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**Waygate
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a Baker Hughes business

Blade Counter (v1.0)

datasheet



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1. Introduction

Waygate Technologies' now offers Feature Detection analytic technology providing the solution for counting blades passing through the live scene during in-situ gas turbine visual inspections.

All of this is now made possible using Mentor Visual IQ borescopes.

Based on the InspectionWorks ecosystem, algorithms (analytics) can be deployed to the borescopes, placing enhanced technology capability at the point of inspection.

The ability to count blades during live video visual inspections enables the user and subsequent reviewers to identify individual blades without subjectivity or influence by human error.

Inspections become more objective; more consistent; more productive.

2. What is the Blade Counter Analytic?

Waygate Technologies has developed the ability to count and display the number on-screen during live in-situ gas turbine visual inspections. It has the ability to:

- Count up or ascend
- Count down or descend
- Bi-directional
- Start the count with user-defined number (default set to '1')
- Facility to enter total number of blades within stage (if known)
- Customize location of 'blade count' text box to coincide with specific user requirements
- Operate using one of two sensitivity options to maximize likelihood of blade edge detection

3. Warnings

Analytic applications are intended to assist the user whilst performing in-situ visual inspections.

Results will vary depending on your application and the method employed during setup.

The user is responsible for following the appropriate procedures and standards.

Waygate Technologies cannot be held responsible for the accuracy and outcome of any inspections.

Users must review this datasheet for intended use and limitations prior to use.

Before use on a live borescope visual inspection, this analytic requires the User to perform a verification process. This is needed to extract the greatest performance from the analytic.

Note that this analytic has an added feature to enable Users to toggle between 'low' and 'high' sensitivity modes. 'Low' setting is the factory default. 'High' setting may be required to detect problematic scenes whereupon sufficient contrast is difficult to achieve whilst operating the default 'low' mode. Only activate this 'high' setting if verification is difficult to achieve whilst in the default setting.

Ensure use of the standard 'low' sensitivity setting during for all other inspections.

4. Prescribed usage

This analytic is designed to operate whilst performing routine gas turbine visual inspection tasks using the Mentor Visual IQ borescope.

It has been developed based on a range of gas turbines from industry leading OEMs.

5. Dependencies

5.1 Device Hardware and Software

- Only operable on the Mentor Visual IQ (MViQ) Flame ("C" model) borescope
- Operating software version 3.60 or later
- Activated with MVIQ-BLADECOUNT Feature Key (free trial or purchased)

5.2 Analytic

Blade Counter analytic will only function if MViQ is in the 'live' video state.

It is however possible to enter other states whilst operating the analytic. In order to ensure continued reliable operation, it is recommended the user first ceases rotation before entering other states within the borescope operating system e.g. Global Menu, Settings or Freeze Frame etc. The analytic will continue to operate once returned to the 'live' state.

Probe Movement: blade counter analytic will only function as designed if MViQ probe is stationary during operation. Some minor movement of the probe is permissible but not recommended. A function to reveal the 'tracking region' or Blade Counter Lines is available. This can be activated to enable probe re-adjustment back to its original position if needed. This function also serves to remind the user of the assigned region and the precise location where the analytic is triggered.

Image Transforms: these are the functions available to users that affect the appearance of the live video e.g. brightness, dark boost and distortion correction. There are however certain image transforms that are not permissible once Blade Counter analytic is activated. As a result, they are deactivated whilst using Blade Counter. They are:

- Invert
- Single view
- Rotate

Blade Counter analytic will only reliably function if setup to ensure the 'tracking region' does not include background static or stator vane aerofoils. This is required to ensure the region includes the contrast associated with the rotating blade only.

6. Operating instructions (3.60 Mentor Visual iQ Release)

6.1 Activating/de-activating the analytic

1. Enter MVIQ Global Menu and select 'Analytics'
2. Review and accept disclaimer
3. 'Still Analytics' page is now displayed. Select 'Live Analytics' softkey to view next page
4. Select 'Blade Counter' tile and toggle from 'off' to 'on' state
5. Press 'Done' softkey

Note the appearance of the analytics icon positioned in the status bar. This remains visible when one or more analytic has been activated.

Repeat this procedure to de-activate the analytic albeit tap the tile from 'on' to 'off' within Step 4.

6.2 Using the Blade Counter Analytic

6.2.1 Setup overview

Upon activation of Blade Counter analytic (outlined within Section 6.1), the user must first undertake a series of steps before being able to conduct a visual inspection with the analytic in operation.

The following steps outline the setup procedure to create an acceptable tracking region in which the analytic will reliably operate.

Setup Rules:

- Entry and Exit Lines must be parallel to the blade at some point as it passes through the Field of View (FoV).
- For views with large changes in blade angle, the distance between the Entry and Exit Lines must be kept short.
- Entry and Exit Lines are the positions where the blade edge enters and exits the FoV in accordance with the preferred direction of rotation.
- Limit Line should be placed between the Entry and Exit Lines.
- The Limit Line should be roughly perpendicular to the Entry and Exit Lines.
- The Limit Line must not cover more than one blade edge at a time.
- The Limit Line should be placed such that stator vane aerofoils or nozzle guide vanes are occluded from view.

- Trigger Point must be positioned to coincide with a location with sufficient visual contrast.
- The Trigger Point should be positioned near to the middle of the Limit Line.

The below image shows a typical setup that follows the rules outlined above.

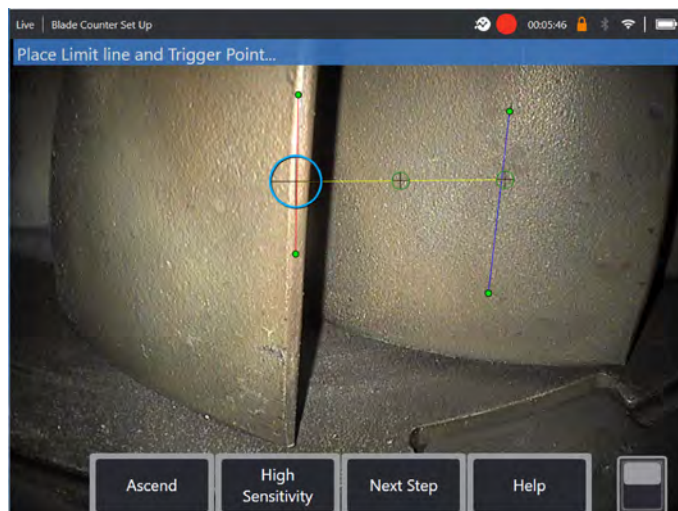


Figure 1a Typical setup showing all lines placed correctly

The below image shows a typical setup that does not follow the rules outlined above.

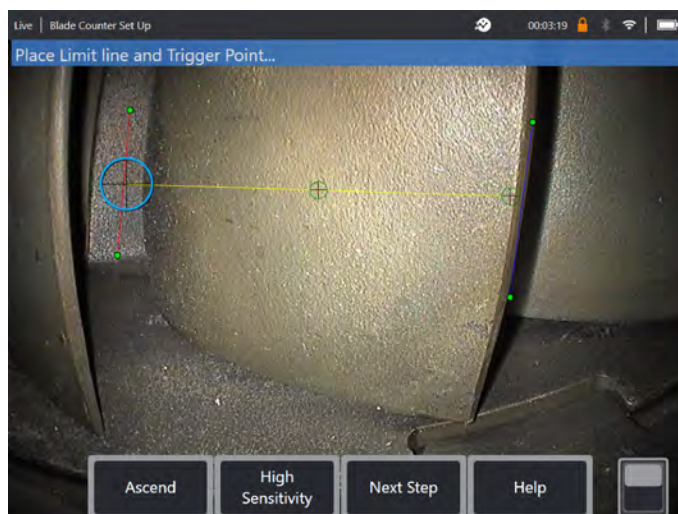


Figure 1b. Typical setup showing lines placed incorrectly i.e. including background scene

6.2.2 Entry Line

Adjust and position the probe to a suitable position upon which to conduct the visual inspection.

The operation of the Blade Counter analytic requires the probe to remain stationary.

Move the blade aerofoil to simulate entering the desired 'tracking region.'

The Entry Line is displayed as a blue line. Adjust cursors and position line to coincide with blade edge (Figure 2a and 2b).

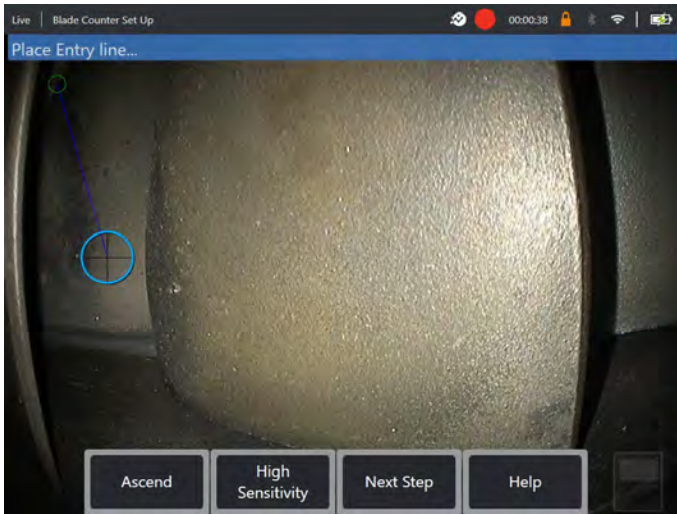


Figure 2a. Initial state post-Analytic activation

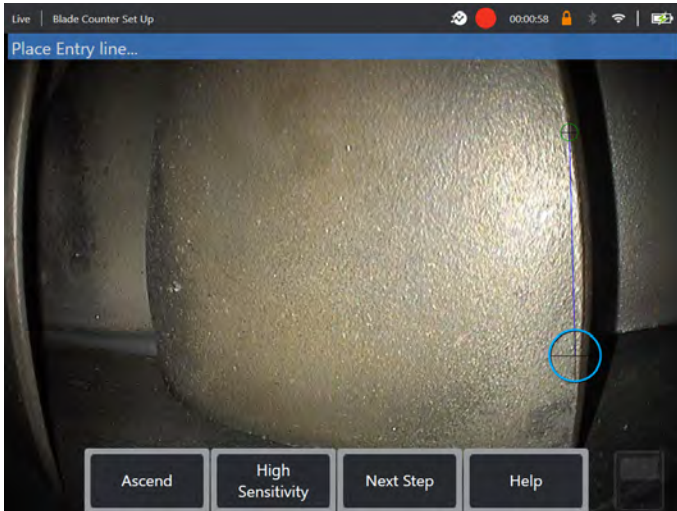


Figure 2b. Adjust Entry Line to aerofoil edge Press 'next step' softkey once complete.

6.2.2 Exit Line

Move the blade aerofoil position to simulate exiting the desired 'tracking region'

The Exit Line is displayed as a red line. Adjust cursors and position line to coincide with blade edge (Figure 3a and 3b).

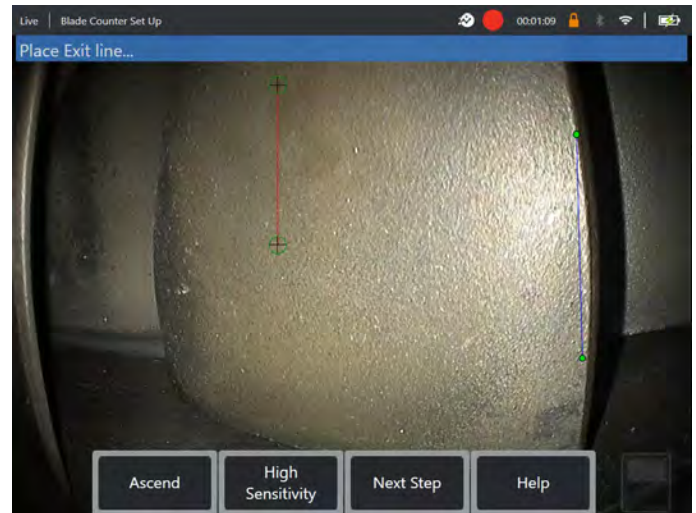


Figure 3a. Initial state post Entry Line assignment

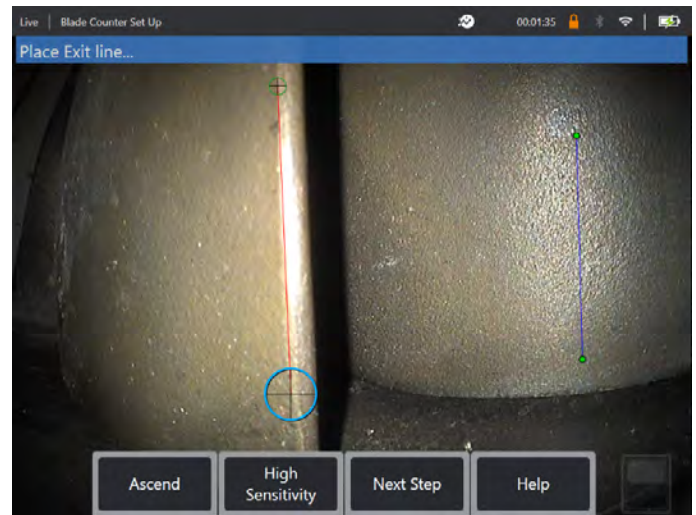


Figure 3b. Adjust Exit Line to aerofoil edge Press 'next step' softkey once complete.

6.2.3 Limit Line & Trigger Point

No movement of blade aerofoil is required within this step.

The Limit Line is displayed as a yellow line. Adjust cursors and position line to coincide with both Entry and Exit Lines (Figure 4a and 4b).

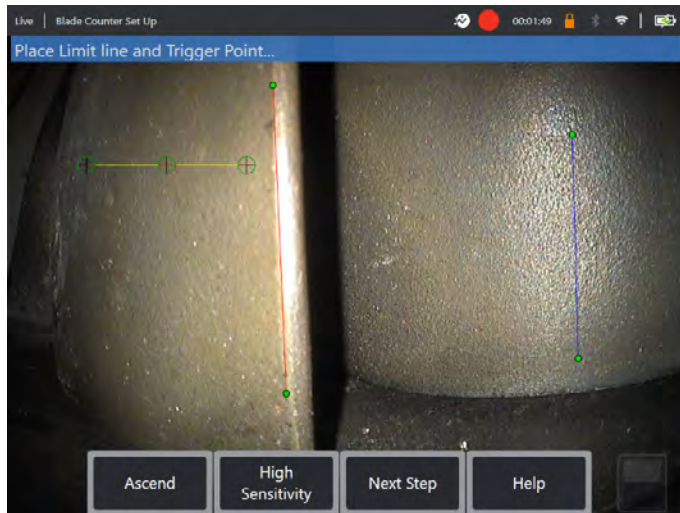


Figure 4a. Initial state post Exit Line assignment

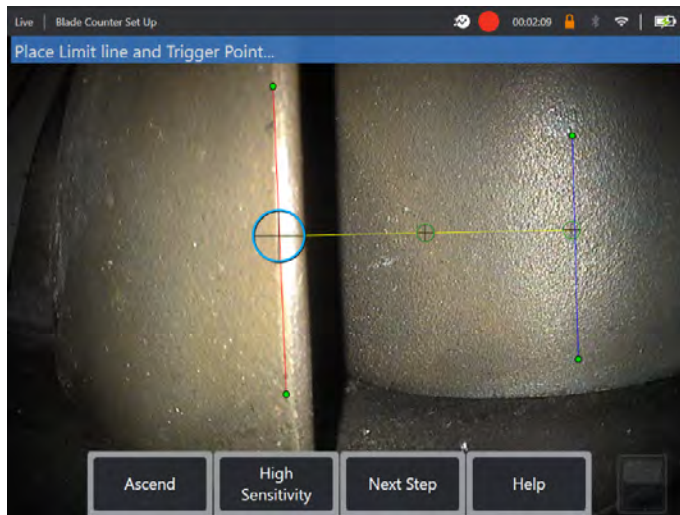


Figure 4b. Adjust Limit Line between both Entry and Exit Lines

The Trigger Point is rendered to the center of the Limit Line. If required, adjust its location to the desired position.

This precise point will coincide with the Blade Counter incrementing one digit (up or down).

6.2.4 Optional Step – Assign ‘Ascend’ or ‘Descend’ Setting

It is possible to configure the Blade Counter to count either Ascending (factory default) or Descending. If the latter is required, press ‘Ascend’ softkey to reveal ‘Descend’ softkey.

The factory default is to count-up as the blade passes from the Entry to the Exit Line.

Note – it is possible to make this adjustment later once the analytic is in operation via the Settings menu.

Press ‘next step’ softkey once complete.

6.2.5 Finalize Cursor Positions

It is now possible to check and re-adjust any of the cursors applied before enabling the subsequent verification process. For example, if probe was nudged and some or all points need to be amended (Figure 5).

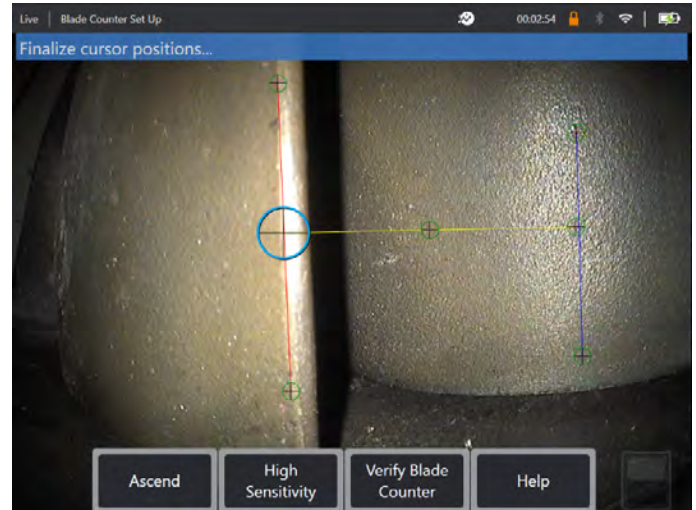


Figure 5. Finalize cursor position positions

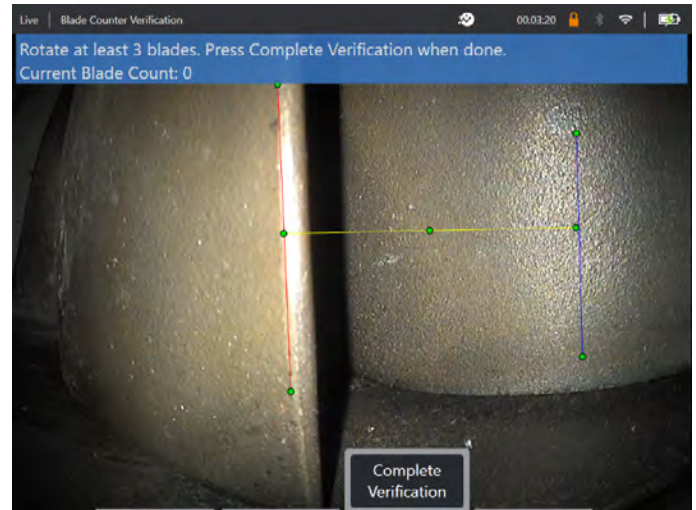


Figure 6. Showing the banner message associated with blade counting during verification.

Ensure the count coincides with the true number of blades passing through the tracking region and more specifically the trigger point.

Stop engine rotation after at least three blades have been rotated.

Now press 'Complete Verification' softkey and answer the following question presented in Figure 7.

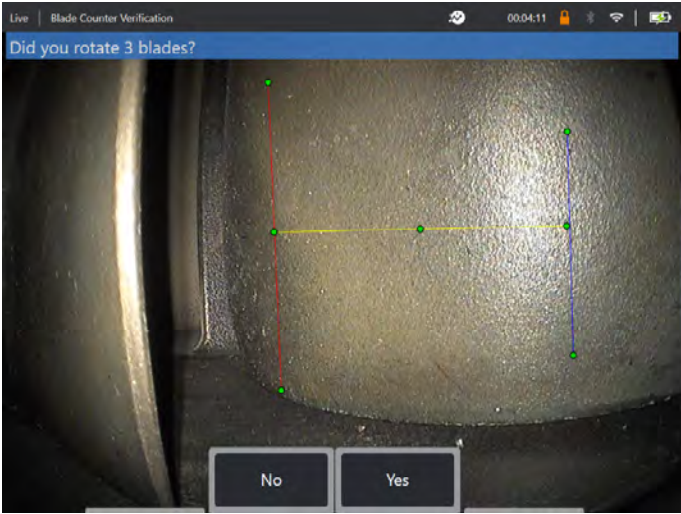


Figure 7. Did you rotate 'x' blades?

If the answer is 'No', then press that softkey and proceed through Section 6.2.7 for further guidance.
If the answer is 'Yes', then press that softkey and follow Section 6.2.6.

6.2.6.1 Post-Verification Number Assignment

Before embarking on the visual inspection, it is now possible to:

- Enter the total number of blades in that stage. This function enables the counter to return to blade number 1 at the appropriate point to ensure a complete revolution had been performed (Figure 8a). Maximum limit is 999 blades.
- Enter the blade number upon which the inspection begins (Figure 8b).

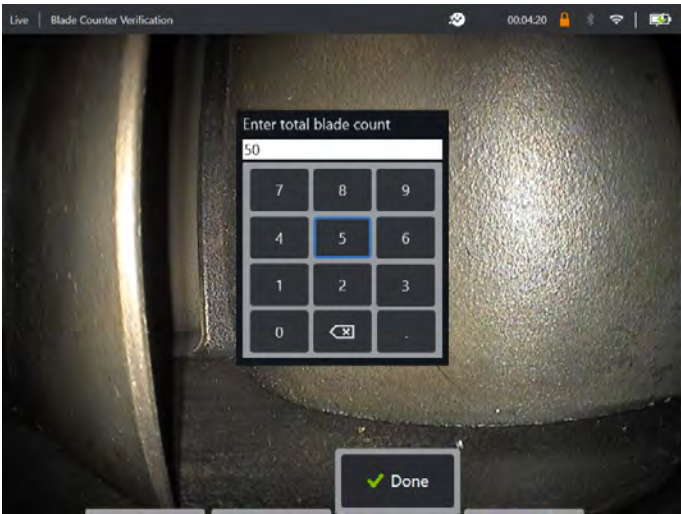


Figure 8a. 'Enter total blade count' prompt

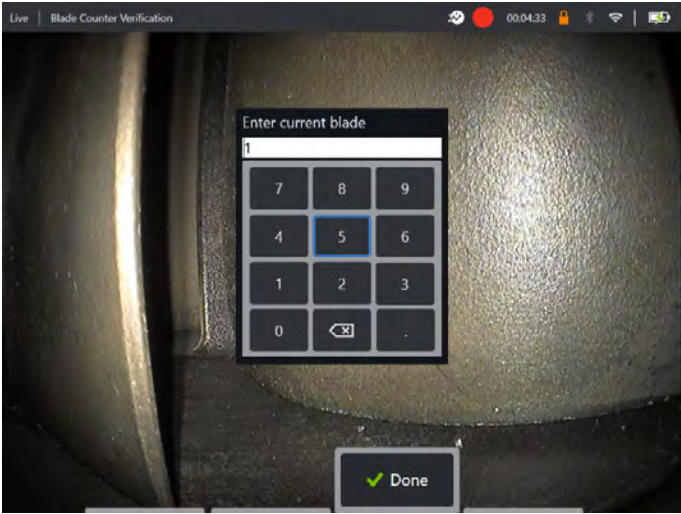


Figure 8b. 'Enter current blade' prompt

Press 'Done' softkey to launch Blade number textbox on screen (Figure 8a).

6.2.6.2 Blade Number Textbox Positioning

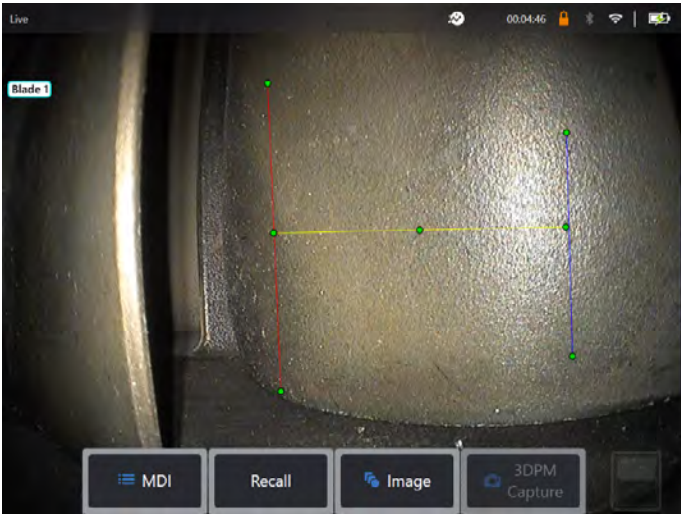


Figure 9a. Blade Counter active showing blade number textbox.

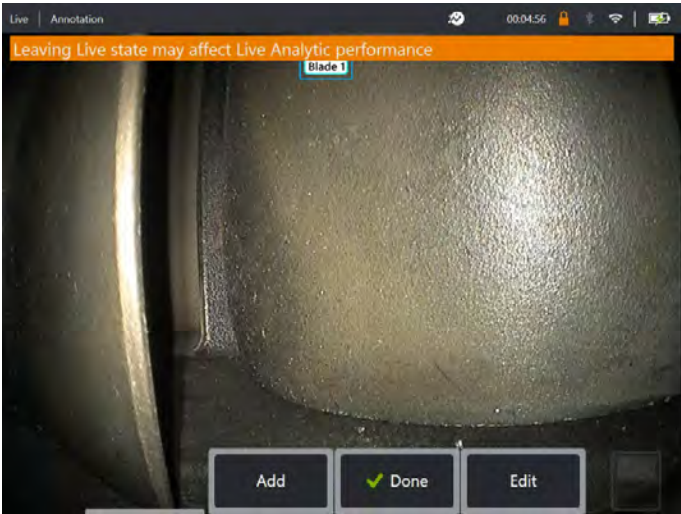


Figure 9b. Blade Counter active showing adjusted blade number textbox.

The textbox can be treated like any other textbox and so can be moved to any desired location on screen. For example, if multiple blades are visible within the FoV, move its location to coincide with actual blade being counted (Figure 9b).

Note however, as stated in Section 5.2 ('Dependencies') that the analytic will pause when the borescope enters a different state e.g. when editing or adjusting position of the textbox. An amber banner is temporarily presented to warn the user of this risk. It is therefore best practice to pause engine rotation should it be needed to enter into a different state. Resuming 'live' state will reactivate the analytic.

6.2.6.3 Blade Number Lines: On/Off

Once the user has positioned the blade number textbox to the desired position or location, the visual inspection can begin.

The facility to view the assigned tracking region exists for any point during the inspection. This offers assistance to remind the user of its relationship with the blade edge if indeed the probe has been moved out of its original position.

From the 'live' state, press 'Image' softkey and press the 'Blade Counter Lines' tile to re-reveal the tracking region (Figure 10a, 10b, 10c and 10d).

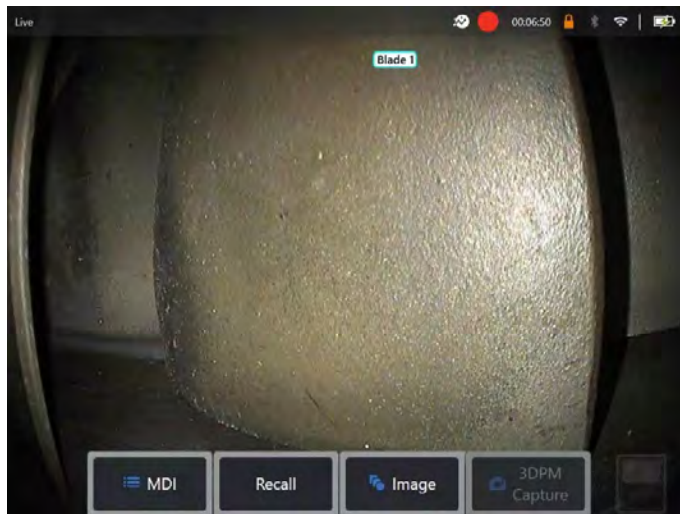


Figure 10a. Blade Counter active showing 'live' state.

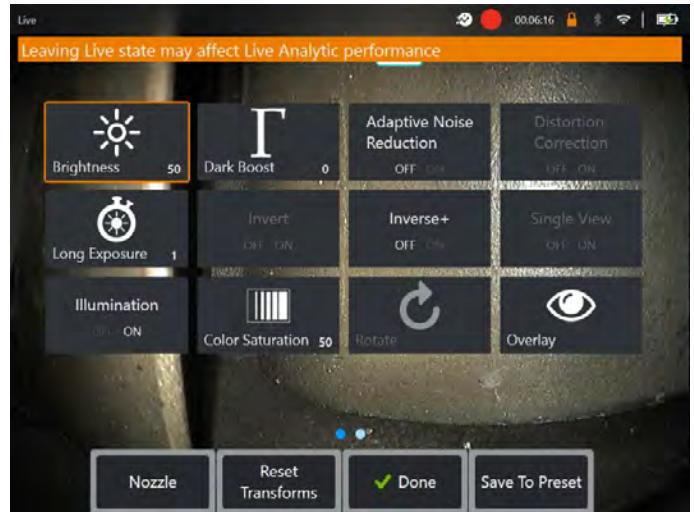


Figure 10b. 'Image' sub-menu showing all image transforms. This view differs dependent on MViQ model. 'Blade Counter Lines' tile can be positioned on Page 2.

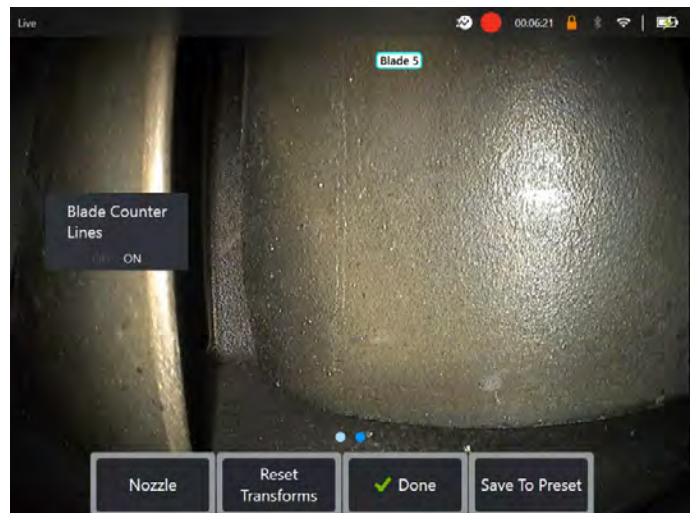


Figure 10c. 'Blade Counter Lines' tile may be located on Page 2 for some MViQ models. Use this button to toggle appearance of lines.

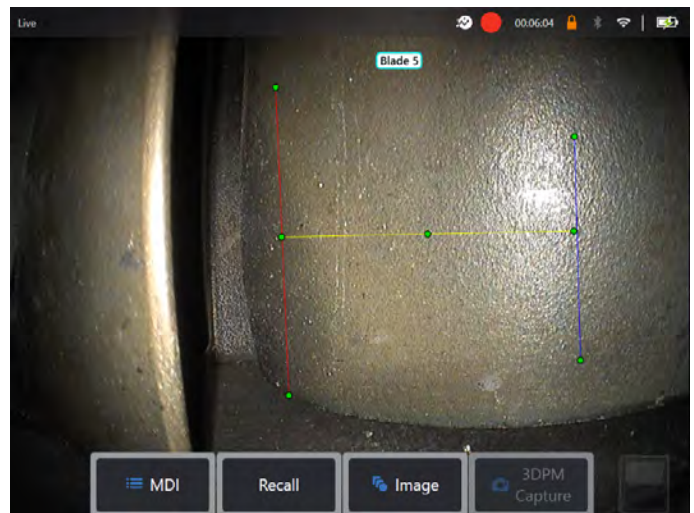


Figure 10d. Blade Counter active showing original tracking region or blade counter lines.

Repeat this process to de-activate the lines at any point during the inspection. Remember however to pause engine rotation to ensure the analytic does not miss any subsequent triggers from passing blades.

Note: The 'lines' are not retained or captured within any subsequent saved images. They do however remain visible if present on-screen during video capture.

6.2.7 Failed Verification – next steps

It is possible for the analytic to not correctly count the aerofoils during verification. Some or all blades may not be detected due to insufficient contrast between the desired blade edge and the adjacent background scene. Alternatively, the Blade Counter may trigger unexpectedly due to other edges detected within the tracking region.

It is therefore important to press the 'No' softkey (shown in Figure 7) and re-attempt blade counter setup.

The user is invited to re-assign the lines in accordance with Section 6.2.2 to 6.2.6. Attempt one of the following actions in order to succeed with subsequent verification attempts whilst adhering to the boundary conditions listed within Section 6.2.1:

1. Re-assign the lines to a different position within the given FoV that presents a greater contrast. For example, rotate the blades to a different position to provide added contrast to the blade edge.
2. Press the 'Sensitivity: low' softkey to activate a function to increase the analytics ability to detect lower contrast threshold limits. Note: 'Sensitivity: low' setting is the recommended default. Note – it is not possible to adjust this setting post-verification i.e. once analytic is operational and showing the Blade Counter textbox on-screen.
3. Re-adjust the probe to an alternative viewpoint in order to achieve greater contrast of the blade edge.
4. Adjust the illumination or brightness setting.

7. Technical Support

Technical Support contact information follows:

Global Phone: 1-866-243-2638 (Mon – Fri 8:00 AM – 5PM E.S.T. North America)

Waygate Technologies Remote Service email:
RemoteService@BakerHughes.com

Please also provide the following important details:

- Handset model number
- Handset serial number

8. Revision history

Revision number	Date issued	Reason
1.0	December 2021	Initial Launch

9. Frequently Asked Questions (FAQs)

Q: How do I obtain this Blade Counter analytic?

A: A free trial should be activated after installing 3.60 software. After that, contact your local Waygate Technologies sales representative.

Q: Is it possible to create other or indeed modify/enhance this Blade Counter analytic for other engine variants; other components or scenes?

A: Yes. Waygate Technologies are committed to delivering Inspection Solutions to the industry. Please contact your local Waygate Technologies sales representative to discuss your needs.

Q: What is 'feature detection' within the Blade Counter analytic?

A: It is technology designed to detect, track and trigger an edge within a defined region of interest. It requires sufficient, and repeatable, contrast to enable reliable triggering from 'edges' that pass through this region.

Q: Why should I consider using the Blade Counter analytic?

A: Provides ability to display a blade number during a live visual inspection.

A: Reduces human factors associated with engine inspections. No more mis-counting, mis-labelling or missed blades.

A: Reduces inspection time by not having to perform manual annotation.

A: Improves consistency and reliability of inspection tasks.

A: Reduces the probability of missing blades during visual inspection tasks.

A: Increases the overall quality of inspection output. Blade Count output can be preserved within i) live video recording or ii) still image capture(s) and therefore embedded into an inspection report.

Q: Which engine components is it designed to operate on?

A: Designed to work on all gas turbines albeit largely tested on commercial aerospace engines.

Q: How was this Blade Counter analytic validated?

A: Extensive testing on a variety of aero-derived gas turbine architecture. This analytic has not been validated by any gas turbine OEM but extensively tested by Waygate Technologies.

Q: Which tips or Optical Tip Adapters (OTA's) are needed for this Blade Counter analytic to function?

A: The analytic is not dependent on tips or Optical Tip Adapters. Stereo measurement OTA's are also compatible provided the 'single view' image transform is not required.

Q: Will this Blade Counter analytic work for all MViQ probe diameter options? i.e. 4mm, 6mm and 8mm

A: Yes.

Q: What factors affect the performance of the analytic?

A: Visual contrast of the blade leading or trailing edge.

A: Background scene e.g. edges associated with other components such as stator vanes or background rotating blades.

A: Probe movement.

A: Speed of rotation.

A: Target distance from probe.

A: Illumination settings.

A: Significant damage on blade edges resulting in local disruption of edges entering tracking region.

Q: Will this analytic work on the MViQ 'Grey' handset?

A: No.

Q: Can I use this Blade Counter analytic whilst inspecting non-aerospace gas turbine variants?

A: Yes although very likely to function, Waygate Technologies is unable to guarantee its performance on Gas Turbine within other applications.

Q: Does the MViQ need to be digitally connected in some way e.g. to the internet, in order for this analytic to work?

A: No. Once the analytic is installed on to the MViQ 'Flame' handset, it does not require internet connectivity to function.

Q: Can I use the Blade Counter analytic post-inspection on the MViQ device?

A: No. This analytic operates on live images only within the MViQ device.

Q: Can this Blade Counter analytic be accessed and operated from within Waygate Technologies Inspection Manager software?

A: No. This analytic operates on live images only within the MViQ device.

10. Glossary

Feature Detection Analytic	The ability to detect, track and trigger a mathematical model based on logic designed to create an inference or output. This model is triggered by edges that move across a pre-defined region of interest to create an increment in blade number (ascending or descending).
Field of View (FoV)	The scene presented to the borescope probe within a given instance.
Entry Line	Is the line to match the edge of the blade when it first enters the tracking region
Limit Line	Is the line delineating the movement of the blade edge through the tracking
Trigger Point	Is the point upon which the analytic is triggered. This point is fixed along the limit line and can be positioned along the Limit Line
Exit Line	Is the line to match the edge of the blade when it exits the tracking region

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