Waygate Technologies
a Baker Hughes business

Gas Power-assist (v5.5)

User Guide

Detect & categorize defects during our visual inspection



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1. Introduction

Waygate Technologies' now offers the ability to exploit artificial intelligence (AI) technology to provide customers a solution for detection and classification of defects directly on their Mentor Visual iQ and Mentor Visual iQ+ borescopes during live visual inspections.

Based on the InspectionWorks ecosystem, analytics can be deployed to the borescopes, placing AI and assisted defect recognition (ADR) at the fingertips of the end-user.

By providing technology that assists with defect detections, inspections become faster, more objective and asset uptime is increased.

2. What is the Gas Power-assist Analytic?

Waygate Technologies has developed an ADR (Assisted Defect Recognition) analytic based on Machine Learning. The latest version (5.5) of the analytic builds upon the foundation laid by version 5.0, which was trained using over 35,000 representative images from gas turbine inspections across both aviation and power generation sectors.

Version 5.5 introduces an incremental update, expanding the training dataset to over 42,000 images. The additional images primarily come from commercial aircraft engine inspections, specifically focused on high-pressure compressor (HPC) components. This data was sourced through Waygate Technologies' continued partnership with GE Aerospace, further enhancing the analytic's ability to detect and characterize defects.

Representative images have been "characterized" to train a neural network to recognize items or areas of interest. Once trained, the model is deployed for inferencing to predict indications on both live video and still images. The Gas Power-assist ADR analytic is optimized to run on the MViQ+ borescope platform and is also available on the InspectionWorks cloud for post-inspection analysis.

The analytic operates in both 'still' and 'live' states, offering two modes of interaction. When activated, the borescope can detect and characterize defects as they pass through the field of view. Operators can enter the freeze frame or 'still' state to interact with detected indications—reviewing, editing or saving them before proceeding to measurement.

3. Warnings

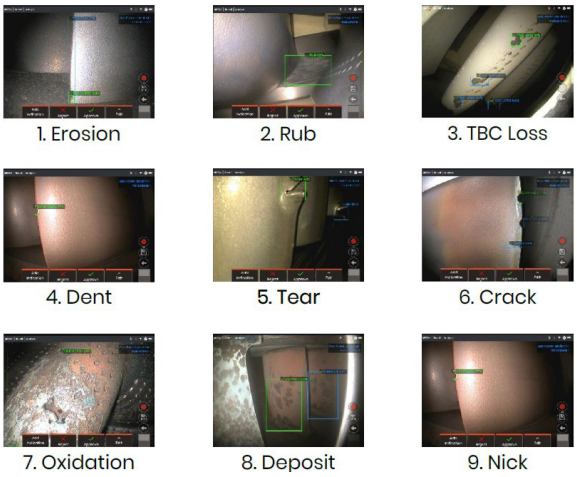
Analytic applications are intended to assist the user during in-situ visual inspections. Results will vary depending on your application. State-of-art analytic applications are generally not 100% accurate and this analytic is no different. Do not rely on this analytic to detect all indications.

You, the user, are responsible for following the appropriate procedures and standards whilst undertaking in-situ visual inspections. Waygate Technologies USA, LP. cannot be held responsible for the accuracy nor outcome of any inspection. You must review this user guide for its intended use and limitations prior to use.

4. Prescribed usage

This analytic is based on ground truth data predominantly originating from the LMS100, LM2500 and LM6000 gas turbine engine variants. It includes content from gas-washed surfaces spanning compressor, combustion and turbine stages.

In order to enhance analytic robustness, images were captured from historical borescope inspections containing many incident angles and stand-off distances from the target component. Indications have been classified using the following nine classifications:



5. Accuracy metrics

Accuracy Metric Definitions:

$$\textbf{Recall} = \frac{\text{Indications Predicted Correctly}}{\text{Actual Indications}}$$

$$\textbf{Precision} = \frac{\text{Indications Predicted Correctly}}{\text{Total Indications Predicted}}$$

	Live(and Still) performance*	
	Recall %	Precision %
Total	81.1(85.2)	78.5(84.8)
TBC LOSS	83.8(82.4)	81.5(89.7)
CRACK	93.7(94.5)	90.1(93.8)
RUB	77.9(71.4)	78.5(82.7)
DENT	77.4(87.1)	71.8(79.2)
NICK	79.8(83.8)	77.9(85.7)
TEAR	88.1(91.6)	81.4(82.0)
EROSION	94.4(95.0)	88.5(92.6)
DEPOSIT	73.6(81.7)	80.0(92.3)
OXIDATION	84.8(84.6)	85.9(91.1)

*Validation was performed using a stratified image-level split to ensure representative coverage across defect types and inspection scenarios.

6. Dependencies

Now operable on:

- MViQ+ borescopes

Operating software version number 4.20 or later.

Activated with MVIQ-GASPWRADR feature key. Available as free trial, one year subscription or perpetual purchase options.

7. Operating instructions

(v4.20 Mentor Visual iQ+)

7.1 Activating/de-activating the analytic

1. Enter MViQ+ Global Menu and select “Analytics”
2. Review and accept disclaimer (can take about oneminute after first boot only to enable initialization)
3. “Analytics” page is now displayed. Select “Gas Power-assist” tile to toggle from “off” to “on”
4. You have the option to activate either the Live or Still option individually by pressing “Options” and making your preferred selection by pressing “Done”
5. Press “Done” softkey
6. The analytic will now be started with on-screen message confirmation
7. Note the appearance of the analytics icon positioned in the status bar. This remains visible when any one or more analytic has been activated.
8. Repeat this procedure to de-activate the analytic albeit tap the tile from “on” to “off” during Step 3.

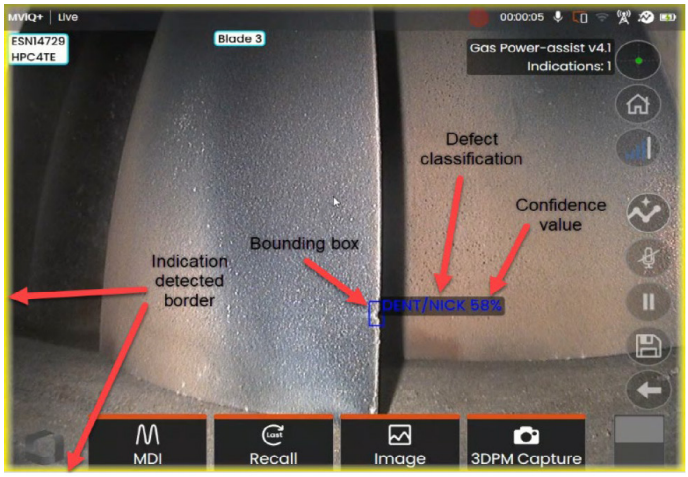
7.2 Generating inferences

7.2.1 Live Image Function

Once activated (see section 7.1), the analytic operates continuously whilst in the ‘live’ state.

Along with an indication count, “Gas Power-assist v5.5” message is visible in the top right hand corner of the screen to indicate its operation. This information is retained within all saved output.

An on-screen Indication Detected Border alerts the user that the analytic has detected an anomaly. This is the factory default setting. A series of additional options are also available to enable the user to customize the view when defects have been detected. See section 7.3.1 for more details.

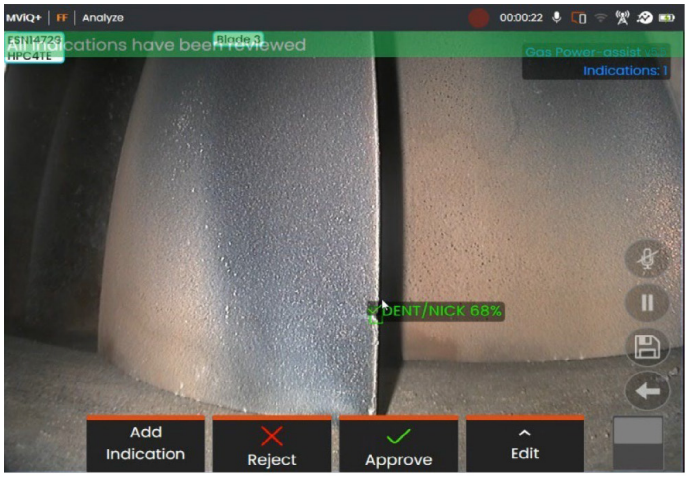


Gas Power-assist in operation. Note that i) Indication Detected Border is highlighted along with ii) bounding box and iii) defect classification label and iv) confidence value are all visible in this image.

7.2.2 Freeze Frame Image Function

From the live video state, tap the touchscreen or press “Enter” hardkey to activate the Freeze Frame (FF) state. “FF” will now appear in the top left status bar.

Initiate “Freeze Frame” to activate ability to interact with the bounding box(es).



Initiate “Freeze Frame” to activate Gas Power-assist ADR-S Analytic.

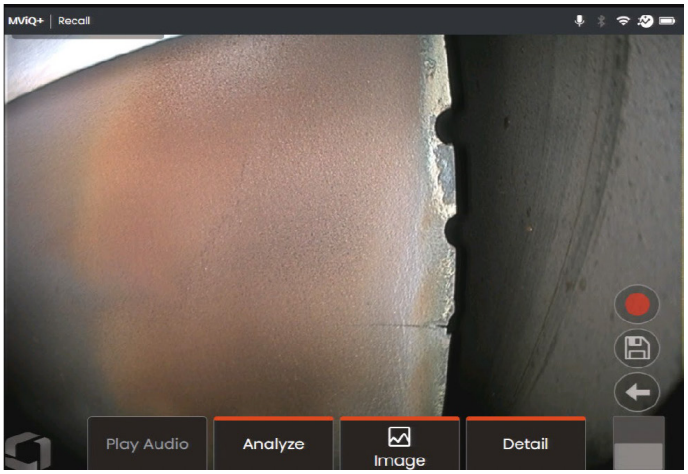
Now save image containing bounding boxes or alternatively cycle through a series of options:

- Manually add an indication
- Accept or Reject each indication
- Edit the indication classification e.g. change from“erosion” to “crack”
- Edit the shape or size of the indication boxGo to section 7.3.2 for more details.

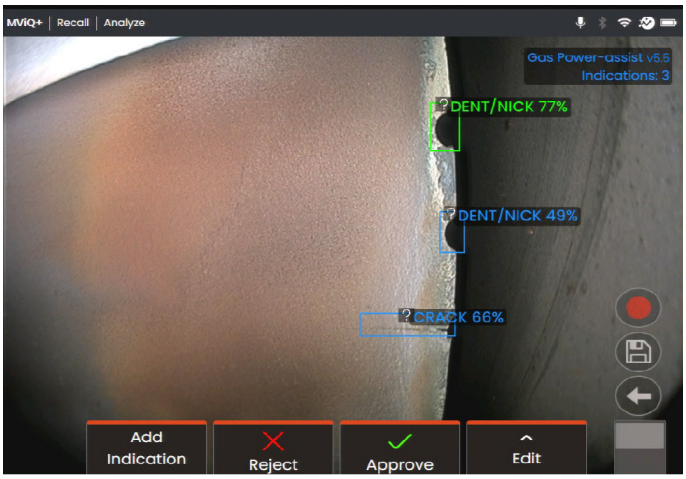
7.2.3 Recalled Image Function

Saved images can be analyzed at any time using the device. Ensure the analytic is activated (see Section 7.1) before following these steps:

1. Tap the Global Menu shortcut on the touchscreen or press"Menu" hardkey to display the Global Menu page.
2. Select "File Manager" tile and then the desired image inorder to load and display on screen.
3. Tap the softkey page button to present the second row ofsoftkeys. Select "Analyze". softkey in order to process the image for indications.



Recalled image showing "Analyze" softkey.



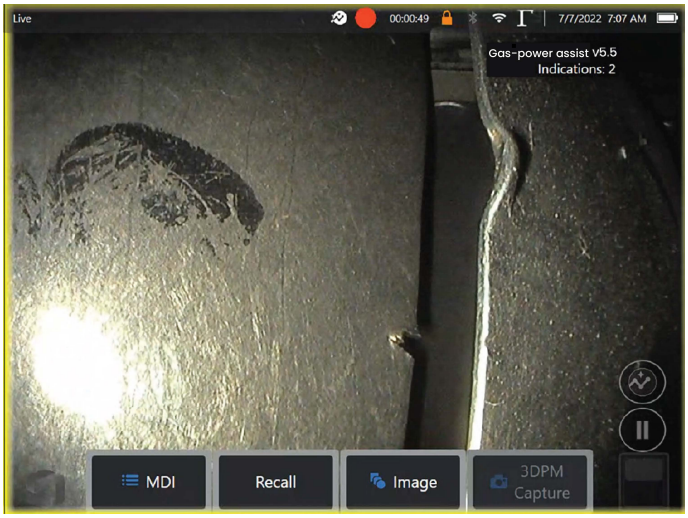
4. Now cycle through the indications to "accept", "reject" or alter any classification(s) as desired as per Section 7.2.2. Go to section 7.3 for more details.

7.3 User functionality

7.3.1 Working with Gas Power-assist during live inspections

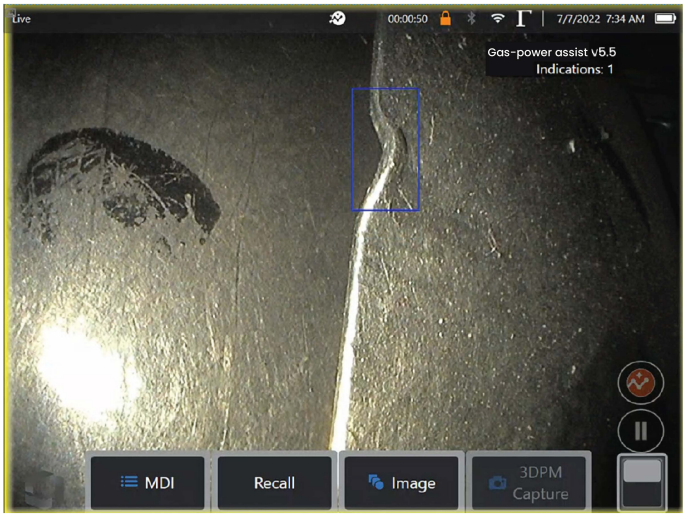
The analytic can detect and categorize defects as they appear on-screen and move through the scene.

A yellow border positioned around the perimeter of the screen indicates the detection of a defect. This is called the Indication Detected (ID) border.



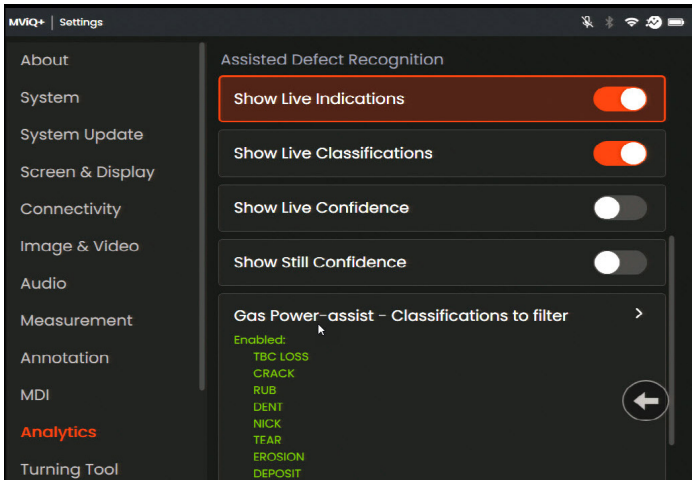
Gas Power-assist activated showing the Indication Detected border highlighting presence of defects.

During this instance, it is possible to tap the 'peek' floaty button (highlighted in image below) and temporarily (10 second duration) view the location of the defect.



Gas Power-assist activated showing the "peek" indication enabled to temporarily visualize the defect location.

A series of additional options are contained within the "Analytics" settings page. These enable the user to customize the view and present more information to the user during the live inspection.



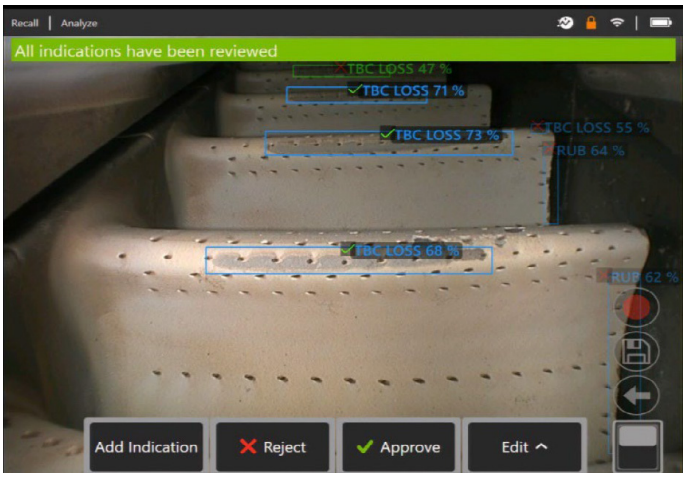
- **Show Live Indications – on/off**
  - This is the four-sided polygon that the analytic generates and places at the appropriate defect location.
- **Show Live Classifications – on/off**
  - This is the text label associated with the indication bounding box. Gas Power-assist analytic is trained on classifications outlined in Section 4.
- **Show Live Confidence– on/off**
  - This is an additional text label to present a percentage indication of the analytics likelihood of how similar the prediction is to the ground truth.
- **Classification Filter**
  - This enables the user to remove specific defect classifications from being presented on-screen. The classification filter is a useful feature to enable the operator to focus attention on detecting certain defects.

7.3.2 Working with Gas Power-assist during still inspections

Once the defect has been automatically detected, it is possible to then enter the Freeze Frame (FF) or "still" state and interact with all on-screen bounding boxes or indications.

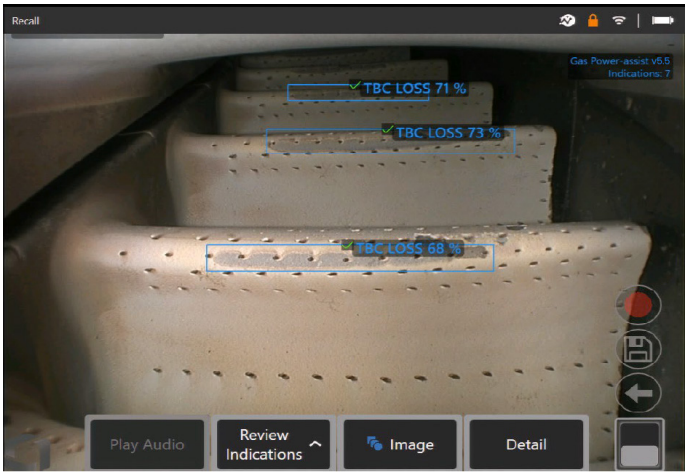
- Add Indication (manually)
- Accept – to agree and retain bounding box
- Reject – to disagree and disregard (not delete) bounding box
- Edit classification – to change the defect category to another pre-determined type (per section 4.0)
- Edit indication – to alter the shape or size of indication
- Hide / Show bounding box(es) and any other additional associated text

1. Tap or press "Enter" hardkey to cycle through any or allinferences whilst pressing "Accept" or "Reject"softkeys. Selecting 'Edit' also enables user to change the classification as required.
2. Here we have an example where many bounding boxes presented on-screen. The user has the choice to accept (indicated as green TICK) or reject (indicated as red CROSS) each one. Once completed, a temporary banner appears to indicate all bounding boxes have been reviewed.



3. Once the image is saved and then subsequently recalled, only the accepted bounding boxes will be immediately visible. This image shows the three bounding boxes that were "accepted." The remaining bounding boxes remain present but hidden within the file. The indication count still displays the total count even through a reduced number are shown on-screen. This indirectly informs the end user or subsequent viewer that this image also contains four "rejected" bounding boxes.

   It is possible to adjust, amend or undo these adjustments anytime once the image has been saved. No data is lost or erased.



4. Confidence Values provide a percentage indication of the analytics likelihood of how similar the prediction is to the ground truth. 'Off' is the factory default setting.

   To show "Confidence Value" navigate to the 'Settings' menu and select 'Analytics' to reveal the 'Show Still Confidence' toggle.

   Tap the toggle or press 'Enter' hardkey to activate this feature. Now recall image and select "Analyze" softkey or activate freeze frame (FF) to generate the inference. All bounding boxes will now be presented with the Confidence Value denoted as a percentage value.

7.4 Review / reanalyze

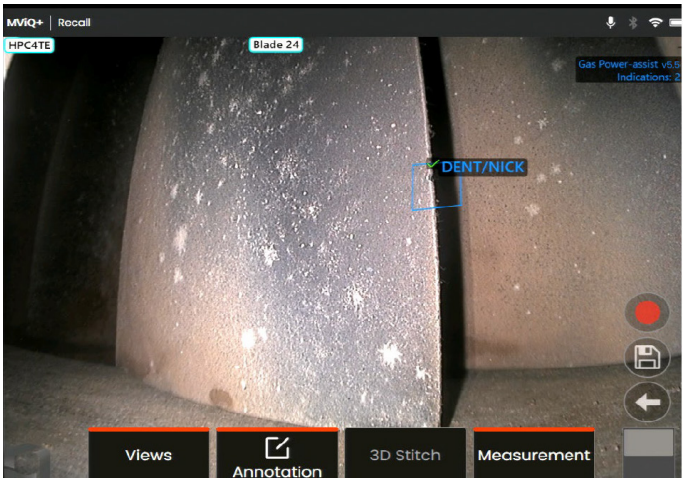
Saved images containing inferences from an analytic can be:

- Reviewed - using saved inferences from original analysis, or
- Reanalyzed - using the analytic activated on the handset

7.4.1 Reviewing saved image(s)

It is possible to review all bounding boxes contained within a saved file from appropriately configured MViQ+ handset. The Gas Power-assist analytic does not need to be activated to enable this feature since all original data is retained within the file.

1. This recalled image is displaying one bounding box although the total number of counted indications is two found in the info box (top right of image).





Use this function to check correct assignment of all detected indications using the original data captured within the file.

7.4.2 Reanalyzing saved image(s)

It is possible to reanalyze all bounding boxes contained within a saved file. To enable this function, ensure the Gas Power-assist analytic is activated (see Section 7.1). This feature enables the current activated analytic to reanalyze the loaded image.

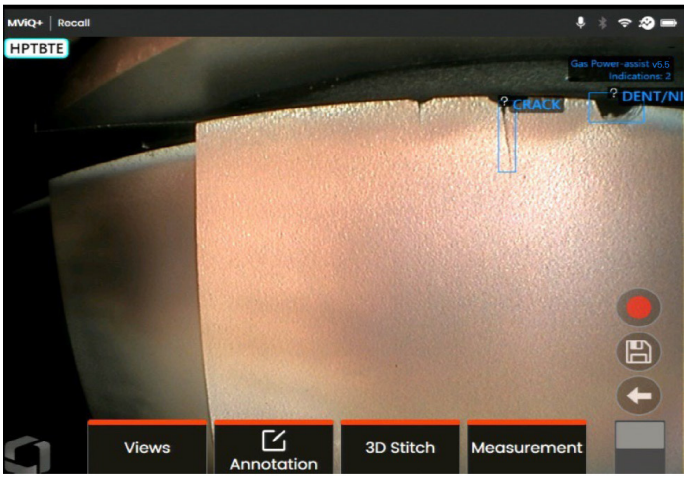
This is applicable if a different analytic version was now in-use.

This recalled image derived from a previous version of Gas Power-assist (version 3.0) and is displaying two indications.

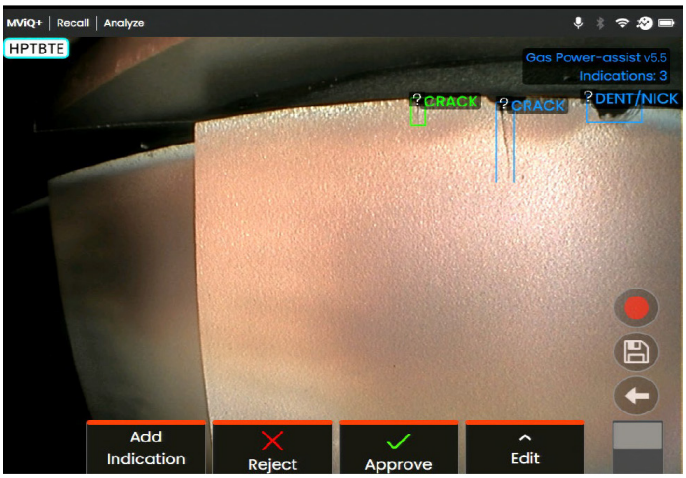


Note that Analytic is activated – icon on status bar is visible.

1. Select ‘Review Indications’ softkey and then “Reanalyze”.



2. The handset overwrites any prior assignments e.g. acceptance or rejections and displays the output from the activated analytic.



Note all inferences are now visible and the user is invited to review as appropriate.

8. 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

9. Revision history

Revision number	Date issued	Reason
1	December 2021	Initial launch
2	July 2022	Introduction of Live-ADR and updated Still-ADR functionality
3	May 2023	Updated analytic and rebranded to reflect updated ground truth data
4	January 2024	Updated analytic and introduced for MViQ+ platform
5	January 2025	Updated analytic to include HPC dataset from GE Aerospace. Separated ‘dent/nick’ into two separate classifications.
6	October 2025	Updated analytic with improved performance.

For validation, the analytic was tested on a set of 3,991 images. These test images were unseen during training, ensuring a robust evaluation of the model’s generalization capabilities. However, it is important to note that the dataset split was conducted at the image level, not at the video level. This means that while the test images were not part of the training set, they may originate from the same inspection videos as some training images. This approach was chosen to maximize the diversity and volume of test data while maintaining a realistic representation of inspection scenarios.

Please note, this analytic has not been formally validated by the LM engine series OEM.

10. Frequently Asked Questions (FAQs)

Q: How do I obtain this ADR analytic?

A: A free 90-day trial should be activated if using MViQ+ software. After that, contact your local Waygate Technologies sales representative.

If however operating Enhance or Pro MViQ+ models, then a 1 or 2 year licence is included. Subsequent renewal is enabled by licence update. Contact your local sales representative for details.

Q: Is it possible to create other analytics designed for other engine variants; other components; or other defect types?

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

A: Due to the common nature of gas turbine architecture and defect classifications, it is likely that this ADR analytic remains applicable to other gas turbine variants beyond those listed section 4.0.

A: Note that LMS100, LM2500 and LM6000 are aeroderivative of the CF6 aero gas turbine series.

Q: What is a 'live image" ADR analytic?

A: It is a Computer Vision model that predicts the presence of; and categorizes the detected indications contained within a "live" image. The model was trained on thousands of images derived from a dataset of images captured from videoscopes used during actual in-situ inspections.

Q: What is a "still image" ADR analytic?

A: It is a Computer Vision model that predicts the presence of; and categorizes the detected indications contained within a "still" or "freeze frame" image. The model was trained on thousands of images derived from a dataset of images captured from videoscopes used during actual in-situ inspections.

Q: Why should I consider using an ADR analytic?

A: Improves consistency and reliability of inspection tasks by leveraging Computer Vision technology to assist the trained Inspector in conducting the visual inspection.

A: Reduces the probability of missing indications on critical turbomachinery components.

A: Increases the overall quality of inspection output.

A: Provides automatic annotation for the user to simply approve.

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

A: No.

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

A: Gas-washed surfaces namely: aerofoils within the compressor and turbine stages plus static combustion hardware.

A: Additional data obtained from a wide variety of aviation based engine types from CFM, Rolls-Royce and GE Aerospace.

Q: How was this ADR analytic validated?

A: Please refer to the section at the bottom of page 8.

Q: What does the confidence value indicate or infer?

A: This index provides an indication of how similar the prediction is to the ground truth the analytic was trained on. It indicates the likelihood of a correct prediction but is not the probability of correct predictions.

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

A: The analytic is not currently dependent on tips or Optical Tip Adapters.

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

A: Yes

Q: What type of indications is it designed to detect?

A: Erosion, Crack, Rub, Dent, Nick, Tear, TBC loss, Oxidation and Deposit.

Q: Will it measure indications?

A: No, these analytics do not have measurement capability. However, Real3D measurement technology can be used to measure indications that have been found by the analytic.

Q: Can I use this ADR analytic whilst inspecting other gas turbine variants?

A: Yes. Waygate Technologies is unable to guarantee its performance or even applicability to other gas turbine variants but visual appearances of gas turbine components are often very similar.

A: Testing is done on a variety of gas turbine engine types possessing a range of defects.

Q: Does the MViQ+ need to be digitally connected in some way e.g. to the Internet or some other device in order to work?

A: No. The analytic operates entirely standalone.

Q: Can I use the ADR analytic post-inspection on the MViQ+ device?

A: Yes. This ADR can process on recalled images. Such images can be: those that have either been previously processed using this analytic; or raw/unprocessed images.

Inferences can be generated and subsequently saved forThis enables the user to have analytics activate at the appropriate stage(s) automatically. Please contact Waygate Technologies support for further information.

11. Glossary

AI (Artificial Intelligence)	The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between
Analytic	A mathematical model based on computer vision logic designed to create an inference or output
Characterization	The ability to add or label images with data enabling analytics to generate inferences
Gas-washed surfaces	Surfaces within the gas turbine directly exposed to air used to generate power, propulsion or thrust
Ground truth	Characterized data used to train the analytic
Inference	The displayed output of an analytic
Bounding box	The area highlighting the presence of an indication
Erosion	Impingement of material that results in localized mechanical wear or deformation or profile edge
Crack	Localized separation of parent material forming a continuous linear indication
Rub	Damage sustained as a result of contact between two surfaces. resulting removal or smearing of parent material
Dent	Depression or localized removal of material
Nick	Depression or localized removal of material
Tear	Gross separation of parent material as a result of heavy impact from foreign object
TBC loss	Localized removal of insulating coating from component revealing appearance of bare substrate. TBC: Thermal Barrier Coating
Oxidation	Thermally driven failure mechanism result in reduction in component wall thickness
Deposit	Material deposited by means of mechanical adherence or chemical precipitation on to a location.

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