

# ENVI Tutorial: Target Finding with SAM and BandMax

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# Target Finding with SAM and BandMax

This tutorial shows you how to use ENVI's SAM Target Finder with BandMax wizard to differentiate planes in an airfield in San Diego, California.

## Files Used in This Tutorial

ENVI Resource DVD: `Data\aviris\sandiego_reflectance.img` (and `.hdr`)

This hyperspectral image is of a naval air station in San Diego, California, collected by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) sensor. The image was atmospherically corrected using ENVI's FLAASH module, resulting in a reflectance image.

# Introduction to the SAM Target Finder with BandMax Wizard

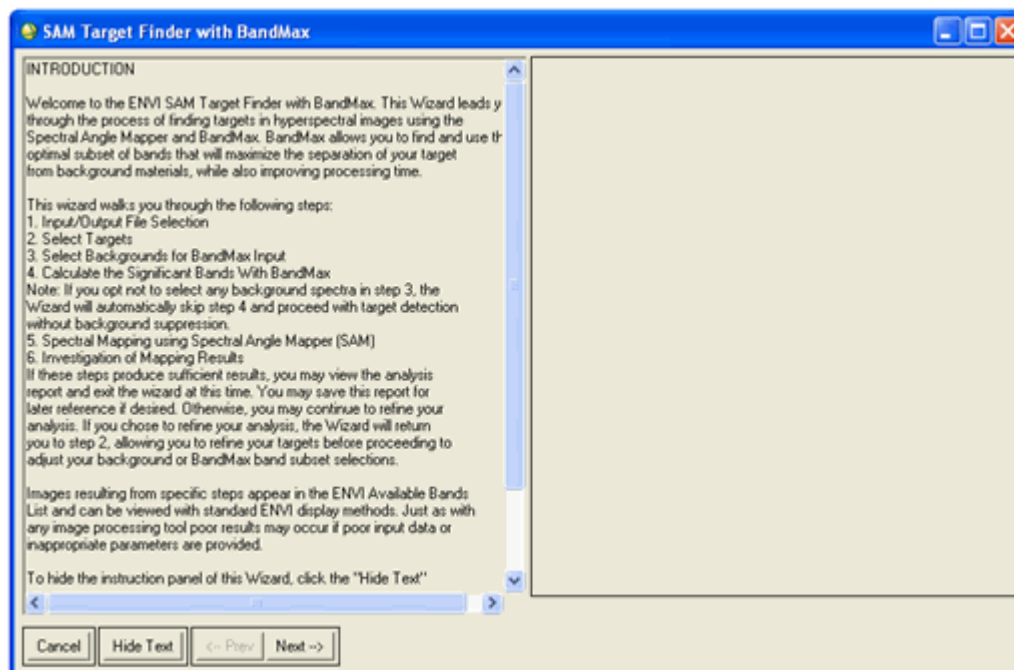
The SAM Target Finder with BandMax wizard guides you through a step-by-step process to find targets in hyperspectral images using a SAM classification and the BandMax algorithm. The BandMax part of the wizard increases classification accuracy by determining an optimal subset of bands to help you separate your targets from known background materials.

The BandMax algorithm was developed by the Galileo Group, Inc. The process is based on the United States patent application titled Spectral image processing system and method for target detection and identification.

See the flowchart on Page 2 for a summary of the wizard workflow, which involves six possible steps, listed below. These steps may occur multiple times in different order, depending upon the your analysis path:

- **Step 1: Select Input Image** — Select the input file and the root name of the output files for the wizard
- **Step 2: Select Targets** — Select the spectra to use as targets
- **Step 3: Select Background** — Select backgrounds to suppress
- **Step 4: Select Band Subset** — Identify significant bands to use in a SAM analysis
- **Step 5: Select SAM Parameters** — Define a SAM maximum angle parameter
- **Step 6: Examine SAM Results** — Analyze and examine SAM results. You may exit the wizard at this time if the results are acceptable

Each step is represented by a panel in the wizard. The Introduction panel (see figure below) explains the overall workflow of the wizard. The other panels in the wizard present the remaining steps.



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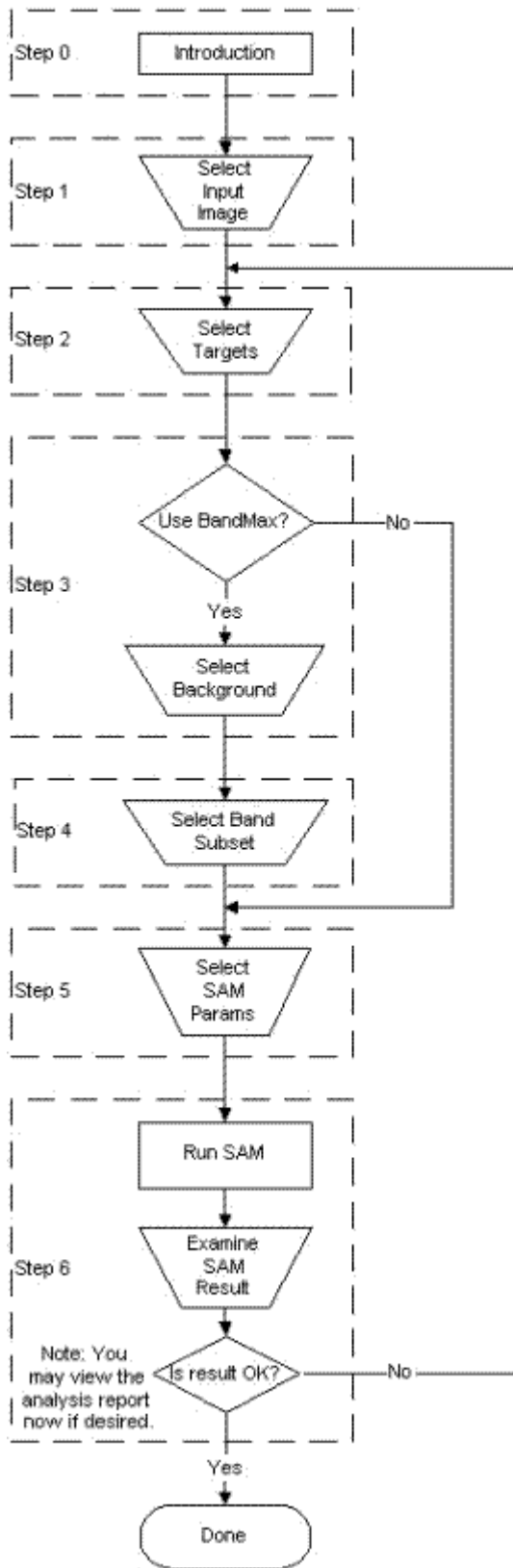
## The BandMax Process

Steps 3-4 represent the BandMax process. Step 3 allows you to select the input background spectra. Step 4 displays the BandMax results and enables you to change the parameters of the process to determine an optimal solution. The results displayed in Step 4 are updated when the parameters are modified.

BandMax rejects background data by determining a subset of spectral image bands that are useful in distinguishing between target and background spectra. These BandMax significance computations determine a band significance value for each band. This value is unitless and ranges from 0 to 1. A list of bands is then derived by comparing the band significance values to the threshold. The resulting band subset maximizes the contrast between selected target and backgrounds. This subset can then be used as input to a SAM analysis to reduce processing time and increase accuracy in processing the data by helping to discriminate targets from background clutter.

Target finding with BandMax is an iterative approach. The SAM analysis on the subset of significant bands may still produce false positives (data included in a resulting class that do not accurately represent a target). If examining the results shows that the classification accuracy is not sufficient, the wizard returns you to Step 2, where you can refine your targets and backgrounds before running BandMax and the SAM analysis again. You may continue to refine targets, select backgrounds, use BandMax to find the appropriate band subset, and re-classify your input data with SAM. Moreover, you may need to adjust the significance threshold in BandMax a few times to obtain an optimal subset for contrasting targets and backgrounds.

When your analysis is complete, you can save and view a report of the processing. Images resulting from specific steps in the wizard appear in the Available Bands List. As with any image processing tool, poor results may occur if you provide poor input data or inappropriate parameters.



## Select Input Data

1. Select **File > Open Image File** from the ENVI main menu bar. A file selection dialog appears.
2. Navigate to `Data\aviris` and select `sandiego_reflectance.img`. Click **Open**. A color composite is automatically loaded into a display group.
3. Double-click in the Image window to access the Cursor Location/Value dialog. Use this dialog to browse the image for objects that can be used as possible targets and backgrounds.



The image contains several planes. The most noticeable are at pixel locations (232, 136) and (244, 144). However, others appear near pixel locations (89, 11) and (143, 338). In this tutorial, you will use the SAM Target Finder with BandMax wizard to locate the planes near pixel location (89, 11) and to differentiate them from those at pixel locations (232, 136) and (244, 144).

## Evaluate Spectra and Start the SAM Target Finder with BandMax Wizard

1. From the Display group menu bar, select **Tools > Profiles > Z Profile (Spectrum)**. A Spectral Profile plot window appears.
2. From the Spectral Profile menu bar, select **Options > Plot Key** to display a legend with the spectrum name.
3. From the Display group menu bar, select **Tools > Pixel Locator**. A Pixel Locator dialog appears.
4. Enter the pixel location (**89, 11**).
5. From the Spectral Profile menu bar, select **Options > Collect Spectra**. This spectrum defines your target.
6. In the Pixel Locator dialog, enter the pixel location (**244, 144**). This spectrum defines a possible background.
7. From the Spectral Profile menu bar, select **Options** and deselect **Collect Spectra** to stop updating the Spectral Profile with spectra from the image.
8. From the ENVI main menu bar, select **Spectral > SAM Target Finder with BandMax**. The wizard appears with the Introduction panel.
9. Click **Next** to proceed to the Select Input/Output Files panel.

## Interacting With the Wizard

The left part of each panel shows a brief description of the step, requirements of the step, background information of the process used in the step, and useful analysis techniques for the step. The right part of the panel contains an interface with specific functions to perform for that step.

You can hide the left part of a panel by clicking Hide Text to only show the right part of the panel. If the left part is hidden, click Show Text to re-display it. Each panel also contains a Next button for continuing to the next step and a Prev button for reverting back to the previous step. Next is only enabled if you provide enough information to continue in the workflow. In some cases, a processing status dialog appears if the next process is performed before the next panel is initialized.

Unlike other wizards in ENVI, this wizard is not linear. It has conditional paths, where your input may induce a different direction in the workflow. You can also use the Next and Prev buttons to loop back through the wizard and repeat a series of steps. The Prev button maintains a list of the steps that were performed. This list enables the Prev button to still work even if you go through a conditional step or a series of steps looping through the wizard.

## Select the Input File

1. This panel represents Step 1 in the workflow. Here, you will specify the input file and the root name of the output files for the wizard.
2. Click **Select Input File**. The BandMax Wizard Input File dialog appears.
3. Select `sandiego_reflectance.img`. Click **OK**. The root name is automatically specified as the output root name.
4. To specify a different root name, click **Select Output Root Name**. The Select Output Files Root Name dialog appears. Specify the root name and path of the output files created throughout the wizard. If files with the specified root name already exist, you are prompted to allow the wizard to delete these files and continue. The files will be overwritten. If you do not want to overwrite the files, click No and specify a different root name in the Select Output Files Root Name dialog.
5. Click **Next** to proceed to the Target Selection panel.

## Select Targets

This panel represents Step 2 in the workflow. Here, you will collect spectra to be used as targets. The right part of this panel contains an embedded version of the Endmember Collection dialog (see ENVI Help for further details).

1. Right-click in the Endmember Spectra table to display a shortcut menu containing the spectra in the plot key of the Spectral Profile tool. Select **Import: X:89 Y:11**. The spectrum from (89, 11) appears in the Endmember Spectra table. This spectrum was collected to represent the target.
2. In the Endmember Spectra Table, select the row number column (on the far left) for the X:89 Y:11 spectrum. To select a spectrum, you must highlight the entire row. You cannot select a spectrum by clicking its Spectrum Name column.
3. Click **Next** to proceed to the Background Selection and Rejection panel. All the spectra selected in the Endmember Spectra table when you click Next are used as targets.

## Select Background

1. This panel represents Step 3 in the workflow. Here, you can select as “background” the pixel spectra that were incorrectly identified as targets in a SAM analysis. The BandMax algorithm will attempt to identify the bands that are best able to distinguish your targets from these backgrounds. This process works best when using a small set of target and background spectra.
2. Toggle **Select Backgrounds to Reject?** to **Yes**. The Select Background section appears in the right part of the panel. This section contains the same items as the Target Spectra section in Step 2 of the workflow. If you did not want to specify any backgrounds, you would leave Select Backgrounds to Reject? set to No. Then, you would click Next to skip to the Select SAM Mapping Parameters panel, which represents Step 5 in the workflow.
3. Right-click in the Endmember Spectra table and select **Import: X:244 Y:144**. The spectrum from (244, 144) appears in the Endmember Spectra table. This spectrum was collected to represent the background.
4. In the Endmember Spectra Table, select the row number column (on the far left) for the X:244 Y:144 spectrum.
5. Click **Next** to proceed to the Select Optional Bands panel. All the spectra selected in the Endmember Spectra table when you click Next are used as backgrounds.

The BandMax algorithm examines your target and background spectra to determine which bands are most significant for distinguishing your targets from the specified background. The best results are usually achieved if one target is selected for each wizard session. In this case, BandMax chooses a band subset that is optimized for that individual target.

## Select Band Subset

This panel represents Step 4 in the workflow. Here, you will customize the band subset used to suppress your backgrounds. The BandMax algorithm calculates a significance value for each band in the input image. This unitless value ranges from 0 to 1, where a higher value indicates the band has a higher probability of distinguishing a target response from a background response. BandMax compares the significance value to a significance threshold to derive a subset of bands, based upon the current list of targets and backgrounds.

1. In the **Band Significance Threshold** field, enter **0.2775**.

The initial threshold (0.2475) was derived to produce a subset containing about 25% of the number of bands in the entire file. Since sandiego\_reflectance.img contains 224 bands, the initial threshold produces 47 significant bands. This number may be too large to accurately differentiate between targets and backgrounds. Increasing the threshold to 0.2775 produces a smaller number of bands (32). You can change either the Band Significance Threshold value or the Number of Significant Bands to determine the optimal band subset for distinguishing between targets and backgrounds. A higher threshold produces fewer bands.

Click **Save Significant Bands to File** if you want to save the band subset in the Significant Bands list to an ASCII file. When you have derived the subset of bands that effectively detects your targets, you may want to use this same band subset to perform a series of classifications on a set of images from the same sensor. This output ASCII file can be used as input when spectrally subsetting a file.

2. Click **Next** to proceed to the Select SAM Maximum Angle Threshold panel. The bands in the Significant Bands list form a band subset that is used as input in the following SAM analysis.

## Define SAM Parameters

This panel represents Step 5 in the workflow. Here, you can specify the maximum angle threshold for the SAM analysis. Decreasing the threshold usually results in fewer matching pixels (better matches to the reference spectrum). Increasing the threshold may result in a more spatially coherent image; however, the overall pixel matches will not be as good as for the lower threshold.

1. In the **SAM Maximum Angle** field, enter **0.08** to refine the SAM analysis.
2. Click **Next** to proceed to the Investigate SAM Results panel.

## Examine SAM Results

This panel represents Step 6 in the workflow. Here, you can display and examine the results of the SAM analysis. The output from SAM is a classified image and a set of rule images corresponding to the spectral angle calculated between each pixel and each target (one rule image per target).

1. Click **Load SAM Class Result**. The class image resulting from the SAM analysis appears a new display group.
2. Double-click in the Image window of the class image to access the Cursor Location/Value dialog. As mentioned in the information text for the Investigate SAM Results panel, targets should appear as spatially coherent classes. The most coherent objects in the resulting class image appear in the upper-left corner of the image near (52, 33), (70, 22), and (89, 11). Other objects appear in the class image, but they are not as coherent as the ones in the upper-left corner.
3. Click **Rule (X:89 Y:11)** in the SAM Rule Image section, then click **Load SAM Rule Image**. The rule image related to the target selected in the SAM Rule Image section replaces the class image in the display group. A histogram tool and a color table dialog also appear. The plot in the Input Histogram section of the tool represents the histogram of the rule image. The flat line between 0.000 and 0.095 verifies that the results contain target information. For example, the targets (with small spectral angles) are well-differentiated from everything else in the scene. Furthermore, the targets are the brightest objects shown in the rule image.

If the targets had not been differentiated, you would click the Next button to return to Step 2 (see "Select Targets" on page 10) to refine your targets, backgrounds, or the BandMax process. The wizard was designed to allow iterations to help you determine the best results. In fact, the Band Significance Threshold and SAM Maximum Angle values used in this tutorial were actually derived by iterating through the wizard several times.

## Report the Results

1. Click **Show Report** in the Investigate SAM Results panel to display the SAM Target Finder with BandMax Summary Report window. This text report contains the following results for the SAM Target Finder with BandMax wizard:
  - Input file (and any spatial subset) for the wizard
  - Specified targets
  - Specified backgrounds
  - Specified band significance threshold
  - Resulting significant bands subset
  - Output files of the SAM analysis
  - Specified maximum angle parameter for the SAM analysis
2. From the text window menu bar, select **File > Save Text to ASCII**. An Output Report Filename dialog appears.
3. Enter the output filename `sd_reflectance_results.txt` and click **OK**. The text information in the window is saved to the specified file.
4. From the text window menu bar, select **File > Cancel**.

5. Click **Finish** in the SAM Target Finder with BandMax wizard.
6. Select **File > Exit** from the ENVI main menu bar.