
OnPoint Targeting v1.3

Vision-Based

The Procerus OnPoint™ Targeting application brings precision target Tracking, Localization, and video Stabilization, available on higher-end UAVs, to small inexpensive UAV platforms. OnPoint is also innovative in its vision-centric focus to UAV guidance and control – easy to use vision-based “click ‘n fly” operation to fly the UAV and point the gimbal at desired targets, with a simple click and drag of the mouse within the video (significantly reduces user load). It also provides “virtual hover” from a circling UAV that shows video much like you would see it from a helicopter.

1. **Target Tracking – Single click**
2. **Target Geo-Localization**
3. **Video Stabilization (and Hover Mode)**
4. **Click n’ Fly – Vision-based flight control**



Video:

Tracking Car: www.procerus.com/video/track_car.wmv

Virtual Hover: www.procerus.com/video/virtual_hover.wmv

OnPoint Targeting Capabilities:

1. Target Tracking – Single click

Single click - gimbal locks on - UAV follows autonomously – moving target’s stats (lat / lon, speed, heading) provided to user real time.

The user can acquire and track a moving target with a single right click of the mouse on the target in video. The gimbal locks onto the object, a cross-hair appears and a box is drawn around the target (box size can be changed by user) providing the user with visualization of the tracked object, and the UAV autonomously follows. Users can also manually track targets using the left mouse (click / hold cursor on the target in the video). Again the gimbal follows your clicks and the UAV flies to those selected points.

While tracking the target, Localization algorithms provide user with the moving target’s heading, velocity, and estimated GPS location.

2. Target Localization

Vision-based target localization allows the user to obtain GPS coordinates of desired ground targets. Within one revolution over the target, our localization algorithms provide the user with the target’s GPS position to within 3-5m, often much less. (commercial GPS)

3. Video Stabilization (and Hover Mode)

One of the key underlying technologies that make localization and tracking compelling and useful is the ability to stabilize the video stream in real time. This offers greater visual appeal and importantly it provides the user with greater precision in acquiring targets. In addition, Hover Mode is an option that allows the user to observe a scene in essentially a “stand still” mode, much like what you would see from a helicopter’s perspective.

4. Click n’ Fly – Vision-based flight control (significantly reduces operator load)

While viewing stabilized video through the OnPoint Targeting application, the ground station operator may, at any time, click on the video and the UAV will proceed to fly to the location that the operator clicked and it will also point the gimballed camera at that location. In this scenario, the operator need only watch video and click on points of interest and OnPoint and the Kestrel autopilot will take care of geo-location, navigation, and gimbal pointing. This navigation mode allows for persistent imaging of static areas of interest as well as dynamic tracking of moving objects of interest.



OnPoint™ Targeting v1.3: Target Tracking, Video Stabilization, Geo-Location

The screenshot shows the Procerus OnPoint Targeting v1.3 software interface. The main window displays a live video feed of a rural landscape with a small aircraft icon overlaid on a target. The interface includes several control panels and data overlays:

- Optional Telemetry Overlay:** Located at the top left, it displays flight data: Lat: 39.98469°, Lon: -111.99063°, Alt: 100.3 m, Roll: -4.8°, Pitch: -0.3°, Hdg: 26.4°, CamAz: 0.0°, CamEl: 0.0°, CamHFOV: 60.1°, AirSpd: 13.6 m/s, Batt: 11.0 V, Sat: 6.
- Target Painting Mode:** Located on the left, it includes buttons for 'Stationary' (highlighted), 'Moving', 'Manual' (highlighted), 'Feature', and 'Global Motion'.
- Target Tracking Location:** Located on the left, it includes 'UAV Modes' with 'Targeting' (highlighted) and 'Other' options, and a 'Reset Gimbal' button.
- Presets: forward, straight down, 45° down, left or right:** Located on the left, it includes a 'Reset Gimbal' button and a 'Forward' dropdown menu.
- Video Stabilization Modes:** Located on the left, it includes 'Reset', 'None', and 'Stabilize' (highlighted) buttons.
- Filtered Target Location:** Located on the left, it includes a 'Hover' button.
- Control Digital and Optical Zoom:** Located at the bottom left, it includes 'Zoom' controls for 'Digital: 72%' and 'Optical: 0%'. It also features a 'Tgt Pos/Vel Estimator' with a 'Reset' button and 'Sensitivity: 76%'.
- Take Snapshot from Live Video:** Located on the right, it points to the 'Snap Shot' button.
- UAV Address Selection for Multi-Agent Control:** Located on the right, it points to the 'UAV Addr' dropdown menu showing '1032'.
- Target Position Filter Controls:** Located at the bottom right, it points to the 'Settings', 'Help', and 'Advanced' buttons.

When coupled with the Virtual Cockpit ground control application which provides UAV telemetry updates, the OnPoint Targeting application can be used to locate and track ground objects through single user mouse clicks. Once an object of interest has been located a user can click onto the object in the video frame and the UAV will adjust its flight path and gimbal pointing direction to lock-on to the object. Once locked on, OnPoint algorithms will track the object using advanced vision tracking algorithms. The user also has the option to manually track the object using the mouse cursor. The coordinate accuracy of stationary targets increases with the amount of time spent tracking that object. Generally one UAV revolution is sufficient to return a lat / lon position to within 3 to 5m, often less.



- **Improved User Interface:**
- **Better Stylus Functionality** - different clicking options now selectable using buttons rather than just keyboard shortcuts
- **Tracking Modes exposed** - Track moving and non-moving targets using different modes by simply clicking on the appropriate button. Also, adjust tracking sensitivity for better control of tracking algorithm.
- **Change UAV Mode From OnPoint** - Any of the UAV modes can now be selected directly from OnPoint
- **Digital and Optical Zoom** - Scrollbars added for both digital and optical zoom
- **Agent List Synchronized** - The agent list in Virtual Cockpit is now correctly synchronized with the list in OnPoint. Only agents available in VC are selectable.
- **Link Status Indicator** - Time since last telemetry received is now shown in OnPoint to verify that telemetry link is not compromised
- **Automatic Reconnection with Virtual Cockpit** - Upon closing and reopening Virtual Cockpit, OnPoint will automatically reconnect (rather than requiring a restart).



Target Localization - Enabling Technologies:

1. Online Gimbal Bias Estimation

Regardless of how carefully the gimbal or fixed cameras are mounted, biases exist which can significantly affect the accuracy of target localization. Our vision-based localization software includes the ability to estimate and correct for these biases online. Gimbal (or mounting) bias estimation is as easy as clicking the mouse while the UAV loiters some object of interest whose coordinates do not need to be determined a priori. After the UAV has completed a full revolution the biases are learned and can be sent to the UAV which will then make the necessary corrections to bring the object of interest into the image center, thereby verifying that the appropriate biases have been determined.

The bias estimation software not only determines the correct biases but also displays to the user the overall improvement in localization accuracy due to the bias estimation. Typical increase in accuracy range from 10 – 40 meters decrease in the standard deviation of individual estimates while loitering the object of interest.

2. Integrated Camera Calibration

Accurate target localization requires precise knowledge of the intrinsic camera parameters including scaled focal lengths and skew factors. Because these parameters are not generally known for various camera/lens combinations our vision-based localization software includes an integrated camera calibration routine based on Zhang's method, currently one of the most widely used and well accepted methods for camera calibration available.

The integrated camera calibration makes determining intrinsic camera parameters as easy as clicking a mouse. The software does the rest, including allowing the user to save any number of camera calibrations to file which can be loaded into the localization software depending on which camera/lens combination is being flown on the UAV.

3. Wind Bias Correction

The vision-based localization software utilizes Procerus' proprietary wind estimation algorithm to correct for localization biases caused by wind. Accurately determining and correcting for localization biases caused by wind can reduce the overall error of a given target position estimate by 50 meters or better depending on wind conditions.

The wind bias estimation and correction, combined with gimbal bias estimation, and optimal flight path generation has been demonstrated to allow localization estimates to within 3-5 meters, very often below 2m of relative GPS error in winds in excess of 50% of the UAVs commanded airspeed.

4. Optimal Flight Path Selection

The optimal flight path for localization of an object of interest using a UAV equipped with a gimballed camera is a circular loiter centered at the object of interest. However, selection of the altitude and radius of this loiter can have a significant impact on the accuracy of the resulting estimate of target location. The vision-based localization software includes algorithms for determining the loiter radius and altitude which is optimal in the sense of minimizing localization error sensitivity.

The optimal flight path for localizing an object of interest using a UAV equipped with a fixed side-looking camera in wind is an ellipse whose eccentricity and orientation are a function of the wind speed and direction. Algorithms are currently being implemented which will determine the ellipse which is optimal in the sense of minimizing localization error sensitivity.

5. Fly by Camera Control

Accurate target localization allows the UAV to be controlled entirely in the frame of reference of the live video stream. This allows the user to completely detach himself from the mundane tasks of operating the UAV and focus entirely on the important information being fed back to the user in the UAV video. The user is able to navigate the UAV and the gimballed camera simply by clicking on areas, or objects of interest in the video. The UAV then flies to and loiters the object or area of interest until the user provides further input. This navigation mode allows for persistent imaging of static areas of interest as well as dynamic tracking of mobile objects of interest. This is all coupled with real-time localization of the object being monitored as well as stabilized video.

