UFODAS

Unidentified Flying Object

Data Acquisition System

Systems for the UFO Data Acquisition Project (UFODAP)

ufodap.com

User Guide

Revised 8-12-21 Version 1.16

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.

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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 four 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:

team.ufodap@gmail.com

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

V2.04 x July 2021

1. Includes MSDAU V2.4 software with revised bootload method.
2. Corrected automatic folder creation if folder did not exist.
3. Improved Run/Stop/Load indications.
4. Compensated for OTDAU restart time so that DAU display does not go offline.
5. Corrected MSDAU triggering indicator text.
6. Corrected MC not getting MSDAU RF trigger.
7. Corrected OTDAU/MSDAU triggering conditions and Run/Stop control of recording.

V2.03 28 June 2021

1. Includes MSDAU V2.3 software that support new automatic installation of MSDAU software updates. **If you have an MSDAU already, please contact us to arrange for a remote install of an initial version so that it will properly communicate with the new version of MC.**
2. Introduced a new method for license key authorization that **does not require any internet access** -- After initially installing OTDAU, no internet connectivity is required to validate a license or camera.

V2.02 10 Mar 2021

1. Added capability to acquire, display and store as a CSV file the atmospheric environmental conditions in the vicinity of each DAU. Added a Weather button next to Status to select this option. The data is derived from the extensive, world-wide sensor resources of OpenWeatherMap.
2. Added capability to acquire, display and save as a CSV extensive data on all aircraft within 10 miles of the geolocation of DAU1. A new Aircraft button has been added to display up to six aircraft details as a table. Data is derived primarily from the OpenSky API which has a very large, worldwide network including ADS-B receivers. All aircraft in the map view are displayed, in close to real-time, on the map as a location indicator, call sign and altitude. The indicator changes from a blue dot to a filled red dot when the first active camera is pointing approximately in its direction enhancing filtering known aviation from unknowns. Since the map is optionally recorded as a continuous video, all of this data is also saved.

3. Added capability to automatically install the latest version of MSDAU firmware each time an MSDAU is initially loaded. The latest version is now included as one of the MC files included with each new release. This provides a means to update MSDAUs for new capabilities and bug fixes with each new MC release. If MC has not been closed then that MSDAU will not be updated again.
4. Updated TCP communication process for boot load of MSDAUs.
5. Corrected MSDAU CSV data file format for correct titles.
6. Includes MSDAU V2.2 software for auto download.
7. Various bug fixes.

V2.01 13 Nov 2020

8. Bug fixes in analog and RF plotting.
9. Added saving configuration json file along with any data files.
10. System configuration json file is now written to the recording folder for any recording for verification during data analysis.
11. Implemented new license validation method. Any number of copies may be run as long as the license number entered is valid.

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

OTDAU SOFTWARE CHANGE LOG

V2.08 7 August 2021

1. Improved scaling of displayed text to window.
2. Greatly reduced CPU loading by code optimizations.
3. Corrected logic for Min events – Now works correctly such that, after an initial detection, there must be Min events additional tracking detections to continue to track the target. Note that as a result, Min events default has been reduced to 10.
4. Corrected initial move due to target detection to properly accommodate the Setup "Set Pan and Tilt offsets" option. The initial move will now properly place the target at the CFOV regardless of this option setting.
5. Digital zoom of target displayed using the Telephoto Aux display selection is retained until either a new Run is started or the System configuration is closed.
6. Wide-Angle display now includes the file name of a displayed test file on line 2.
7. Various bug fixes and error detection and notifications added.

V2.07 26 June 2021

1. Modified and corrected new license validation process to allow entry of all four parts of a camera IP address to support different router addresses and remote, port-forwarded cameras.
2. Corrected validation to properly allow/disallow IP camera use when USB is selected.
3. Revised video streaming to properly handle any sequence of camera type opening and closing.
4. Corrected automatic camera re-open for any read faults including changes to encoding mode.
5. Allowed both .avi and .mp4 video file selections for test and analysis files.
6. For each camera configuration, the recording CODEC may be set to either MJPG to write uncompressed .avi files or to MP4V to write compressed .mp4 files.
7. New Bounding Circle option to support panoramic (all-sky) cameras. Click Bounding Circle, and then hold down the left mouse button to adjust the circular bounding area centered on the CFOV and release to save it. Bound converts to a rectangular crop box after target detection during tracking. Works with any camera.

V2.06 14 June 2021

1. Enhanced Analytics operation: Added You Only Look Once (YOLO) deep learning option. Added thumbnail digitally-zoomed image of identified object in upper-right corner. Note that YOLO is often slower than the SSD option.
2. Introduced a new method for license key authorization that **does not require any internet access** -- After initially installing OTDAU, no internet connectivity is required to validate a license or camera.
3. Added some error notifications and corrected bugs.
4. Improved stabilization of digitally-zoomed image tracked during non-PTZ operation (Telephoto selection).
5. Corrected data folder and file selection operation.
6. Corrected Analytics default folder selection and relocated configuration file to C:\.
7. Improved initial absolute move to detected target by improved calibration and use of float values for camera horizontal and vertical field of view. Enter actual maximum values from the camera data sheet – for example, for 50230UNI-A use 67.8 for Horizontal FOV. The Vertical FOV (38.1) is automatically computed as (HFOV / HRes) * VRes. That is, for HRes x VRes of 1920 x 1080, 38.1 = (67.8 / 1920) * 1080. The Vertical FOV field in Camera Configuration is now gray to indicate that it is automatically filled in when the form is saved. Enter a value to manually set VFOV or 0 to have it automatically computed. When tracking, the FOV is adjusted for the current zoom level.
8. **Major improvement to initial move to detected object position** and start of continuous tracking. 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 now 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. The number of detections used for this calculation is the "Min events" parameter in the Tracking menu.
9. **New initial target detection method that provides continuous background sampling and suppression. Does not need to rely on any of the parameters used for subsequent continuous tracking.**
10. Improved termination of tracking when background clutter is encountered in the path of the tracked object.
11. Validation now provides for using OTDAU with USB cameras or test files only when a UFODAP IP camera is not part of the system or unavailable. To enable this feature, enter 'USB' for the Camera IP in Validation.
12. Corrected Auxiliary file recording.

13. Corrected Analysis after each target acquisition function.
14. Improved response to clicking on Run before system fully stopped. System will automatically resume scanning when ready instead of displaying an error.
15. PID values are now internally calculated and do not need to be entered by the user. The OTDAU PID tracking loop now implements proportional gain scheduling for the proportional constant.
16. The Auxiliary Video Display, Telephoto selection was the same as the annotated Wide-Angle display. It is now 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 an event. Suggest using this along with higher values of the Min events Tracking parameter (typically 45 or more) to reduce false triggers. Recording selection of Raw will still record entire raw video frames and the Telephoto selection records the digitally zoomed image.

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

MSDAU HARDWARE AND SOFTWARE CHANGE LOG

V2.2 10 Mar 2021

1. Added display indication for Rebooting and Loading.
2. Added support for boot loading by MC command.
3. Various bug fixes.

V2.1 15 Aug 2020

4. Corrected time value sent to MC.

V2.0 1 Sep 2020

1. Added joystick functions for IP address selection and display brightness control

V1.1 15 Aug 2019

1. Added joystick functions for IP address selection and display brightness control.
2. Increased sampling rate.
3. Fixed bugs related to data averaging and triggering.

V1.0

Initial production release

SYSTEM REQUIREMENTS

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

- Windows 10 OS on a PC Computer with Core i3 processor, 4GB memory and 150MB free disk memory. A faster computer, e.g., i5, i7, i9 or with higher speed ratings may provide higher analysis frame rates and thus better tracking of faster targets.

- 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 are:

Dahua   DH-SD59A230TN-HNI, 50230UNI-A, 50232XANR, 49425TNI, NK8BR4, N51BD22, N53AB52, 49425TNI

Sony   SNC-RX570N, RZ25N

Amcrest   IP2M-841

Trendnet   TV-IP450P (V1.1R)

Samsung   SNP-3750

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.

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 of the 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 fairly 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 is capable of acquiring 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 actually provide the initial trigger for subsequent data collection.

The software also provides a number of 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.
- Upload collected data to a Google Drive account.
- Saves automatically named photos and videos to folders it creates in local memory.
- A sophisticated Graphical User Interface (GUI) for user-friendly operation.

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.
- Real-time track correlation with data from flightrader24.com or directly from an ADS-B radio in the MSDAU to distinguish unknowns from aircraft.
- 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 of this 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.
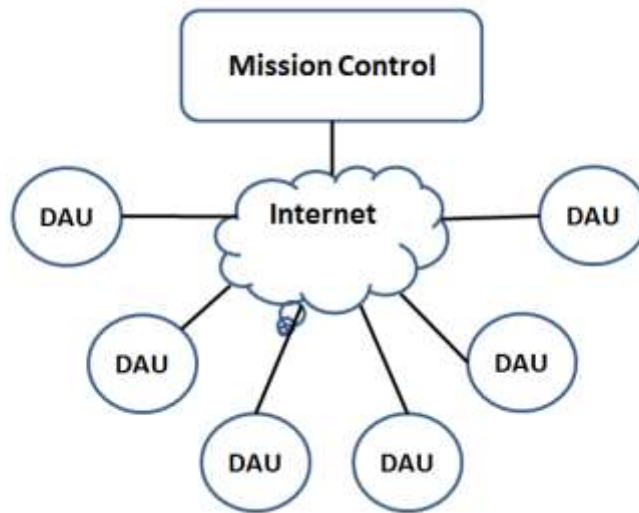
OTDAU and MC software may be run on a computer local to cameras and MSDAUs, connecting to them directly or via a router. In this case, the computer, camera(s) and MSDAU(s) each connect to the same router. All of these devices would be on the same Local Area Network (LAN).

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 also separately. 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, an UFODAS system can take a number of 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 so as 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 (FOV) 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 center FOV 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 uploaded to a Dropbox account. Another option sends 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 into its configuration. Alternately, an MSDAU can provide GPS location and accurate time. All of 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 of this functionality is setup 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 particular user 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 of 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 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
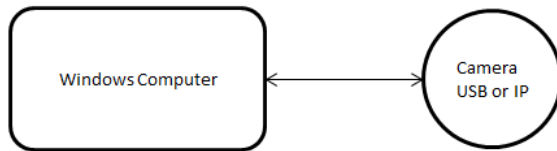Triangulation feasible if cameras widely spaced
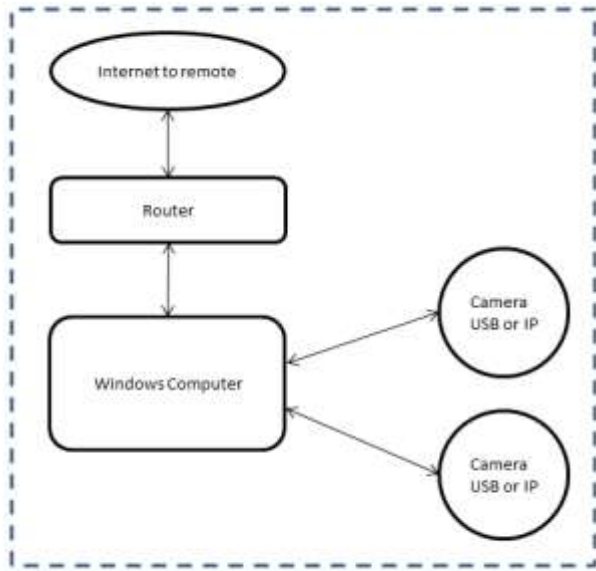
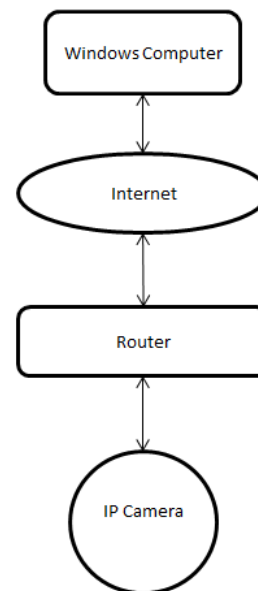**Wide-Area system suitable for triangulation and data analysis**
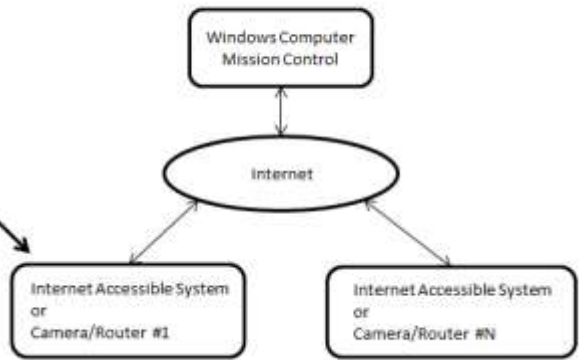
NOTE: "Camera USB or IP" may also include a Multi-Sensor Unit combined on a single Ethernet cable.
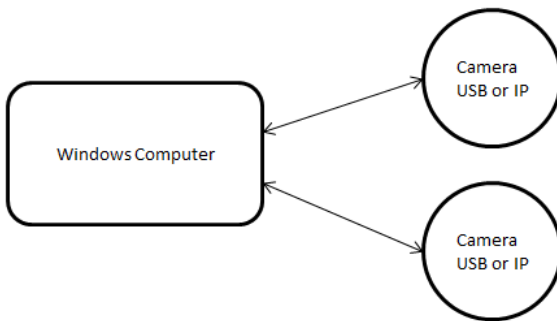
Standalone data collection

Direct connect to internet, remote computation

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

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. In particular, 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 of 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 INSTALLATION AND UNINSTALLATION

UFODAS software is distributed as a typical Windows setup.exe file. The name of this file is setup-mc-x.xx.exe where x.xx is the version number.

The file is provided by means of an invitation via email from SendOwl with includes your software license number. Download the file to any convenient location on your computer, such as:

C:\Users\<your user name>\Downloads

That is the typical default location for downloads and does not have to be explicitly selected.

NOTE: If you have created or modified any Mission or Sensor configurations while using a prior version and want to retain them for the new version, copy the folders

> C:\Program Files (x86)\Mission Control\missions
>
> C:\Program Files (x86)\Mission Control\MSDAUconfigs
>
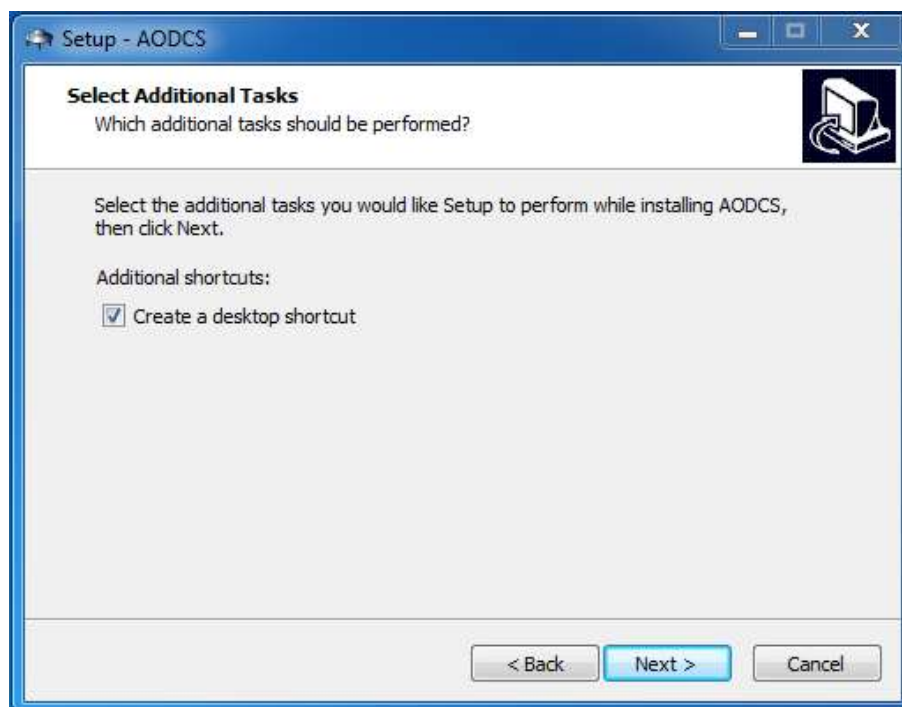> C:\Program Files (x86)\Mission Control\OTDAUconfigs

to another folder such as your Desktop before uninstalling the old version. Copy them back after installing the new version.

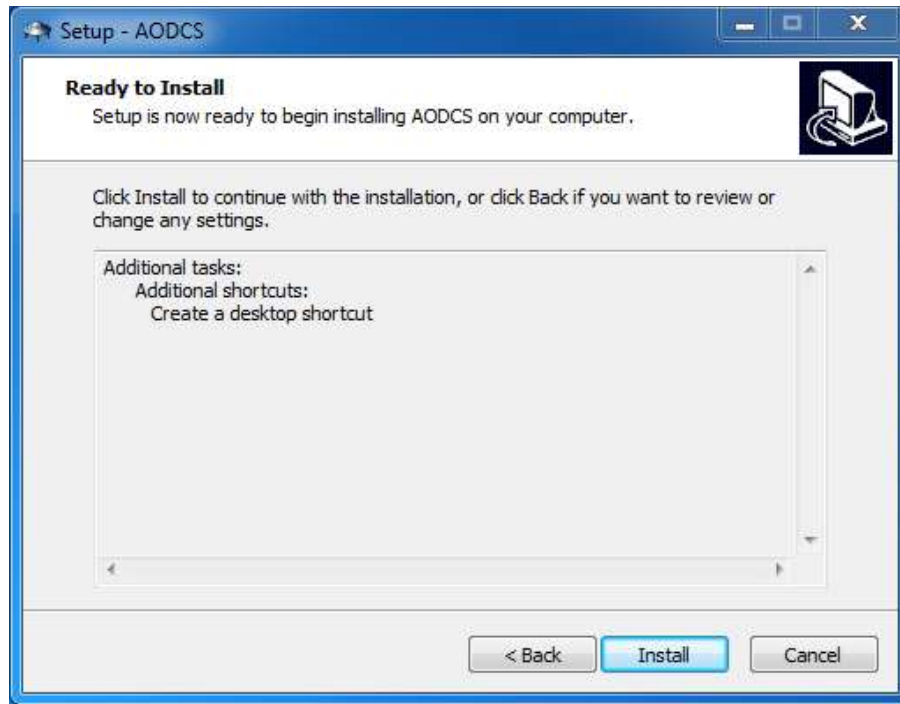Double click the setup-mc-x.xx.exe to initiate installation.

Accept the License Agreement
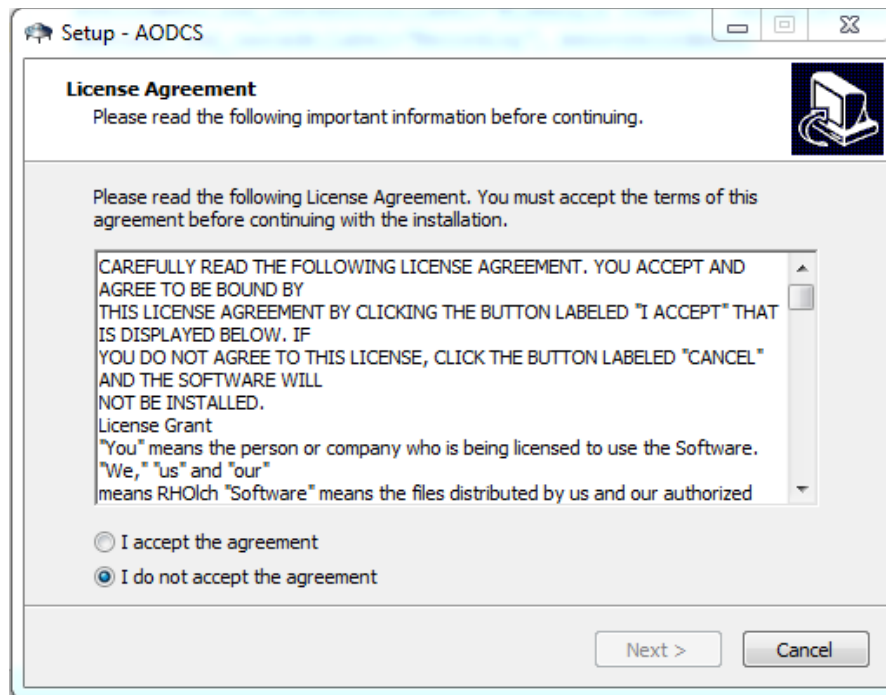
Select Create a desktop shortcut:

Install the software:

To uninstall the software, open Control Panel > Programs and Features.

Right click on MC version x.xx (the currently installed version number) and then click uninstall.

All parts of the software and the desktop icon will then be removed from your computer. If any items remain, the following folder may be manually deleted without harm.

C:\Program Files (x86)\Mission Control

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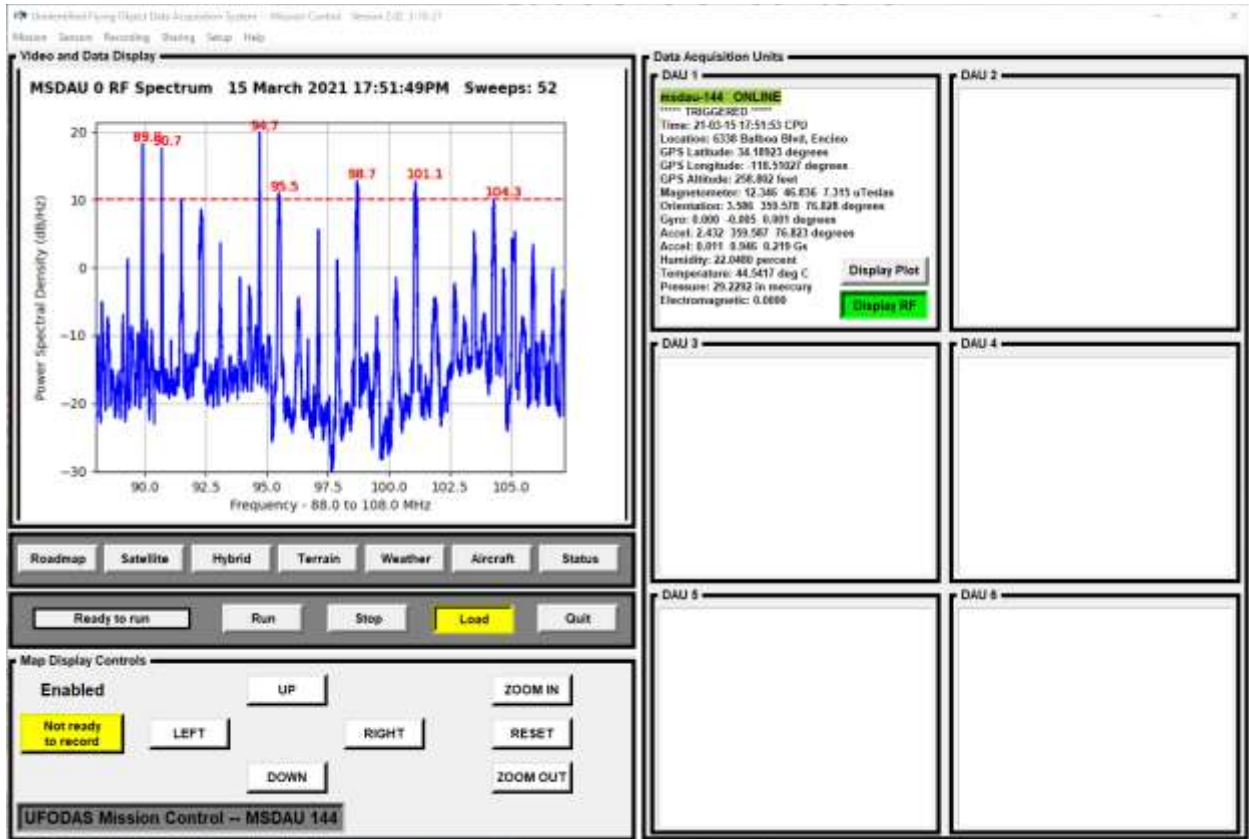
The minimum and maximum frequencies to be swept and the peak detection level are selected in the MSDAU Configuration, as shown below.

Display with trigger level of 10 dB and anomalous peaks for fmin and fmax that encompasses the entire FM broadcast band:
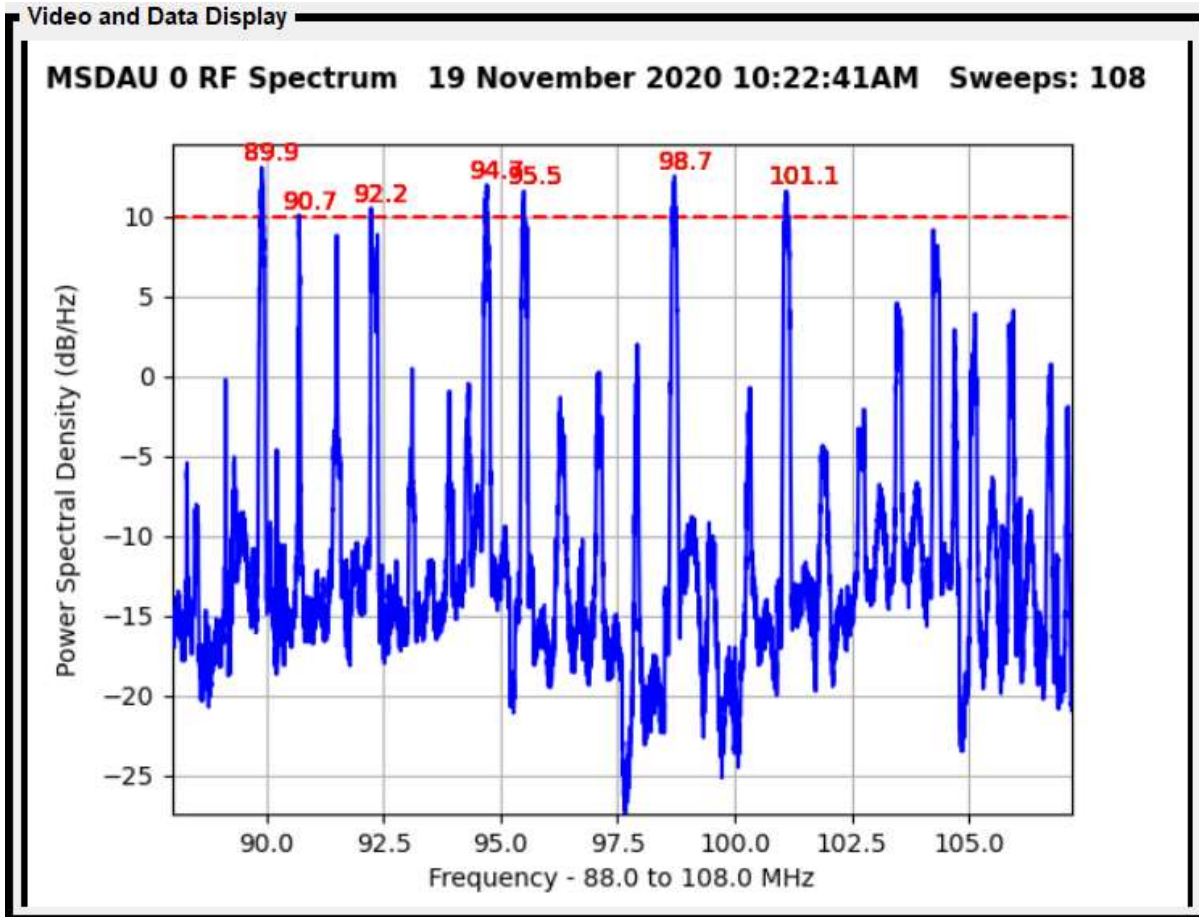
The peak detection level is a value in dB which is displayed as a dashed red line. Initially, the system makes a number of measurements of the specified RF band and retains that as a background level. Subsequently, if any energy is detected that exceeds that level then those peak values are highlighted with their specific values displayed in red, as shown above.

A trigger condition results from any frequency values exceed 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.

Operating the Mission Control application requires the user to setup 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
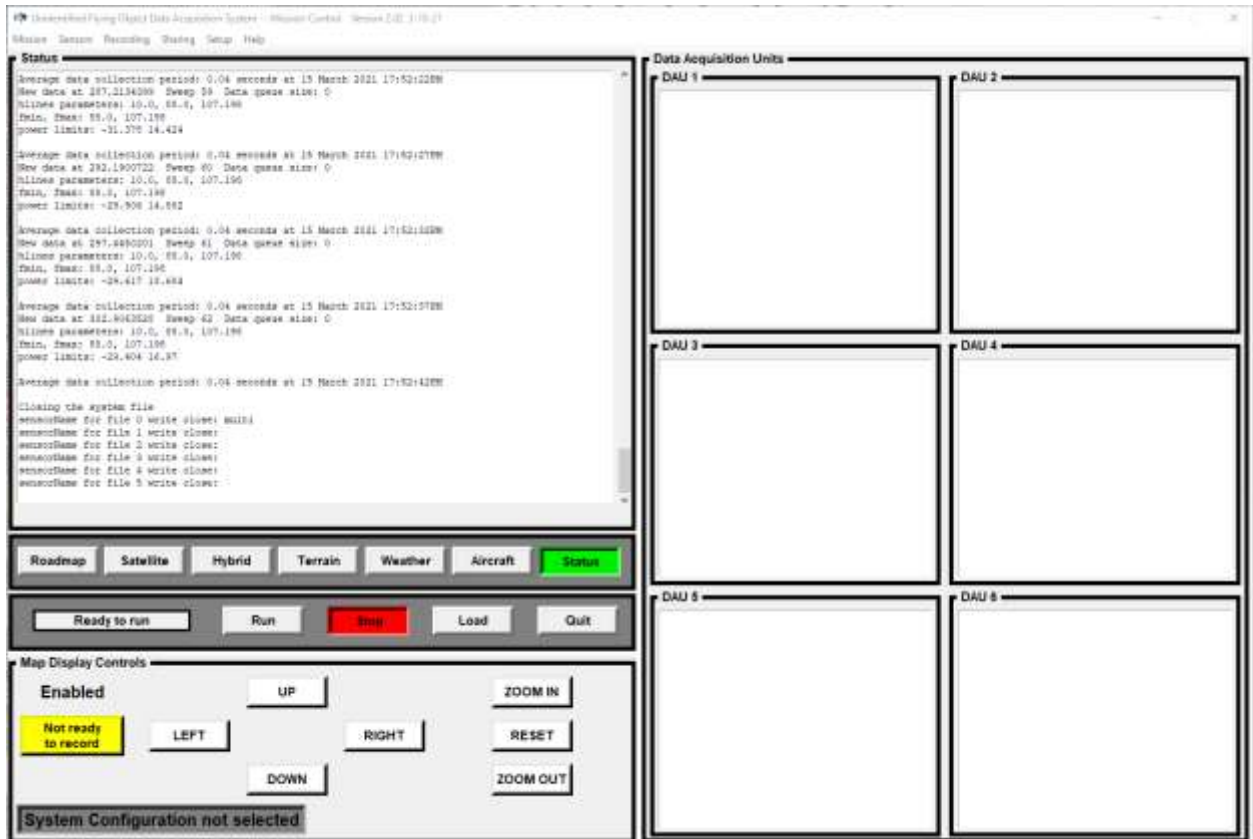
Mission Control application GUI prior to mission configuration selection.

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 two PTZ cameras and corresponding Sensor Units.

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

The geolocation of Sensor 1, an MSDAU, is exactly the same as camera 0 so its pin is obscured by that of Sensor 0.

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 three satellites.

Otherwise, the location will be that entered as the Location in the MSDAU configuration.

TARGET Lat: 34.218064   Lng: −118.524437   Alt: 3099.668 feet AGL
Ground Speed VX: −617.30   VY: −532.80   VZ: −150.92 mi/hr
Size W: 256.03 H: 212.05 feet   Distance LOS C1: 11119.17   C2: 13134.24 feet

Monday 17 February 2020 08:21:41AM
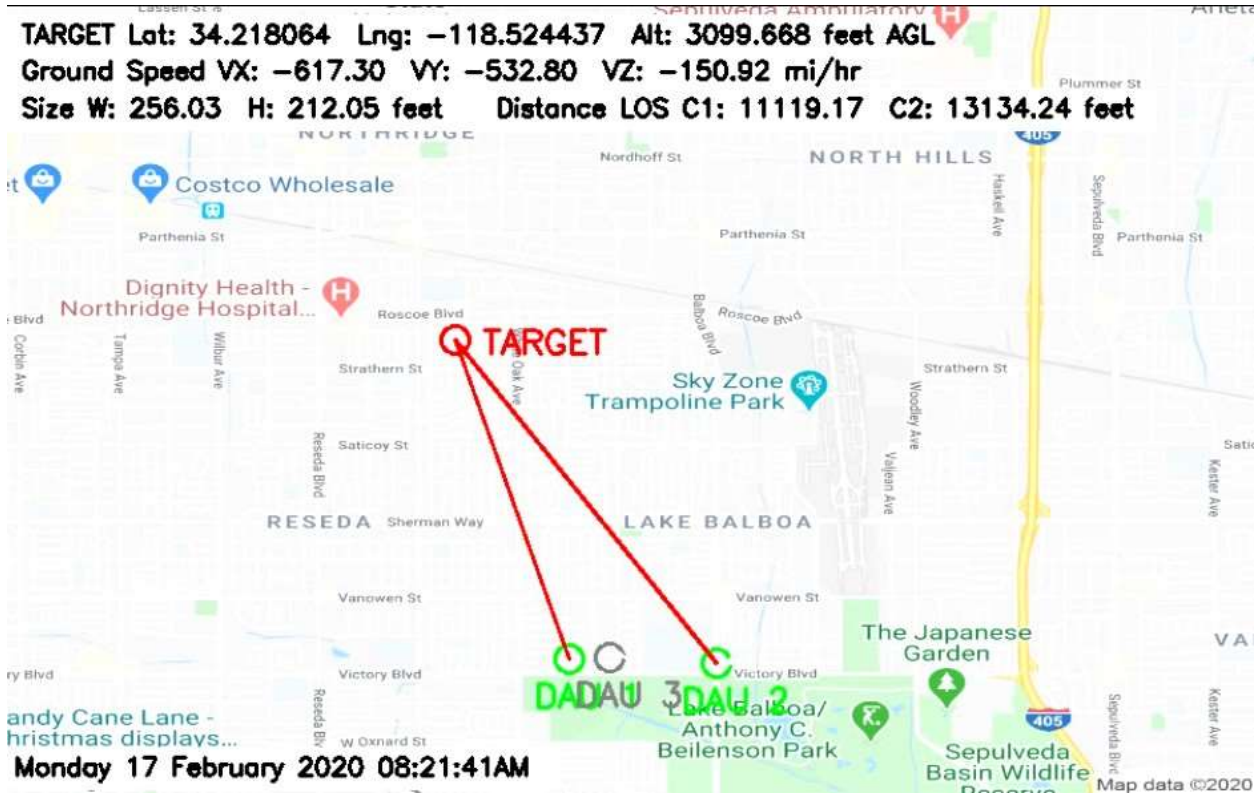
MC with Google roadmap after a target has been acquired by both cameras and triangulated. The target latitude, longitude and altitude are now displayed.

Real-time recording of the map, both camera video streams and all of 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 upload all collected data to Google Drive or Dropbox.

SYSTEM STATUS CONTROLS

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

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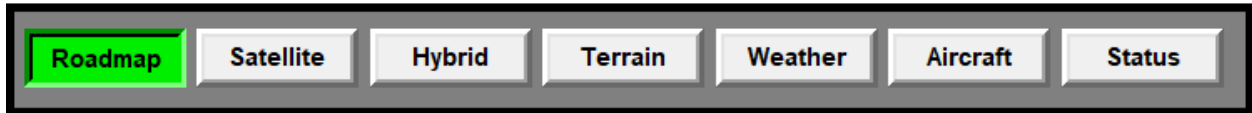
The Roadmap, Satellite, Hybrid and Terrain buttons govern what kind of map display is shown.

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 thru 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.

```
┌─ Status ──────────────────────────────────────────────────────────────────────┐
│                                                                            ┌─┐  │
│  ------------------------------------------------------------------------- │▲│  │
│  ADS-B Flight Data -- 14 Aircraft       UFODAP Mission Control       15 March 2021  18:17:09PM │
│  -------------------------------------------------------------------------     │
│  Data Item           Flight 1     Flight 2     Flight 3     Flight 4     Flight 5     Flight 6 │
│  -------------------  -----------  -----------  -----------  -----------  -----------  ----------- │
│  ICAO transpdr adds  ada595       a831b2       a28f80       aba324       a63bf4       a4ae48 │
│  Callsign            FDX1387      QXE2466      SKW3748      ASA233       SWA854       SKW3309 │
│  Origin Country      United State United State United State United State United State United State │
│  Last Position Time  18:17:09     18:17:09     18:17:09     18:13:25     18:12:22     18:16:39 │
│  Last Contact Time   18:17:09     18:17:09     18:17:09     18:13:34     18:12:22     18:16:40 │
│  Longitude           -118.48      -118.25      -118.37      -118.37      -118.40      -118.42 │
│  Latitude            33.92        34.04        33.96        33.94        33.95        33.95 │
│  Barometric Alt - m  1112.52      1333.50      228.60       99.06        76.20        45.72 │
│  Surface Report      False        False        False        False        False        False │
│  Velocity - m/s      130.81       120.73       57.38        57.49        64.26        38.41 │
│  True Track - deg    230.43       83.15        264.34       263.32       263.10       262.30 │
│  Vertical Rate - m/s 18.53        -5.85        -2.93        -3.25        -3.90        -0.33 │
│  Sensor IDs          N/R          N/R          N/R          N/R          N/R          N/R │
│  Geometric Alt - m   1051.56      1280.16      190.50       60.96        38.10        7.62 │
│  Squawk Code         4777         1737         3601         2103         7354         3130 │
│  Special Purpose Ind False        False        False        False        False        False │
│  Position Source     ADS-B        ADS-B        ADS-B        ADS-B        ADS-B        ADS-B │
│                                                                                 │
│  N/R -- Not Reported    Typical data latency is ~10s to 2min    6 of 14 flights shown │
│  Reporting area is a rectangle, 10 mi/side, centered on the location of 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.
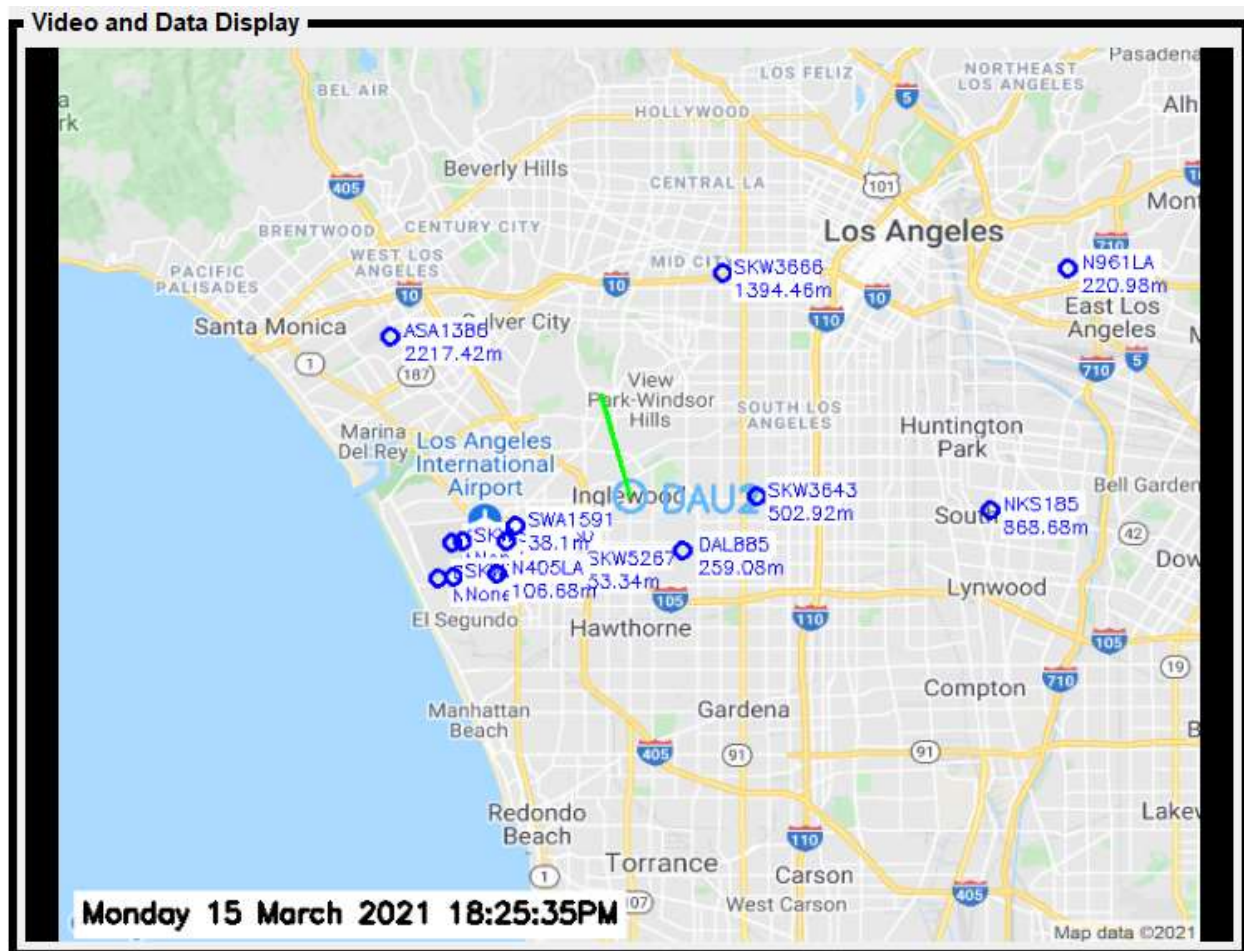
The call sign and geometric altitude are also geolocated and displayed on the map. Each such indicator moves whenever the data is updated, typically every 10 seconds.

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.

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.

```
Map Display Controls
  Enabled                    UP                    ZOOM IN

  Not ready        LEFT              RIGHT          RESET
  to record

                            DOWN                   ZOOM OUT

  UFODAS Mission Control -- MSDAU 144
```
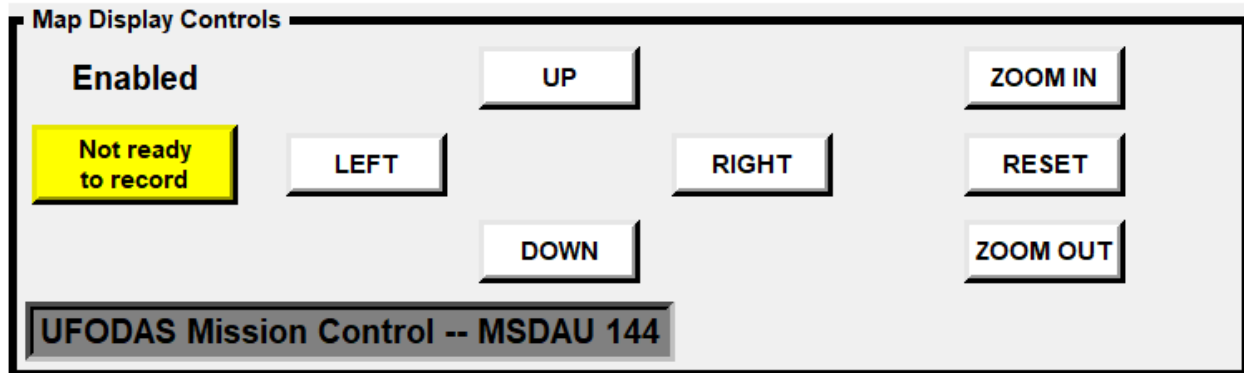
When Map Controls are enabled, the user may move the portion of the displayed map up, down, left or right by clicking on the corresponding buttons. Holding down the left mouse button while over a direction allows continuous movement in that direction.

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. 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). Stop the Mission and make adjustments as necessary.

All of the MC parameters and menus are described below.

MISSION CONFIGURATION

An MC is configured for operation for a particular application by setting a number of 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 of 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.
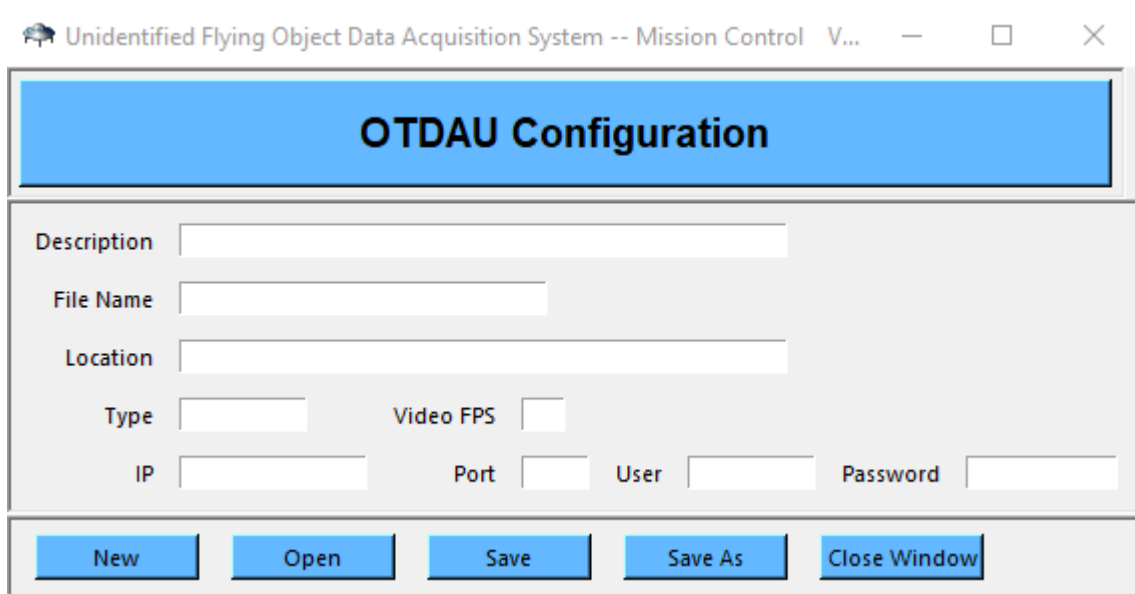
DAU – Up to six DAUs of any type may be specified. During Run time, each DAU will be monitored and its data displayed in the right panel.

Recording Trigger – Enables the system to start recording if the associated DAU sends MC a trigger signal.

Associated Sensor – Tells MC to use the location of the Associated Sensor 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.

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 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 of the computer running OTDAU as x.x.x.x, e.g., 192.168.1.37:51000. 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.

User – A user name for the PC (not currently used).

Password – A password for the PC (not currently used).

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.

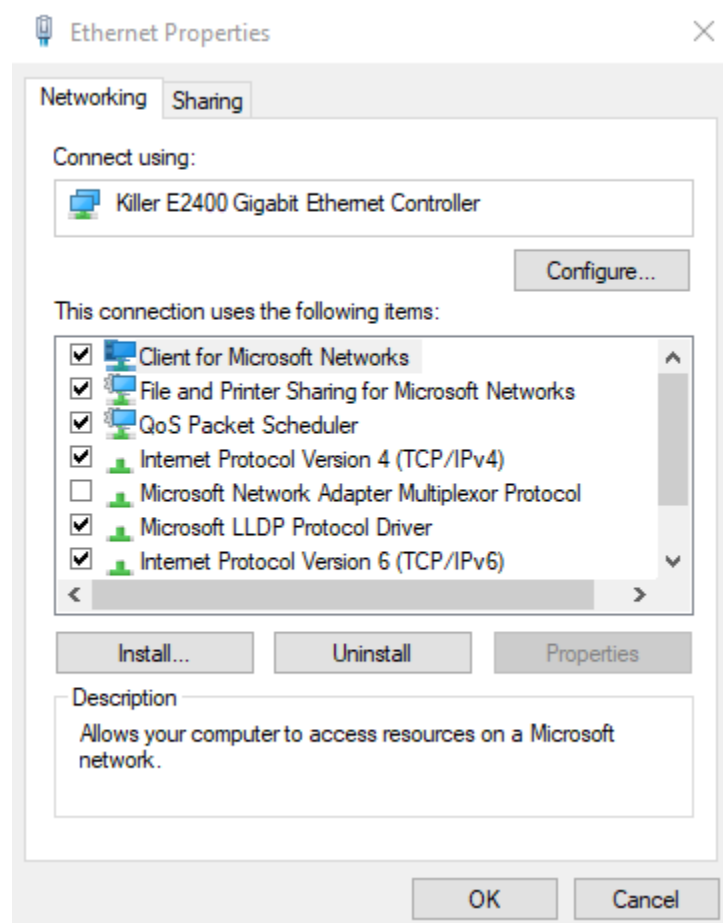**Close Window** – Closes the configuration widow.

To setup a computer with a static (non-DHCP) address:

Click Windows icon > Settings (gear wheel) > Network and Internet > Change adapter options

Double click on Ethernet or Wi-Fi depending on how the computer running OTDAU is communicating with your router. For example:
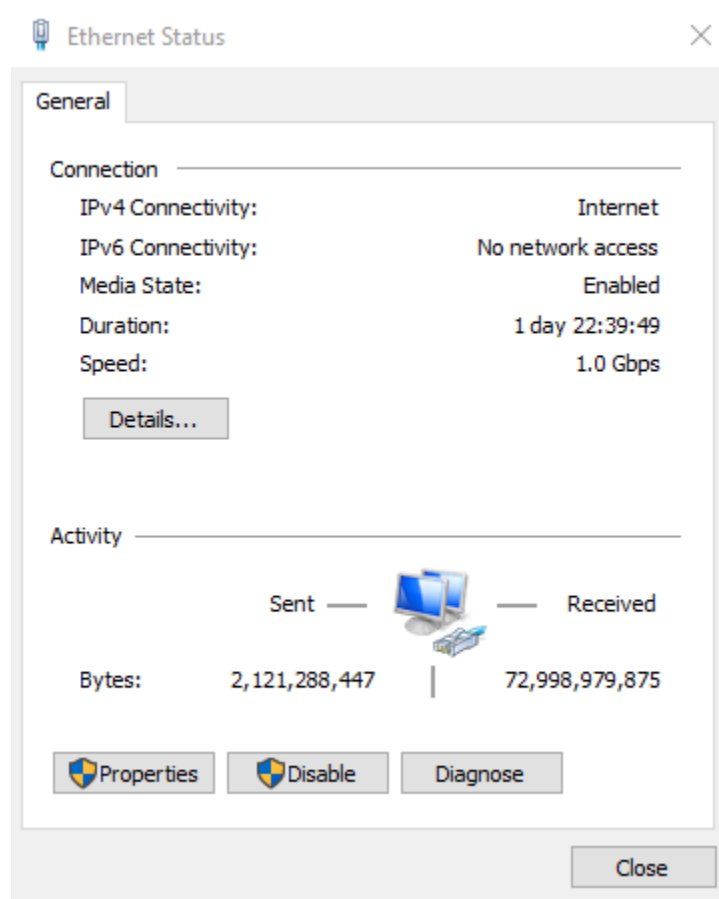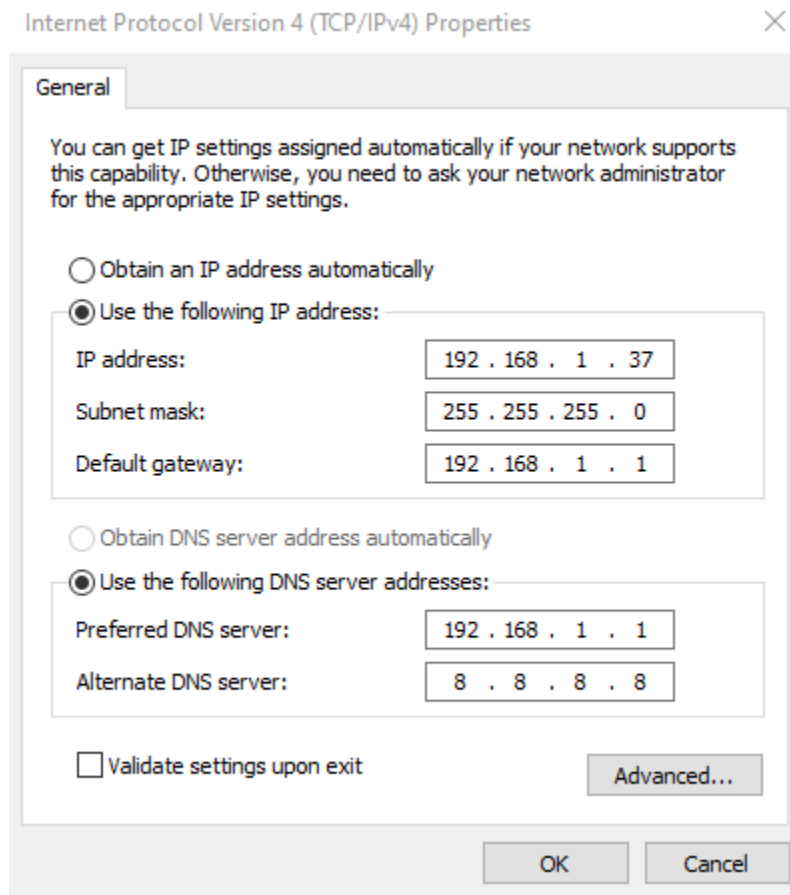
Click Properties:

Click on Internet Protocol Version 4 (TCP /IPv4) to highlight it and then click Properties

Change the values shown to the selections below (the IP address 37 is shown as an example but could be any value that does not conflict with a camera or DHCP-assigned address)

Internet Protocol Version 4 (TCP/IPv4) Properties   ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: 192 . 168 . 1 . 37

Subnet mask: 255 . 255 . 255 . 0

Default gateway: 192 . 168 . 1 . 1

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: 192 . 168 . 1 . 1

Alternate DNS server: 8 . 8 . 8 . 8

☐ Validate settings upon exit   Advanced...

                                         OK   Cancel

Click OK and Close to save this selection. Now you can use 37 as the entry for IP in your MC OTDAU 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.

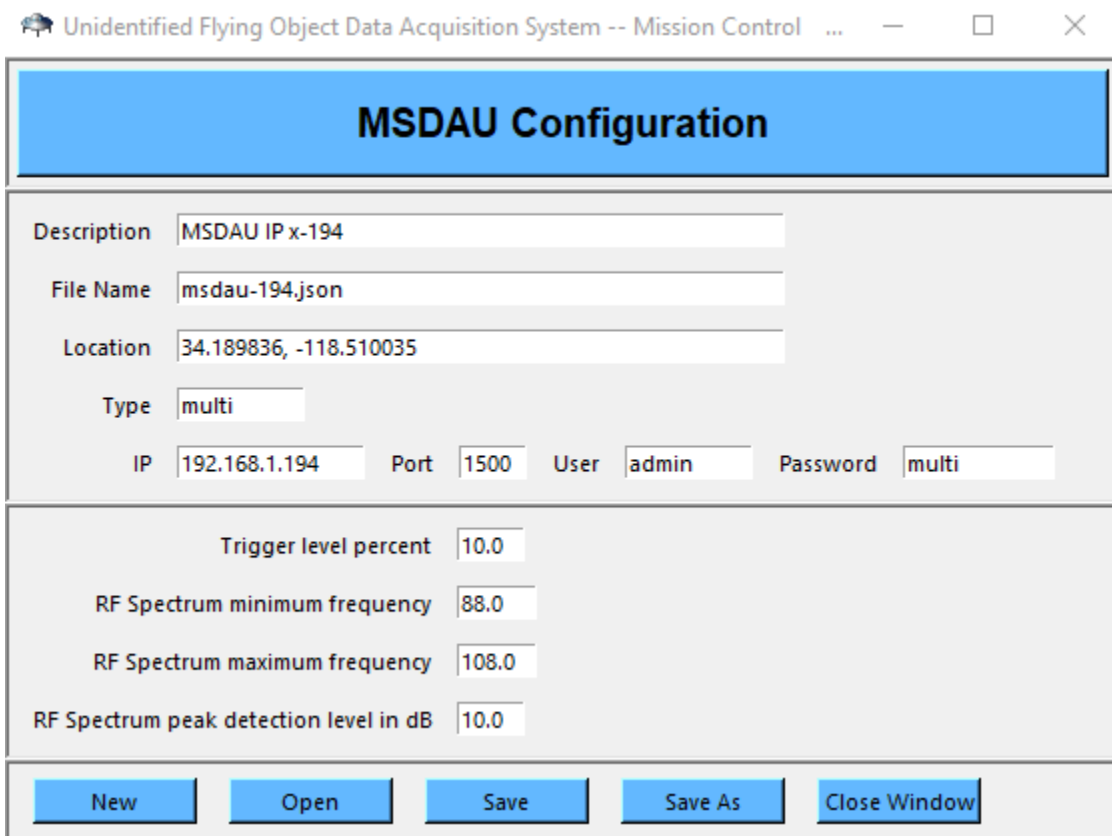**RF Spectrum minimum frequency** – Starting frequency for RF spectrum sweeps.

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

Enable recording – Enables recording of the following selections if checked.

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.

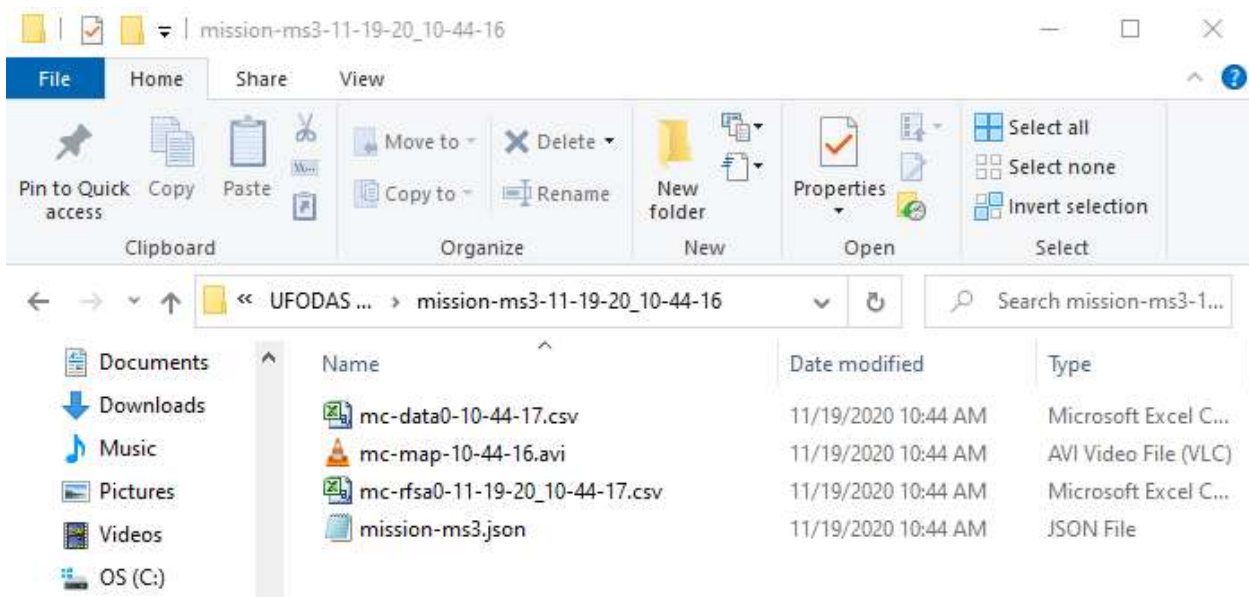**Video 2** – Record video from the second active camera.

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.

For example, with Recording Options set as shown below:
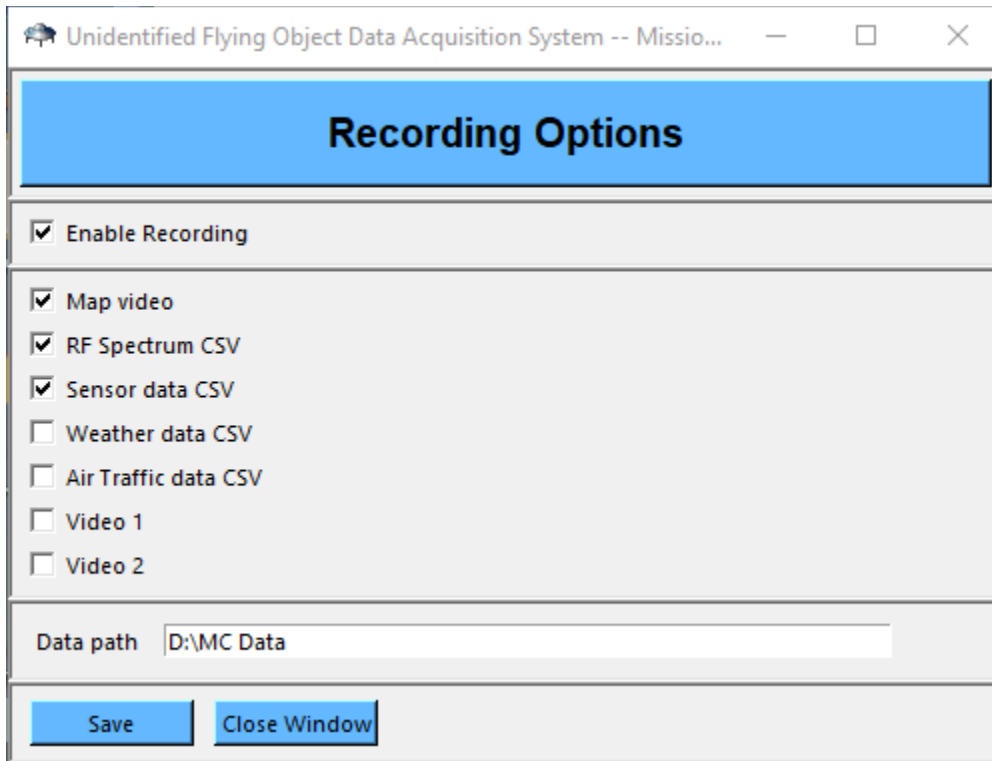
After an MSDAU trigger condition occurred, the following files will be written:
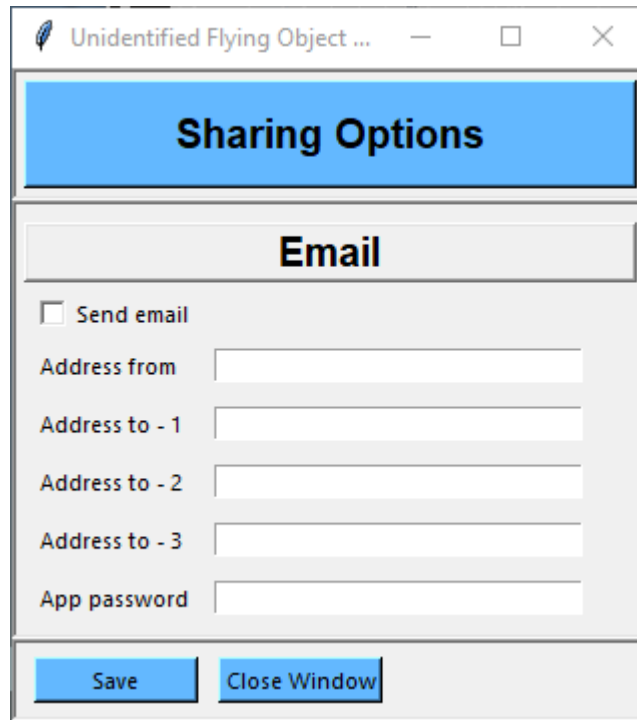
The MSDAU data CSV file contents looks like:

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

The RF spectrum table (partial) reads:

	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

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. 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.

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.

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

Help –
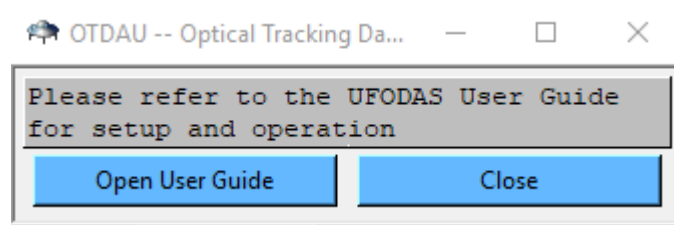
Clicking on "Open User Guide" will open this document as a pdf in a browser window. You can then leave it open for reference.

About –

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

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 Enter.

OPTICAL TRACKING DATA ACQUISITION UNIT (OTDAU)
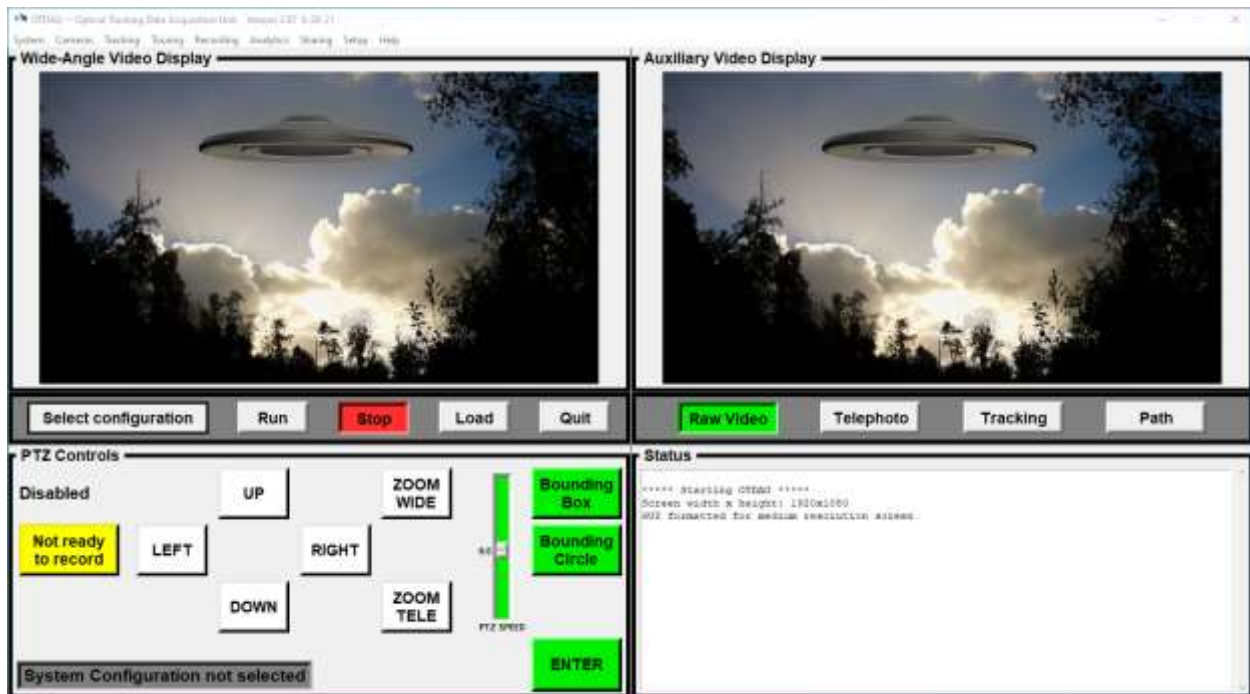
INTRODUCTION

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 setup 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 fairly 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 is capable of acquiring 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 INSTALLATION AND UNINSTALLATION

UFODAS software is distributed as a typical Windows setup.exe file. The name of this file is setup-otdau-x.xx.exe where x.xx is the version number.

The file is provided by means of an invitation via email from SendOwl with includes your software license number. Download the file to any convenient location on your computer, such as:

C:\Users\<your user name>\Downloads

That is the typical default location for downloads and does not have to be explicitly selected.

NOTE: If you have created or modified any System or Camera configurations while using a prior version and want to retain them for the new version, copy the folders

C:\Program Files (x86)\OTDAU\configurations

C:\Program Files (x86)\OTDAU\cameras

to another folder such as your Desktop before uninstalling the old version. Copy them back after installing the new version.

Double click the setup-otdau-x.xx.exe to initiate installation.

Accept the License Agreement:
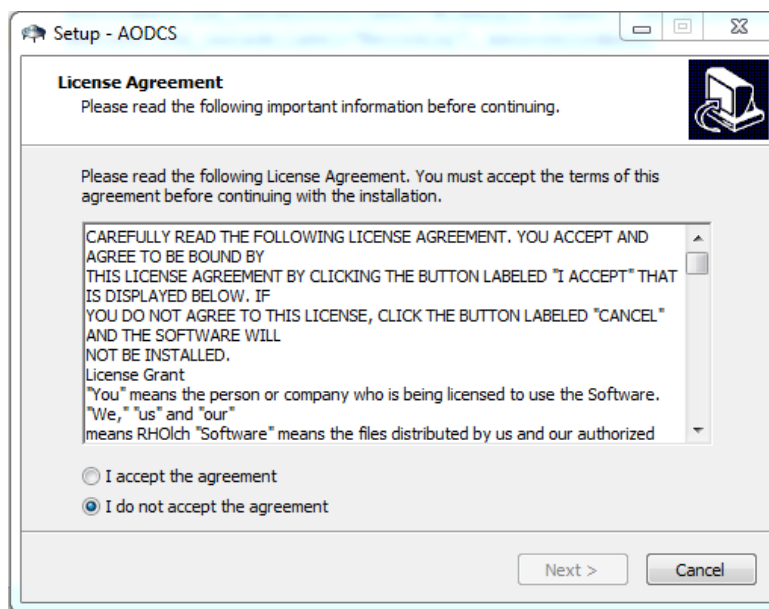
Select Create a desktop shortcut:
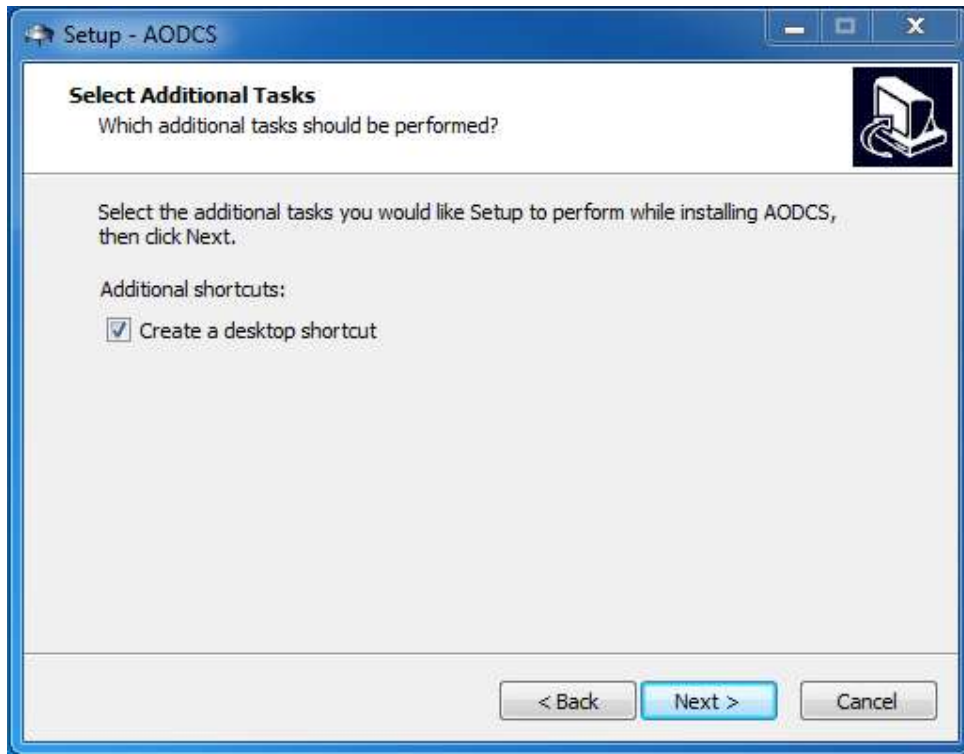
Install the software:
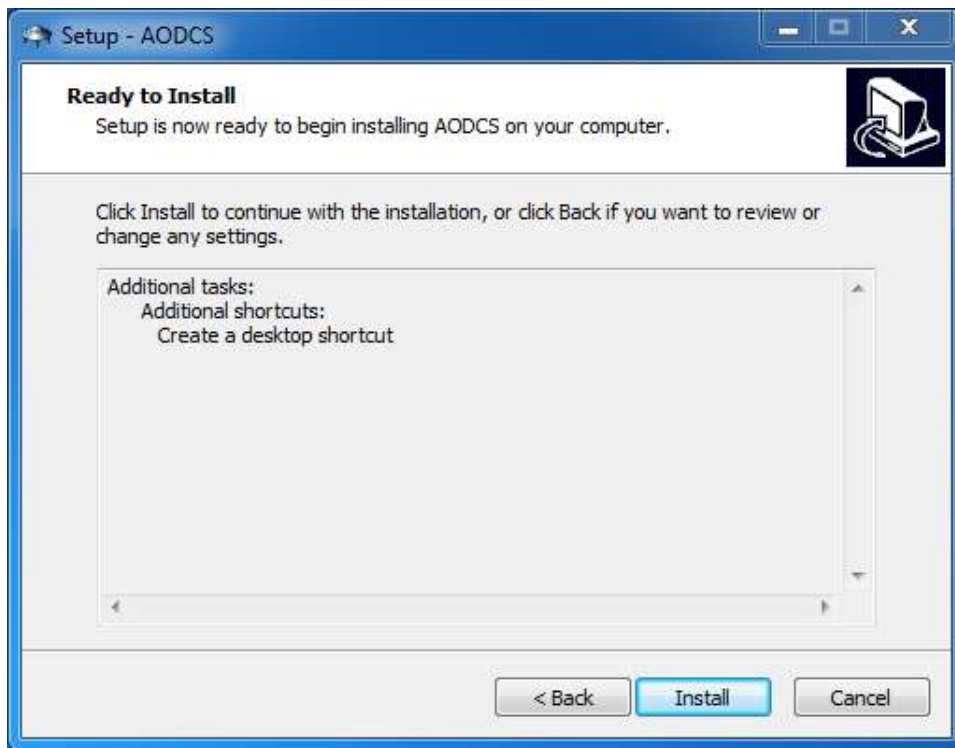
The OTDAU software and supporting files will then be saved to the file:

C:\Programs(x86)\OTDAU

To uninstall the software, open Windows Control Panel > Programs and Features.

Right click on OTDAU version x.xx (the currently installed version number) and then click uninstall.

All parts of the software and the desktop icon will then be removed from your computer. If any items remain, they may be manually deleted without harm.

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. Run the configuration

Clicking the Run button starts scanning for moving objects and thus, all of 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.
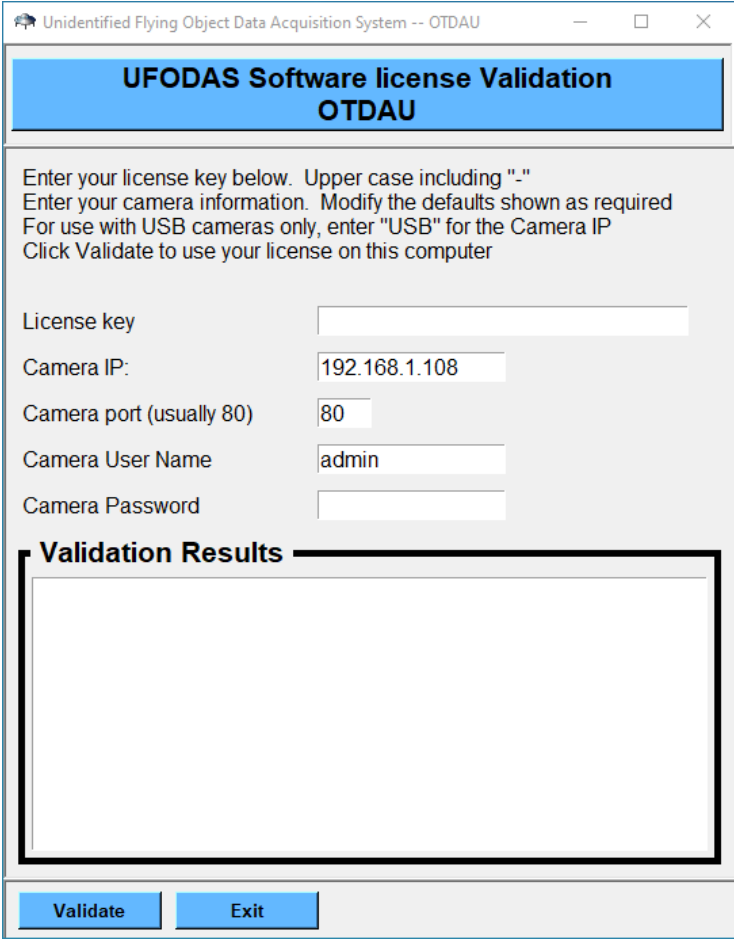
Setup:

- 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:

- If this is the first time you are running OTDAU, you will see License Validation form:

Fill in your license key, provided by SendOwl in the email you received for program download. Modify the camera IP, port and user name if necessary and fill in the password. UFODAS cameras are usually provided with a default password that reflects the type of camera, such as "dahua42212".

If no UFODAP IP camera is available then OTDAU may still be used with USB cameras only by entering "USB" (no quotes) instead of an IP number. This mode will also allow use with the built-in test configurations or external avi files.

Click on Validate. The result of the attempt to validate the camera will be shown in the Validation Results box. If both the key and camera validate successfully, then click Exit to open the OTDAU GUI. If there is a validation problem, check your inputs and try Validation again. If you are not able to validate your system, please contact us at team.ufodap@gmail.com to resolve the problem.

■ 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 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 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 multiple camera views

- 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 is in contrast to an older Sony camera with fairly 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. Only the Dahua camera is rated for IP67, outdoor use. Many other cameras were evaluated but did not provide features better than the Dahua for their cost and also 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 50A230UNI-A. 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 fairly 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 42212TNI, 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 a number of 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 thru using your mouse wheel or the slider on the right side of the Status display.

```
┌ Status ─────────────────────────────────────────────────────┐
│                                                            ^ │
│  Validating camera...                                        │
│  IP: 192.168.1.108  Port: 80  User: admin  Password: dahuaN51│
│  Connected to ONVIF camera                                   │
│  Get device information ---                                  │
│  ONVIF camera hostname: Dahua_N51BD22                        │
│  --- Camera information ---                                  │
│  Mfgr: Dahua                                                 │
│  Model: N51BD22                                              │
│  S/N: 5D04D26PAG23DEB                                        │
│  Hardware ID: 1.00                                           │
│  Local Time: 10:20:32                                        │
│  Write the license key to a text fileExiting license validation │
│                                                            v │
└──────────────────────────────────────────────────────────────┘
```

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.

After opening the System tab in the main window, click the Open button. A file selection window will open as shown below
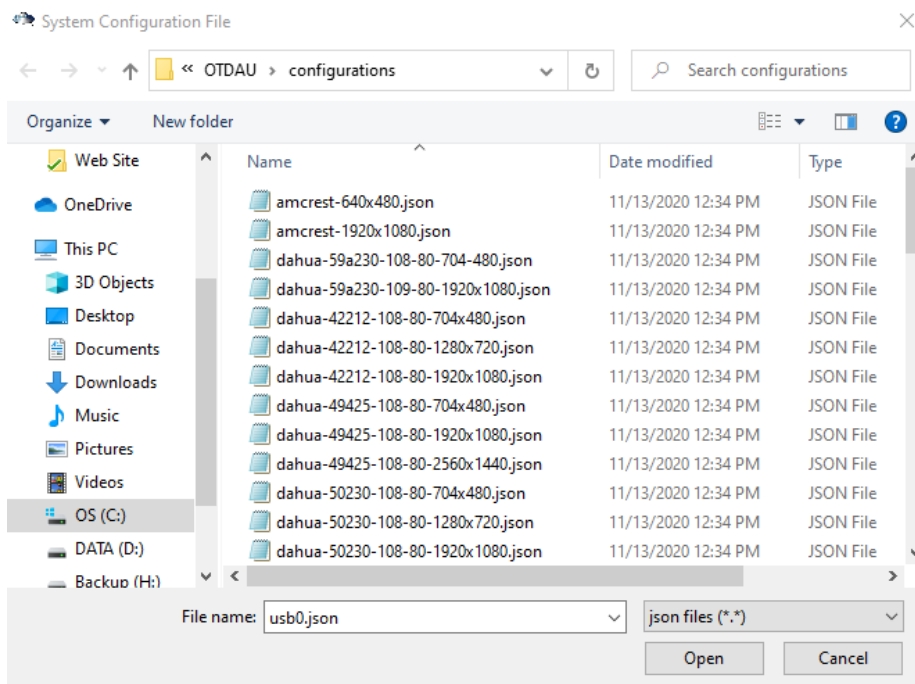
This window shows all of the available system configurations. To select one, double click or click it once and then click on Open or your selection. Note that local-usb0 is the default selection, so simply clicking Open will select the configuration that uses the USB0 device for both Wide and Telephoto camera.

A different configuration may be selected by clicking 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, "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. Particular cameras selected for the Wide-Angle and Telephoto devices are shown in the Configuration menu. The unique aspects of a camera type is shown in the Cameras menu although camera specific parameters are stored in the cameras folder and modified via the Cameras menu.

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.

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.

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.

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. May be the same as the Wide-Angle Camera.

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.

Zoom interval – Optical zoom occurs in increments and never decreases during a tracking sequence. This interval is the time from the end of one zoom increment to the next. Zoom cannot occur faster than this.

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.

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 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.

After selecting a System Configuration, click on the Load button located below the Wide-Angle Video Display area. The status box on the left, also below that display area will indicate load progress ("Initializing") and, when the load has been completed, it will display "Ready to Run".

The Wide-angle display at the top left of the main window will now display the video stream from the selected 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:
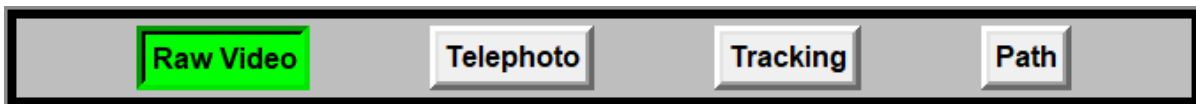
- Raw Video -- Default selection that displays the Wide-Angle camera video stream without any meta-data overlay.

- 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 boxes 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 complete main window, with Raw Video selected, will now appear as follows
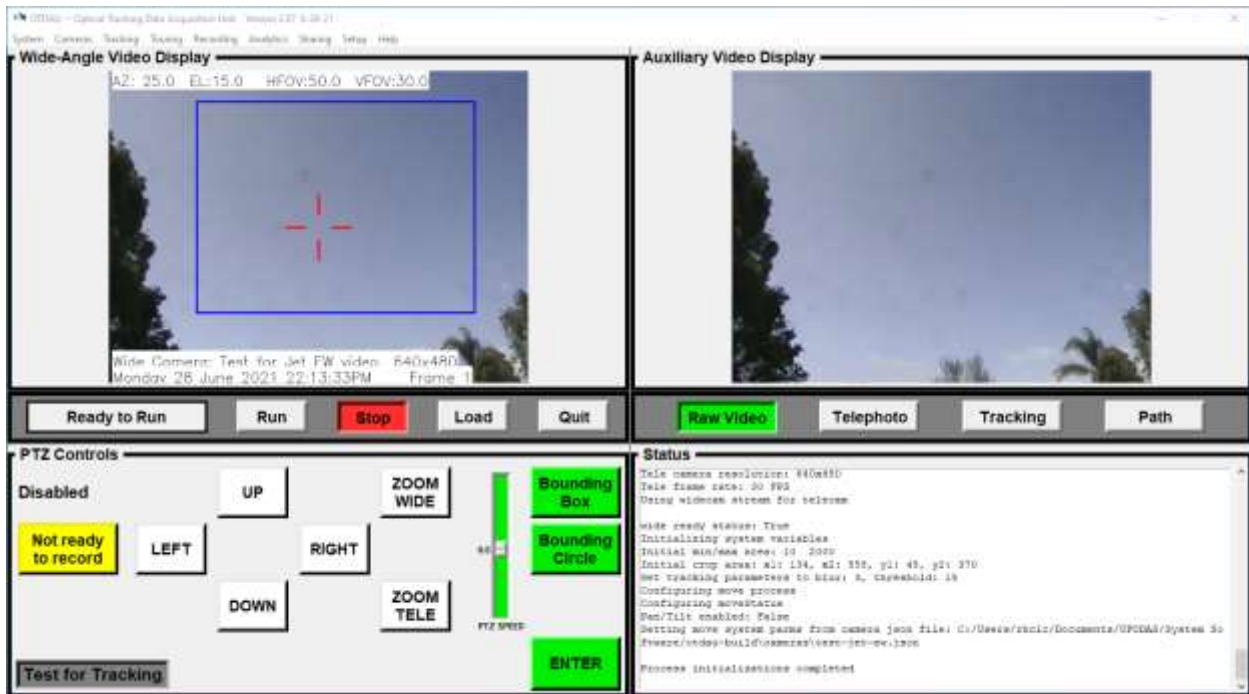
The scrolling text in the Status window, on the lower right, provides an indication of what the system is doing at all times. It may be used to confirm what files and cameras are in use, error conditions and other operational status.   Status messages that have scrolled out of view can be viewed by moving the slider on the right or clicking into the Status window and using your mouse scroll wheel.

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.
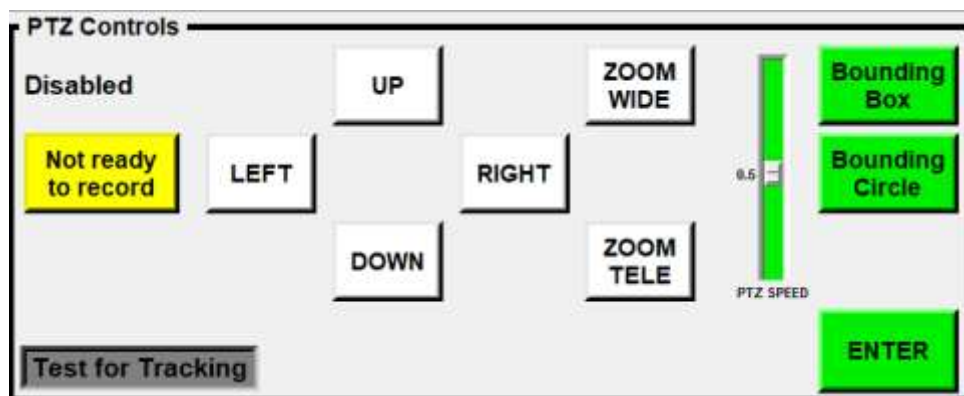
POSITIONING A PTZ CAMERA

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.

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.

There are two methods for setting this 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.

- Load a System Configuration. 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.

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 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 particular 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.

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 setup a two-camera system where the second camera is PTZ-capable, prior to running, start by enabling FOV calibration marks in the Setup Options. Then move the initial position of the PTZ camera so that its Center Field of View (CFOV, as indicated by the red cross-hairs) is aligned with the CFOV of the fixed camera. 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 are 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 as long as the addresses and port numbers are set correctly in the System configuration.

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.

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 devises to select from. Just select the resolution and click Connect. You can find this free tool at:

<center>www.bustatech.com</center>

- 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 of 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, as shown below.

IP CAMERA SETUP

Setting up an IP camera for use with OTDAU involves a number of 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, as shown above.

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 is in conflict with another device on the same LAN. Use the Dahua Config Tool 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 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 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, brings 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 during zoom, 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. It is usually best to set the camera zoom option to Manual and then set focus as follows:

  1. In daytime lighting, using IE, center the camera FOV on an object with sharp edges or writing.

  2. Zoom 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.

4. Notice that now the object and other parts of the view will stay in focus regardless of zoom level.

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 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, 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).

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 address, i.e., 192.168.1.x.

SETUP FOR ALL-SKY CAMERA

OTDAU supports IP and analog cameras with ultra-wide angle lenses, also known as All-Sky Cameras (ASC). 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 the system may be configured to a handoff mode wherein the ASC makes an initial target detection and then hands-off subsequent tracking to the PTZ camera. At handoff, the PTZ camera is moved such that its FOV is centered on an estimated target position. The PTZ 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 make 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 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 of that area may be useful. Additional

calculations or experimentation may be required to determine how much of the FOV of a ASC would be useful.

For the ASC to provide the PTZ camera 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) Position the PTZ camera as close to the ASC as is practical to minimize positioning errors.

2) Load the System configuration so that the Wide and Tele camera views are shown. Use Flip = 0 for the ASC camera configuration.

3) Orient (rotate) the ASC so that the right side of the Wide display is North.

4) Use the PTZ Controls to manually move the PTZ camera to horizontally center the ASC in the Telephoto display image.

5) Tilt the PTZ camera up to as close to 90 degrees as possible. If you overshoot and the camera automatically rotates 180 degrees, the moving it up again will cause the camera to rotate 180 degrees again. Check that downward tilt will point toward the ASC and repeat accordingly.

6) Enable Handoff from wide to tele camera in Setup Options:
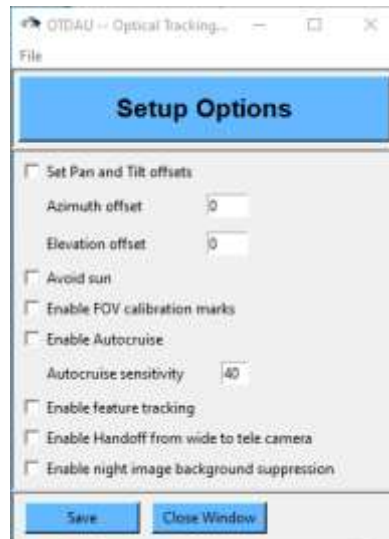
7) The system is now ready to Run.

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:

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

3. Rotate the wide camera so that the horizon is parallel to the lower part of its FOV.

4. Using the PTZ Controls, move the tele camera down and rotated so that it displays the wide camera centered in its FOV.

5. Move the tele camera UP to 90 degrees. Some cameras will automatically rotate 180 degrees when tilt moves beyond 90. In any case, move the tele camera so that an object moved over the wide camera moves in the same relative direction on the tele camera. It may be necessary to enable or disable the Flip check box on the PTZ camera configuration to achieve this.

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 loose 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 Chrome and the NACL plugin. (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 (x12 or x30 depending on camera)

7. Zoom back to x1 and verify that the image stays in focus throughout the zoom range.

8. Click Lens Init 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/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 setup 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. The number of detections used for this calculation is the "Min events" parameter in the Tracking menu.

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 uses controls the PTZ velocity in a closed loop to move the CFOV toward the target. However, the speed of the target may be sufficient so that the CFOV always trails the target. Now, in addition to those methods, OTDAU will also make a rapid absolute jump to try to "catch up" if the CFOV to target distance exceeds a given value.

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 and event. This feature may be used along with higher values of the Min events Tracking parameter (typically 45 or more) to reduce false triggers.

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 set to Raw Video.

A camera is initially setup for OTDAU sharing by setting the camera's OSD as shown in the following screen displays.
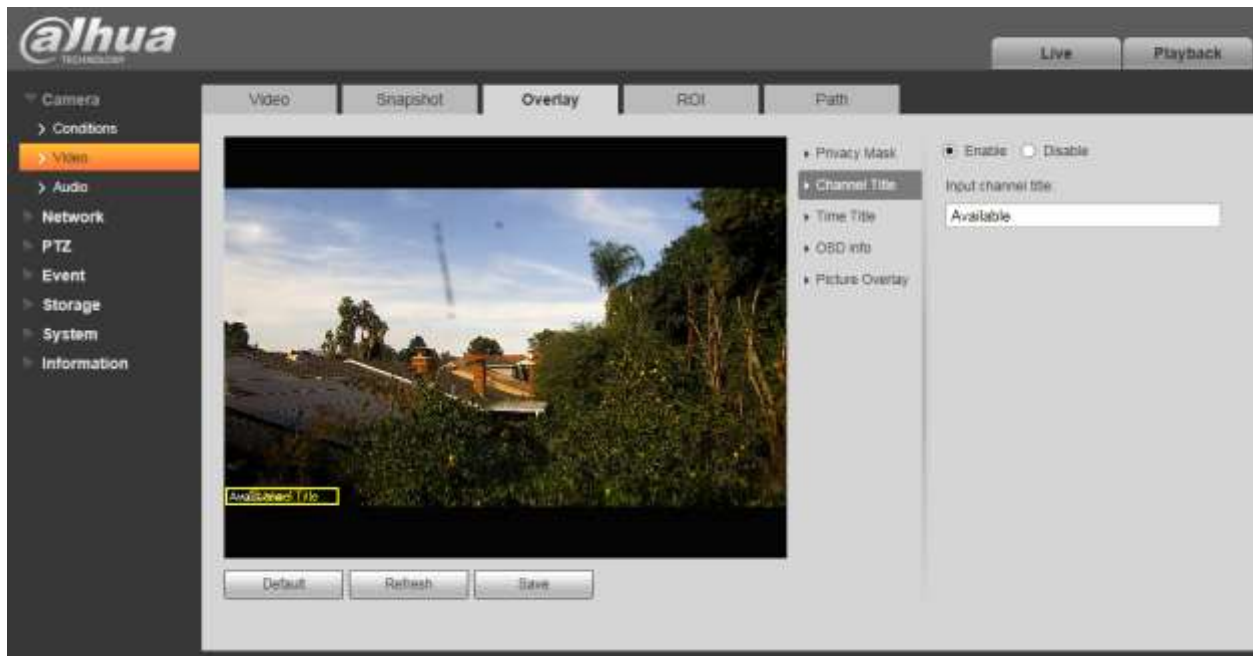
For a Sony camera, turn on Superimpose and edit its settings as shown below

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 (Ron-PC), as illustrated below.
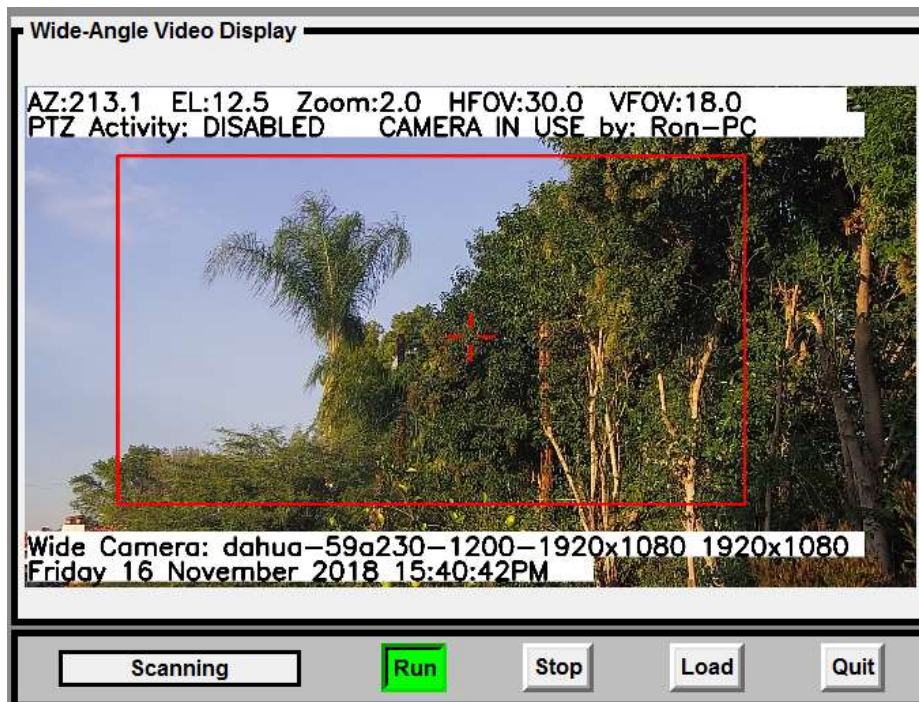
CAMERA CONFIGURATION OPTIONS

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

Name – One of the following unique supported camera model identifiers:

- "Dahua SD50A230"
- "Dahua 50230"
- "Dahua 50232"
- "Dahua 42212"
- "Dahua NK8BR4"
- "Dahua ASC"
- "Dahua N51BD22"
- "Dahua N53AB52"
- "Amcrest IP2M-841"
- "Samsung SNP-3370"
- "Samsung SNP-3750"

- "Sony RZ25N"
- "Sony SNC-RX570N"
- "USB"
- For pre-recorded test files, Name can be any description of the test

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

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

IP – The IP address of the wide-angle camera as x.x.x.x, e.g., 192.168.1.10.

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 – User name to access the camera. Typically 'admin' but could be whatever user name matches that used for the camera.

Password – Password to access the camera. The default will be provided by the camera manufacturer but should be changed by the user via access to camera settings.

Video URL – The full URL needed to stream video from this camera. Such URLs vary by camera and manufacturer. The field is shown in gray because it is automatically composed and filled in from the type of camera and the IP, port, User, Password and Stream. 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. Current values may be:

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

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

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

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

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.

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 and Sub Streams. 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.

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.

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 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 to CFOV as % of horizontal FOV -- The maximum distance from the target image from the CFOV to allow the start of zooming. It is specified as a percent of the overall horizontal image resolution. For example, if the horizontal resolution is 1920 pixels then if the zoom distance is set to 10 then zooming will start when the CFOV is brought within 192 pixels from the target.

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

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

Zoom restart interval -- The minimum time 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 it 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.

Control buttons

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

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

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 on the background.

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.

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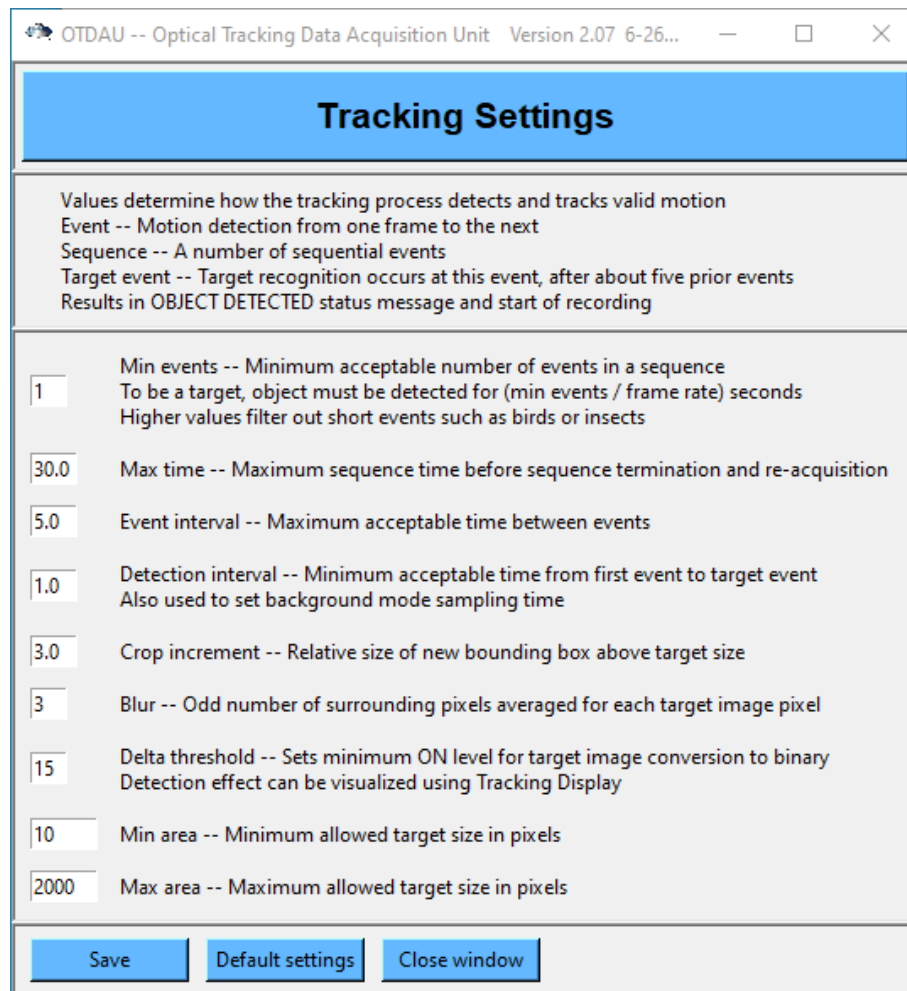
Note the distinction between potential target detections vs events. In OTDAU, a detection means that some motion was detected in a single video frame. An event is initiated when the characteristics of a series of detections indicates that a target of interest may be in view.

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.

Minimum events – The minimum number of per-frame target detections to allow recording of the sequence.

Target tracking begins if motion is recognized in at least this number of video frames.

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.

Detection interval – Minimum time that motion detections must occur before actual detection events are allowed. Small values filter out short sets of detections such as bird flybys and random noise.

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. **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 trigger on 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. A larger number helps ignore video "noise", clouds, etc. 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 blur 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 difference from 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.

Min area – The motion detection algorithm measures the contours of any "objects" sufficiently different from frame to frame. The area within these contours are tested to verify if they are 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 note that small differences 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 of the 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.

TOURING CONFIGURATION

OTDAU has the capability to move a PTZ camera between up to eight 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.

OTDAU -- Optical Tracking Data Acquisition Unit   Version 2.04 11-13-20

Touring Configuration

Description: Sample tour

File name: C:/OTDAU/tour 1.json

Position	Pan	Tilt	Zoom	Duration Hrs	Duration Mins	Duration Secs		
1	98.0	0.0	1.0			4	Set	Remove
2	128.1	0.0	1.0			4	Set	Remove
3	155.0	0.0	1.0			4	Set	Remove
4							Set	Remove
5							Set	Remove
6							Set	Remove
7							Set	Remove
8							Set	Remove

Start tour   Stop tour

Loop mode   Open   Save   Close Window

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

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

Save – Saves the tour values to the named file.

Close Window – Close the Tour Configuration window

To setup a tour:

Open a System configuration for the desired camera.

For each of eight Positions –

1. Move the camera to the desired position and zoom value.

2. Click Set to save those values into one of the eight Positions

3. Repeat move and Set for up to eight 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 to save the tour position values.

Test the tour by clicking Start tour.

Click Stop tour at any time to abort tour movements.

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 setup the tour

3. Click Run to start the tracking process

4. Click Start tour

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.

Primary Selections

Enable recording – 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 thru all changes to configurations or Run/Stop until OTDAU is shut down (Quit).

Wide-Angle video -- Checkbox to enable recording of wide-angle 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 values 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 vales will be at the next detection time.

Auxiliary Selection

None – Click to select no Auxiliary recording.

Raw video -- Click to record the Wide video stream without any overlaid meta-data.

Telephoto video -- Click to enable recording of telephoto 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.

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

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.

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 of the 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.

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 similar to 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.

Enable analysis after each target acquisition – Enables analysis of a target data collection sequence 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. **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.**

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.

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 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 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.

Data path <path name> -- The name of the path and, optionally, the file to be analyzed. If no particular 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"

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.

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:
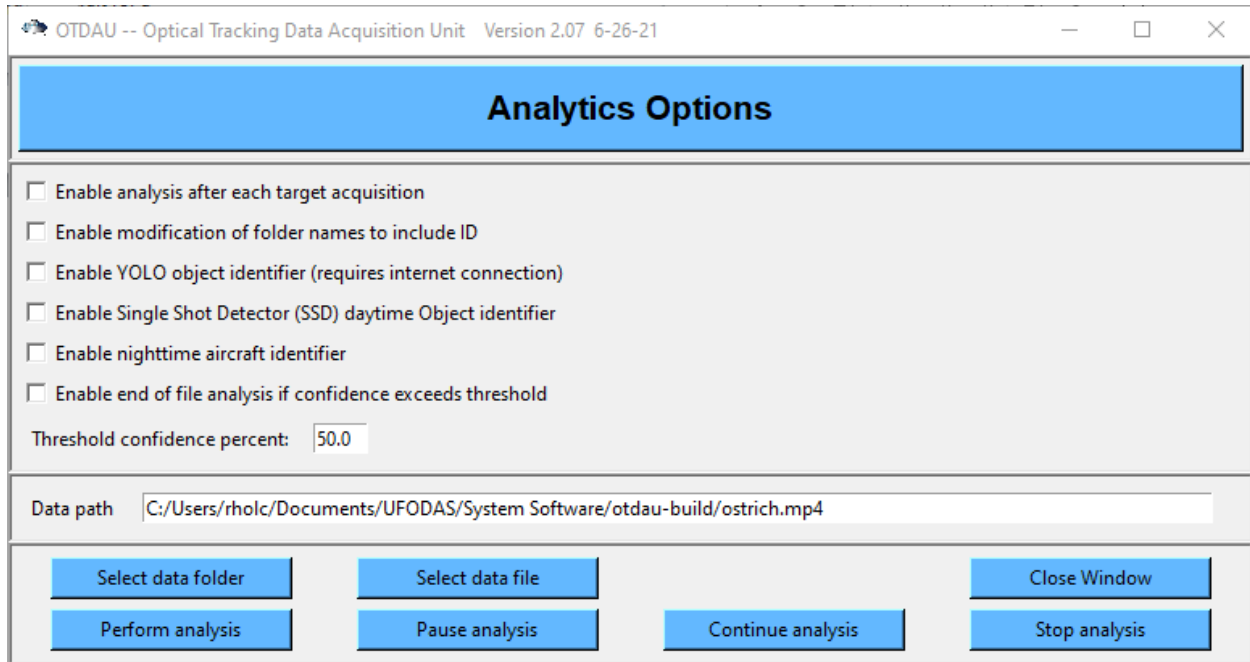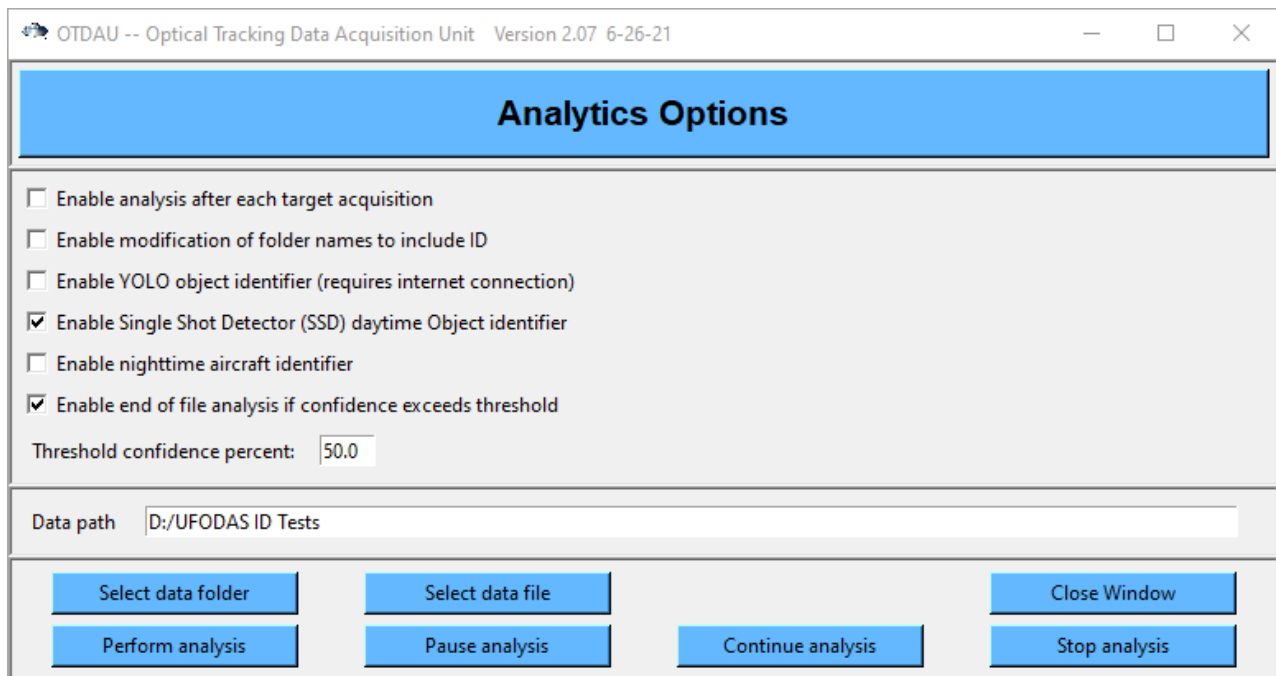
Clicking on Select data folder opens a folder browsing window:
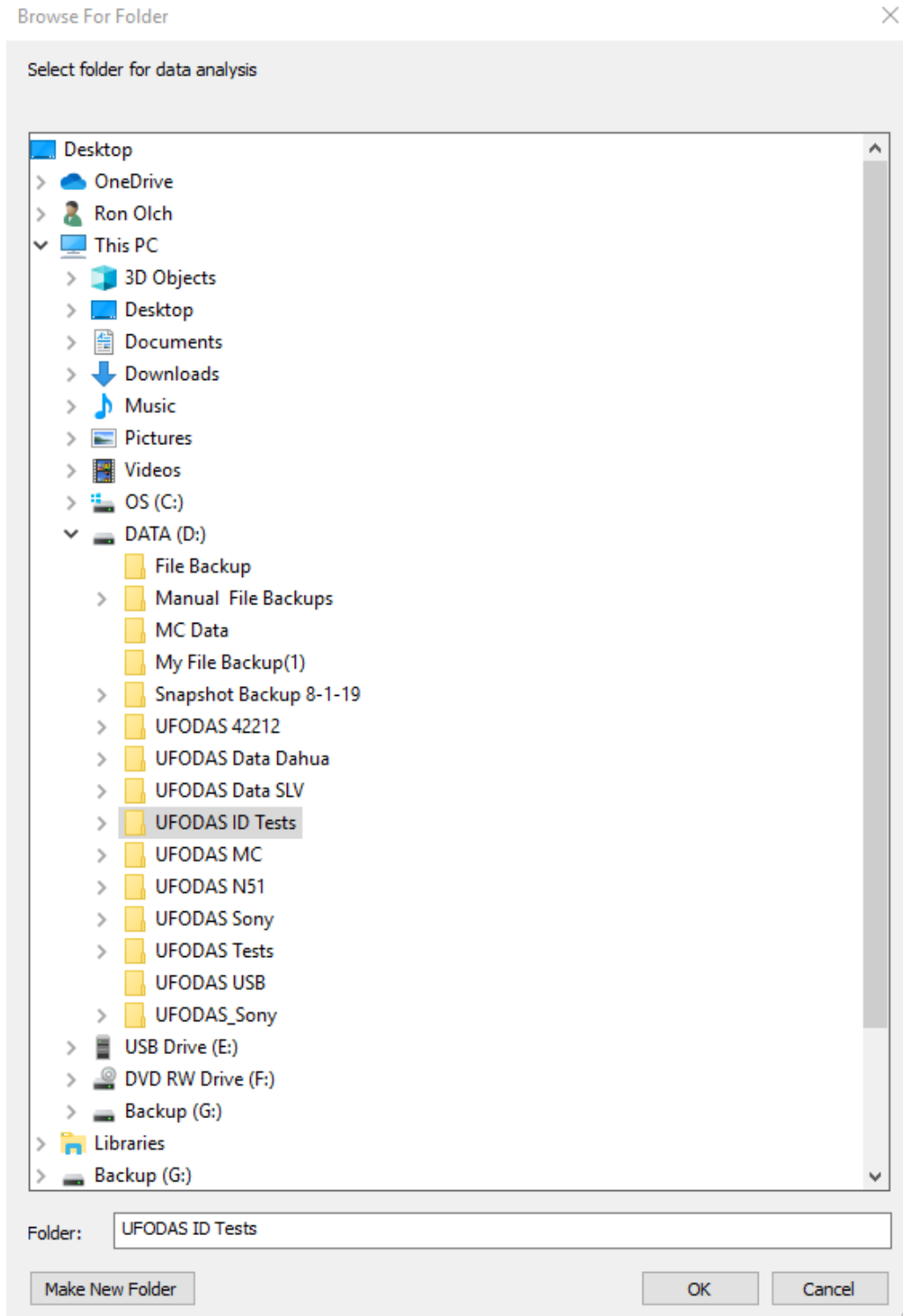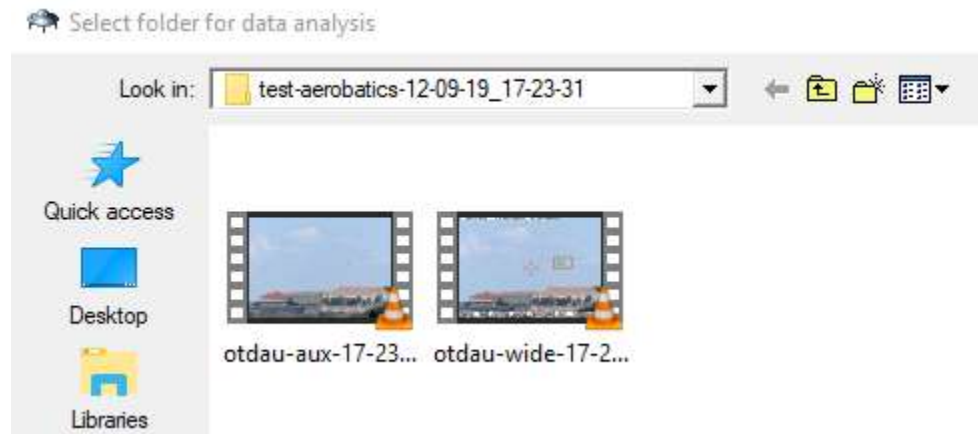
A fragment of the window above is shown below after "UFODAS ID Tests" was clicked, exposing the folder "test-aerobatics-12-09-19_17-23-31below it:
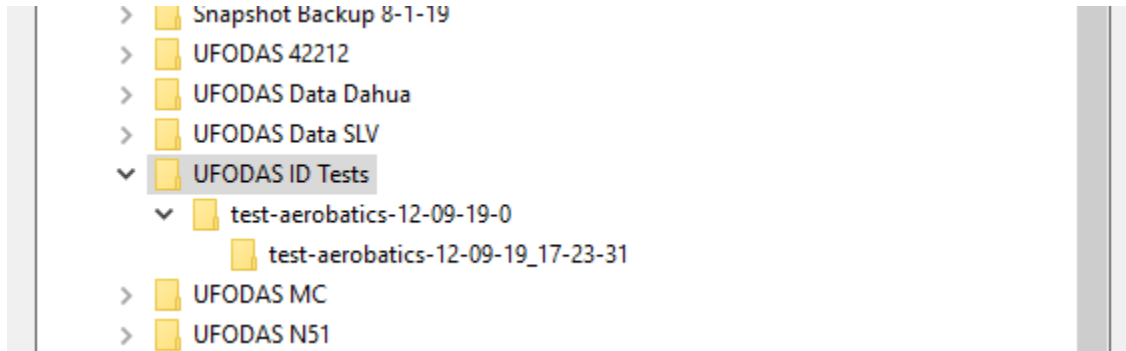
After selecting the test-aerobatics folder, its path populates the Data path field:

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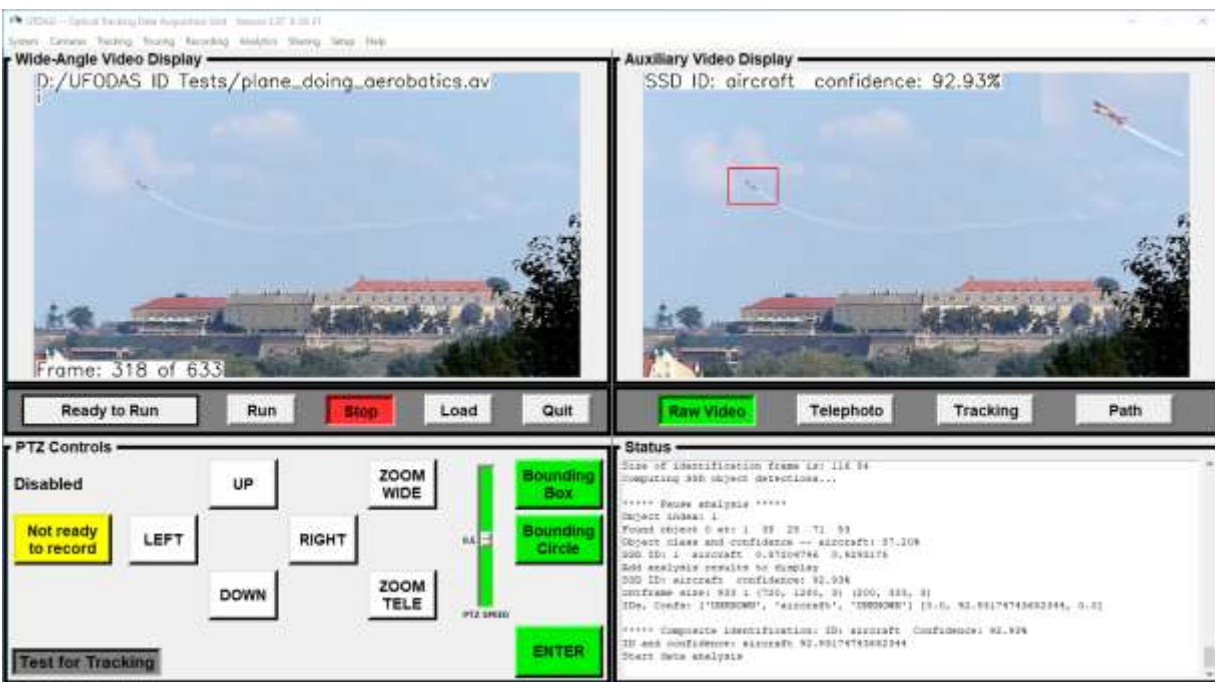
Note that if the folder "test-aerobatics-12-9-19_0 had been selected instead, any video files in folders below it would have been analyzed. The example above only shows one folder below, but there could be many – one for each target acquisition during a run.

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.
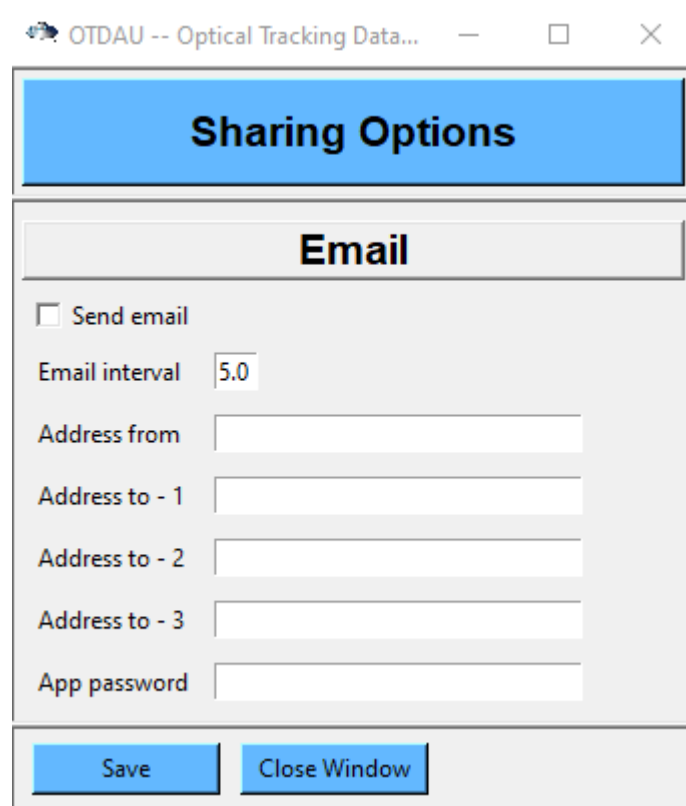
The Frame similarity value on the bottom of that display indicates the similarity of this frame to the last using the SSIM (Similarity Index) method. Since the initial bounding box used when the video data was originally captured is not known, this process is employed to determine if "motion" in the 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.

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 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.

FILE SHARING OPTIONS

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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 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. 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.

Operational options that modify system behavior during run time. Note that these selections are not stored as part of the System or Camera configuration files and so must be reset each time the OTDAU software is run. However, they are retained between changes to those configurations.
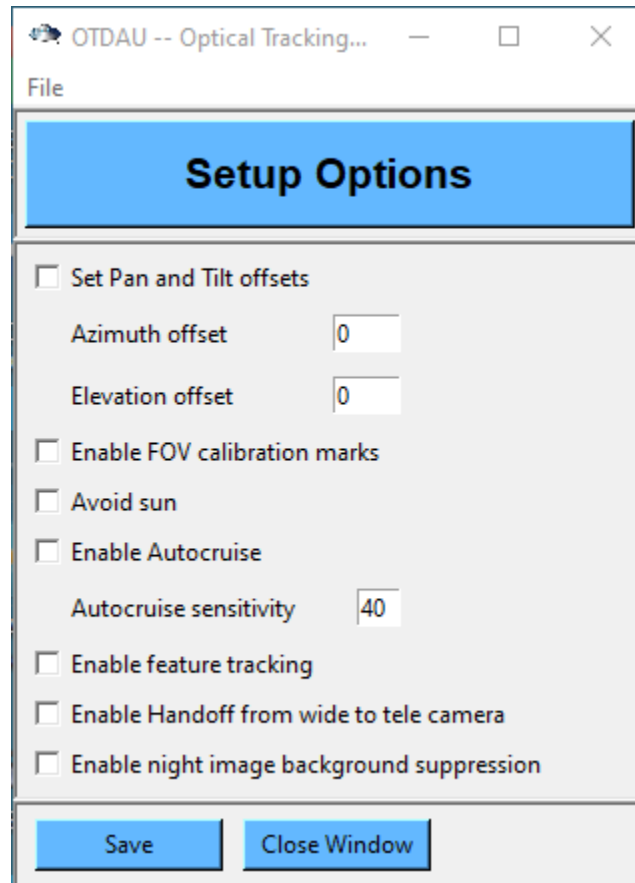
Set Pan and Tilt Offsets -- Check to cause OTDAU to create offsets to the current pan and tilt positions such that the offset positions rather than the actual positions are sent to MC during triangulation. This option is typically set after pan and tilt have been manually moved to due North and the horizon. 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 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.

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

Avoid Sun -- Check to cause OTDAU to continuously measure, during Run time, 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 away from the sun, defaulting to a position directly down, at the horizon. This condition will be cleared by Stopping and restarting the Run.

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 Handoff from wide to tele camera – 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.

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 screen shot 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.
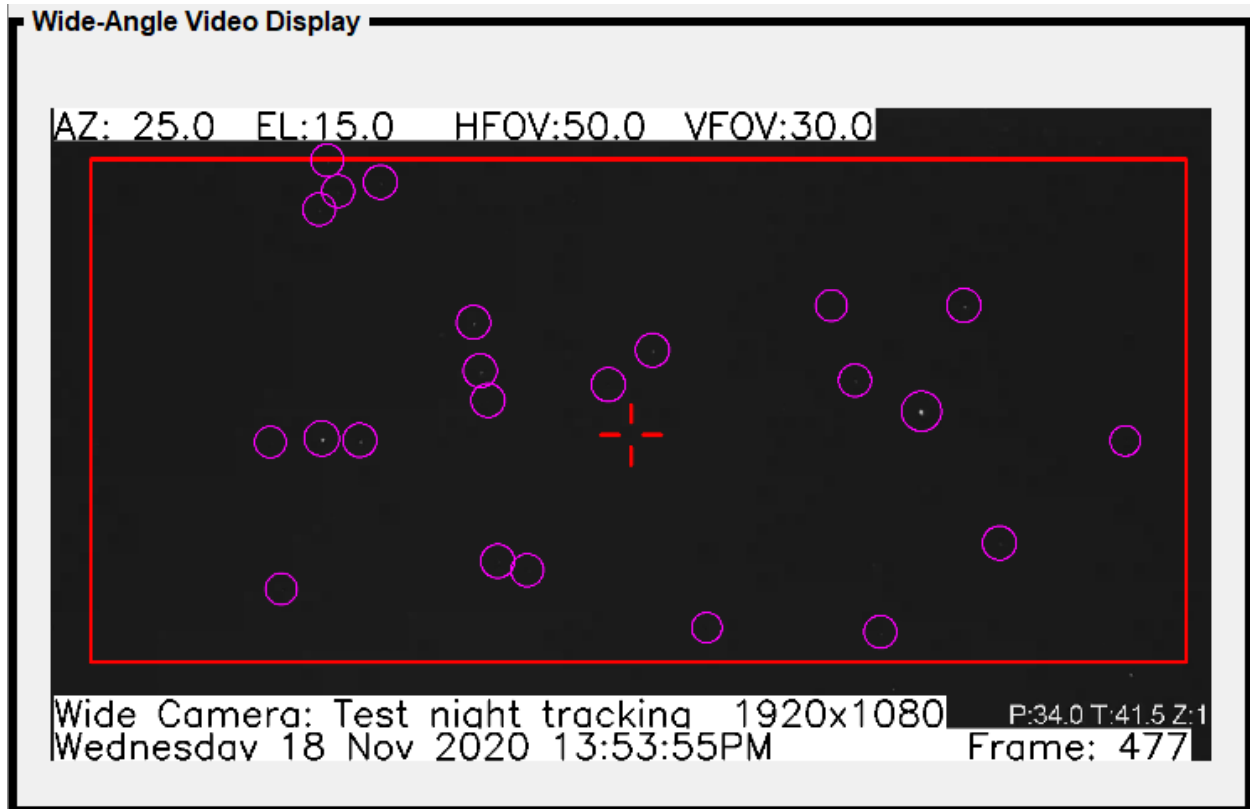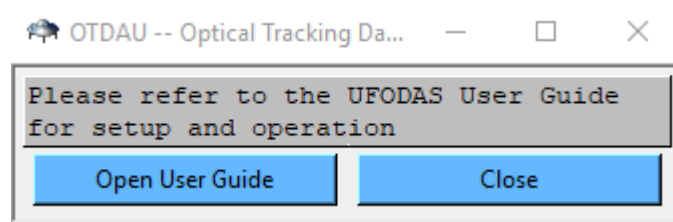

Control buttons

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.
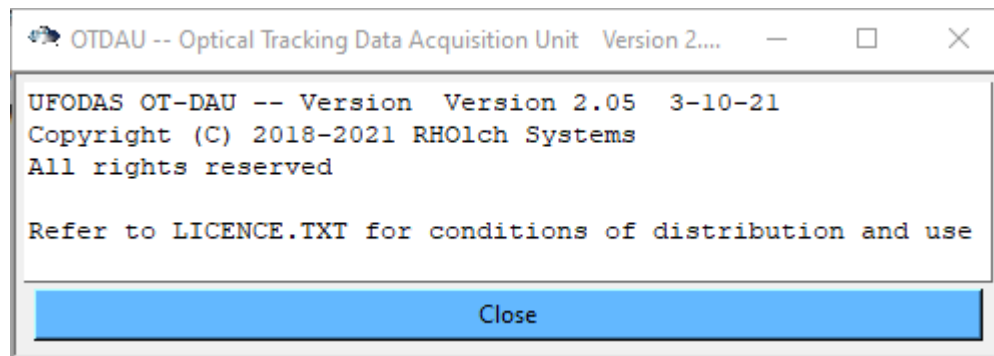
Help –

Clicking on "Open User Guide" will open this document as a pdf in a browser window. You can then leave it open for reference.

About –

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

Manage license –

Displays the license validation GUI. Allows the key and camera information to be modified or re-validated.

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 a number of 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 street lamps

There are two methods to loading files for test –

Select a default avi file:

1. Click on the System tab and then "Open configuration"

2. Double click on one of the System configurations a file name that begins with "test"

3. Click Load

Select any avi 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

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:
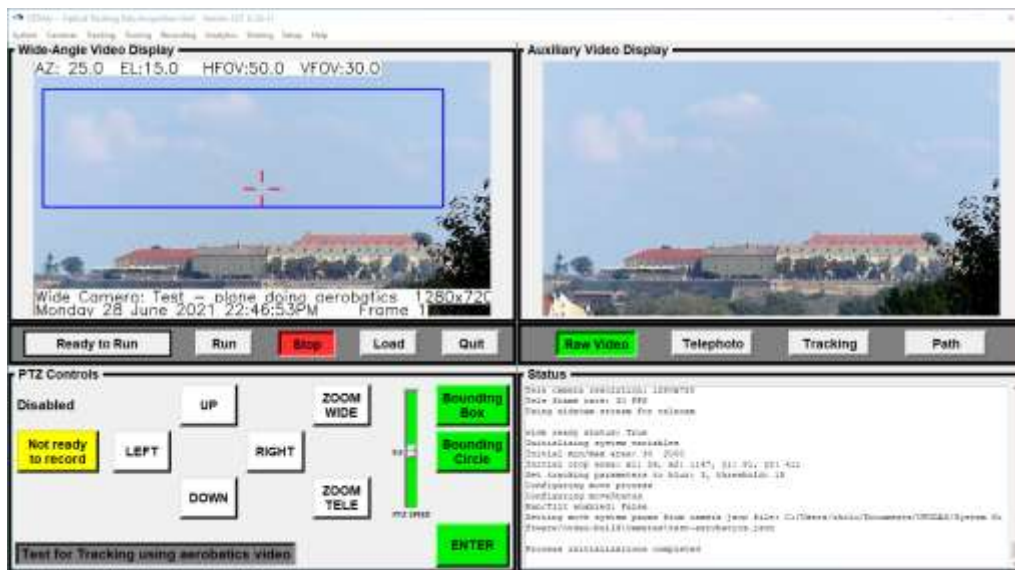

Clicking Run will play back the test avi file and cause OTDAU to detect and track the target object, in this case, a stunt plane:
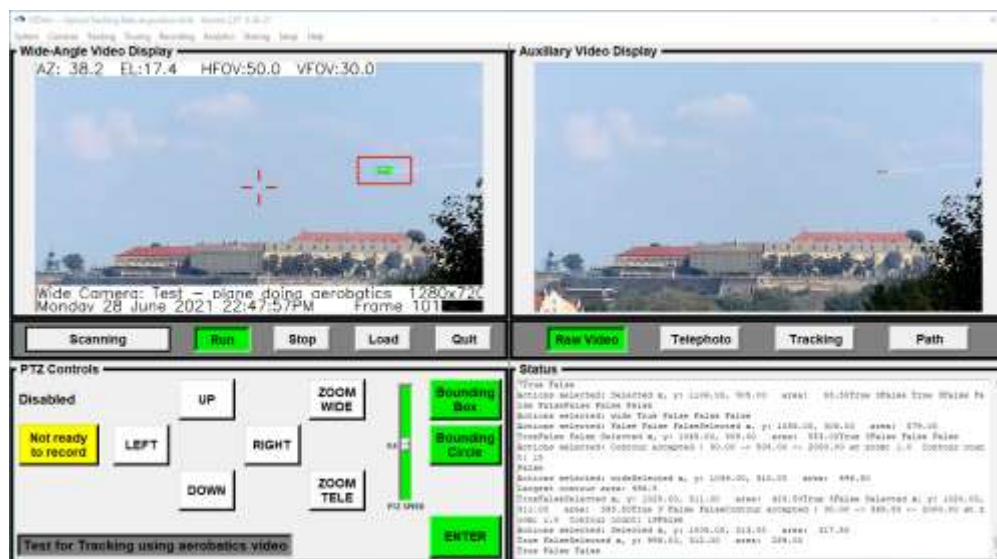
Playback may be stopped at any time by Clicking Stop. It will restart from the first frame when Run is clicked. Playback will automatically restart from frame 1 if the file is allowed to play to its end, as indicated by the Frame number no longer incrementing. Clicking on Stop then Run will restart playback from frame 1.

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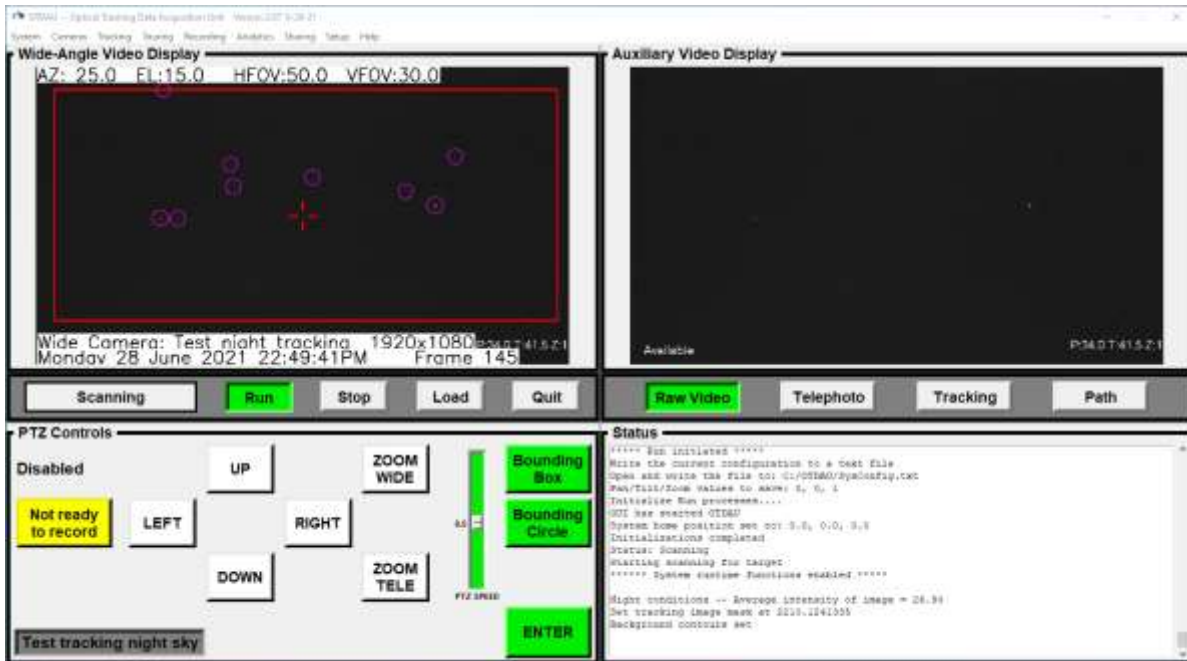
The ability to select any avi file for test may be used to improve tracking parameters for existing tracking runs. If you include Wide-Angle video as one of the Recording Options, then select any recorded avi file with a file name beginning with "otdau-aux-". Double clicking that file will load it, ready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

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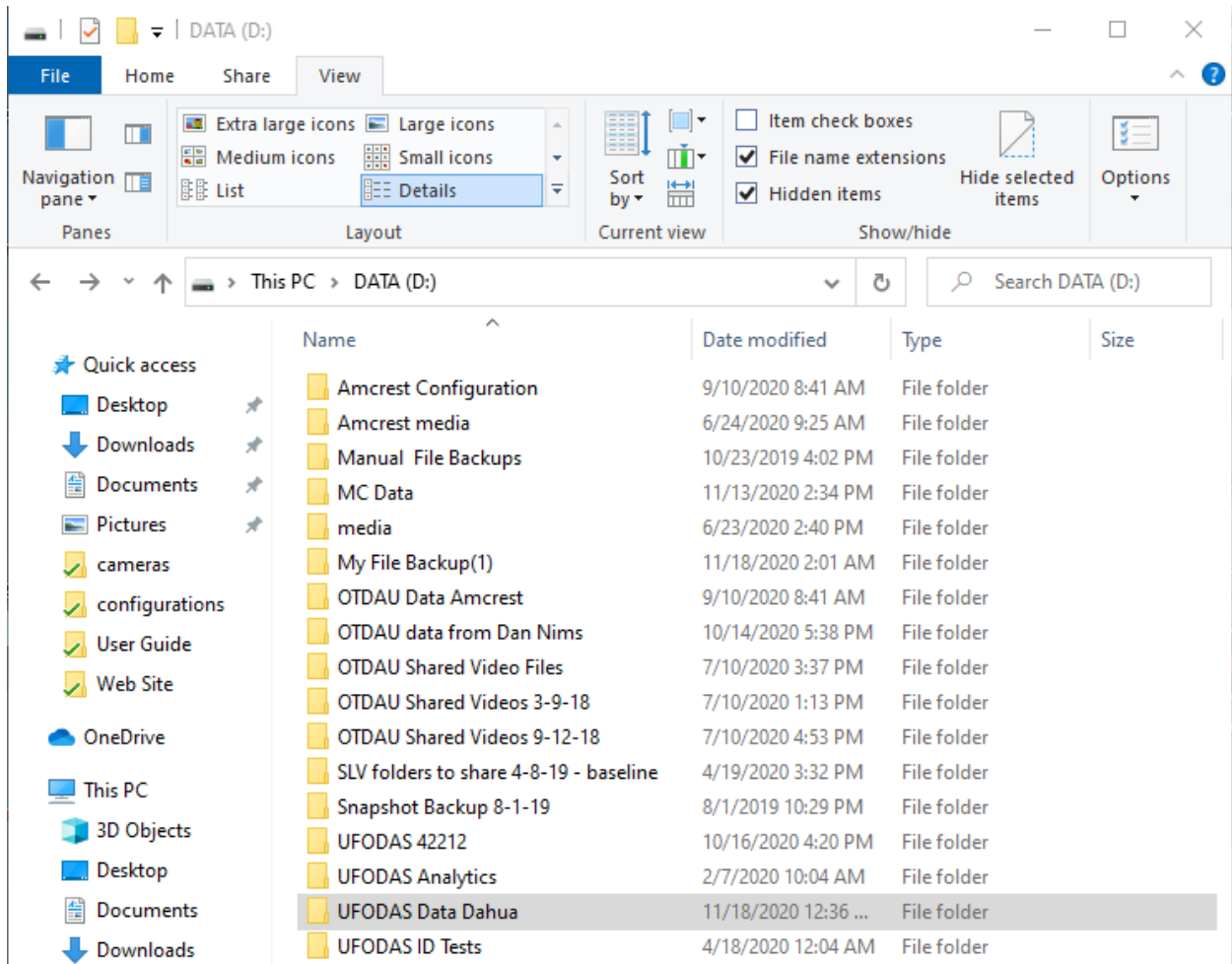
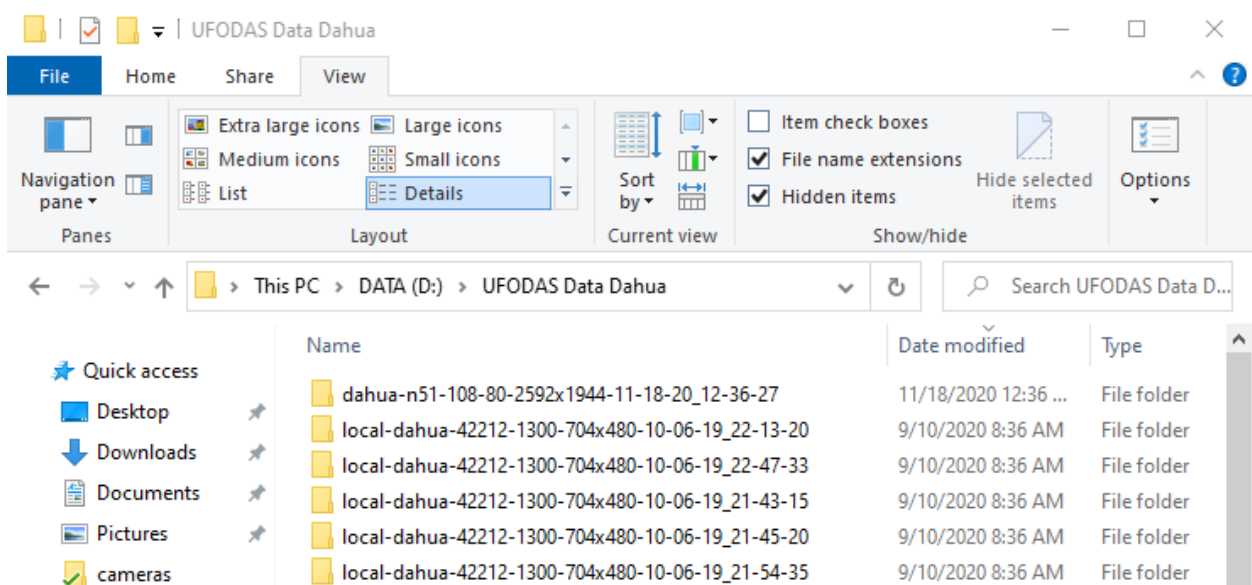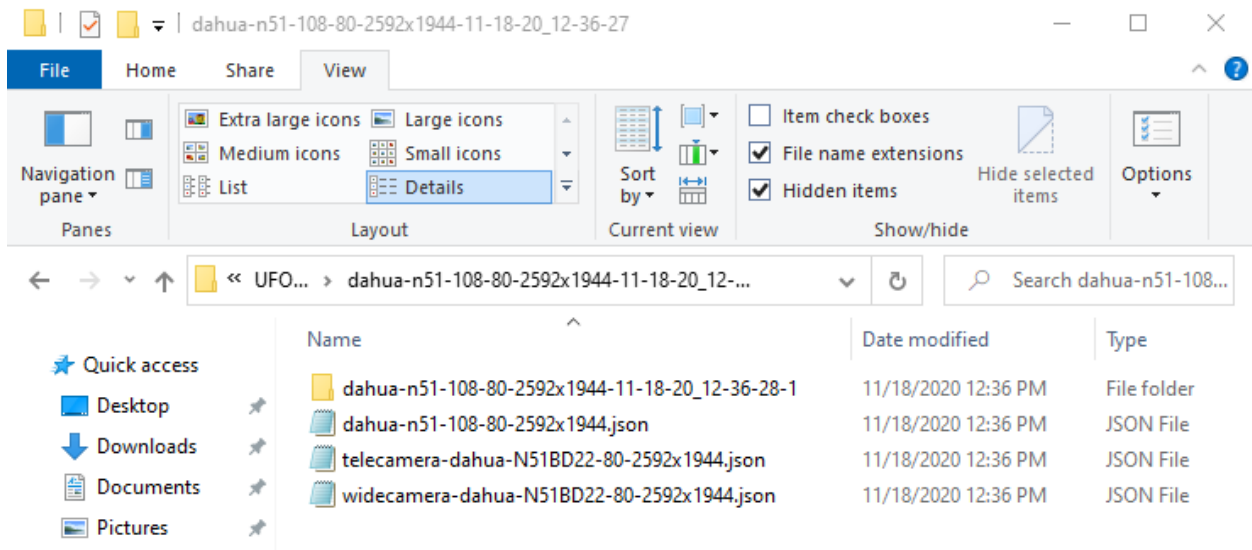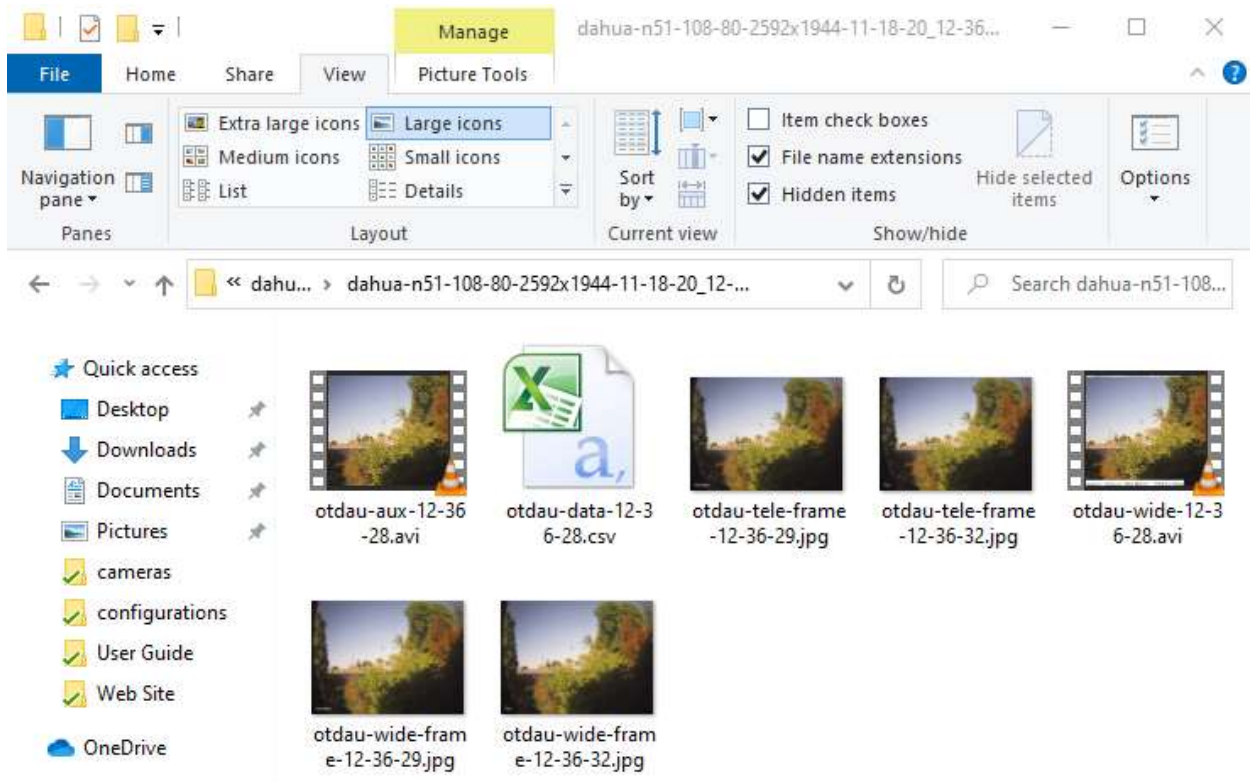A Group folder under D:\UFODAS Data Dahua (dahua-n51-…) is show below:

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, UFODAS software is located in the directory:

C:\Program Files (x86)\UFODAS

Within this folder are a number of folders and files that make up the UFODAS 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.

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. It 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

Within any such data folder 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.

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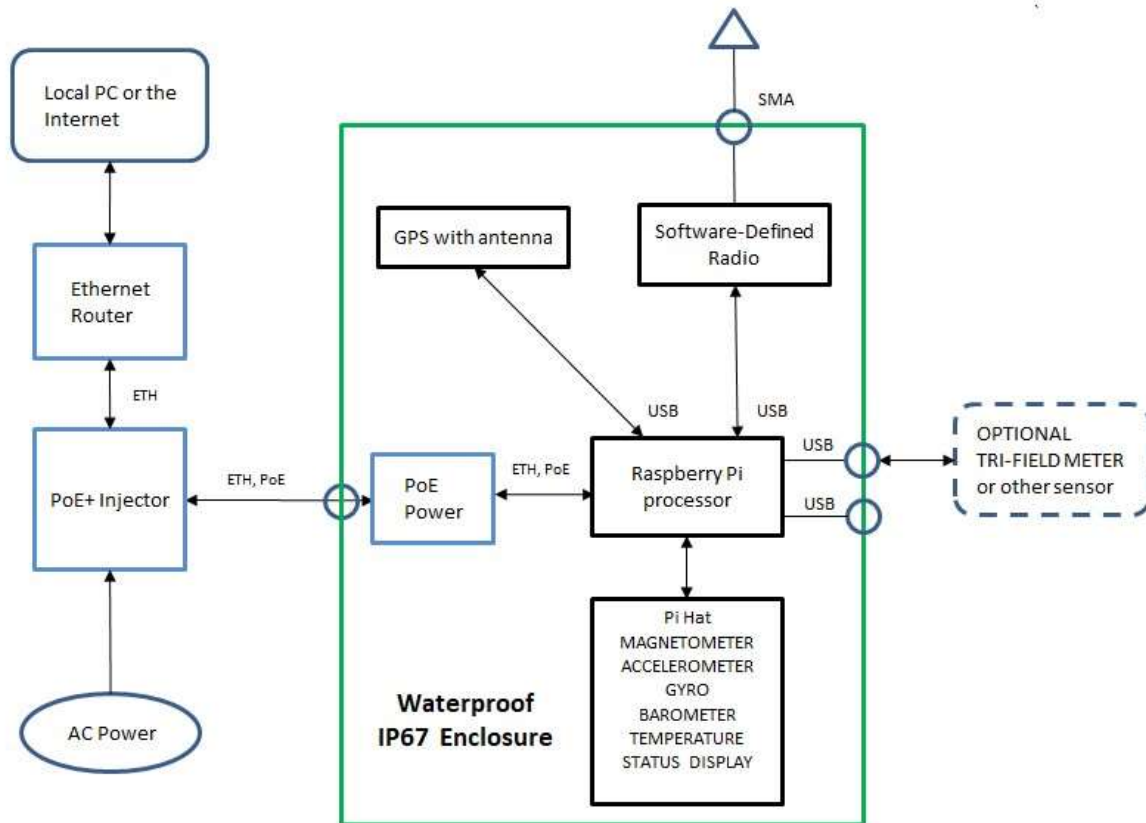
The Pi has four USB ports of which two are available externally; one is used for the internal GPS receiver and one for the SDR.

Cameras and associated MSDAUs do not have to be in close 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 OTDAU. 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 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 plastic 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
- 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 a number of 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.
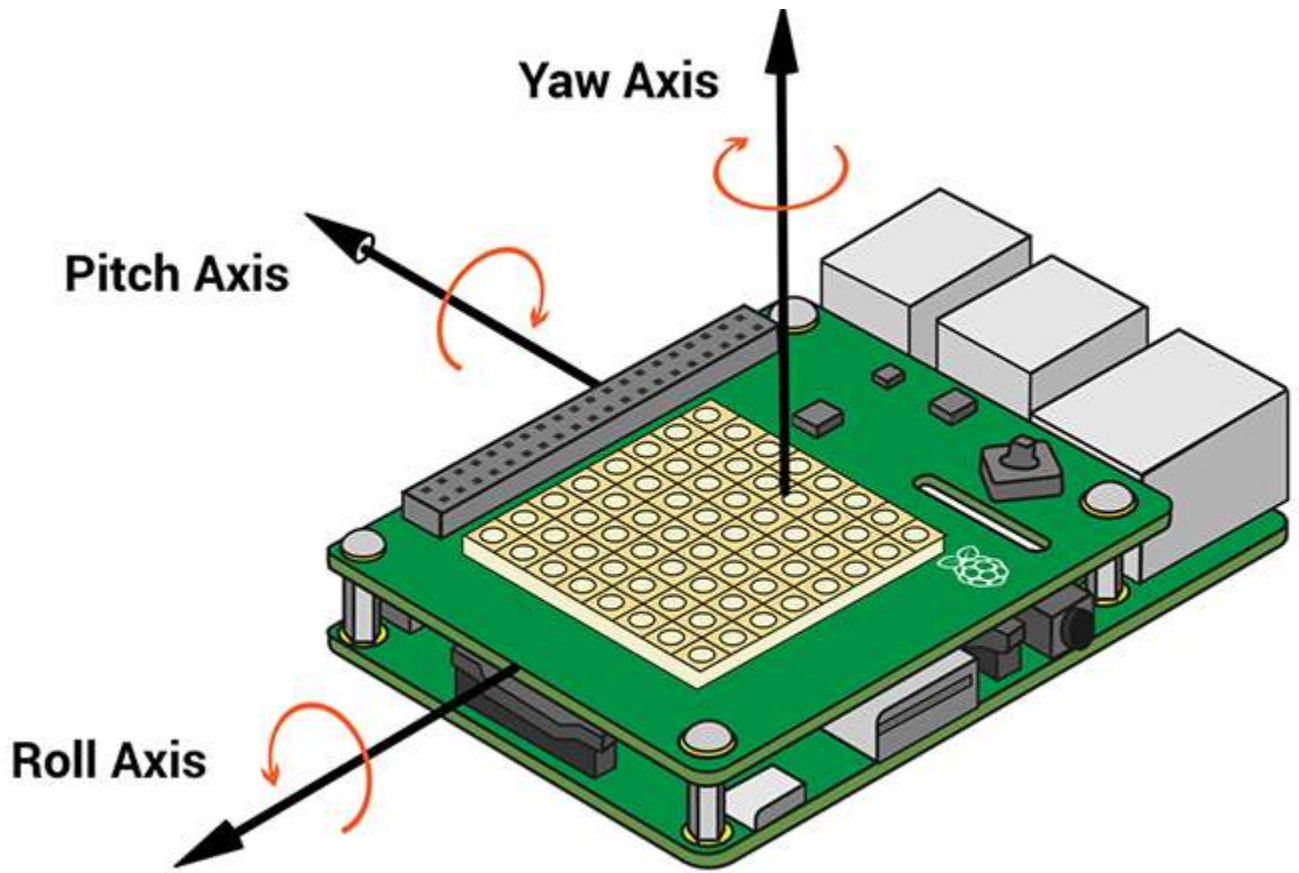
Above picture shows the axes of motion as measured in the Sense HAT.

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

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 current status of MSDAU operations. The display may be:

- Square green box -- The power up and initialization sequence has been completed.
- 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 and error scrolling text messages.

The trigger threshold is specified in the MC Setup menu.

Pressing the center button on the Sense HAT joystick will cause the MSDAU to stop operating and display the right-most value of its four-value IP address. Pressing the joystick up will increment this address up and pressing the joystick down will decrease this value. When the desired MSDAU address is reached, press the center button to resume operation. The initial value of the IP address is:

192.168.1.144

After stopping the MSDAU with the center button, moving the joystick left will set the display at a higher illumination level. Moving it right will set it to a lower illumination level.

The IP address and illumination level are retained thru MSDAU power cycles.

The red and green LED indicators on the Pi 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 commands the MSDAU to enter a boot loading mode. This is indicated on the MSDAU display as "=== REBOOTING ===" in red.

3. The MC downloads the latest version of MSDAU code to the MSDAU. The display will go blank during this process.

4. The MSDAU then reboots, displaying in green "=== MSDAU Vx.x ===" where x.x is the version of software loaded.

5. The MSDAU starts running, communicating data to the MC which indicates the MSDAU's ONLINE status.
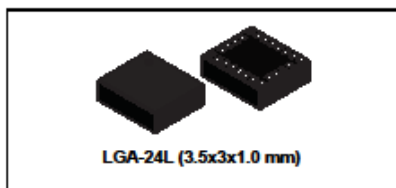
If the MC is closed or communication is otherwise lost, the MSDAU continues to sample data while checking for a new connection. Communication with the MC will be automatically resumed when the MC is restarted and a Mission is loaded.

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 ±2g/±4g/±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.
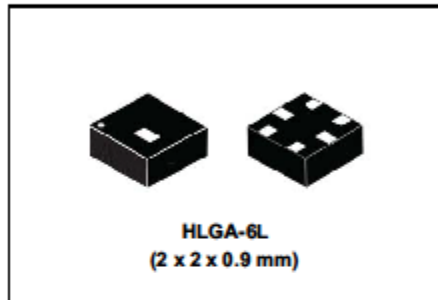
The LSM9DS1 is available in a plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

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

www.st.com

HTS221

Capacitive digital sensor for relative humidity and temperature

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

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.

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

Table 1. Device summary

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

150