PlateSmart Technologies

CALIBRATION GUIDELINES

for Setting Up a PlateSmart ALPR Solution

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Introduction

Why Perform Calibration?

While PlateSmart ALPR software applies cutting-edge AI and deep learning to read both license plates and vehicle data, it must be configured properly to ensure consistent accurate results. Additionally, since the camera serve as the "eye" through which the software "sees" the license plates, it must be calibrated to provide the software with imagery that is consistently within the specifications required for the software to perform properly. Thus, calibrating both the camera and the software ensures consistent, accurate operation of the entire LPR system.

What this Manual Covers

This manual covers the proper calibration of both cameras and PlateSmart ALPR software to ensure the best operation of the system.

If You Need Help

If you need help with any configuration issue, please contact our support team at (813) 749-0892 or via email at support@platesmart.com.

Camera Calibration

Calibrating a camera has two aspects:

1. Physical calibration: the mounting and precise physical orientation of the camera.
2. Digital calibration: selecting the settings within the camera for best performance.

	**The following physical and digital calibration steps are intended to serve as best practices only for rapid camera calibration. Very precise camera calibration is needed for high-speed traffic (over 60 MPH), long distance to the LPR capture zone, and/or very low light conditions. Please contact PlateSmart for a much more precise and mathematical camera calibration process.**

Physical Calibration

Physical calibration should be done first. It will likely require a team of at least two people: one person at the camera physically and the second on a computer with access to the cameras management web interface monitoring the camera's field of view (FOV).

	**The camera should be mounted on a stable structure so that it doesn't vibrate or move. Mount the camera using the manufacturer's recommended mounting hardware and in compliance with all appropriate codes and regulations.**

	**The mounting location of the camera relative to the LPR capture zone is beyond the scope of this document. Please see the resource on choosing an LPR camera location document.**

The physical alignment of the camera to the LPR capture zone should be done as follows:

1. Zoom the camera in all the way so that the camera has the tightest FOV possible.
2. Place a reference object in the middle (with regard to length and width) of the desired LPR capture zone. This object can be a parked vehicle, a cone, or other object that can stand about 3 ft. above the road surface and be easily visible from the camera.
3. Position the camera so that the object is clearly visible within the center of the camera frame. This might require loosening the camera's mounting hardware.
4. Rotate the camera so that the license plate or reference object is parallel to the bottom of the camera frame. This will ensure all license plates passing through the camera's FOV are straight and not at a rotational angle.

	**As most roads are curved for drainage, some slight angle is to be expected. The objective is to minimize that angle within the cameras FOV.**

5. Zoom the camera halfway out and verify that the object is still centered within the camera frame.
6. If necessary, tighten the mounting hardware enough to prevent the camera from moving.

	**The mounting hardware might have to be loosened again during the digital calibration phase. Do not tighten the hardware completely.**

7. Proceed to digital calibration.

Digital Calibration

The following digital calibration steps should be done during a well-lit time of day:

1. Set the camera's primary stream to RTSP and H.264 with a resolution of 1920x1080. LPR is better achieved from the camera's primary stream instead of an alternate stream.
2. Verify that the desired traffic lanes to be captured are well within the camera's FOV and that the typical traffic pattern will allow license plates to flow through the camera's FOV.

	**Generally speaking, if a camera is mounted about 15 ft. above the ground and pointed at traffic from the left- or the right-hand side of the road as it moves away from the camera, traffic should flow from a bottom corner of the camera's FOV towards the opposite top corner of the camera's FOV.** **For example, a camera mounted on the right-hand side of the road will see traffic flow from the bottom left-hand corner towards the top right-hand corner of the camera's FOV. This allows for the license plate to be within the camera's FOV for the longest possible distance.**

	**A perfect corner-to-corner traffic pattern may not be possible. However, the objective is to maximize the distance the plate is traveling through the camera's FOV.**

3. For the RTSP stream being used for LPR, determine and set the appropriate frame rate. **Use the reference table in the Appendix on page 18**.
    a. Choose the depth of your FOV.
    b. Pick a speed at which traffic will typically be travelling through the FOV. Err on the side of faster rather than slower speeds.
    c. Each of the remaining columns tells you the frame rate required to capture the designated number of frames. For example, an 11-ft. DOF with traffic traveling 20 MPH will require you to set the frame rate to 9 FPS in order to capture three views of each plate.
        i. Frame rates highlighted in red exceed the maximum number you can specify for use with the PlateSmart ALPR software. Thus, if you have a 9-ft. DOF with traffic going 60 MPH, you will not be able to capture more than two views of every plate. If you require more to ensure accuracy, you will have to either adjust your DOF or ALPR processor suppression settings (see "Working with Suppression" on page 9).
    d. Set the frame rate in the camera according to the manufacturer's directions.

	**If you are unable to use the table, 15 FPS will work for many applications. For slow traffic (under 20 MPH), a setting of 10 FPS works in many applications.**

4. Complete the remaining best practice settings on the camera:
    a. Turn Wide Dynamic Range (WDR) off.
    b. To ensure a high-quality image from the camera, set the bit rate on the LPR video stream to a minimum fixed 6500. If there is a network throughput concern, this can be set lower.
    c. To reduce/eliminate motion blur on the license plates traveling at speed, set the shutter speed to a constant 1/1000. If the lighting in the LPR capture zone is dim, this setting can be reduced.
    d. Set the camera to automatically transition from day to night, and set the threshold setting to medium sensitivity to changes between daytime and nighttime conditions.

	**The transition sensitivity may need to be adjusted depending upon the scene and the camera's capabilities.**

    e. Set the camera's infrared illuminators to turn on at night and to be in sync with the camera.

	**Additional external infrared illuminators may be required depending upon the distance to the LPR capture zone and the environmental conditions surrounding the capture zone.**

    f. If your camera supports them, disable any "gatekeeper" or pan-tilt-zoom (PTZ) events that may alter or change the camera's FOV. Save the camera's "home position" to the set LPR position once calibrated.

	**After completing the digital calibration during daylight hours, an additional digital calibration session at night may be needed depending upon the license plate order results at night. PlateSmart recommends allowing the LPR system to capture plates over a 24-hour period to better understand how lighting conditions influence the LPR results.**

Software Calibration

The ALPR processor is managed via the browser-based PlateSmart Service Hub. The Service Hub allows you to perform the necessary integrations, make calibrations, monitor plate reads, and troubleshoot connections.

Calibrating the software for a particular installation is done via Applications. When you click on “Applications” in the left panel of Service Hub, you will see your integrations (Figure 1).

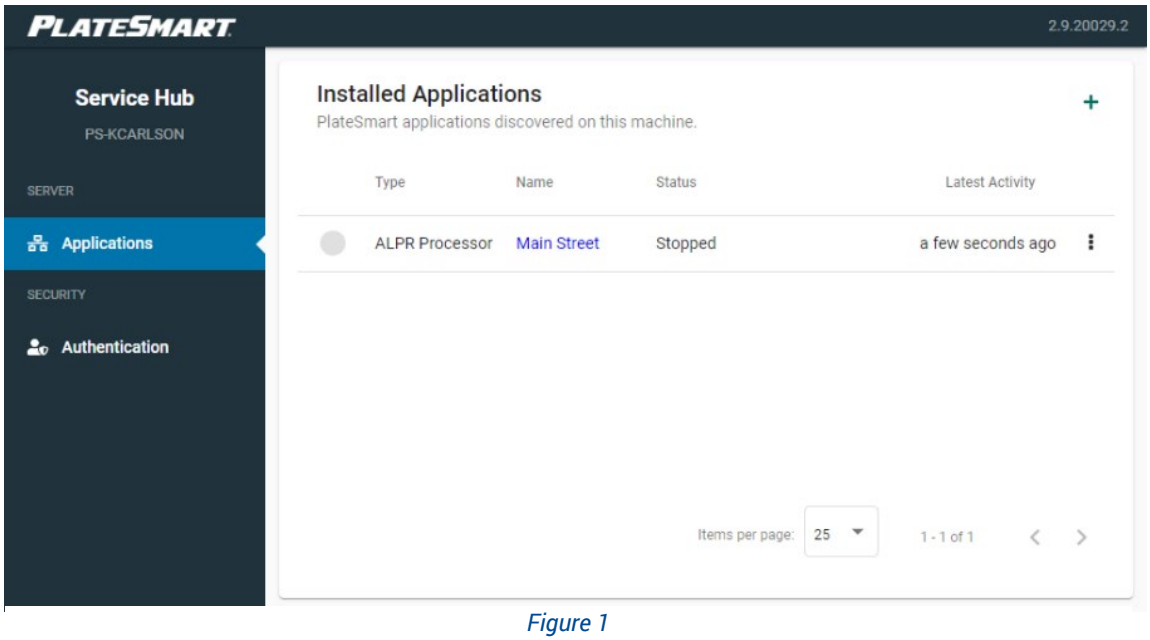


Figure 1

To configure the application, click its name. This will open a new processor application window with several configuration options as well as other options (Figure 2).

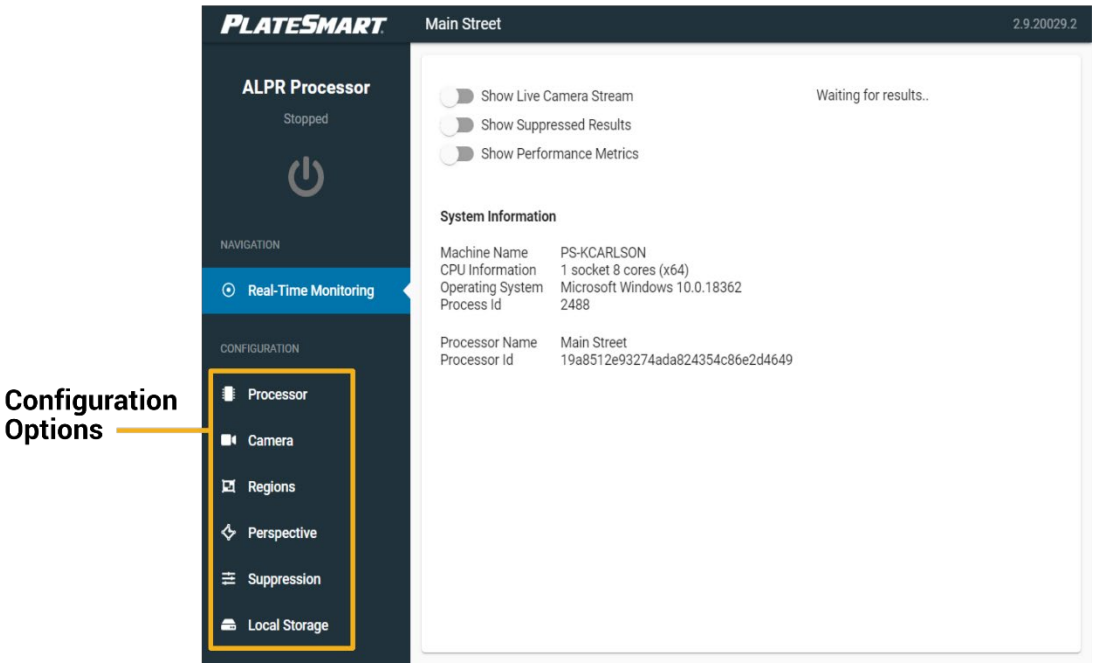


Figure 2

All of these options except for local storage can be used to properly calibrate the software.

Before performing any of these calibrations, however, we need to focus the camera.

1. Zoom the camera in to the point that a license plate or other reference object achieves 120 pixels per foot (PPF) open at the far end of the LPR capture zone.

FYI	**Determining 120 PPF requires the use of a graphic measurement tool. Some camera manufacturers provide a pixel count tool. Otherwise you can capture a native video frame from the camera and measure it. See "How to Measure a License Plate or Target Image" in the Appendix on page 19 for complete instructions.**

2. Zoom the camera out about halfway.
3. Focus the camera so that the license plate or reference object in the middle of the LPR capture zone is in sharp focus. You can initially use the camera's autofocus setting to help achieve focus. Then turn the autofocus off and fine-tune the focus manually.

FYI	**The license plate should be slightly out of focus when it enters the camera's FOV. As the vehicle approaches the center of the LPR capture zone, the plate will become completely in focus. Then as the vehicles leaves the capture zone, the plate will become increasingly out of focus again.**

Now move on to calibrating the ALPR processor. Click "Processor" on the left panel. While there are many options here, the one we are most interested in from a calibration perspective is "Maximum Processing Rate" (circled in red in Figure 3), which we now use to set the frame rate for the processor.

The default frame rate is 15 fps. It can be set to a maximum of 20 fps. You should set the frame rate to match the rate you set in the camera (see page 5).

If you are not able to set frame rate at the camera, then follow the instructions for determining frame rate outlined in step 3 of "Digital Calibration" on page 5.

Once you have chosen your frame rate, enter it in the "Maximum Processing Rate" field and click "Save."

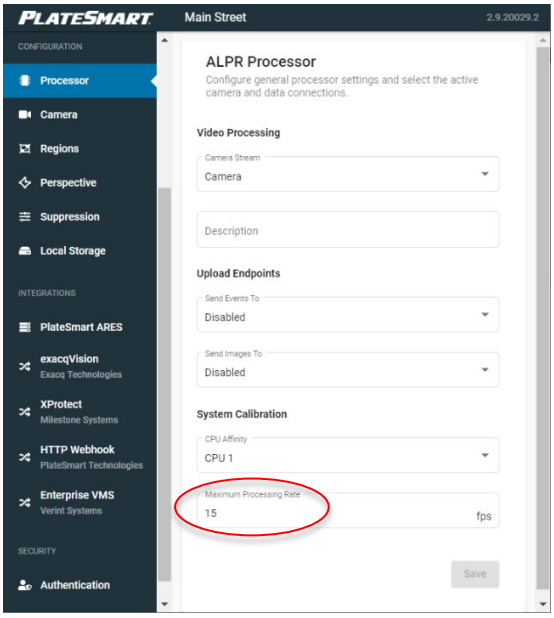


Figure 3

Working with Suppression

In addition to frame rate, suppression can be used to choose how many duplicate plate reads the processor looks at when determining a plate read that the software will return as a final result. The more images of the plate that the processor compares the more accurate the result.

Low Speed, High Speed and Partial Suppression

- Low Speed: When **higher accuracy — the accuracy of the plate reads that are returned vs. the number of plate reads that are returned** — is required, **low-speed suppression** should be selected. That will allow you to specify the number of identical matches required within a given number of results (suppression window) for maximum accuracy. *Typical use case: a gated entrance to a campus or residential community, or the drive-through for a restaurant.*
- High Speed: If it is **more important that as many plates reads as possible are returned** regardless of accuracy, **high-speed suppression** should be selected. *Typical use case: citywide surveillance or monitoring of a major thoroughfare or highway.*

FYI	**Partial or distorted plates can be ignored when using either low- or high-speed suppression by checking the "Reject distorted or partial plates" box. This is recommended when doing perspective correction.**

- Partial: If it is important that **ONLY** partial plates be ignored, this kind of suppression is recommended.

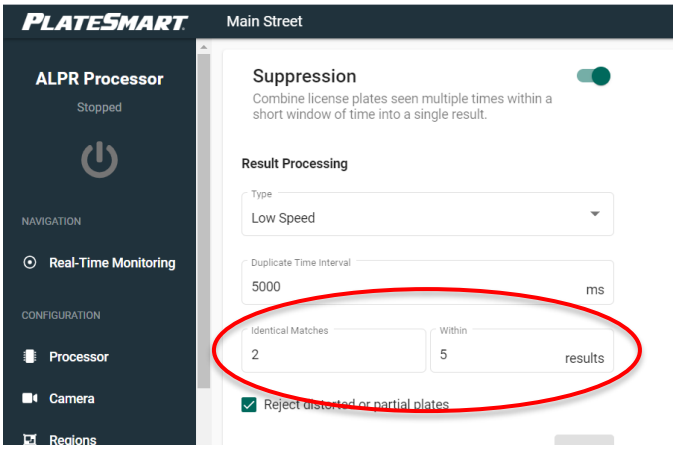
FYI	**High speed and partial suppression should be used with caution. Consult PlateSmart before using these suppression settings.**

1. Under “Configuration” in the left panel, click “Suppression.”
2. At the top of the window, you will see a toggle switch next to the “Suppression” headline. This is used to toggle suppression on and off. The default position is on.

FYI	**PlateSmart recommends NOT turning suppression off, as the processor could become inundated with duplicate plate reads.**

3. Under “Result Processing,” choose the type of suppression you would like.
    a. Low speed: you will also have to choose a duplicate time interval. This setting is used to determine vehicle dwell time. **With slow or stop/go traffic**, increase the duplicate time interval to cover the maximum time the vehicle is in the frame. This will avoid duplicates.
        i. You will also have to choose the number of duplicates you want the processor to review within a given number of results. As with choosing FPS described earlier, **use the reference table in the Appendix on page 18** to guide you.

FYI	**Choose the smallest number of duplicates required to get consistent accuracy. This will reduce demands on the CPU.**

FYI	**The default number of results within which the processor will look for duplicates is five. DO NOT change this setting without first consulting PlateSmart.** 

ii. Check the box next to “Reject Distorted or Partial Plates” if you would like to ignore such reads. PlateSmart recommends keeping this checked.

b. High speed: as with low speed suppression, you will also have to choose a duplicate time interval. You can also choose to reject distorted or partial plates.

FYI	**High speed suppression doesn’t offer an option for choosing the number of duplicates the processor should review, as high speed traffic generally doesn’t allow for many duplicates.**

c. Partial: there are no additional options to choose if you only want to suppress partial plate reads.

4. Click “Save.”
5. You can monitor suppressed results in real time (see page 9).

Using Perspective Correction

Some plates that are especially hard to read are those captured at an angle. PlateSmart Service Hub includes technology called Perspective Correction that allows users to instruct the software to take plate images captured at up to 40 degrees and essentially straighten them so they can be more easily — and accurately — read.

FYI	**Plate capture images with horizontal and vertical angles between 0 and 20 degrees and rotational angles between 0 and 15 degrees DO NOT require perspective correction in good environmental conditions.** **Plate capture images with horizontal, vertical, and rotational angles over 40 degrees will require the camera to be physically repositioned.**

1. Make sure the processor is running.
2. Under “Configuration” in the left panel, click “Perspective.”
3. Read the introductory information and click “Continue.”
4. In the upper right of the window, click “Start Recording.” This will give you the opportunity to pull a representative still image of a vehicle from your live camera feed to which you can apply Perspective Correction.
    a. If your camera is not yet live or if you do not currently have a lot of traffic to choose from, you can upload a representative series of still images on which you can perform perspective correction. Do this by clicking the “Upload” button — — to the left of the “Record” button.

5. Once you feel you have enough images from which you can choose one, click “Stop Recording” in the upper right. You will have a matrix of 42 images to choose from (Figure 4).

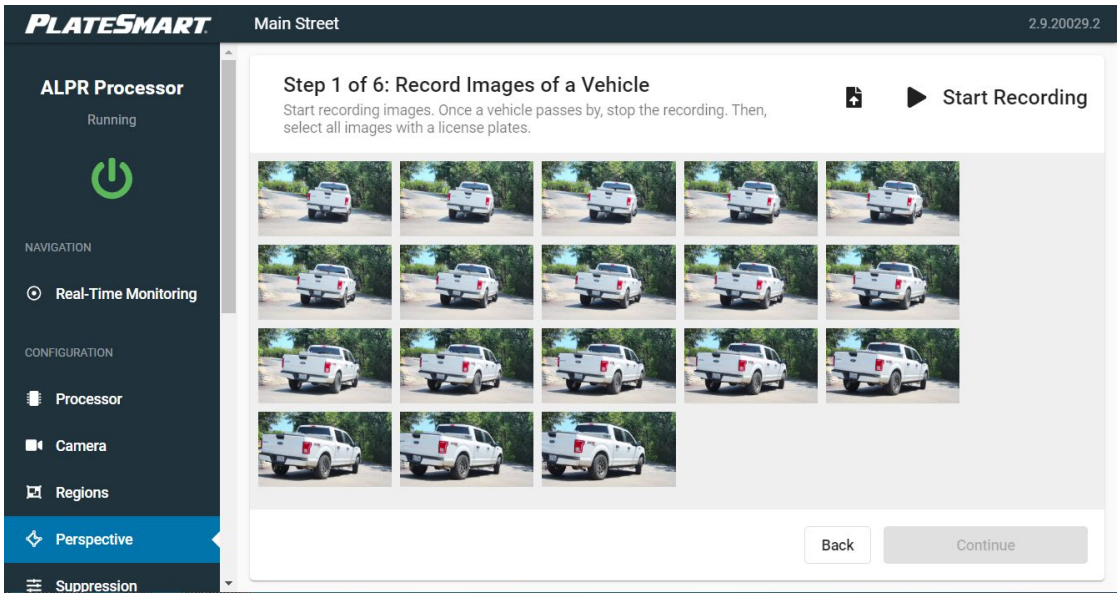


Figure 4

6. Click on one or more images that will be good candidates for Perspective Correction.
    a. Select images with plates at an angle of between 20 and 40 degrees.
    b. Choose images in which the license plate is as close to the center of the desired capture zone as possible.
7. Click “Continue.”
8. Now choose a single image on which you want to perform Perspective Correction. Again, choose an image with a license plate that is centered within the capture zone. Click “Continue.”
9. Draw a box around the license plate. The image will automatically zoom in on the box and the plate. You will see the box is defined by a dotted line with large dots on each corner.

10. Click each dot and move it so that the dotted lines align as closely as possible with the edges of the license plate (Figure 5). Click “Continue.”

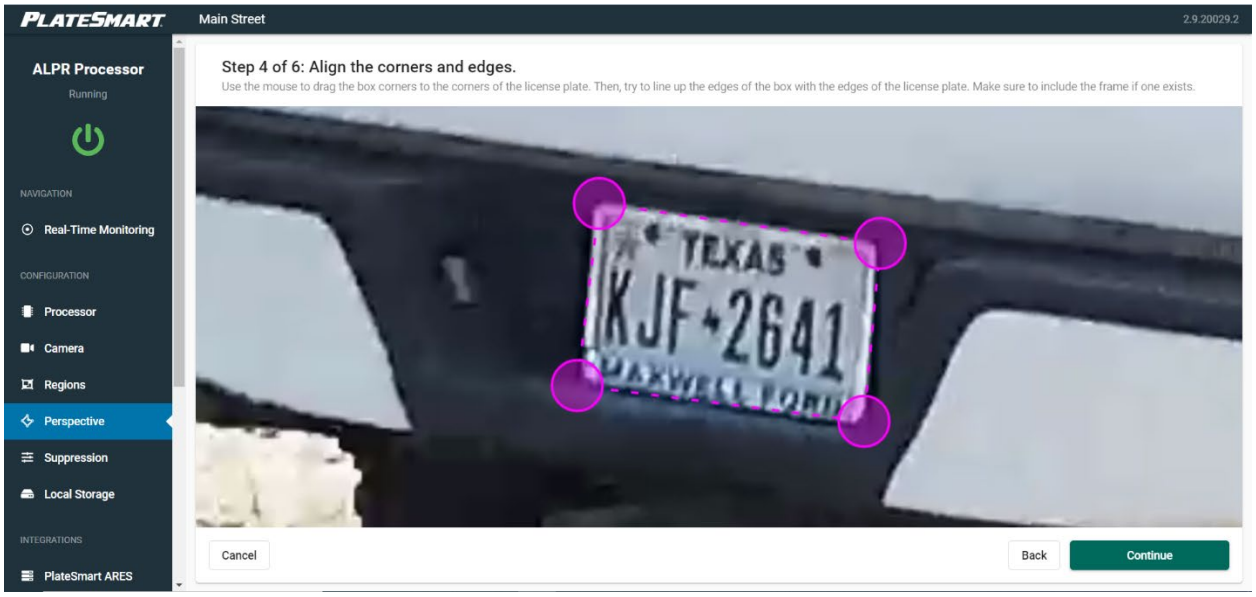


Figure 5

11. If necessary, drag the image so that the transformed license plate is in the center of the designated area. Click “Continue.”
12. Review the transformation to ensure it is correct (Figure 6). If it is not, use the “Back” button to go back through the steps of the transformation. If you are happy with the transformation, click “Save.”

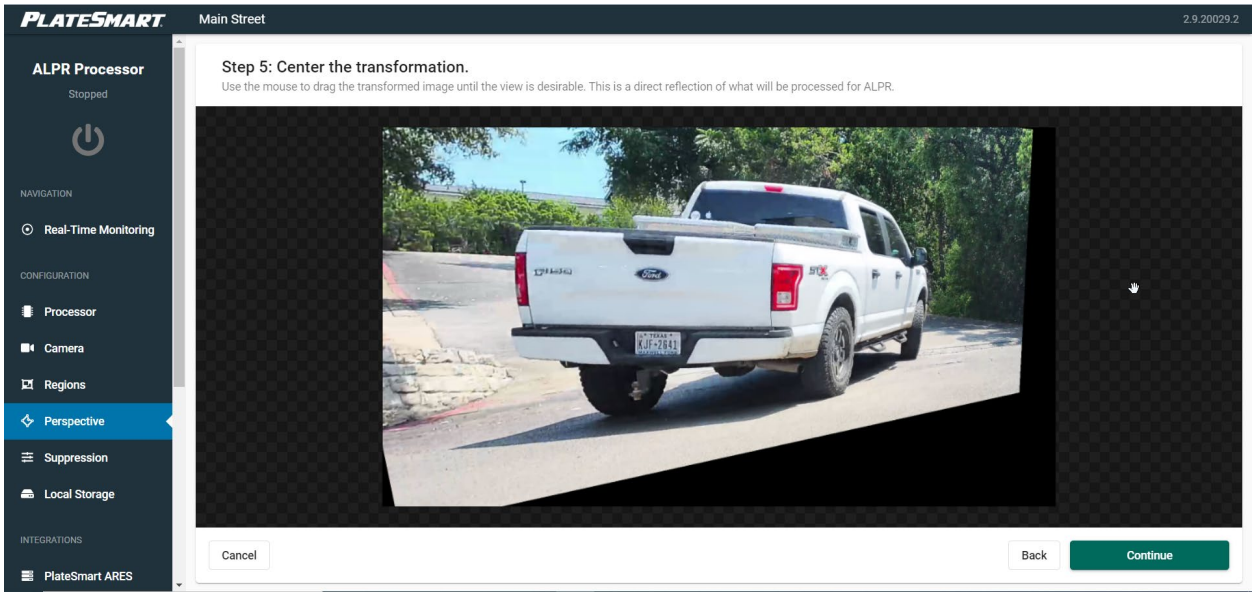


Figure 6

	**Review plate images captured near the left and right edges of the frame to ensure that the correction did not distort those images or otherwise make them unreadable. If this is the case, perform Perspective Correction again.**

	**The perspective correction will apply to the video feed moving forward. However, it DOES NOT affect the stored image, which will be the native frame in its original form, before correction.**

	**Perspective correction will incur an additional CPU load.**

Using Regions of Interest (ROI), Motion Triggers and Masks

Regions of interest (ROI), motion triggers and masks allow you to customize where and how images are captured within the frame.

- ROI can be used to filter out unwanted vehicle reads, such as those from an unwanted lane in the frame.
    - When adding an ROI, only the plates that appear in those regions will be processed by the ALPR processor.
    - You can create multiple ROI, for instance to capture two lanes of a four-lane road.
    - ROI can overlap, ensuring that plates do not get missed or to create unusual geometric regions.
- Masked areas prevent certain unwanted areas of the frame to ever be read by the ALPR processor.
    - While the processor can generally avoid being triggered by extraneous motion, masks can be used to cover areas with tree branches swaying, flags flying, etc.
    - Masks can be used to avoid any plate reads, such as those from a lane that the camera sees but is extraneous in nature.
- Motion triggers prevent the processor from doing any work until motion is detected in the frame. Additionally, depending upon the FOV, the motion trigger can also reduce the strain on the CPU.
    - Motion triggers prevent the processor for taking any action until motion is detected within the trigger region.
    - Motion triggers can help avoid extraneous motion from triggering the processor.
    - If vehicle traffic is infrequent, motion triggers can avoid taxing the CPU by causing the processor to only “pay attention” when motion is detected.

1. Make sure the processor is running.
2. Under “Configuration” in the left panel, click “Regions.”
3. You will see a window with a still image from your video feed.
4. In the upper right you will see four icons:
    a. Add an ROI
    b. ■ Add a mask
    c. Add a motion region
    d. Refresh the image
5. Choose the icon to add the item you want or to refresh the feed.
6. All regions are drawn as rectangles (Figure 7 on page 16). Click on a corner of the area you want to affect and drag until the rectangular area covers the area you want to affect.

	**You can draw multiple instances of ROI and masks on the screen, but you can only have a single motion trigger region. You can use these items in any combination to create fully customized effects for your application. As with perspective correction, these effects DO NOT affect the stored image, which will be the native frame in its original form before the effects are applied.**

    a. ROI appear as green rectangles.
    b. Masks appear as black rectangles.
    c. Motion regions appear as yellow rectangles.

7. If you want to redraw any area, click “Reset” to clear the screen.

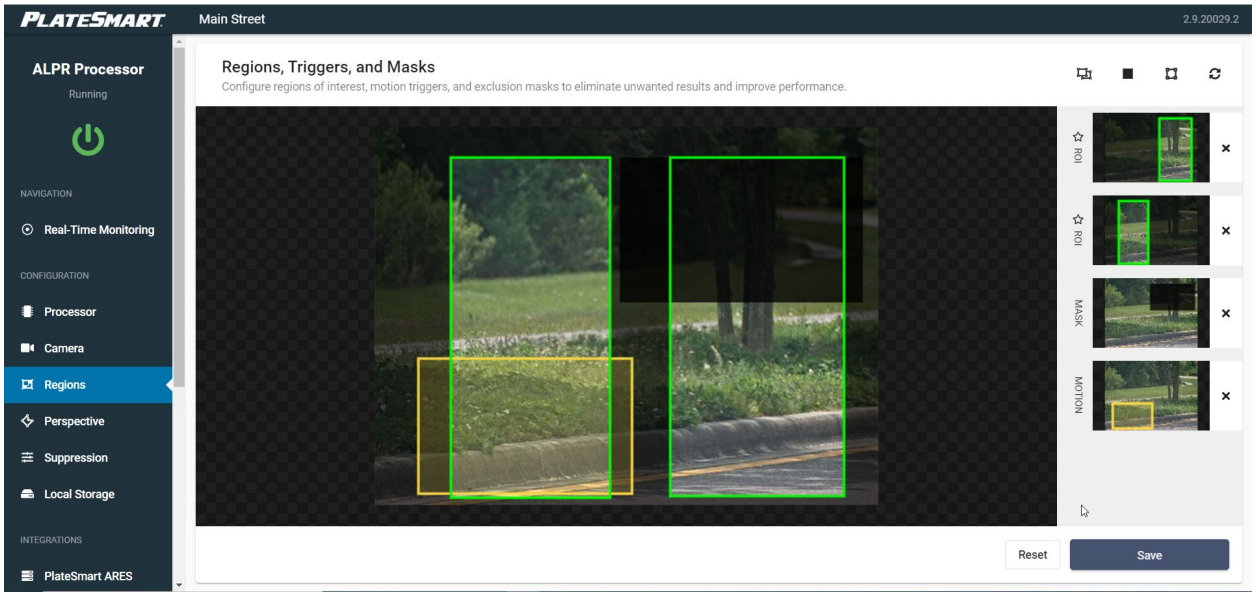


Figure 7

FYI	**You can draw multiple instances of ROI and masks on the screen, but you can only have a single motion trigger region. You can use these items in any combination to create fully customized effects for your application. As with perspective correction, these effects DO NOT affect the stored image, which will be the native frame in its original form before the effects are applied.**

8. Once you are happy with the regions, click “Save.” Your saved set of effects will appear on the right of the screen below the icons.

FYI	**You can create multiple sets of regions to be used at your discretion. They can be deleted individually, as well.**

Real-Time Monitoring

After these configuration steps, you will have the opportunity to monitor plate reads in real time. This is useful to ensure the system is working properly.

FYI	**This monitoring option is intended for diagnostic purposes only. DO NOT use this tool as a way for security personnel to continuously monitor traffic.**

1. Make sure the processor is running.
2. Below the on/off button, under “Navigation,” click “Real-Time Monitoring.”
3. To the right of the monitoring window, you should see a running list of plate reads that includes an image of the plate as well as the plate and vehicle data.
    a. In the upper left of the monitoring window, you should see a static image from your video source. Below this image are three switches:
    b. Show live camera stream: turn this switch on to view the live camera stream. As vehicles pass the camera, you should see their plate and vehicle information captured to the right of the monitoring window (Figure 8).

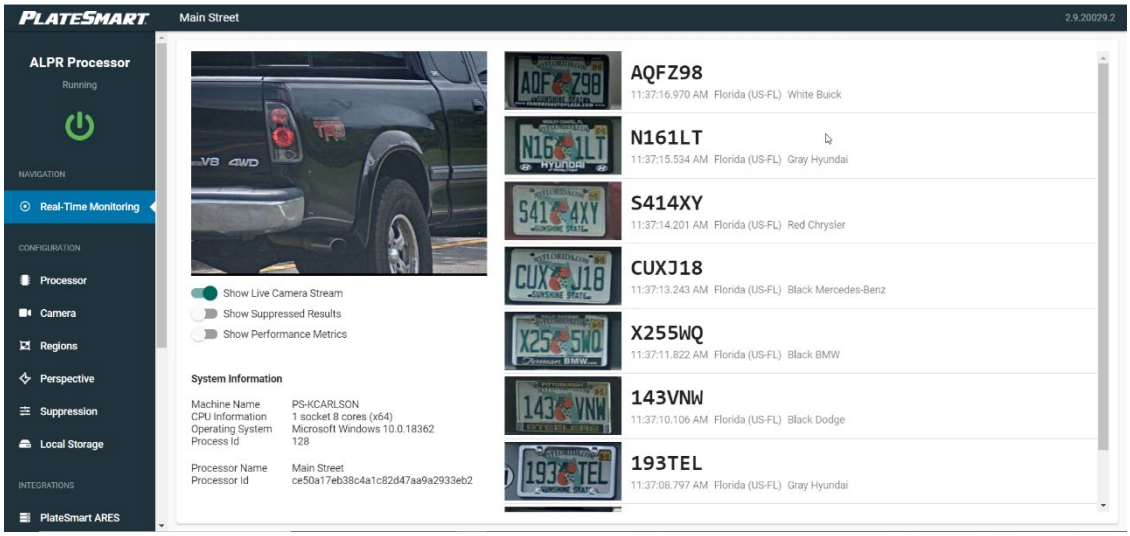


Figure 8

    c. Show suppressed results (see page 9).
    d. Show performance metrics. These metrics are typically used by PlateSmart support to help clients troubleshoot issues.

Appendix

FPS Reference Table

Frame rates highlighted in red exceed the maximum number you can specify for use with the PlateSmart ALPR software.

FOV Depth (ft)	Speed (MPH)	FPS Required to Get Specified Number of Plate Views		
		1 Plate View	2 Plate Views	3 Plate Views
9	5	1	2	3
	10	2	4	5
	20	4	7	10
	40	7	14	20
	60	10	20	30
	70	12	23	35
	80	14	27	40
	90	15	30	45
11	5	1	2	3
	10	2	3	5
	20	3	6	9
	40	6	11	17
	60	9	17	25
	70	10	19	29
	80	11	22	33
	90	13	25	37
13	5	1	2	2
	10	2	3	4
	20	3	5	7
	40	5	10	14
	60	7	14	21
	70	8	16	24
	80	10	19	28
	90	11	21	31
15	5	1	1	2
	10	1	2	3
	20	2	4	6
	40	4	8	12
	60	6	12	18
	70	7	14	21
	80	8	16	24
	90	9	18	27
17	5	1	1	2
	10	1	2	3
	20	2	4	6
	40	4	7	11
	60	6	11	16
	70	7	13	19
	80	7	14	21
	90	8	16	24
19	5	1	1	2
	10	1	2	3
	20	2	4	5
	40	4	7	10
	60	5	10	14
	70	6	11	17
	80	7	13	19
	90	7	14	21

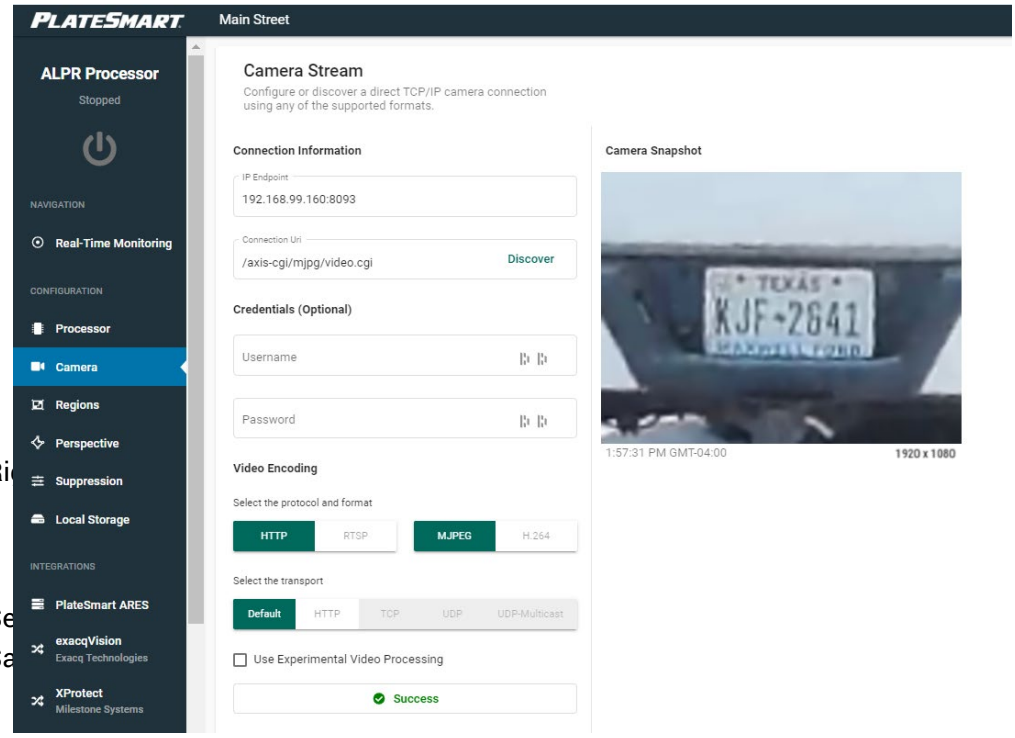
How to Measure a License Plate or Target Image

If your camera does not have an onboard tool for measuring pixels, you will have to do it manually.

Capturing a Representative Frame from the Camera

For calibration purposes, it's important to capture a *representative* frame from the camera — one that represents what the camera actually sends to the ALPR software. As such, **traditional screen captures WILL NOT work.** Instead, use the following procedure:

1. Open PlateSmart Service Hub.
2. Open the installed application that you are calibrating by clicking its name. This will open a new processor application window.
3. Under "Configuration," click "Camera."
4. Scroll to the bottom of the Camera Stream window and click "Test the connection."
5. If the connection is successful, you should see a static image from your camera in the upper right corner of the screen. This image is representative of what the camera is sending to the ALPR processor (Figure 9).



6. Ri
7. Se
8. Sa

Figure 9

Measuring Pixels

Many graphics programs can be used to measure the pixel width of a plate or reference image within the capture zone. PlateSmart recommends using Microsoft Paint, as it is readily available.

1. Open Microsoft Paint on your laptop.
2. Open the representative image described above in Microsoft Paint.
3. Using the rectangular selection tool, select the license plate only.
4. Observe the dimensions in pixels at the bottom of the window. (circled in red in Figure 11 below).

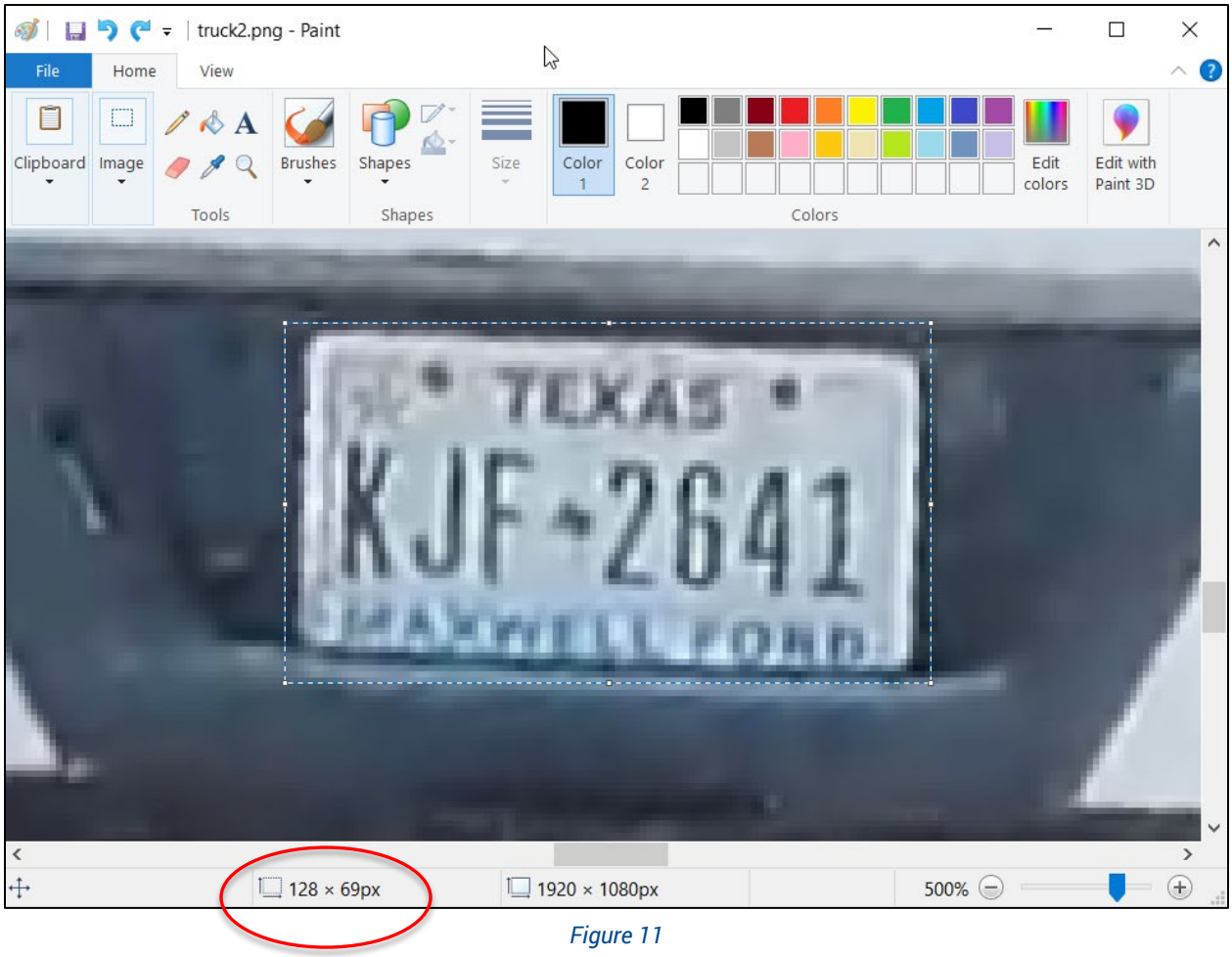


Figure 11

5. The width of the plate or reference object needs to be at least 120 px wide in order to achieve the 120 PPF requirement.