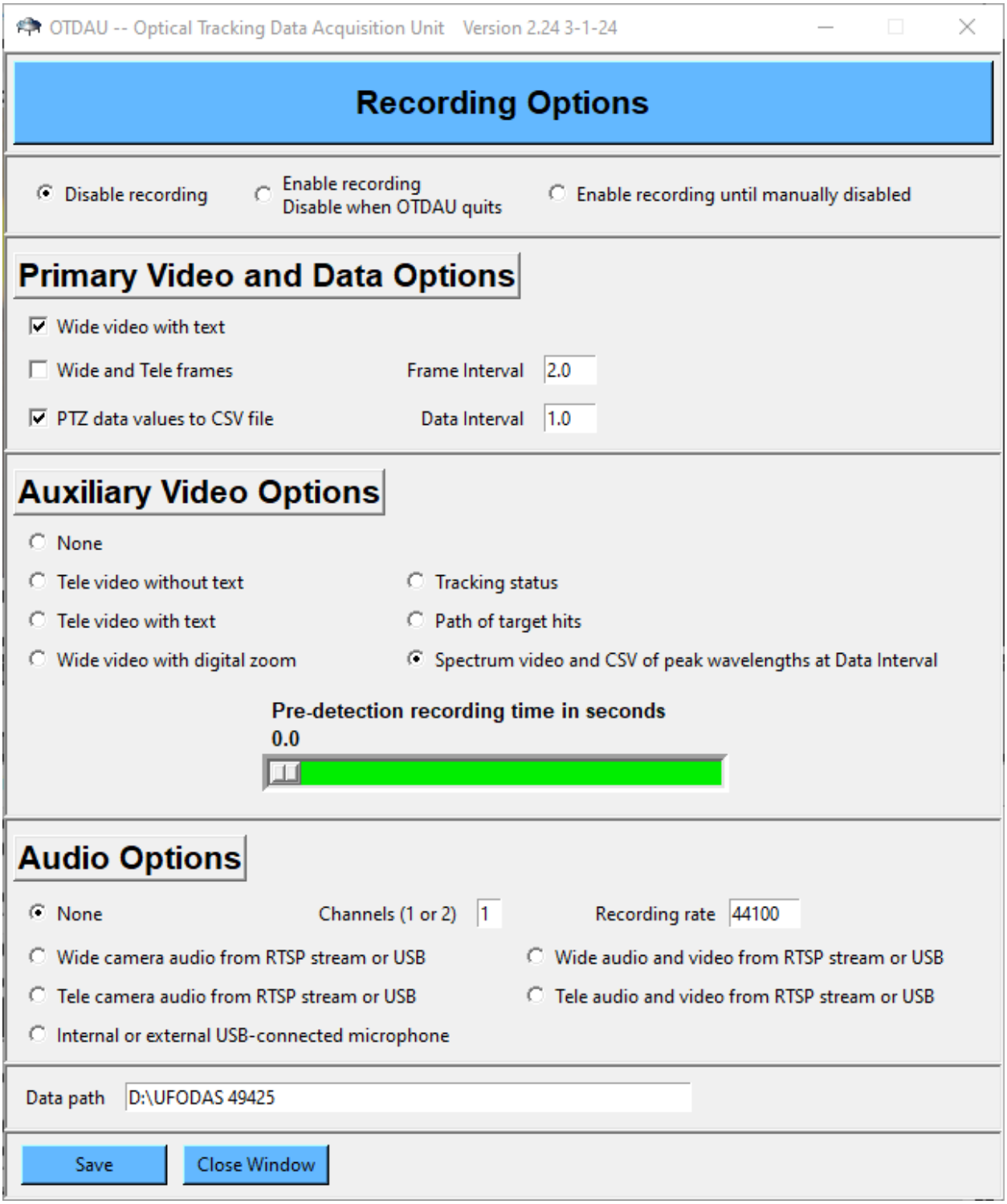
Click Stop tour at any time to abort tour movements.

Touring may be used with Pan/Tilt offsets to zero-out a PTZ camera home position.

To use touring during a tracking run:

1. Setup and save a tour as above or Open an existing tour.
2. Load a System configuration for the camera used to set up the tour.
3. Click Run to start the tracking process.
4. Click Start tour. Stop/Run and starting or stopping a tour can be set independently.
5. At any time, click Stop to stop the Run or Stop tour to continue Running but at a fixed position.
6. Clicking Loop mode will enable the tour to automatically restart at Position 1 and continue the tour after all positions have been moved to.

RECORDING OPTIONS



PRIMARY VIDEO AND DATA OPTIONS

Disable recording – Disables recording enabled by either of the following two selections.

Enable recording – Disable when OTDAU quits – Enables the following selections to control data recording if checked. Defaults to disabled when the system is started to prevent accidental recording during the typical system startup. Startup may involve testing camera positioning, parameter tuning such as Tracking settings followed by rest Runs. This setting is retained through all changes to configurations or Run/Stop until OTDAU is shut down (Quit).

Enable recording until manually disabled – Enables recording but does not automatically disable when OTDAU quits. Recording is automatically reenabled whenever OTDAU starts. This option may be used with the AutoStart option to allow recording when OTDAU restarts.

Wide video with text -- Checkbox to enable recording of wide-angle camera video with overlaid data.

Tele video with text -- Checkbox to enable recording of Aux camera video with overlaid data.

Wide and Tele frames -- Checkbox to enable recording of individual wide-angle camera frames without overlaid data.

Frame Interval -- The number of frames per second at which wide-angle frames are recorded. For example, a value of 3.0 will record 3 frames per second. Decimating the data this way is particularly helpful to reducing the number of frames attached to a subsequent email to a number adequate to get a sense of the event. Later viewing the complete wide or telephoto video saved to the computer or uploaded to Google Drive will provide the entire captured video.

PTZ data values to CSV file -- Accumulate values of pan, tilt and zoom with associated time during an event and, at the end, write all values to a standard CSV (comma-delimited) ASCII file (name.csv). This file may be directly opened by Excel, for example, for graphing, data analysis, etc.

The format of the CSV file is a comma-separated list of values in seven columns. The first row contains the names of the data items:

Frame Time Pan Tilt Zoom TargetX TargetY

Each row thereafter is the values at each frame in which a target detection occurred, recorded at the Data Interval, below.

The Pan and Tilt values are in degrees and the Zoom value is the current optical zoom. The TargetX and Y values are the center of the target in pixels ranging from 0 to the horizontal and vertical size of the video frame.

Data Interval -- Interval in seconds between PTZ value recording. For example, a value of 3.0 will record a set of PTZ values once every three seconds. If a target detection has not occurred within this interval, then the next recorded values will be at the next detection time.

IP camera writes do not skip frames due to the write loop being slower than the frame rate because frames are queued for writing. If the time it takes to write a frame to disk exceeds the frame rate, then the queue will eventually be full resulting in dropped frames. A new warning Status line indicates that condition. The write time is a function of the frame size and your computer's write speed. You can test for this problem by starting Manual recording (click on Ready to Record) and monitor the track queue messages to verify that the queue length does not keep increasing until it is exceeded. If so, reduce the camera frame rate or resolution. Be sure these are also changed in the Camera configuration. Some examples by camera of maximum frame rates for a given frame size and rate on my system (your results may vary) for no frame drops:

NK8BR4, 4000x3000 (12MP) set to 25FPS: 21 FPS
NK8BR4, 2880x2880 (8MP) set to 30FPS: 30 FPS
N65CL5Z, 3072x1728 (5MP) set to 25FPS: 25 FPS
42212, 1920x1080 (2MP) set to 30FPS: 30 FPS

AUXILIARY VIDEO OPTIONS

None – Click to select no Auxiliary recording.

Wide video without text / Tele video without text if in Handoff mode -- Click to record the Wide video stream without any overlaid meta-data. Records the Tele video stream if Handoff is enabled.

Wide video with digital zoom -- Click to enable recording of telephoto (digitally zoomed and stabilized) camera video with overlaid data.

Tracking status -- Click to record the Tracking view of the Auxiliary Video Display.

Path of target hits -- Click to record the Wide video stream with overlaid sequence of track boxes indicating all of the detections during the Run.

Spectrum – Record video of the generated optical spectrum if that feature is enabled and operational.

Pre-detection recording time in seconds – Specify up to five seconds of camera video prior to a target event to be included in a recording. OTDAU continuously saves video frames in a circular buffer prior to an event. This feature only applies to Auxiliary video selections. Slider control adjustable from 0.0 to 5.0 seconds to set the period of the selected Auxiliary video source, prior to the start of a tracking event, to be recorded along with video starting at start of the event. Source data is continuously saved in a circular buffer and the requested length is appended to the beginning of the output file when the tracking sequence is over.

NOTE: The System and Camera configuration files used for the recorded tracking session are also recorded at the Group level, defined below.

AUDIO OPTIONS

OTDAU can record audio as a .wav file derived from an RTSP camera stream, from a USB camera or from a microphone interfaced to the computer. It can also combine that audio with the camera's video frames and record an .avi file. Audio encoded into an RTSP stream might come from a microphone built into the camera or from a cable to the camera.

In addition to the Primary and Auxiliary Options, you can record audio during a tracking event (or manually). Recording may be from an IP camera with a microphone or from a USB mic or webcam mic. Recordings may be audio alone, resulting in a .mp4 file or combined with video resulting in an .avi file. Number of channels may be selected as well as the audio recording bit rate. Standard rates are: 8, 16, 24, 32, 40, 48, 64, 80, 96, 112, 128, 160, 192, 224, 256, or 320 (add a k after each to get that rate). Any value in this range will work but will be truncated to the closest 1KHz. With your particular computer, if you check the actual file bit rate (using file > Properties > Details) the maximum rate might lower, such as 48kbps even if a higher rate was selected. Note that AV (avi) files are about 3 seconds longer than the tracking period to record the full period audio.

None – No audio or A/V will be recorded.

Channels (1 or 2) – Number of audio channels recorded: 1 (mono) or 2 (stereo).

Recording rate – Audio recording bit rate, typically 44,100 bits per second. Enter a value without a ‘,”.

Select one of the following five options:

- **Wide camera audio from RTSP stream or USB**
- **Wide audio and video from RTSP stream or USB**
- **Tele camera audio from RTSP stream or USB**
- **Tele audio and video from RTSP stream or USB**
- **USB- or PC-connected microphone**

DATA PATH

Enter the disk drive path where the system will create a folder that will contain any video or image files collected during run time, as selected above. At the time data is written, the folder will be created if it does not already exist.

The path format is: <drive letter>:\<name>

For example: D:\UFODAS Data

The name must be in Windows standard format and may be anything the user finds descriptive, composed of upper and lowercase letters, numbers and special characters not including:

< (less than)
> (greater than)
: (colon - sometimes works, but is actually NTFS Alternate Data Streams)
" (double quote)
/ (forward slash)
\ (backslash)
| (vertical bar or pipe)
? (question mark)
* (asterisk)

The following filenames are reserved and cannot be used:

CON, PRN, AUX, NUL
COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9
LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, LPT9

Also, filenames cannot end in a space or dot.

Note that if recording is Enabled, and no other selections are made, the minimum that will be recorded is raw video, namely, the Wide camera view without overlaid metadata.

CONTROL BUTTONS

Save – Saves the current settings as part of the currently loaded System configuration.

Close window – Closes the Recording Options window. If the window is closed before any changes to settings are Saved, then those changes are lost.

LOG FILE

A log file is opened in the Group folder when the folder is initially created. The file name format is “otdau-logfile-<date>_<time>.txt”. Various messages are written to the log during Run time that may be useful for debugging or data analysis. The file is closed at manual Stop. More types of messages may be added in the future.

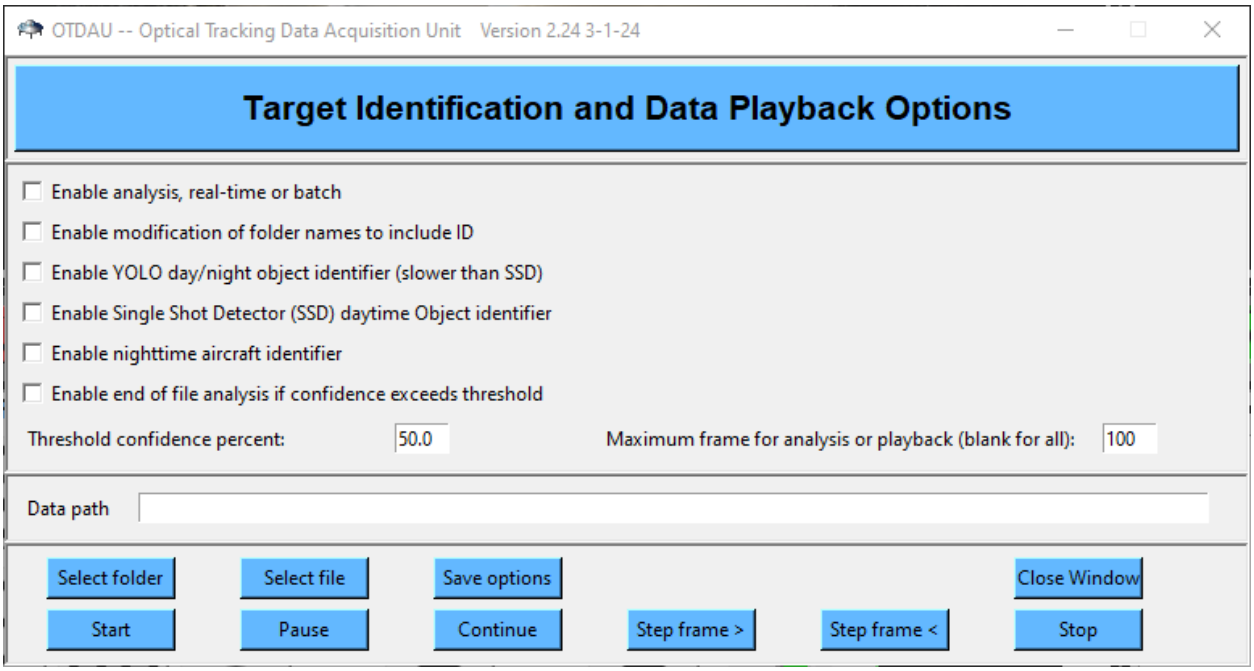
DATA ANALYTICS OPTIONS

The Analytics tab selects two sets of data analysis tools:

- Object Identification
- Spectral Analysis

OBJECT IDENTIFICATION

Object Identification provides the following real-time and offline tools:



OTDAU includes tools for online and offline analysis of collected data. Typically, a long data collection run will record many event sequences triggered by mundane targets, such as aircraft and birds. Manual analysis of those events requires opening each Group folder and playing at least one recorded file for the event, looking for true unknowns. That can take a long time if many events are recorded.

OTDAU Data Analytics can greatly reduce the time to analyze collected data by automating recognition of known target objects in collected data. It utilizes advanced methods of machine vision and deep learning technologies to scan all files under a user-selected folder, determining the most likely initial target object in each and then modifying the associated folder name to include its identification and confidence measure. The user can then focus further analysis on files labeled UNKNOWN or those

with low confidence. The identification process may be run online, following each target event or offline, for a batch of events under a single folder.

OTDAU supports reading and streaming all the following file types for A/V files: avi, mp4, mov, flv, wmv and mts (AVCHD).

Currently, objects that the software attempts to recognize include:

In daytime lighting conditions --

- Aircraft of all types as well as helicopters
- Birds in many modes of flight
- Foliage such as trees

In nighttime conditions –

- Aircraft with standard blinking navigation lighting

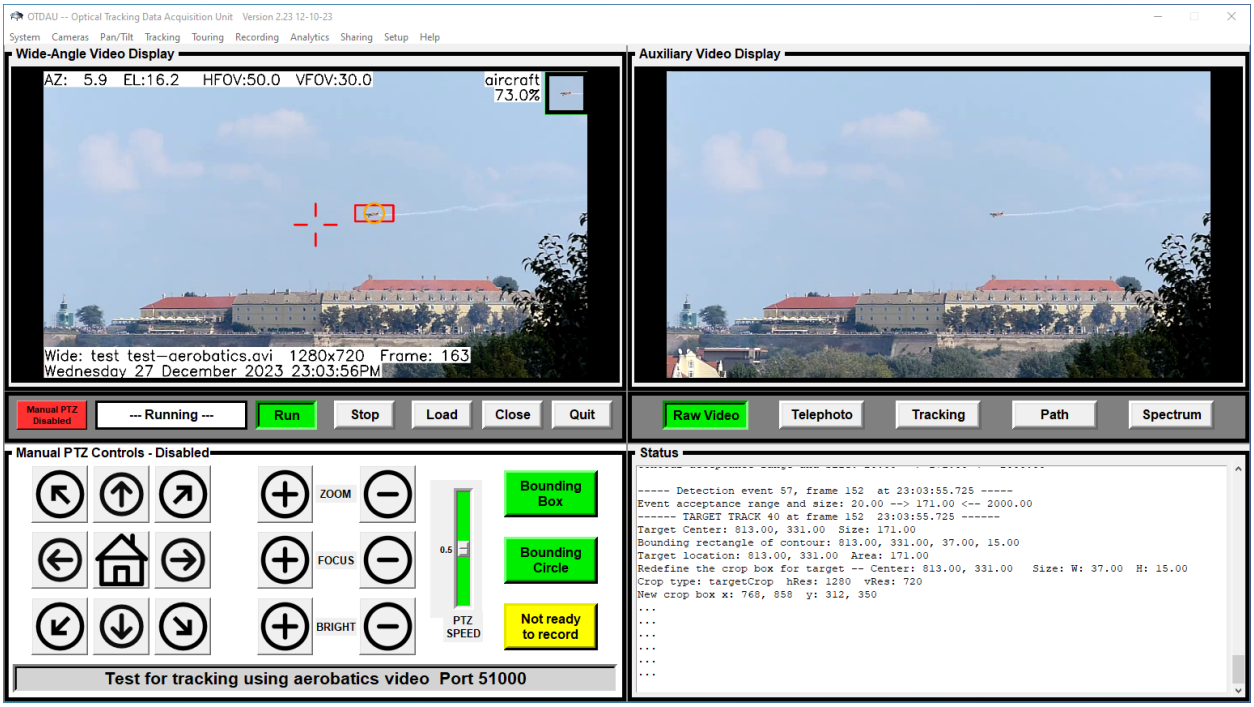
Note: Since the analytics functions do not know the user-specified bounding box at the time the recording was made or how it changed during tracking, a bounding box that initially includes most of the frame is assumed when analysis of a file is started. Analytics detects the target object by methods like those used by OTDAU when the target was originally detected and recorded. It reduces the bounding box after initial detection to a value most useful to the recognition functions. Under some conditions, the box may be returned to maximum size until another detection of a moving object is found.

Somewhat more accurate and faster recognition may be obtained by enabling recording of CSV files during OTDAU data collection. This is because analytics will use such a file, if it finds one associated with the video data, to only locate and bound the target according to the TargetX and TargetY values in the CSV file instead of examining every frame.

All Analytics options are saved in C:\OTDAU\AnalyticsOptions. Options are saved when the “Save options” button is clicked and are read and displayed when Analytics is subsequently opened.

Enable analysis, real-time or batch– Enables analysis of a target data collection sequence both during tracking and immediately after collection has completed, Recording has been selected and the associated, new video and data files have closed. Enabling this option will delay automatic scanning for another event while analysis is in progress. If enabled, a thumbnail video of the tracked target with the current identification will appear in the upper right corner of the Wide-Angle Video Display. **Do not Start Analysis after this selection – just checking this box will cause auto-analysis after each detection/tracking and recording interval after Run is activated.**

An example of real-time analysis:



Enable modification of folder names to include ID – Enable modification of analyzed folder names to include the ID and confidence determined for the collection of files in that folder.

Enable YOLO day/night object identifier (slower than SSD) – Enables a “You Only Look Once” deep learning identifier for birds and various types of aircraft.

Enable Single Shot Detector (SSD) daytime Object identifier – Enables “Single Shot Detector” identification method. Depending on scene content, operates up to about 80% of the real-time frame rate. Best for daytime lighting conditions but can be enabled for low light conditions. Can detect birds and various types of aircraft.

Enable nighttime aircraft identifier – Enables an alternate method of aircraft identification in nighttime lighting conditions. Can be enabled for any set of day or night files and will automatically be engaged for videos with low light. May be enabled for all lighting conditions but may not identify aircraft lights in daylight.

Enable termination of file analysis if confidence exceeds threshold -- Enable a time-saving method of terminating analysis of a file if the identification confidence is greater than the percent entered. If more than one identification method is enabled, then any of them that exceed this value will terminate analysis.

Threshold confidence percent: -- Minimum percent confidence level required to label a file as identified.

Maximum frame for analysis or playback (blank for all) – Enter the maximum frame number as a limit to the number of frames that will be played back for review or identification. If the field is blank, then all frames in a file will be played.

Data path <path name> -- The name of the path and, optionally, the file to be analyzed. If no file name is selected, then the software will search for and analyze any files it finds, even if in sub-folders, below this named folder.

File names that are analyzed have the following elements in their filename:

Start with “otdau-aux” or “otdau-tele” and end with “.avi”

Maximum frame for analysis or playback (blank for all) – Analysis will be performed on all input frames up to this value and then stop. If no identifier is selected, then the video file is simply played back for visual review. If this value is 0 or blank, then all available frames are played or analyzed.

Control buttons

Click on the seven buttons on the bottom of the Options display to perform an analysis as follows:

Select Data Folder – Opens a Browse for Folder window. Click on any folder that contains collected data (or has a folder below it that contains the data) and then click OK. When your selection has been completed, the complete path to the selected folder will be shown in the Data Path box. If a non-existent folder is selected, the browser will start at the top, Desktop level. You can browse to any folder from this level.

Select data file – Opens a window showing all of the files under the folder in the selected Data Path. Double click (or click and then Open) one of these files to analyze that file only. If the window contains a folder, you may double-click it to open the files or folders it contains, ultimately selecting the file you want. When your selection has been completed, the complete path to the selected file will be shown in the Data Path box.

Close Window – Closes the Analytics Options window. The selection shown in the Data Path box is saved in a file called analytics_config.txt within the folder that contains the OTDAU software.

Perform analysis – Starts the analysis process by opening the folder and file (if any selected) designated in the Data Path box. If only a folder specified, then the tree of sub-folders below it will be traversed to find any .avi files to analyze. The functions specified in the check boxes, described above, will be enabled during the analysis. The most likely reason for misidentification or low confidence is that the target object was too small for the identifier to recognize.

Pause analysis – Pause reading and processing frames from the currently open video file.

Frame-by-frame – Click to advance the display to the next frame. Can be the first action after selecting a data folder or file or, when a file is running, it will stop playback at the current frame and then may be used to advance frames one at a time.

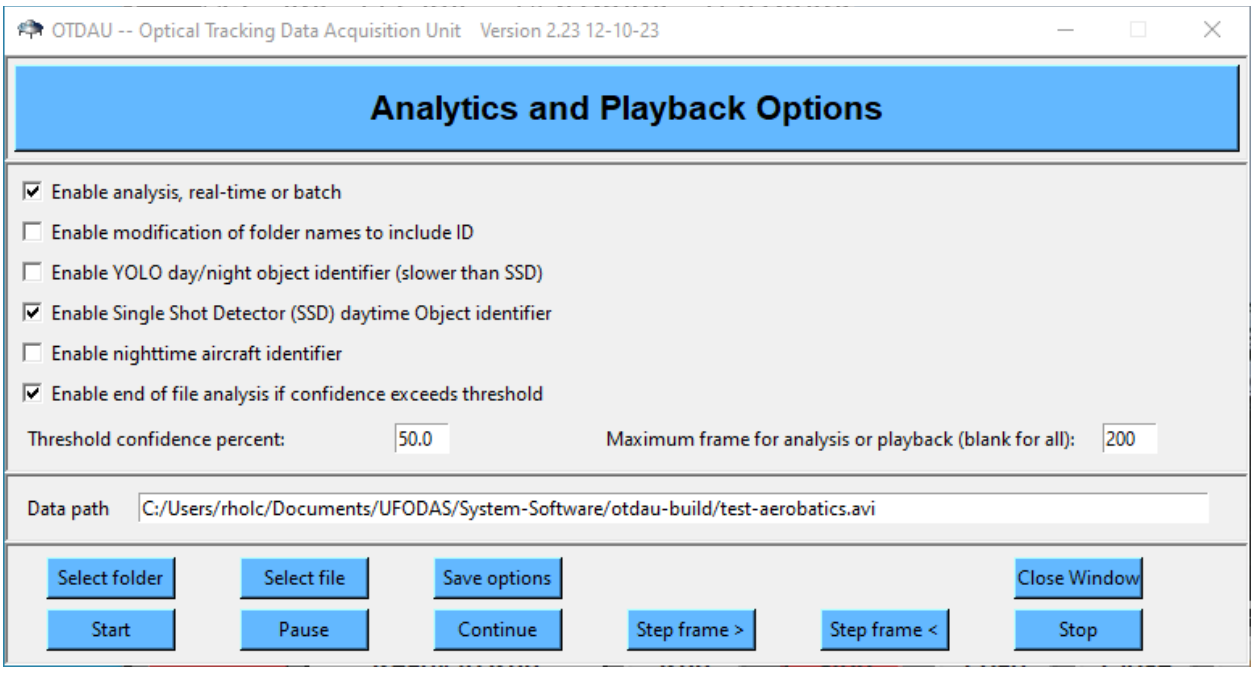
Continue analysis – Continue processing video frames from the point at which processing was paused.

Stop analysis – Stop all processing. After selecting this option, Pause and Continue have no effect. Selecting Perform analysis will restart all processing. If any

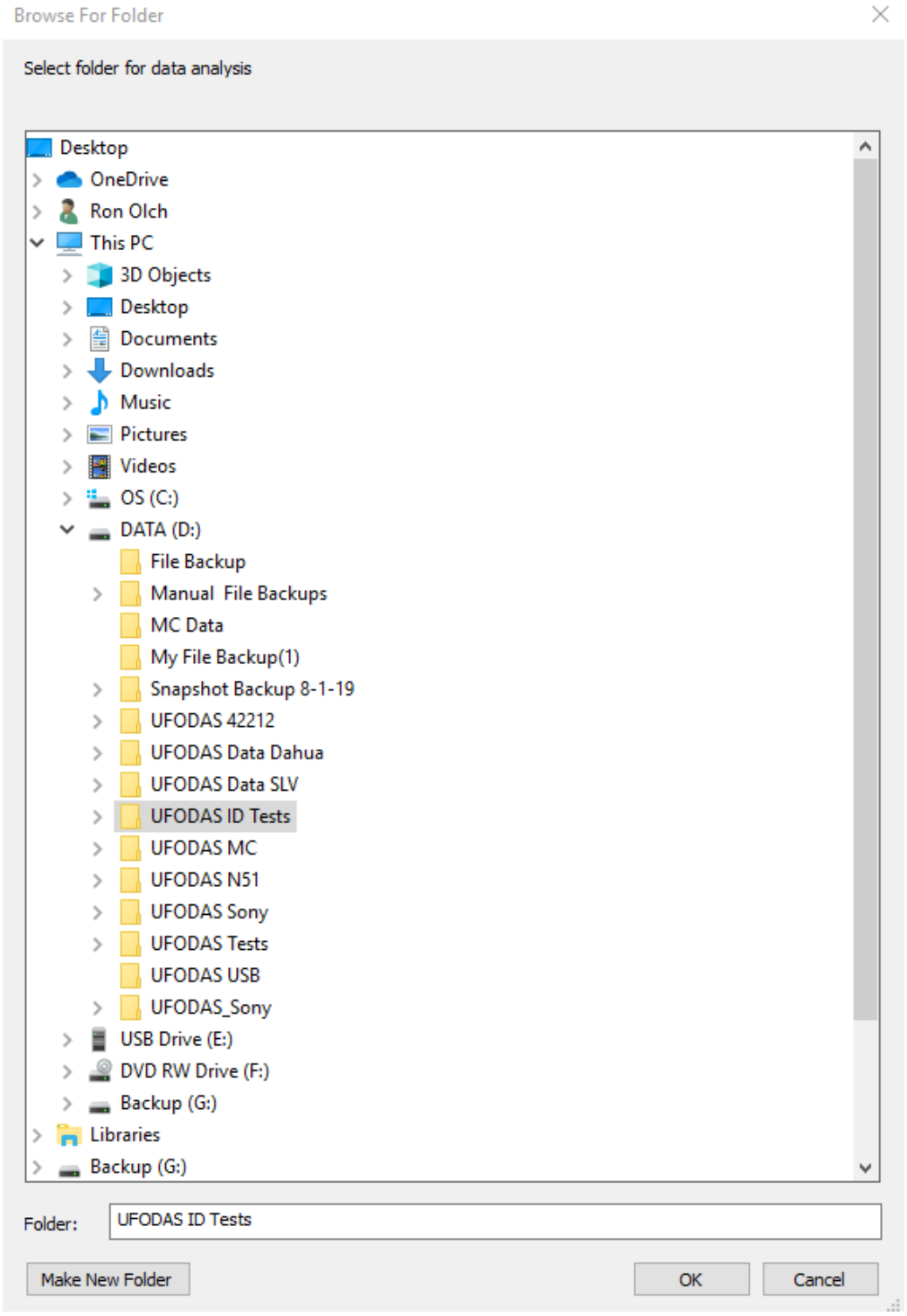
folder names were modified due to prior analysis, then they will be changed again to conform with any new analysis results.

Some examples of file selection and analysis are shown below.

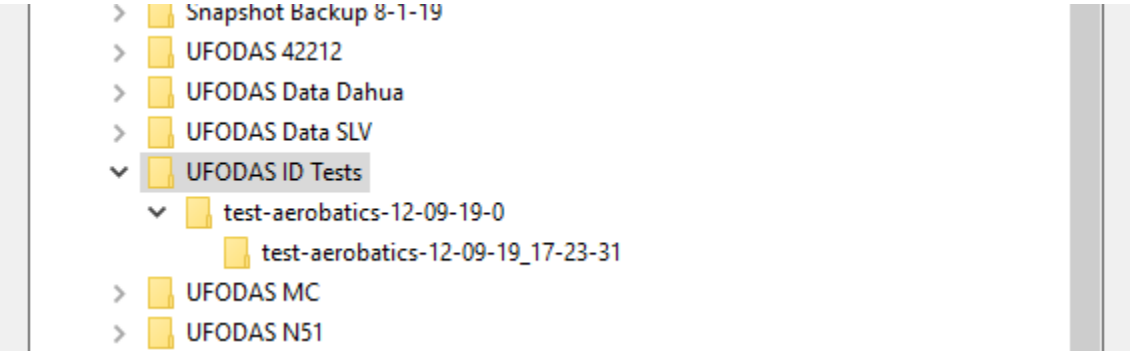
SSD analysis and termination upon >50% confidence enabled. The Data path is specified was either typed in or was retrieved from analytics_config.txt when Analytics Options was selected:



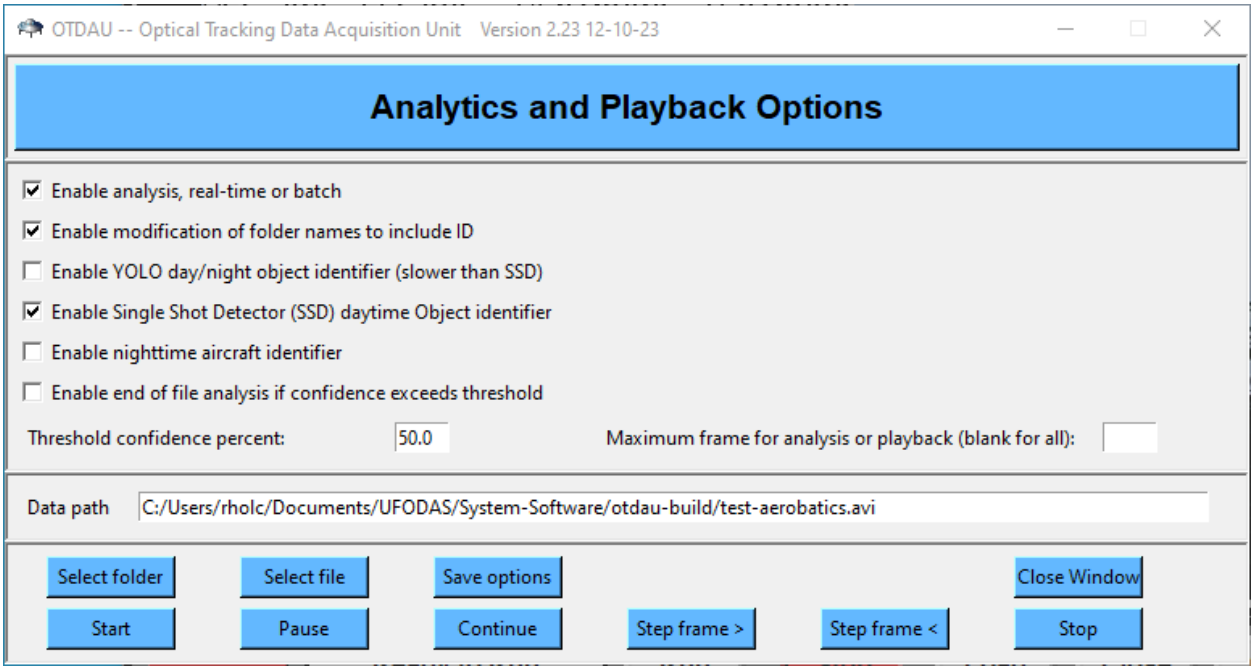
Clicking on Select data folder opens a folder browsing window:



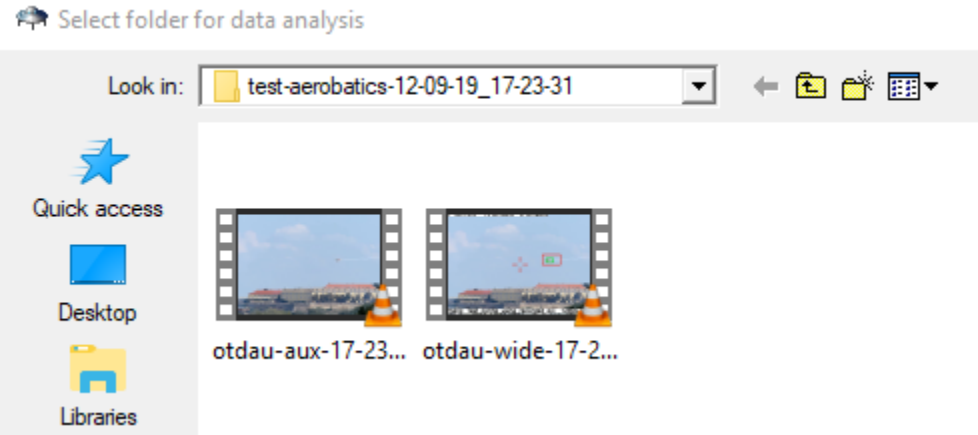
A fragment of the window above is shown below after “UFODAS ID Tests” was clicked, exposing the folder “test-aerobatics-12-09-19_17-23-31below it:



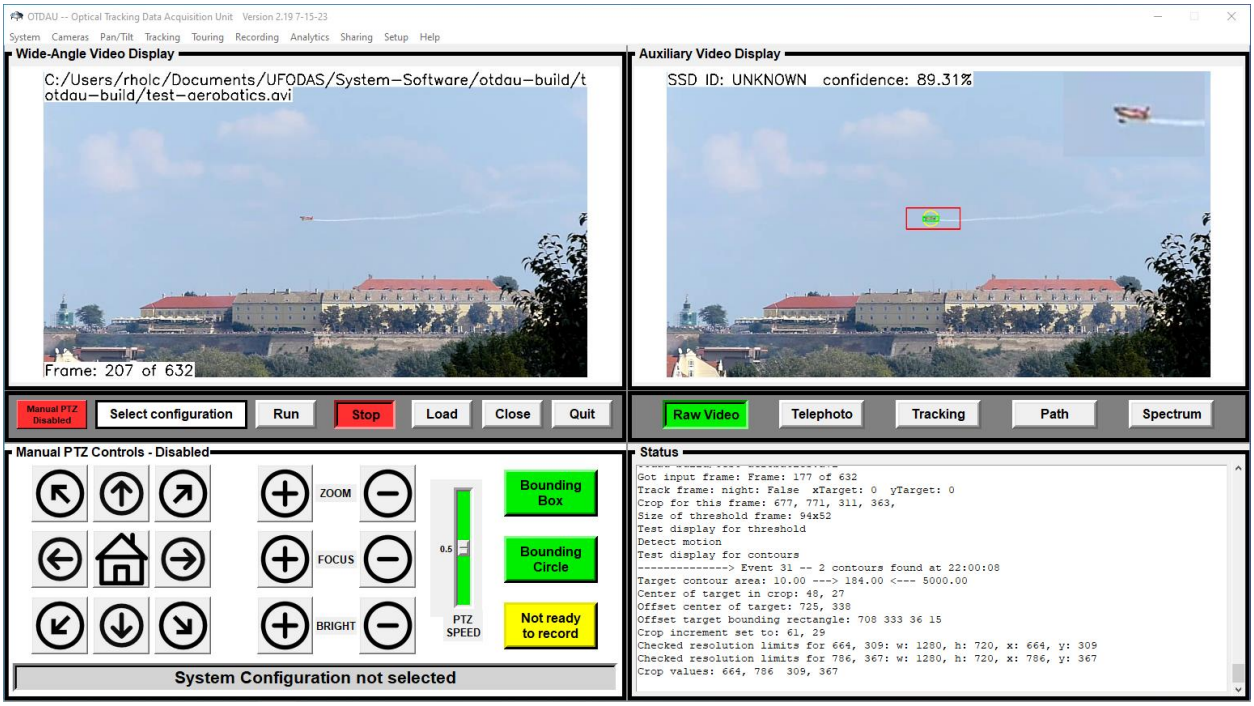
After selecting the test-aerobatics folder, its path populates the Data path field:



This fragment shows the files contained in the selected analysis folder:



Now, when Perform analysis is selected, the file “otdau-aux-17-23-31 is read and analyzed frame-by-frame with the result that the aircraft is correctly identified to a confidence level of 98.08%. Analysis has been Paused to obtain the snapshot shown below:



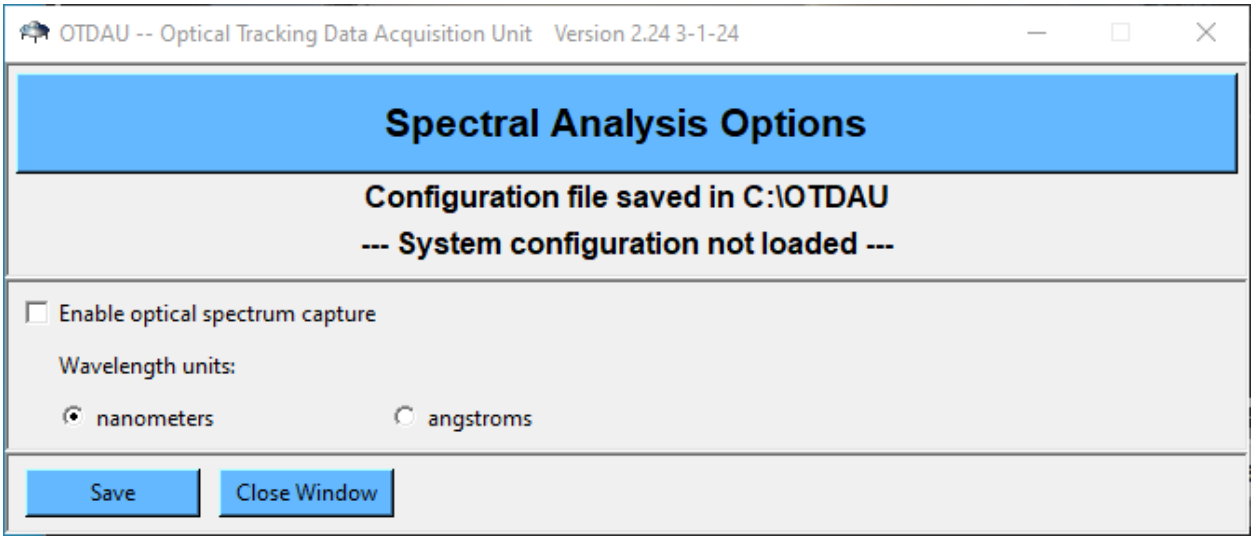
Note that if the folder “test-aerobatics-12-9-19_0 had been selected instead, any video files in folders below it would have been analyzed. The example above only shows one folder below, but there could be many – one for each target acquisition during a run.

If the other analysis option, nighttime, were also selected prior to analysis, then a separate line for each would be added to the top of the right-side display along with the SSD result.

The Frame similarity value on the bottom of that display indicates the similarity of this frame to the last using the SSIM (Similarity Index) method. Since the initial bounding box used when the video data was originally captured is not known, this process is employed to determine if “motion” in the frame was due to actual target motion or camera motion and, if the latter, is rejected. Thus, the identification analysis methods are more likely to be applied to the actual target that caused the recording to have been made.

Note that during analysis, the software automatically selects and moves the bounding box. Since the box could be anywhere in a collection of analyzed files and because the analysis process is automated, it would not make sense for the user to try to set it for every file.

SPECTRAL ANALYSIS



Enable optical spectrum capture – Enables automatic location of the line spectrum generated by use of a transmissive optical grating mounted in front of the camera lens. The located spectral line is then used to create an optical power spectrum plot (relative power vs wavelength) that may be viewed using the Spectrum button or optionally recorded. This option allows the real-time spectrum of a tracked object to be recorded for later analysis.

Wavelength units – Selected how the spectrum plot and recorded CSV file represent and label wavelength data.

Control buttons

Save – Saves the current settings for use during the next Run period.

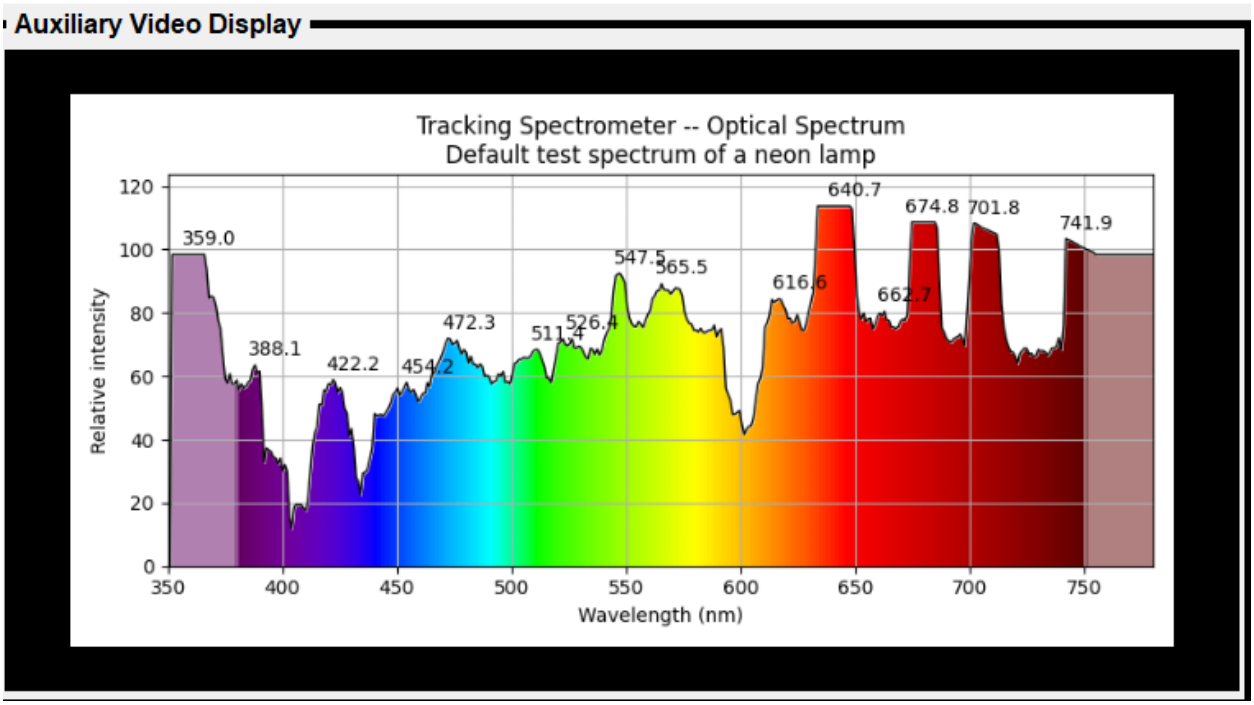
Close window – Closes the Setup Options window. If the window is closed before any changes to settings are Saved, then those changes are lost.

To use the optical spectrum feature, a blazed grating must be mounted in front of your camera lens. The grating must be rotated such that the spectral line resulting from a point-like light source is horizontal and on the left of the point.

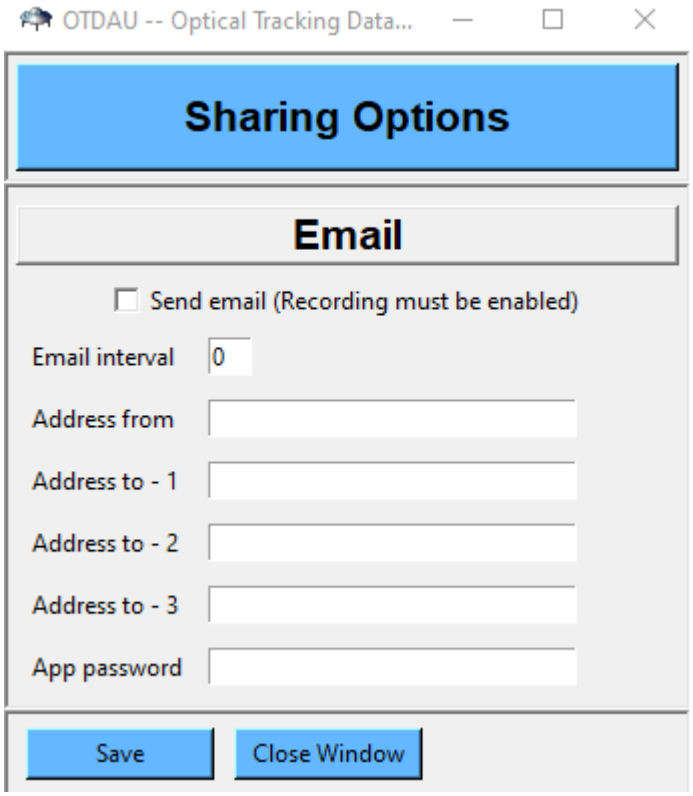
For spectrum generation, go to the new Spectral Analysis menu, enable spectrum capture, and select nanometers or angstroms for the wavelength unit display. Running the System configuration will cause continuous spectrum capture and plot generation.

Select Spectrum for the Auxiliary Video Display to see spectrum plots. You can record both a video of that display as well as a CSV table of peak wavelength/intensity values via the Spectrum selection in the Recording Options menu. The time between recorded sets of peaks is governed by the Data Interval setting.

If the Spectrum function has been enabled but tracking is not running yet, a sample spectrum of a neon lamp is displayed:



FILE SHARING OPTIONS



EMAIL SETUP

Checking the **Send Email** checkbox will cause the system to send an email including all recorded video and still frame files as well as the current System configuration JSON file for reference.

Email interval – The minimum time in seconds between possible email transmissions. This is used to avoid too many emails when target conditions result in many rapid sequential identifications.

'**Address from**' – Your email address, for example: johndoe@gmail.com.

'**Address to – 1, 2, 3**' -- Up to three email addresses that you would like the system to send emails to. A copy of the same email will be sent to each address.

‘**App password**’ -- The application-specific password associated with the named Gmail account. This is not your Gmail password you use for access to emails via gmail.com.

You can generate an app password by the following process:

https://support.google.com/accounts/answer/185833?hl=en

Start by navigating to your Google Account via the hyperlink in the above page. Follow the process to “Create & use App Passwords”. When asked to select an app, enter OTDAU and then click GENERATE. Type this 16 character, lower-case password into the Email password field and click Save.

If the Send email box is checked, an email will be sent just prior to the system returning to the camera Home position if the following conditions are met:

- After each data collection sequence is complete and data is saved
- After a target object has been identified and tracked until lost to view
- The system accepts the tracking sequence (e.g., it was long enough) and just prior to the system returning to the camera Home position.
- Recording was enabled

Note that Gmail imposes a limit of 20MB to the sum of all attachments. OTDAU will attempt to attach all the collected files up to this limit and notify you via the Status box of what was attached and what could not be attached due to this limit.

The log file is included as an attachment to the email.

SETUP OPTIONS

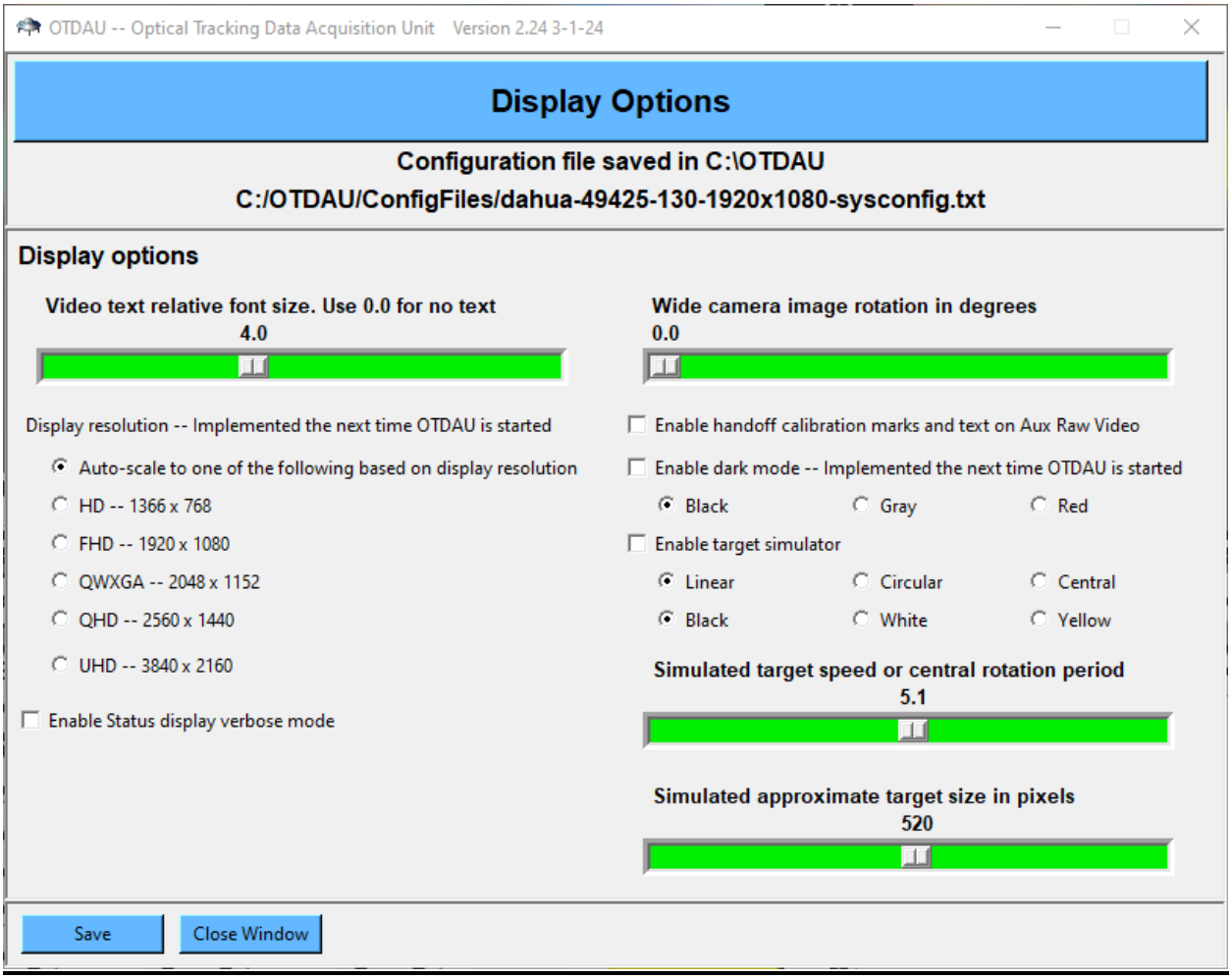
Operational options that modify system behavior during run time. Note that these selections are saved in a text file in C:\OTDAU when a System configuration is closed or you Quit out of OTDAU. They are read whenever the corresponding System configuration is opened. If you click Load without selecting a configuration, OTDAU automatically selects the last configuration Loaded or provides a list of recent configurations to choose from.

Setup options is organized into three subsections:

- Display
- PTZ Control and Tracking
- AutoStart

The contents of each of these sections are described below.

DISPLAY OPTIONS



Video display relative font size -- Video display text font size is control slider. Set the slider from 0.0 to 10.0 for relative size control. If set to 0, no overlay text will be displayed. Click Save to immediately see the effect on video overlay text. The size value is saved in the configuration file for the currently loaded configuration. (**NOTE**: All sliders can be adjusted by moving with the mouse or by clicking on either side of the slider. Holding the mouse down will move the slider in the direction of the mouse.) **NOTE**: Take care not to eliminate text you may later want to record for identification and analysis.

Display resolution selections -- The size of the OTDAU display may be changed to better fit the available computer monitor size. If Auto-scale is selected, then OTDAU uses a size based on the detected monitor size. Selecting one of the other sizes forces

OTDAU to use that size. The size is implemented when OTDAU is started and not when the display resolution selection is saved.

Enable Status display verbose mode – Enabling verbose mode attempts to display all OTDAU process messages. Default is verbose mode OFF which provides summary messages for target tracking but uses verbose mode when OTDAU is Stopped. Both modes attempt to display as many messages as possible but some will not be visible due to higher speed of message generation than display. Messages may be manually scrolled when the system is Stopped.

Wide camera image rotation in degrees – The orientation of the Wide video image can be rotated by sliding this control from 0.0 degrees to 360.0 degrees. This is particularly useful when setting up an ASC camera in handoff mode so that the image may be rotated such that the top of the view corresponds to what is due North of the camera.

Enable handoff calibration marks and text on Aux Raw Video – Displays lines and text on the Wide display to indicate the four compass directions and enables camera and date/time data to be displayed on the Aux Display. Useful for setting up two cameras in Handoff mode.

Enable handoff calibration marks and text on Aux Raw Video -- Check to cause OTDAU to draw short horizontal and vertical calibration marks on the sides of the Wide camera view. This is helpful when determining the actual FOV of a camera for entry into a camera configuration.

Enable ark mode –

Enable target simulator – When enabled and a System configuration is Run, a small moving round dot is shown that moves in either a selected linear or circular path. The color of the dot may also be selected for optimal tracking detection based on the background color of the video. OTDAU software adds the dot to the image from the Wide camera such that all subsequent processing assumes that the dot is an actual part of the camera video stream.

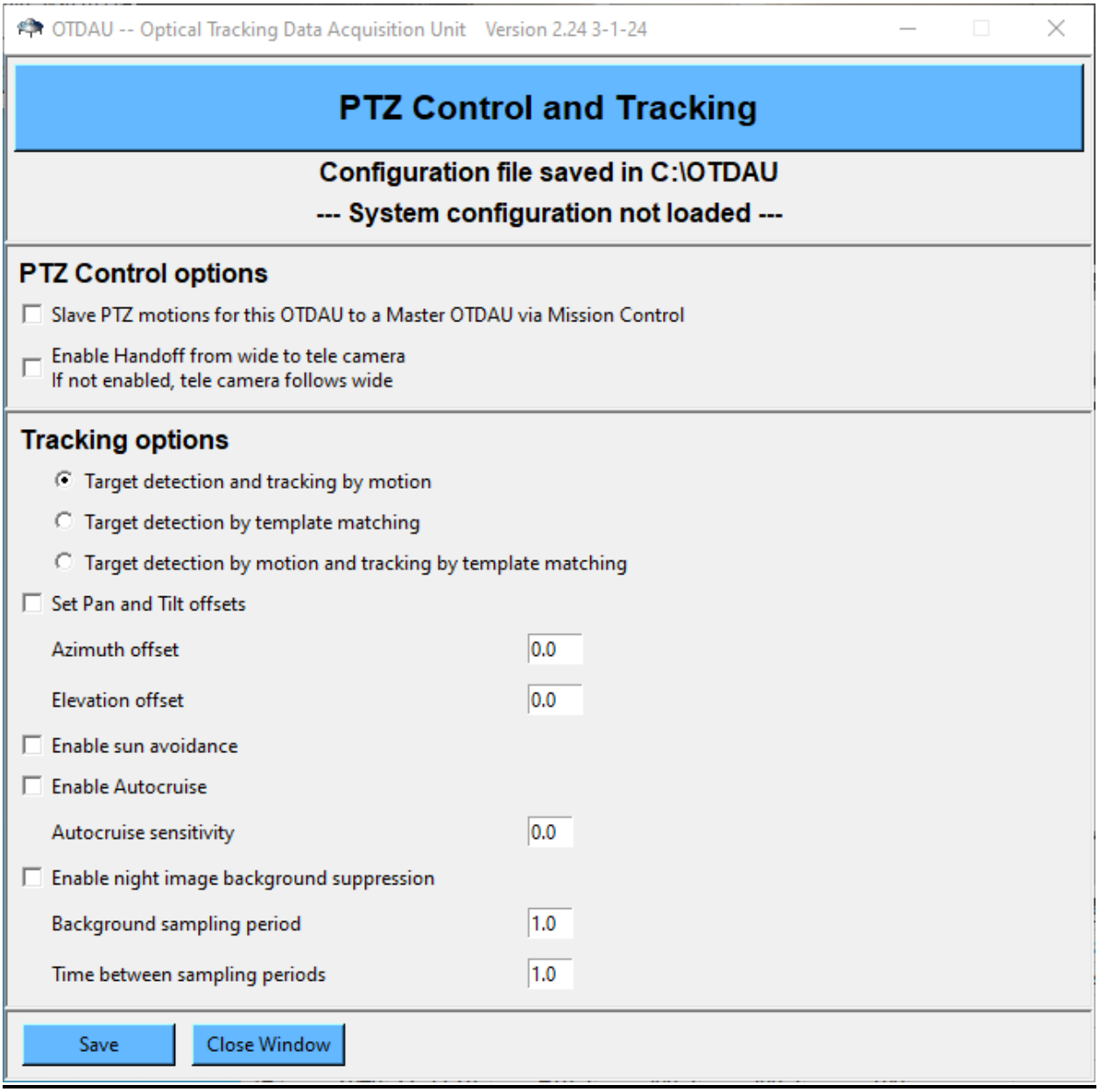
Linear, Circular, Central – Selection for type of simulated target: Linear moves a dot from right to left, lowers, then moves left to right, then raises again. Circular moves in a circular pattern with a radius dependent on the vertical video frame size. Central moves a dot in a small area around the CFOV.

Black, White, Yellow – Selection for the fill color of the target simulation dot.

Simulated target speed or central rotation period – The relative speed of the simulated target dot.

Simulated approximate target size in pixels – The relative size of the simulated target dot. The cluster size as measured and displayed in Status during tracking will only approximate this value.

PTZ CONTROL AND TRACKING OPTIONS



Slave PTZ motions for this OTDAU to a Master OTDAU via Mission Control –

Enables designation of this copy of OTDAU to be a Slave. Any number of slaved OTDAUs with PTZ cameras will follow the motion of the Master, including manual positioning for setup and homing as well as triggered recording. Slave camera manual PTZ controls will also function normally. If a slave is enabled for recording, then its Manual recording function is available, and it will also start recording whenever the Master does. This feature allows one camera to be used to detect/track a target while

pointing several other cameras (or other equipment on independent pan/tilt heads) at the same target. This feature depends on also running Mission Control through which all Master data is distributed to Slaves. Prior to use, position all cameras to have the same CFOV and then Save the Setup with Slave enabled for any OTDAU instances that need to be slaved. NOTE: Triangulation may be operational in this configuration but would not be valid. OTDAU Telephoto, Tracking, Path and Spectrum options are not available in any slave since tracking and target position data did not originate with the slave. Be aware that the FOV of any slave will not perfectly correspond to that of the Master, with an offset related to the distance between them.

To slave an instance of OTDAU:

1) Move the Master to its home position,

2) Move the Slave so that its CFOV aligns with that of the Master

3) In the Slave Setup Options, enable Slave PTZ motions and Set Pan and Tilt offsets which zeroes its AZ and EL indications.

Enable recording in Master and/or Slave as desired. Test by manual PTZ control of the Master and observe the corresponding motion of the Slave.

Enable Handoff from wide to tele camera
if not enabled, tele follows wide – Enables the system to handoff target detection and tracking to a telephoto PTZ camera after initial detection by a wide fixed-field unit such as a 360-degree panoramic camera. The wide camera makes the initial detection and then the tele camera is pointed to the approximate location of the target. The tele camera then proceeds with its own detection and tracking as if it had made the initial detection. This re-detection process compensates for inaccuracies in pan/tilt values derived from the target location from non-linear optics such as an All-Sky (panoramic) camera.

NOTE: Setup for Handoff using a non-ASC fixed camera (or PTZ camera with PTZ disabled), in typical situations where the target is distant – Instead of aligning the crosshairs, use manual motion to initially point the tele camera in the same compass direction as the wide camera. That is, move the tele PTZ camera such that its pan and tilt angles match that of the wide camera. When using a fixed wide camera, move the tele PTZ camera so that its direction of view is parallel to that of the wide camera. Use a larger Crop increment and Event interval than normal. Use the Display setup option to rotate the ASC view so that objects to the North are at the top of the display.

Note that When in Handoff mode and tracking results in a handoff to the Tele camera, the PTZ position data and video frame sent to MC changes from Wide to the Tele camera data.

Target detection and tracking by motion, Template matching, Both --

Alternate tracking methods are provided to support “star tracking” or similar targets. If a target is visible prior to Run, then it may be manually designated as the tracked target. In Setup > Tracking there are three options: Target detection and tracking by motion (the original method), both detection and tracking by template matching and detection to set the template by motion detection but tracking by matching. To use template matching, draw a tight bounding box around the target of interest and then Run. OTDAU will capture the first frame after Run as a template and attempt to identify the same target in all subsequent frames. To use the first or third option, use a larger bounding box, a low value of Tracking > Min events to allow faster recognition of initial target motion and a Crop increment greater than 2. Bounding box, and target location indication are the same as in normal tracking mode. Use with Tracking Settings > Max time set to 0 for long-term tracking. Useful for targets of any speed but particularly for slow-moving such as celestial objects or satellites. See the ISS and jet-clouds test configurations for examples.

NOTE: Template matching alone does not use any of the non-time Tracking parameters. It may lose lock due to target size and orientation changes. It does not function well if in Handoff mode due to a non-specific initial frame crop area. Template matching automatically terminates tracking if the quality of a match is significantly different than the last successful match.

When template matching is enabled, the Wide camera video display shows a thumbnail frame of the template with a SSID (deep learning) assessment of the object ID with its confidence value below it and, if the confidence is zero, UNKNOWN. The resulting object class and confidence level are appended to the Wide video filename if that option is selected in Analytics.

Set Pan and Tilt Offsets -- Check to cause OTDAU to create offsets to the current pan and tilt positions such that the offset positions rather than the actual positions are sent to MC during triangulation. This option is typically set after pan and tilt have been manually moved to due North and the horizon. If this box is checked and then you click Save, OTDAU samples the current pan and tilt values of the camera and saves them. Until this box is unchecked, OTDAU subtracts these values from the actual camera pan

and tilt values to provide offset values used for the AZ and EL displays and for data to MC.

Offsetting pan and tilt is also helpful to set, as above, prior to any PTZ camera Run so that the actual azimuth and elevation of the camera are saved for later image analysis.

Azimuth offset -- If Pan and Tilt Offsets is checked, this value is added to the net offset for pan at Run time. This may be used to emulate a PTZ camera for triangulation when using a fixed camera to obtain a desired azimuth angle regardless of the camera's actual angle.

Elevation offset -- If Pan and Tilt Offsets is checked, this value is added to the net offset for tilt at Run time. This may be used to emulate a PTZ camera for triangulation when using a fixed camera to obtain a desired elevation angle regardless of the camera's actual angle.

Avoid Sun -- Check to cause OTDAU, during Run time, to continuously measure the brightness of the brightest spot on the Wide image of a PTZ camera. If this spot sufficiently increases in brightness, indicating that the camera has the sun in its FOV, then the system will move the camera up, away from the sun, for one second. Scanning for motion will continue at the new position. Do not enable this option if the type of object that may be detected is very bright, otherwise tracking will be lost just after it starts.

Enable Autocruise -- Check to enable the Autocruise process. This is a feature designed to maximize target viewing time despite the target passing a foreground or background object, such as tree foliage, that may confuse the tracker. Autocruise works by continually monitoring the velocity of the target. When the velocity makes a sudden change, as defined by the sensitivity value, the tracker stops attempting to directly track the object and instead, continues smooth PTZ motion in the direction and at the velocity of the object last measured prior to the change. OTDAU will stay in Autocruise until the end of the current tracking event sequence.

Autocruise sensitivity -- Enter a relative value that will be used when Autocruise is enabled, to determine the level of velocity change required to cause the system to go into Autocruise mode. A larger value is more sensitive.

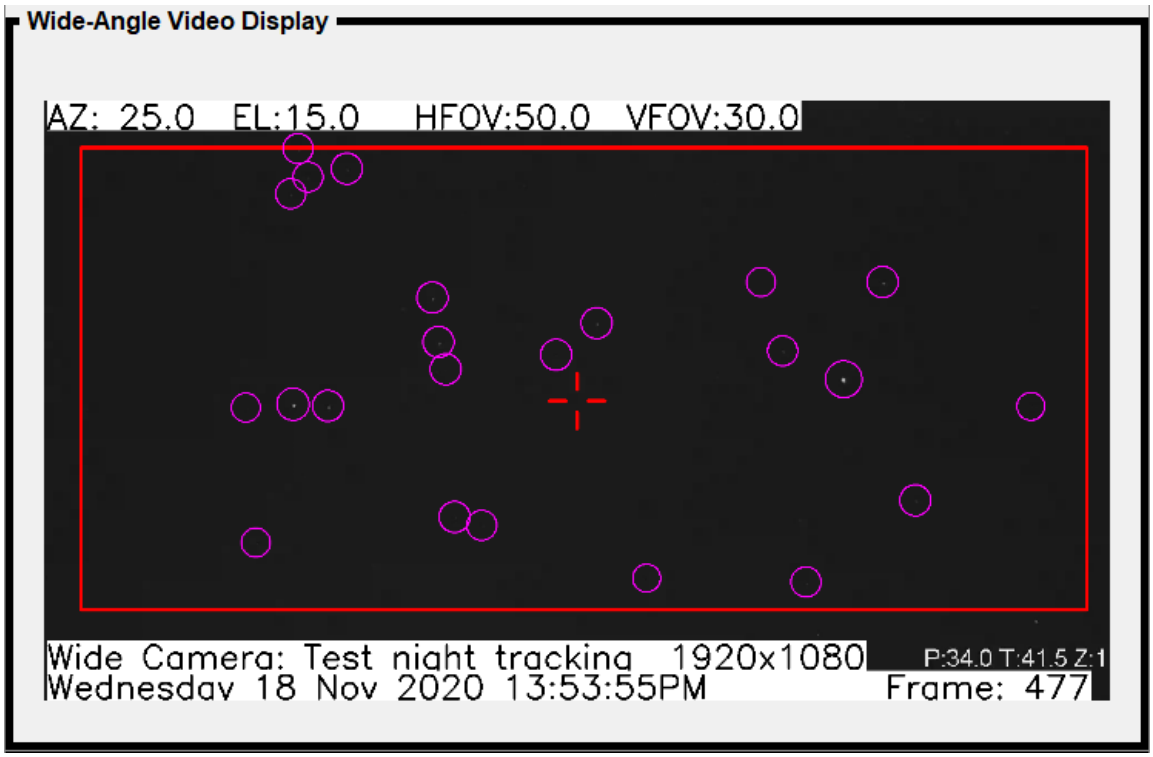
Enable night image background suppression – Enables the automatic, periodic identification of non-moving night sky objects. This feature uses this identification to ignore such objects when qualifying actual new, moving objects to become tracking targets. The screenshot below is an example of this process using the test-night-stars.json test configuration. Each purple circle encloses an object that has been detected with intensity above an internal threshold. Any new object that is found inside the bounding box after the initial background sampling period is detected and tracked while fluctuations in the background objects are ignored.

Background objects to be excluded are determined by sampling during the Background sampling period entry, in seconds. The sampling period and its termination are indicated by an onscreen display messages.

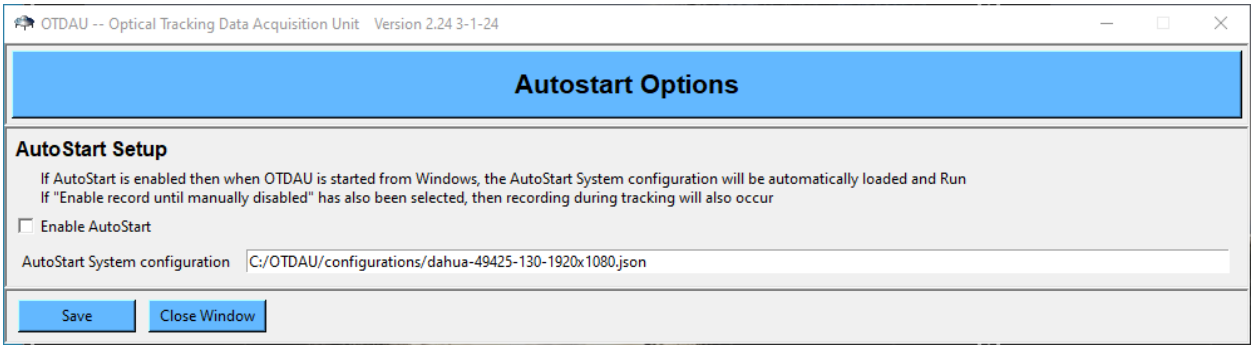
Since the background may change over time (e.g., stars shift position), the sampling process is periodically repeated at a rate set in seconds by the Time between sampling periods entry.

All excluded objects are displayed as green circles in the Raw Video display. Note that if a potential target is moving during the sampling period, then every point it passes through during the sampling period will be part of the exclusion set.

Note: To avoid the effects from very small objects, it may be necessary to to increase the values of Blur to perhaps 7 and Delta threshold to about 25. Some experimentation may be required, pre-Run, to get the best results.


Wide-Angle Video Display
AZ: 25.0 EL:15.0 HFOV:50.0 VFOV:30.0
Wide Camera: Test night tracking 1920x1080
P:34.0 T:41.5 Z:1
Wednesday 18 Nov 2020 13:53:55PM
Frame: 477

AUTOSTART SETUP



OTDAU can automatically Load and Run any System configuration when started from Windows. This may be useful for situations where system power may not be reliable – when power drops out and then returns, and the computer reboots, OTDAU can restart, running, with the same options enabled as when power went down.

AutoStart may also simply be used to manually startup OTDAU in a Run mode in the least time.

If AutoStart is enabled and a System configuration is selected and saved, then when OTDAU first starts up, that configuration is Loaded and Run. Disable AutoStart to start up normally but retain the selected System configuration. AutoStart may be used with or without the Record until disabled option to automatically start, run and record during tracking just by running OTDAU.

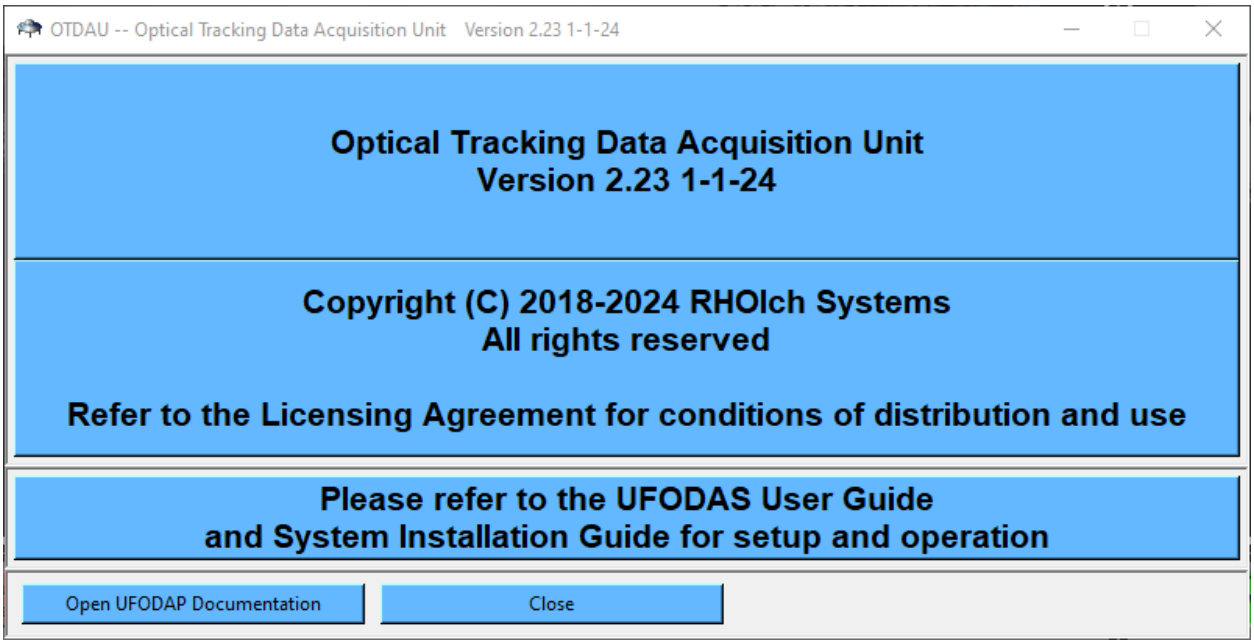
Use Windows Task Scheduler or another method of your choice to automatically start OTDAU during Windows startup.

Enable AutoStart – Enables automatic Load and Run the next time OTDAU is started.

AutoStart System configuration – Clicking in this field will open a list of System configurations. Selecting one of those will populate this field with the selected configuration.

HELP

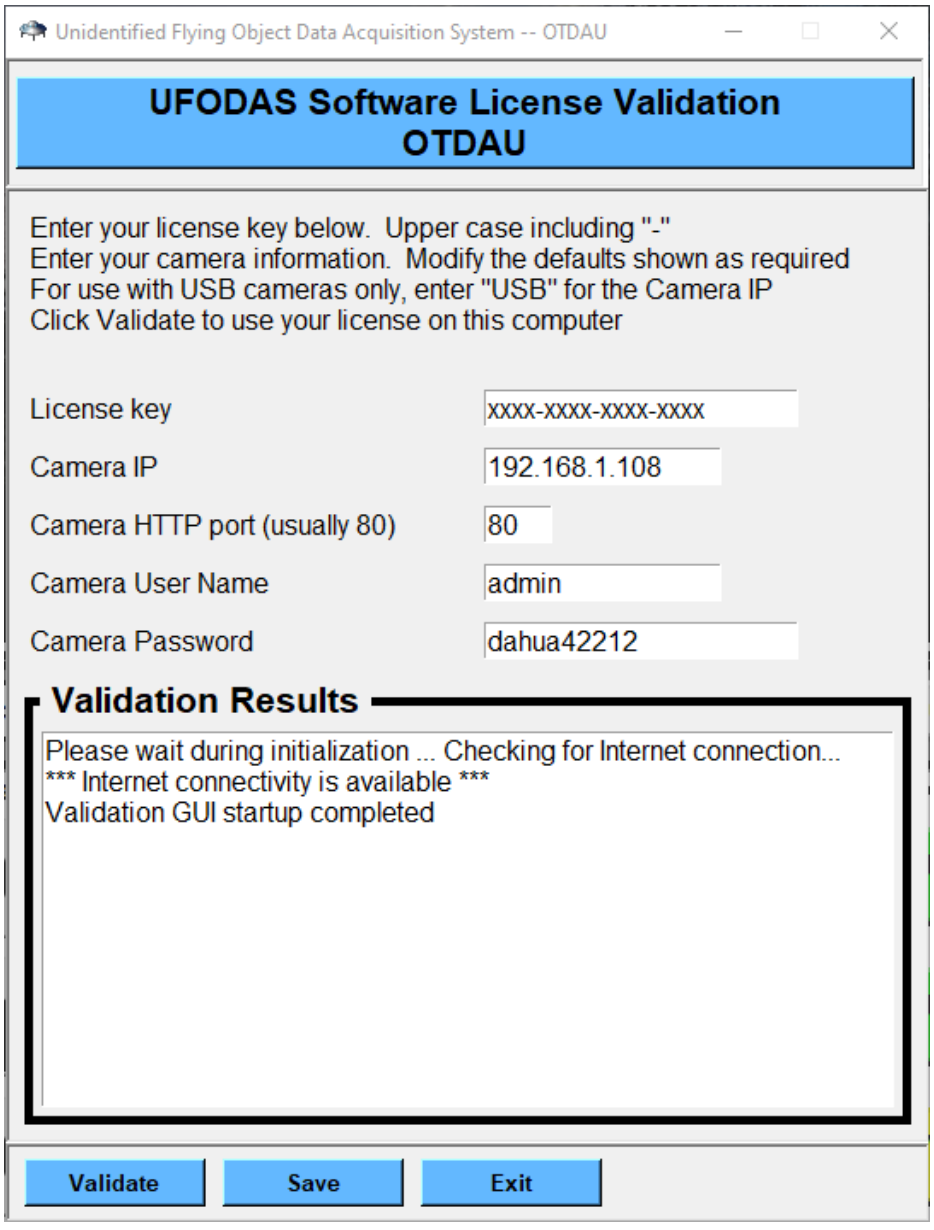
About –



This window shows the current version of OTDAU software. The version is also shown at the top of the main display. Clicking on “Open UFODAP Documentation” will also open the ufodap.com Downloads page in a browser window.

Manage license –

Displays the license validation GUI. Allows the key and camera information to be modified or re-validated. Use this option to, for example, implement an IP camera for validation instead of a USB camera or use a different IP camera for validation.



Make any necessary changes and then click Save. If not Saved before Exiting, then when Manage Validation is selected again, the original validation information will be shown.

After clicking the Validate button, the Validation Results box shows the resulting validation check results including validation of the key and if the selected camera can be accessed. Both must validate to run OTDAU after clicking the Exit button.

Note that OTDAU can be used with only a USB camera if the Camera “IP” is set to “USB” instead of an IP address.

USING TEST CONFIGURATIONS

OTDAU software is provided with a number of System and Camera configurations for your use or as a starting point to create your own. This includes several test configurations and the avi video files they reference.

OTDAU will perform all detection, tracking, recording, analysis, etc. operations on test data as if it was from a live, streaming source such as a camera. This is very helpful when developing or testing Tracking options to verify that a similar object will be captured without too many false positives from other in-frame objects such as:

- Birds
- Insects
- Moving foliage
- Twinkling lights such as stars or streetlamps

There are two methods to loading files for test –

Select a default avi file:

1. Click on the System tab and then click “Open configuration”
2. Double click on one of the System configurations that has a file name that begins with “test-”
3. Click Load

Select any video file:

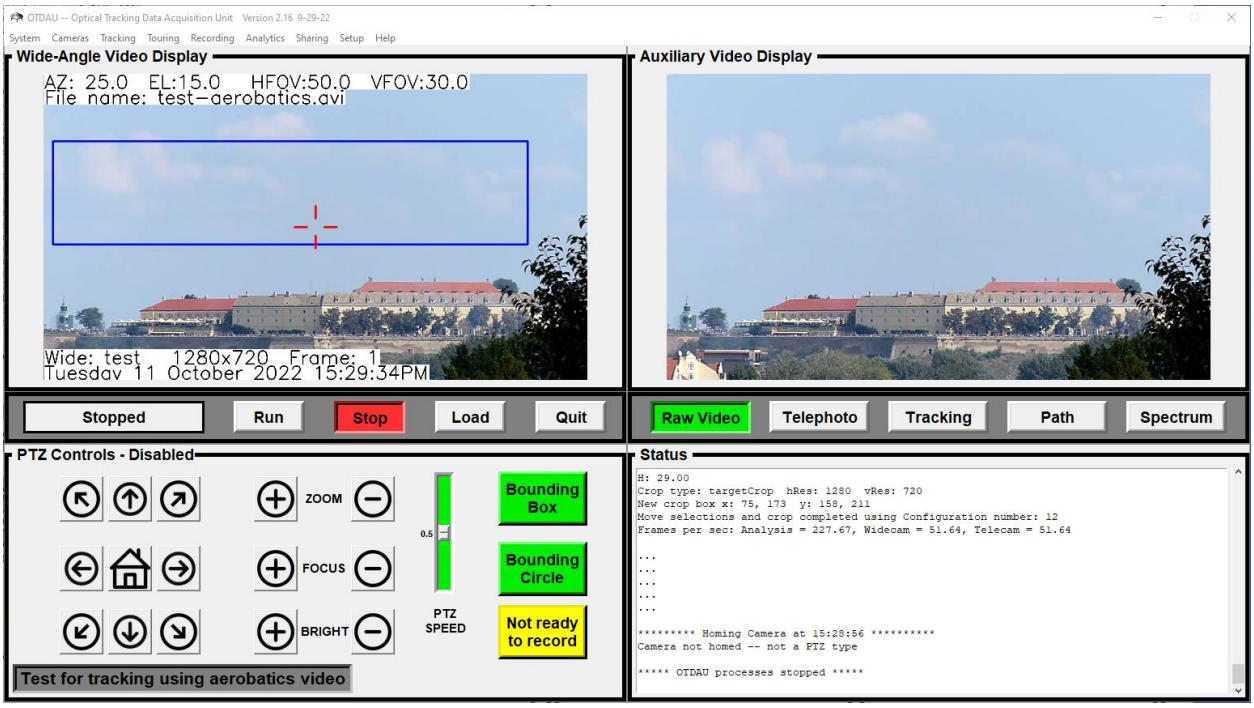
1. Click on the System tab
2. Click “Open a video file for test”; A window will open showing folders and avi files in your Program files (x86)\OTDAU directory.
3. Navigate to any avi file in this directory or anywhere else on your computer.
4. Double click on the selected avi file.

Video files may be of type (dot extension):

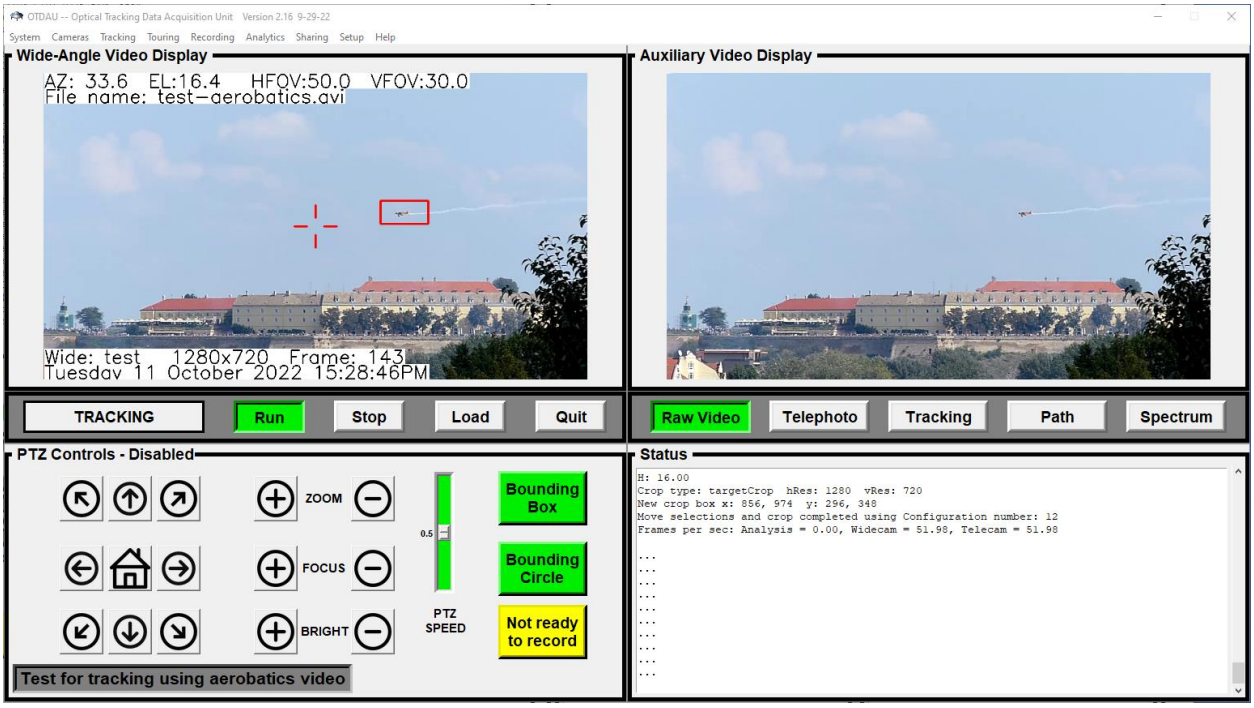
avi, mp4, mov, flv, wmv, mts, dav

Note that the latter method uses all System and Tracking settings as the “test-aerobatics.json” System configuration. Thus, running the selected file will use those settings and modifying those settings will affect subsequent use of the test-aerobatics test configuration.

After the selected configuration or file has been loaded, the first frame of the test avi or mp4 file is displayed, for example:



Clicking Run will play back the test avi file and cause OTDAU to detect and track the target object, in this case, an aerobatics stunt plane:



Playback may be stopped at any time by Clicking Stop. It will restart from the first frame when Run is clicked. Playback will automatically restart from frame if the file is allowed to play to its end, as indicated by the Frame number no longer incrementing. Clicking on Stop, then Run will restart playback from frame 1.

Several test configurations are provided so that the user may experiment with settings for different situations, including, for example, a clear night sky with many star-like objects, as shown below.

The ability to select any avi file for test may be used to improve tracking parameters for existing tracking runs. If you include Wide-Angle video as one of the Recording Options, then select any recorded avi file with a file name beginning with “otdau-aux-“. Double clicking that file will load it, ready for a tracking run.

Note that since such file uses the “test-acrobatics” configuration, you may have to change the Bounding Box or Tracking parameters to run the test. You can stop playback, change a parameter and Run again as many times as required.

To better understand what is being tracked, try the Telephoto, Tracking and Path options for the Auxiliary Video Display selection.

RECORDED FOLDER AND FILE STRUCTURE

If OTDAU runs with recording enabled and a target event occurs, then folders and files are created on the Data Path specified above. If the event sequence terminates and it does not meet criteria such as the Event Interval in Tracking Settings, then the data collected will be deleted.

The following defines the data structure that OTDAU creates for a target event –

Top Folder name: <Data Path>

Group Folder name: <SCN> + <today's date> + <folder count>

Data Folder name: <SCN> + <today's date> + <time folder created>

Files of videos and data selected in Recording for the event named:

"otdau-aux" + <time recording started> + ".avi"

"otdau-wide" + <time recording started> + ".avi"

"otdau-data" + <time recording started> + ".csv"

"otdau-tele-frame" + <time recording started> + ".jpg"

<Data Path> as specified in Recording Options

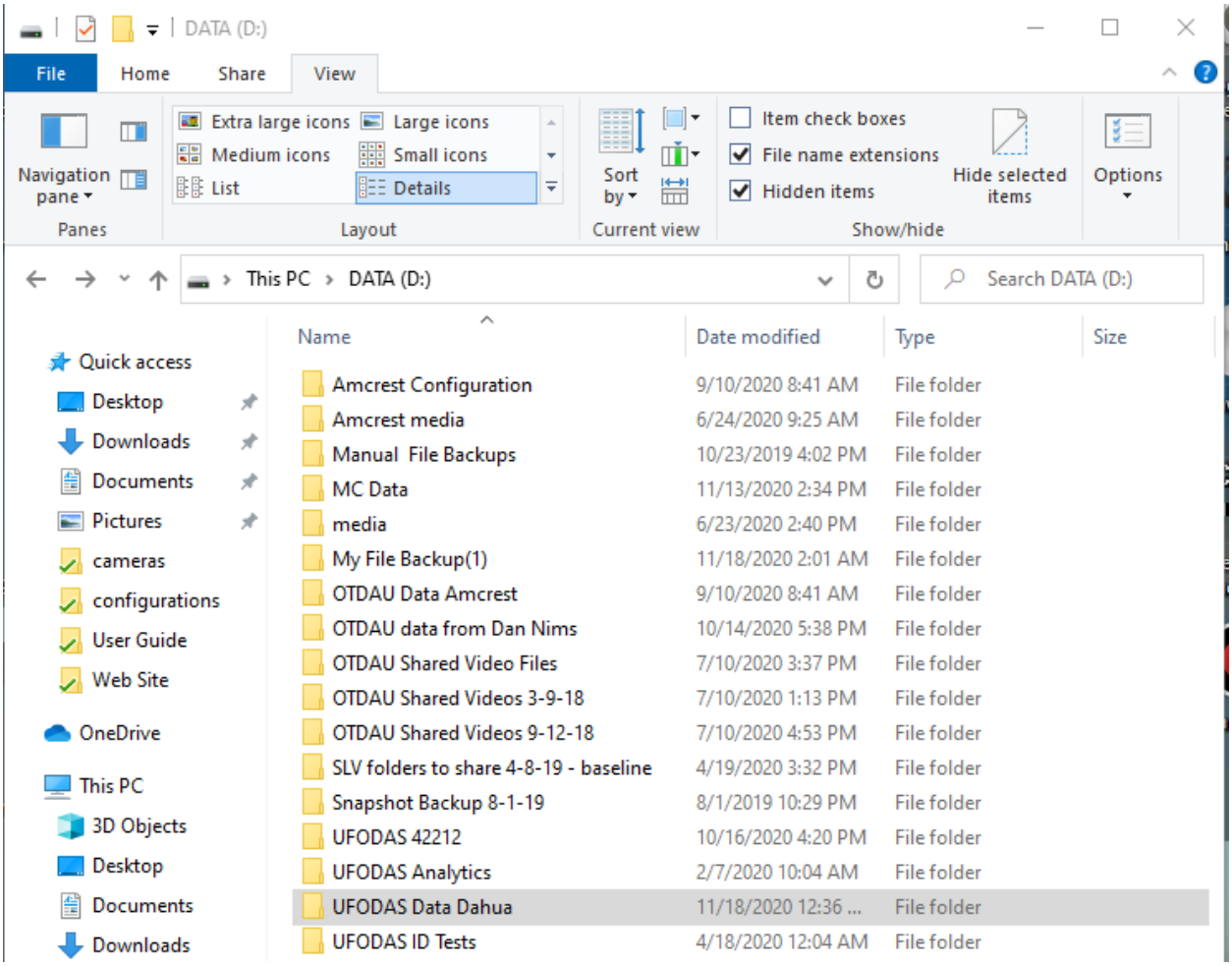
<SCN> System Configuration Name as selected in the System menu

<folder count> initially 0, increments by 1 each time OTDAU begins to Run, creating a new Group Folder name. A new Data folder will be created under this Group folder for each target tracking sequence until either the user Stops the run or the sequence times out per the Maximum time in Tracking Settings.

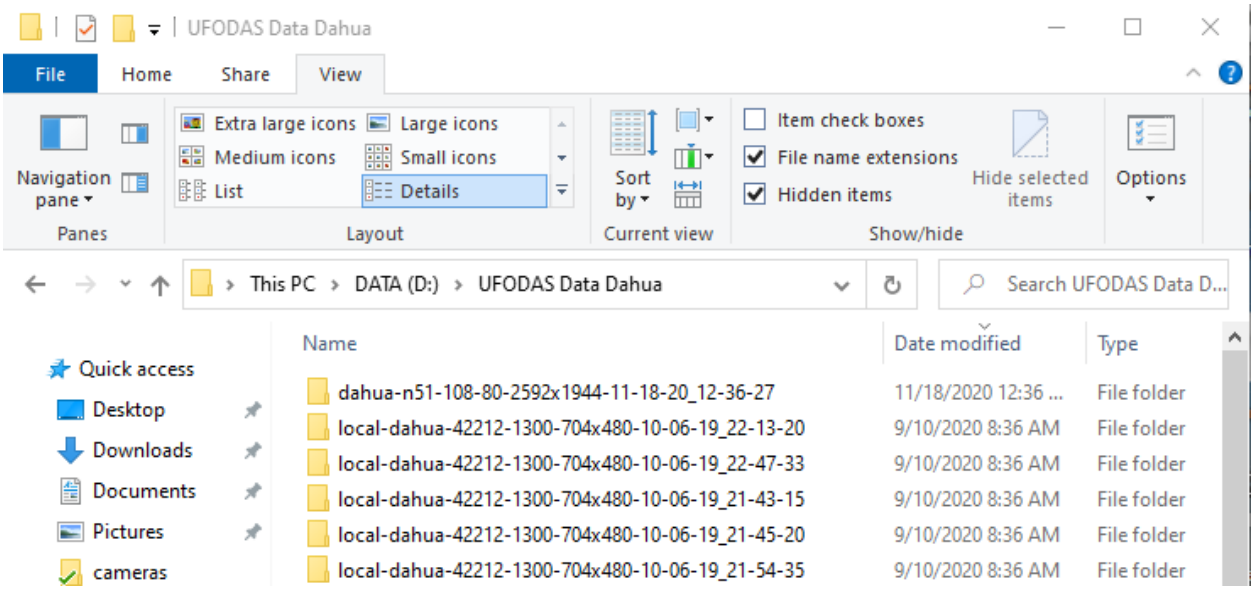
For example, see the following Windows File Explorer snapshots –

Drive D: contains several Top data folders.

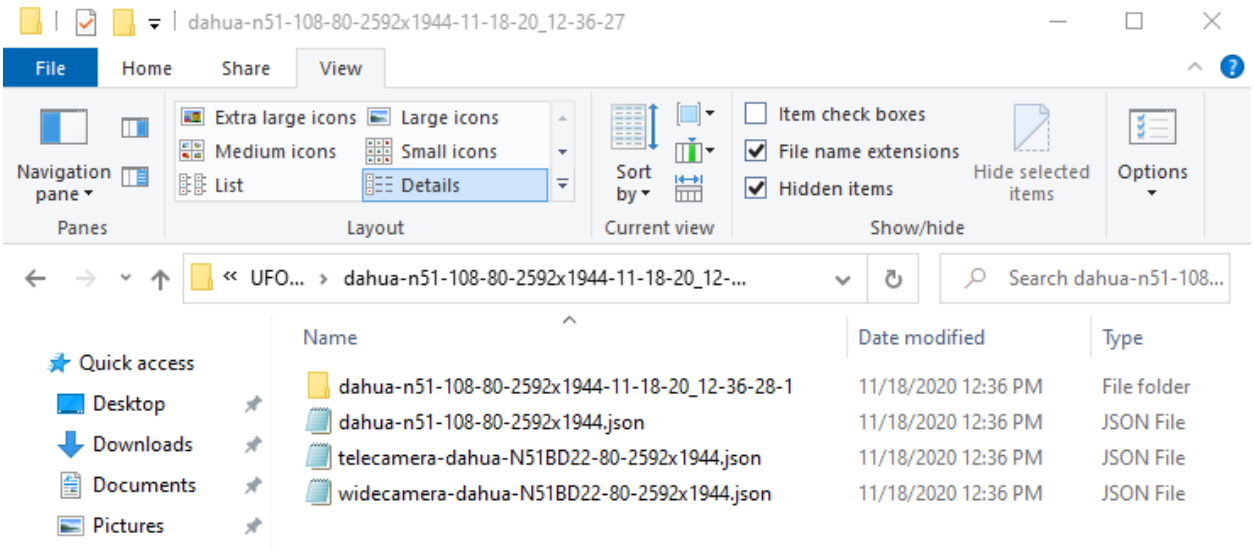
D:\UFODAS Data Dahua is selected:



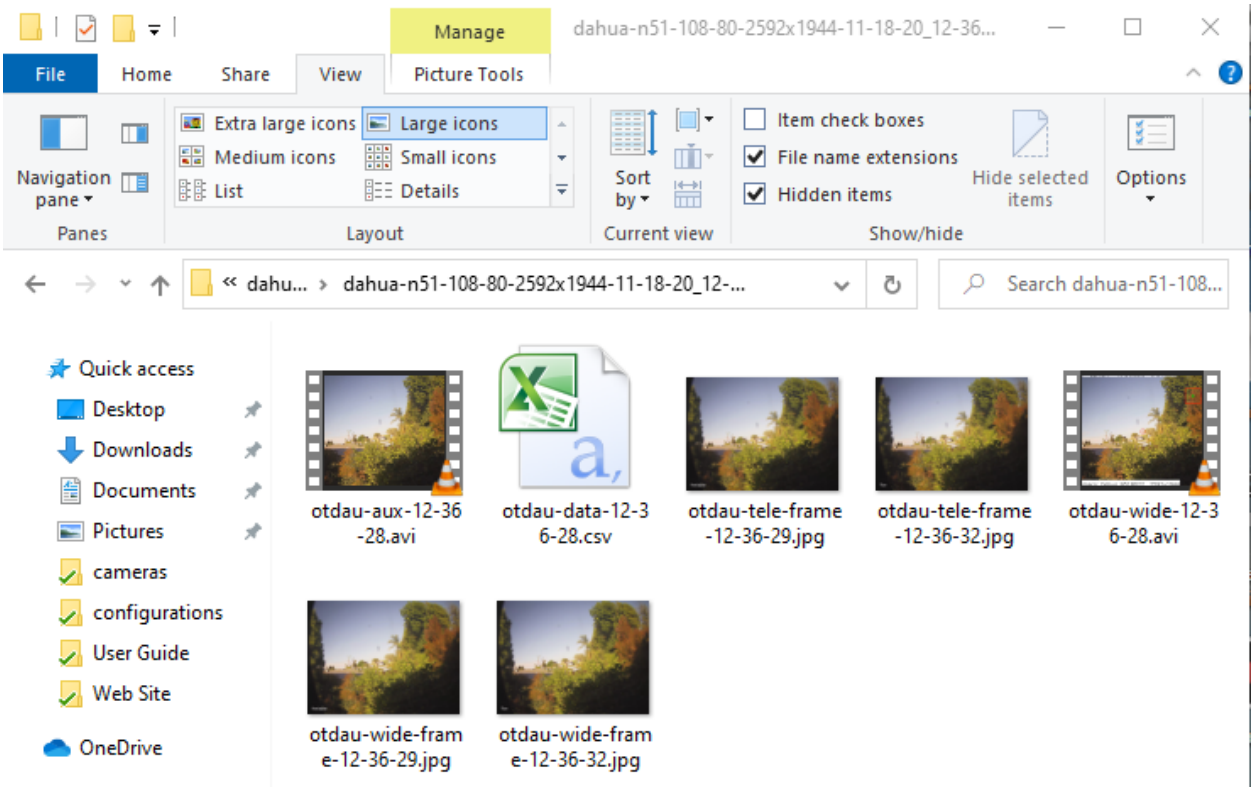
A Group folder under D:\UFODAS Data Dahua (dahua-n51-…) is show below:



These data folders are under the Group folder. Notice the System and Camera json configuration files:



These data files are stored under the first of the above data folders:



PROGRAM AND CONFIGURATION FILE STRUCTURE

After installation on a computer, OTDAU software is located in the directory:

C:\Program Files (x86)\OTDAU

Within this folder are several folders and files that make up the OTDAU software. Among these are the following:

- otdau.exe – The operational software file contained in C://OTDAU. Double clicking on this file will run the UFODAS system. The same startup function is also accomplished simply by clicking on the desktop icon created during system installation.

- configurations – Contains all of the configuration files that may be selected to configure the system for a particular use. These files may have been given an arbitrary name, typically selected to designate the location of the system and its complement of cameras. Each file must have .json as its dot extension.

- cameras – Contains a file for each type of camera that is available for system configurations. The file contains a set of parameters that provide the system with a description of hardware features of that camera. Each file must have .json as its dot extension.

- positioners -- Contains a file for each type of pan/tilt positioning unit that is available for system configurations. The file contains a set of parameters that provide the system with a description of hardware features of that PTU. Each file must have .json as its dot extension.

If the user selects a recording option which results in the system collecting data on an acquired target, any such data will be saved in the folder selected in the Recording Options, Data Path entry. If that folder does not exist the first time OTDAU needs to save a recording, then it will be created. The folder may be on any drive and have any name. For example -- C:\My UFO Data.

During operation, other subfolders will be added to the selected folder. Each subfolder will contain data from each target acquisition and tracking instance. Thus, one or more such subfolders may be created during a data collection period (from Run to Stop).

The format of the folder names created consists of the configuration file name appended with the date and time the file was created. For example, if home-sony was selected as the configuration file then a typical data folder may be:

C:\<My UFO Data\home-sony-06-09-17_08-43-00

TIP: If you want to save a prior release of OTDAU for future use, despite installing a newly released version, rename C:\Program Files (x86)\OTDAU to something like C:\Program Files (x86)\OTDAU-V2.22 to match the old version. Windows may ask for Administrator permission to do this – reply yes. After doing that, you can install the new version which will be in a new C:\Program Files (x86)\OTDAU folder.

To use the old version, just navigate to the renamed folder and double-click the otdau222.exe file. You can also set the old OTDAU v2.22 desktop icon by right clicking it and selecting browse – Browse to the associated version and change the Properties of the icon so that the old version is the "Target" file and the "Start" folder is the old folder name.

When OTDAU loads and if there is no C:\OTDAU\ConfigFiles folder, then it creates one and copies all System and Camera configuration files from C:\Program Files (x86)\OTDAU to C:\OTDAU\configurations and \cameras. If the ConfigFiles folder does exist, then the only files from Program Files that are copied are those **with names that do not exist in C:\OTDAU\configurations and \cameras** – In this way, new versions of OTDAU can add new configurations and cameras for anyone's use. Any subsequent loading and changing of System or Camera config files are made to those in the \OTDAU\configurations and \cameras folders. Thus, the user can make any modifications or additions desired, and they will be retained regardless of running OTDAU or new OTDAU version installations.

Within any data folder that was created as named in the Recording menu, there will be a number of files collected during the run. Their filenames are created as follows:

- Wide-angle video: otdau-wide-<time>.avi. For example, otdau-wide-08-43-00.avi
- Telephoto video: otdau-tele-<time>.avi.
- Still images: An equal number of still frames are collected and named otdau-wide-<time>.jpg and otdau-tele-<time>.jpg.
- Log file: otdau-logfile-<date_time>.txt

All times are in 24-hour format.

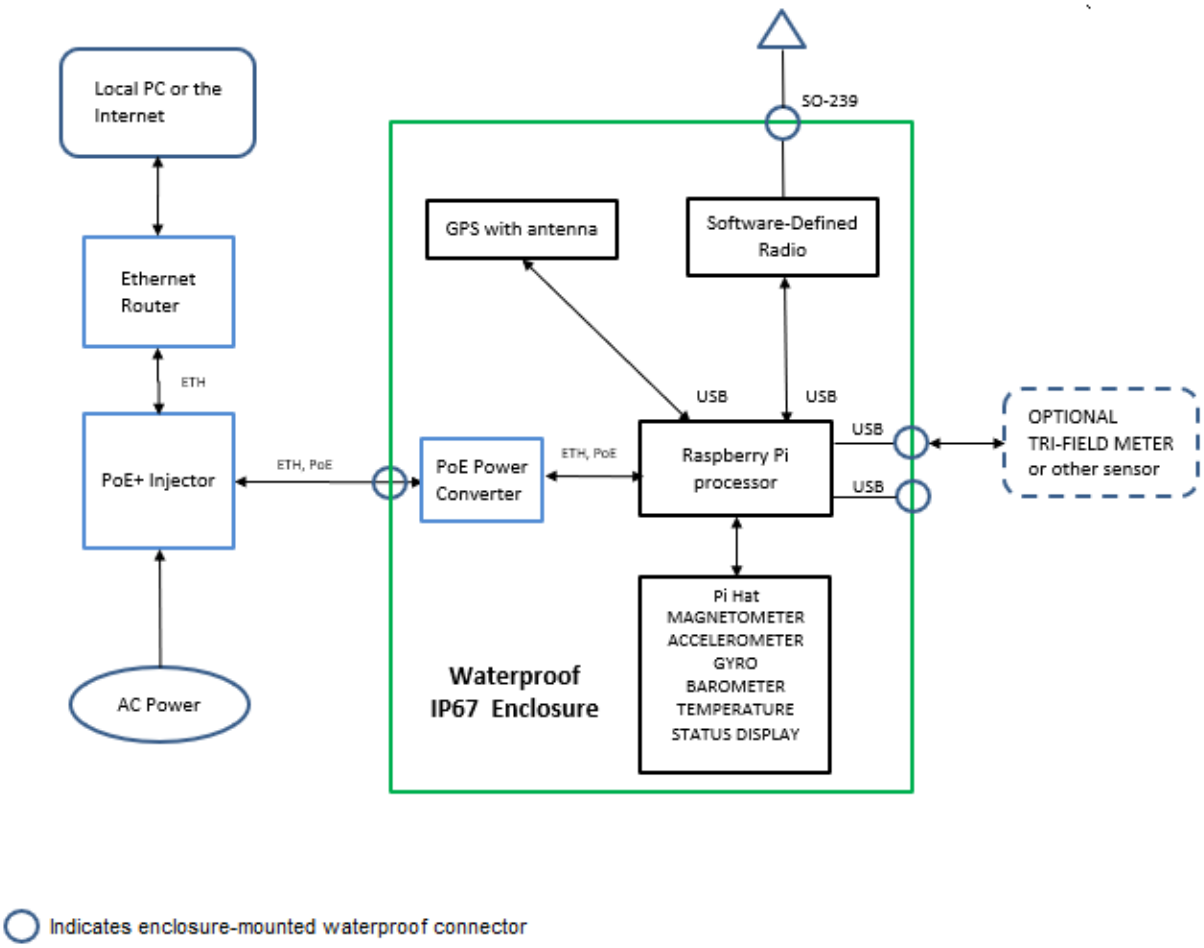
MULTISENSOR DATA ACQUISITION UNIT (MSDAU)

INTRODUCTION

The MultiSensor Data Acquisition Unit (MSDAU) hardware consists of a waterproof enclosure containing a small computer (Raspberry Pi) and a collection of sensors on a second board mounted on top of the Pi. The sensor board and its specifications are described below. Power over Ethernet (PoE) and bi-directional communications are provided via an external waterproof RJ45 connector. Two other waterproof connectors provide for two external USB interfaces. An SMA RF antenna connector provides signal for the internal Software-Defined Radio (SDR) that generates RF spectrum data.

The MSDAU also includes an internal GPS receiver and provides two waterproof USB connectors for external equipment interfaces.

A block diagram of the MSDAU is shown below. Note that power and communication to an OTDAU or MS is accomplished by a single Ethernet cable.



The Pi has four USB ports of which two are available externally; one is used for the internal GPS receiver and one for the SDR.

Cameras and associated MSDAUs do not have to be in proximity. The MSDAU is not the camera processor or controller – the OTDAU software does that job. Camera control via MSDAU may be a subject of future development.

When using two nearby cameras for triangulation, each camera is connected (locally or over the Internet) to a separate instance of the OTDAU software. So, for example, two cameras may be on separate tripod mounts and either or both may share that mount with an MSDAU. The distance between them is only limited by cable length. Practically, close cameras, less than one meter apart, can be used for triangulation but

the farther apart they are, the more accurate the position and altitude measurements. Triangulation is accomplished by MC software on the same computer or a computer at some other location.

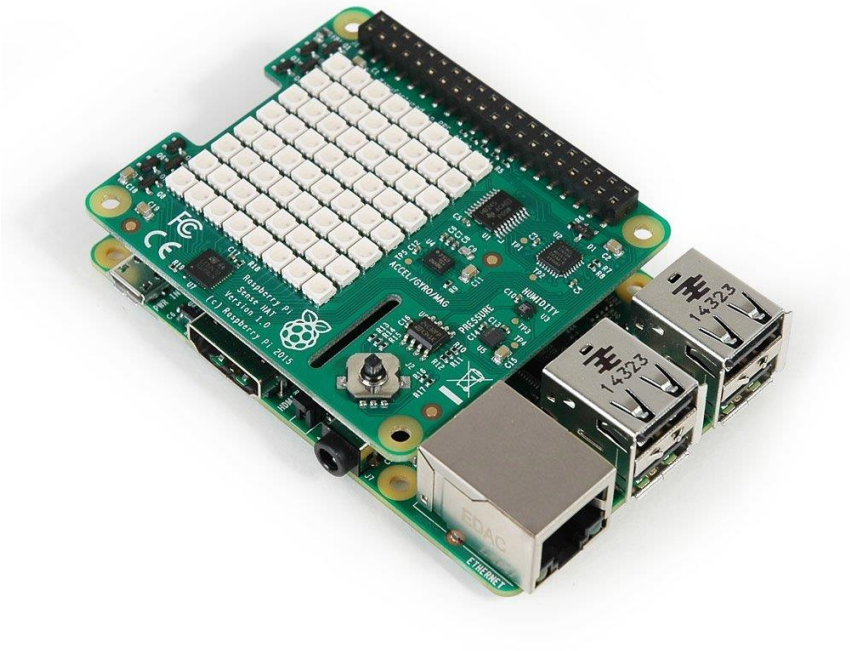
An MSDAU may be mounted to a System mounting bracket that provides a tripod mount and optionally share that mount with a camera. An MSDAU may also be poll or building corner mounted using an adapter bracket with the rear System Mounting plate. See the UFODAS System Installation Guide for details.

DESCRIPTION AND SPECIFICATIONS

The MSDAU is housed in a non-metalic enclosure, sealed when closed to IP66 and NEMA 1, 2, 4 and 4x specifications.

- External size: 8.27in (210mm) long by 6. in (160mm) wide by 3.94in (100mm) deep
- Gore vent for internal/external pressure equalization without condensation
- Waterproof connectors for Ethernet and two for USB
- Pi Sense Hat with 15 sensors, 8x8 multi-color display and joystick
- Internal GPS receiver with SiRF Star IV GPS Chipset
- Internal SDR receiver with frequency range of 25MHz to 1750MHz or 6000MHz
- Clear cover for display and indicator visibility while sealed
- Power: <4W
- Temperature range: 0 to 50 degrees C internal; external could be lower

The MSDAU implements several sensing functions by means of an add-on board for the Raspberry Pi computer, made especially for the Astro Pi mission known as the Sense HAT. This combination, shown below, was packaged for use in the International Space Station in December 2015 – and is now available for general use.



The Sense HAT has an 8×8 RGB LED matrix, a five-button joystick and includes the following sensors:

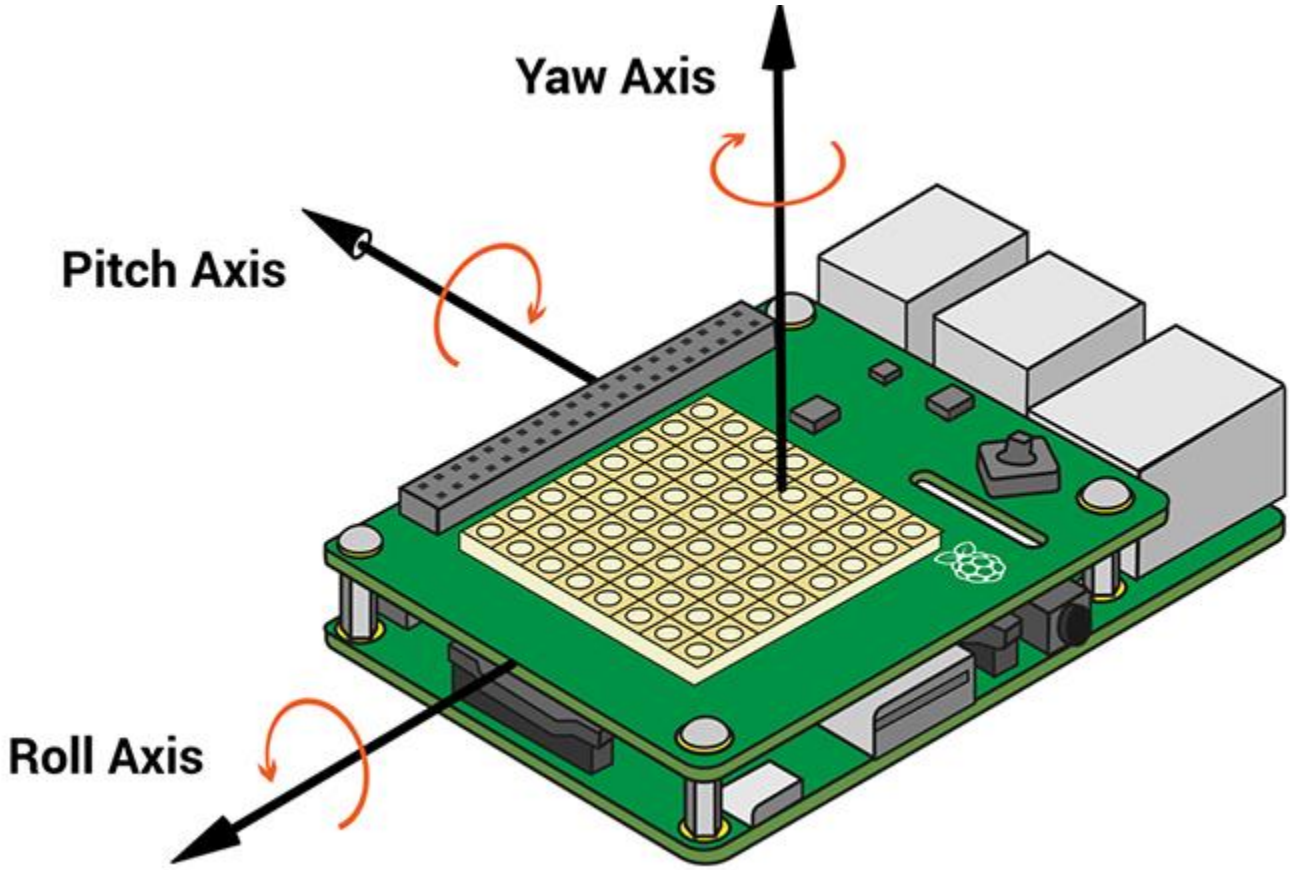
- Gyroscope - angular rate sensor: +/-245/500/2000dps
- Accelerometer - Linear acceleration sensor: +/-2/4/8/16 g
- Magnetometer - Magnetic Sensor: +/- 4/8/12/16 Gauss
- Barometer: 260 - 1260 hPa absolute range (accuracy depends on the temperature and pressure, +/- 0.1 hPa under normal conditions)
- Temperature sensor (Temperature accurate to +/- 2 degrees C in the 0-65 degrees C range)
- Relative Humidity sensor (accurate to +/- 4.5% in the 20-80%rH range, accurate to +/- 0.5 degrees C in 15-40 degrees C range)

The board is compatible with the Raspberry Pi B+, A+, Pi 2, 3 and 4. The MSDAU uses the latest Pi 4 Model B with 2GB of memory. In the ASTRO PI, the Raspberry Pi Sense HAT is being used by the Raspberry Pi Foundation to perform science experiments aboard the International Space Station (ISS). For more information see Appendix A for the first page of each data sheet:

Inertial measurement sensor: ST LSM9DS1
A 3D accelerometer, 3D gyroscope and 3D magnetometer combined in one chip. It will give you the pitch, roll and yaw orientation of the Astro Pi and therefore the ISS itself. It can also be used to detect when the ISS booster rockets are being fired or just as a compass to find the direction of North.

Barometric pressure and temperature sensor: ST LPS25H
Provides measurement of air pressure in Pascals or Millibars as well as the temperature in centigrade.

Relative humidity and temperature sensor: ST HTS221
Measures percentage of relative humidity as well as the temperature in centigrade. The sensor is good enough to detect the water vapor in human breath.



Above picture shows the axes of motion as measured in the Sense HAT.

The MSDAU also includes a GPS receiver and antenna that provides MSDAU/camera location, altitude and time to the associated MC.

Bear in mind that since the Sense HAT board in inside the enclosure, measurements of temperature and humidity reflect its local conditions, not the surrounding atmospheric environment.

DISPLAY AND INDICATORS

The MSDAU includes an 8 x 8 color LED display visible through the clear cover when the enclosure is closed and thus environmentally sealed.

This display provides an indication of the status of MSDAU operations. The display may be:

- Scrolling software version number in green upon bootup
- A temporary static display indicates that the software update and reboot process has begun.
- Flashing concentric green boxes -- The MSDAU is sending data to an MC. If these boxes change to red then the value of at least one sensor has exceeded the user-specified change threshold, causing a trigger condition.
- Various status text messages during use of the joystick for MSDAU setup

The trigger threshold is specified in the MC Sensors > MSDAU menu for each selected MSDAU configuration.

JOYSTICK SETTINGS

The joystick on the Sense HAT board can be used to modify the display brightness as well as the third and fourth octet of the MSDAU IP address (192.168.x.x). The initial value of the IP address is 192.168.1.144.

Press the center of the joystick button –

Scrolls “Bx” and displays “x” where x is the current brightness value

Note that brightness 0 will disable the display during normal operation and

will be initially 2 when the joystick is used again.

Moving the joystick right or left selects which value to change –

Scrolls “.x” and then displays “x” for the third number in the IP address

Scrolls “.abc” and then display “c” for the fourth number in the IP address

Where the IP address is 192.168.x.abc

Moving the joystick up or down increments or decrements the value. The new value is displayed.

Joystick center button will display the final selection and then go back to normal operation. If any part of the IP address was changed, then the MSDAU will restart.

- Gamma correction is utilized to provide a non-linear relationship between the illumination value and the perceived brightness – 1 is very low and 5 is very bright. Setting this value to 0 turns the display off. As the joystick is moved left or right, the selected illumination level is displayed at the corresponding level to provide an idea of how bright the display will be.
- The IP address and illumination level are retained through MSDAU power cycles.
- The red and green LED indicators on the Pi CPU board indicate power ON and solid-state disk access, respectively.

SOFTWARE BOOT PROCESS

There may be periodic updates of MSDAU software to add or change features or correct bugs. An MSDAU is often mounted in a location that would make it difficult to implement these changes if it were necessary for the user to access its enclosure directly. Therefore, part of the Ethernet communication protocols between the MSDAU and Mission Control (MC) software implement a means for remote reloading of MSDAU software and rebooting the MSDAU to run it.

MSDAU software updates are included with each MC release. The user does not need to take any special action to install an update on an MSDAU – this is accomplished automatically the first time a Mission is loaded on MC with an MSDAU included as one of its DAUs. When this happens, the user will note a longer than normal Load time and status messages will indicate this process in progress. If a Mission is closed and another one loaded with the same MSDAU, then that MSDAU will not be reloaded again.

The rebooting process consists of the following processes:

1. When an MSDAU is powered up (its Ethernet cable is plugged into an active injector) it starts running the version of software last downloaded to it. The display indicates the software version running as in step 4, below. It samples its internal sensors even if no MC is running. Normal operation is indicated by green concentric squares on the display.

2. When MC first establishes communications with an MSDAU, it uploads the current MSDAU software version and compares it to that of the version included with the last MC release. If the new version is higher than the existing version, MC downloads the new version to the MSDAU and commands the MSDAU to reboot. After the MSDAU reboots, it automatically runs the MSDAU software.

3. The MSDAU starts running, communicating data to the MC which indicates the MSDAU's ONLINE status.

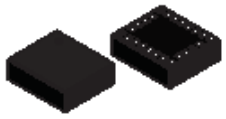
If the MC is closed or communication is otherwise lost, the MSDAU continues to sample data while checking for a new connection. Communication with the MC will be automatically resumed when the MC is restarted, and a Mission is loaded.

APPENDIX A. MSDAU COMPONENT DATA SHEETS

LSM9DS1

iNEMO inertial module: 3D accelerometer, 3D gyroscope, 3D magnetometer

Datasheet - production data



LGA-24L (3.5x3x1.0 mm)

Features

- 3 acceleration channels, 3 angular rate channels, 3 magnetic field channels
- ±2/±4/±8/±16 *g* linear acceleration full scale
- ±4/±8/±12/±16 gauss magnetic full scale
- ±245/±500/±2000 dps angular rate full scale
- 16-bit data output
- SPI / I^2C serial interfaces
- Analog supply voltage 1.9 V to 3.6 V
- "Always-on" eco power mode down to 1.9 mA
- Programmable interrupt generators
- Embedded temperature sensor
- Embedded FIFO
- Position and motion detection functions
- Click/double-click recognition
- Intelligent power saving for handheld devices
- ECOPACK®, RoHS and "Green" compliant

Applications

- Indoor navigation
- Smart user interfaces
- Advanced gesture recognition
- Gaming and virtual reality input devices
- Display/map orientation and browsing

Description

The LSM9DS1 is a system-in-package featuring a 3D digital linear acceleration sensor, a 3D digital angular rate sensor, and a 3D digital magnetic sensor.

The LSM9DS1 has a linear acceleration full scale of ±2*g*/±4*g*/±8/±16 *g*, a magnetic field full scale of ±4/±8/±12/±16 gauss and an angular rate of ±245/±500/±2000 dps.

The LSM9DS1 includes an I^2C serial bus interface supporting standard and fast mode (100 kHz and 400 kHz) and an SPI serial standard interface.

Magnetic, accelerometer and gyroscope sensing can be enabled or set in power-down mode separately for smart power management.

The LSM9DS1 is available in a plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 1. Device summary

Part number	Temperature range [°C]	Package	Packing
LSM9DS1	-40 to +85	LGA-24L	Tray
LSM9DS1TR	-40 to +85	LGA-24L	Tape and reel

HTS221

Capacitive digital sensor for relative humidity and temperature

Datasheet - preliminary data

HLGA-6L
(2 x 2 x 0.9 mm)

Features

- 0 to 100% relative humidity range
- Supply voltage: 1.7 to 3.6 V
- Low power consumption: 2 µA @ 1 Hz ODR
- Selectable ODR from 1 Hz to 12.5 Hz
- High rH sensitivity: 0.004% rH/LSB
- Humidity accuracy: ± 4.5% rH, 20 to +80% rH
- Temperature accuracy: ± 0.5 °C,15 to +40 °C
- Embedded 16-bit ADC
- 16-bit humidity and temperature output data
- SPI and I²C interfaces
- Factory calibrated
- Tiny 2 x 2 x 0.9 mm package
- ECOPACK® compliant

Applications

- Air conditioning, heating and ventilation
- Air humidifier
- Refrigerators
- Wearable devices
- Smart home automation
- Industrial automation

Description

The HTS221 is an ultra compact sensor for relative humidity and temperature. It includes a sensing element and a mixed signal ASIC to provide the measurement information through digital serial interfaces.

The sensing element consists of a polymer dielectric planar capacitor structure capable of detecting relative humidity variations and is manufactured using a dedicated ST process.

The HTS221 is available in a small top-holed cap land grid array (HLGA) package guaranteed to operate over a temperature range from -40 °C to +120 °C.

Table 1. Device summary

Order codes	Temperature range [°C]	Package	Packing
HTS221TR	-40 to +120	HLGA-6L	Tape and reel
HTS221			Tray