Aiir Edge Hot (v6.6)

Datasheet v2.0

Detect & categorize defects during your visual inspection

Contents

1. Introduction

In collaboration with AI for borescope inspection expert Aiir Innovations, Waygate Technologies' Mentor Visual iQ borescopes now offer the ability to exploit artificial intelligence (AI) technology to provide customers a solution to identification of detects directly on their borescopes.

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 uptime of the asset is increased.

2. What is the Aiir Edge Analytic?

The all new Aiir Edge - Hot & Cold ADRs allow users to get real-time indications during inspections, these ADRs replace the Aiir Lite - Rotate & Combustor ADRs which could only process single images. With this new capability & naming, we make it simpler to choose the best ADR for the task. Additionally, the Aiir Edge ADRs bring a more robust performance to help improve your detection rate across the fleet thanks to the addition of over 30 new engine configurations to the data, a new AI model architecture and a large increase in the amount of training data used.

The Aiir Edge analytic is a standalone light-weight version of the analytic used by the Aiir Inspection software. The analytic was trained using more than a thousand hours of borescope footage to teach the neural network about areas of interest during inspections.

Once the model is trained, it is deployed for inference to predict indications on new footage. The Aiir Edge analytic was optimized to run offline on the Mentor Visual iQ edge device.

The Aiir Edge analytic comes in two variants Aiir Edge - Cold, for airfoil surfaces, and Aiir Edge - Hot, for the coated hot section. This is the datasheet for Aiir Edge - Hot.

3. Warnings

Analytic applications are intended to assist the user whilst performing 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. Aiir Innovations B.V. and Waygate Technologies USA, LP. cannot be held responsible for the accuracy and outcome of any inspection.

You must review the datasheet for intended use and limitations prior to use.

4. Prescribed Usage

This analytic is based on ground truth data originating from a wide variety of clean and dirty turbine engines used in commercial aviation, including but not limited to:

- CF6-80
- CF34 series
- CFM56-3 series
- CFM56-5 series
- CFM56-7 series
- LEAP-1A/B
- GEnx
- GE90
- V2500
- PW 1000G series
- PW 2000
- Trent 700
- Trent 900
- Trent 1000

The Aiir Edge - Hot analytic ground truth data is limited to the combustor, and the TBC coated sections of the high pressure turbine and thus does not include the high, intermediate, and low pressure compressor and low, and intermediate pressure turbine. For the latter (excluded) modules use the Aiir Edge – Cold analytic.
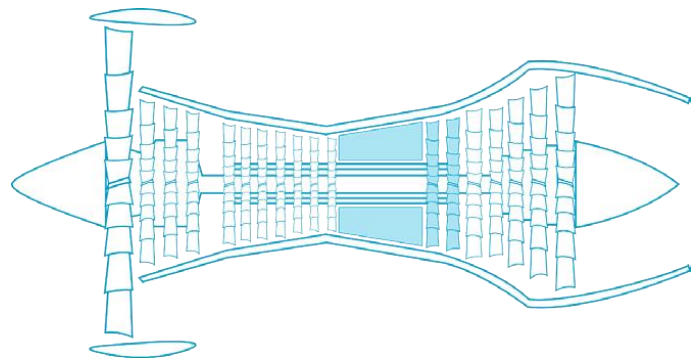
Images were captured from a multitude of incident angles and stand-off distances from the target component during historical borescope inspections in order to enhance analytic robustness.

5. Accuracy metrics

	Detection in combustor
Cracks	Average
Missing material	Strong
Missing TBC	Average

Definition:

	Detection rate
Excellent	> 80%
Strong	60-80% (human performance, Aust et al, 2021.)
Average	40-60%
Weak	< 40%

6. Dependencies

- Only operable on the Mentor Visual iQ (MViQ) Flame ("C" model) borescope
- Operating software version 3.70 or later
- Activated with MVIQ-AIIRADR feature key. Available as free trial or one year subscription.

7. Operating instructions
(3.70 Mentor Visual iQ Release)

7.1 Activating/de-activating the analytic

1. Enter MViQ Global Menu and select "Analytics"

2. Review and accept disclaimer (can take about one minute after first boot only to enable initialization)

3. "Analytics" page is now displayed
   Select "Aiir Edge Hot" 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
   The analytic will now be started with on-screen message confirmation

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

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, "Aiir Edge Hot v6.6" 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.
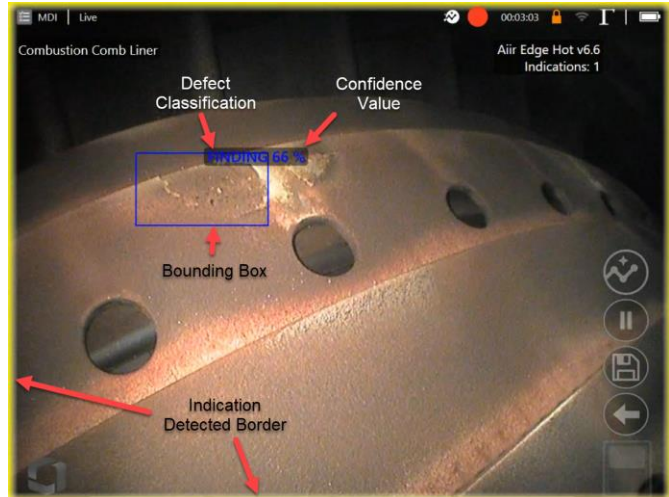
Aiir Edge Hot in operation. Note that i) Indication Detected Border is highlighted along with ii) bounding box, iii) defect classification label and iv) confidence value are all visible in this image.

Note: all defect classifications in the 'live' state are labelled as Finding until the operator enters the Freeze Frame state and makes the appropriate alteration or edit.

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).

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 box

Go 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 then 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 in order to load and display on screen.

3. Tap the softkey page button to present the second row of softkeys. Select "Analyze". softkey in order to process the image for indications.
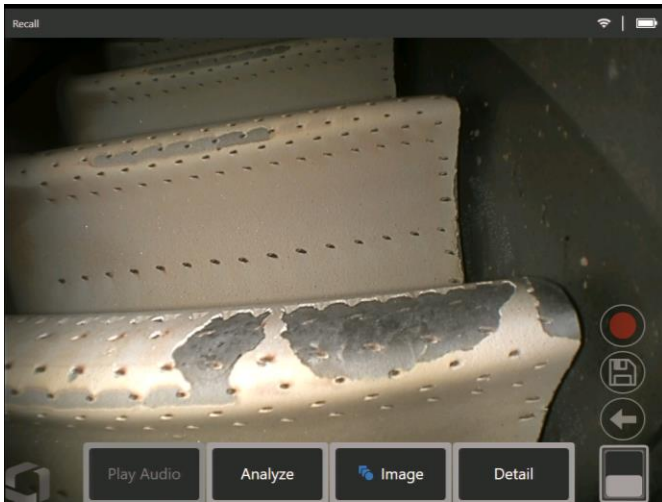
Recalled image showing "Analyze" softkey.

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 Aiir Edge Hot during live inspections

The analytic is capable of detecting and categorizing 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.

Aiir Edge Hot activated showing the Indication Detected border highlighting presence of defect.

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.

Aiir Edge Hot activated showing the "peek" indication enabled to temporarily visualize the defect location.

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

• Indication bounding box – on/off
  This is a four-sided polygon that the analytic generates and places at the appropriate defect location

• Defect classification – on/off
  This is the text label associated with the indication bounding box. Aiir Edge Hot analytic returns a "Finding" classification. The user has the ability to edit this label when working in the Freeze Frame (FF) state. See section 5.0 for the classifications this model is trained upon

• Confidence value – 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

7.3.2 Working with Aiir Edge Hot 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 bonding box

• Reject – to disagree and disregard (not delete) bounding box

• Edit classification – to change the defect category to another pre-determined type (per section 5.0)

• 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 all inferences 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.
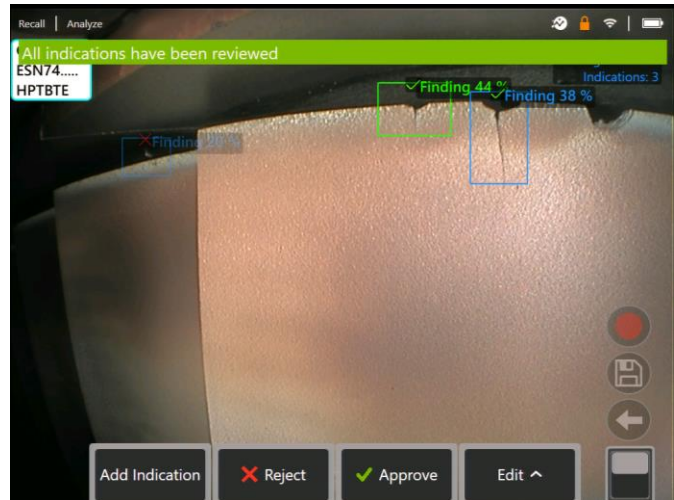

3. Once the image is saved and then subsequently recalled, only the accepted bounding boxes will be immediately visible. This image shows the two bounding boxes that were "accepted." The remaining bounding boxes remain present but hidden within the file. The indication count still displays the total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

It is possible to adjust, amend or undo these adjustments at anytime once the image has been saved. No data is lost or erased.
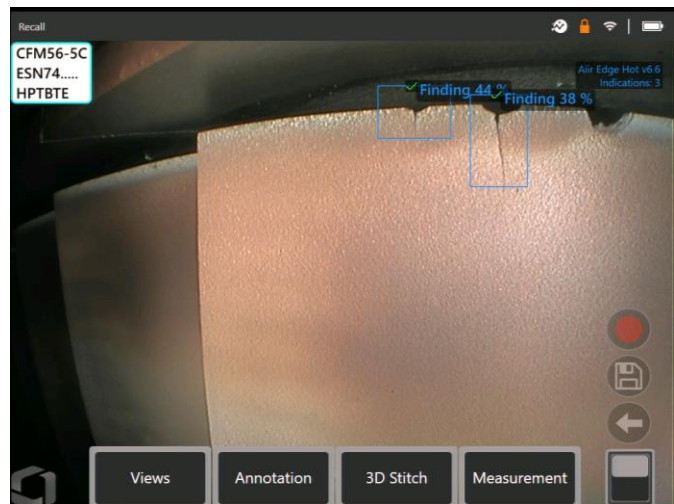
4. Confidence Values provide a percentage indication of the analytics likelihood of how similar the prediction is to the ground truth. 'Off' is the factory default setting.

   To show "Confidence Value" navigate to the 'Settings' menu and select 'Analytics (Still)' as shown below.

   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.
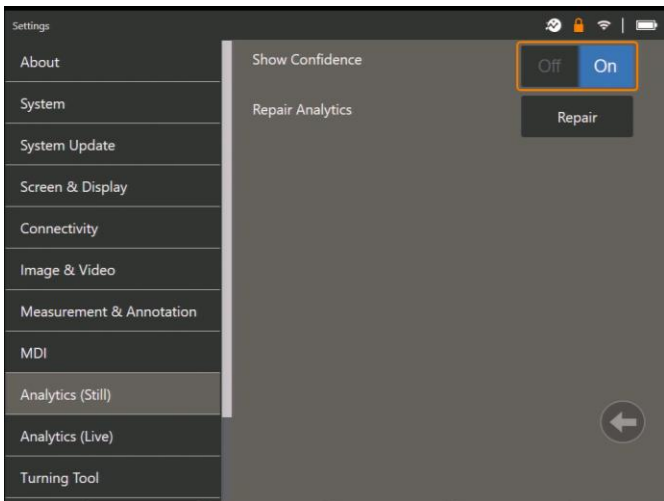

7.4 Review / reanalyze

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

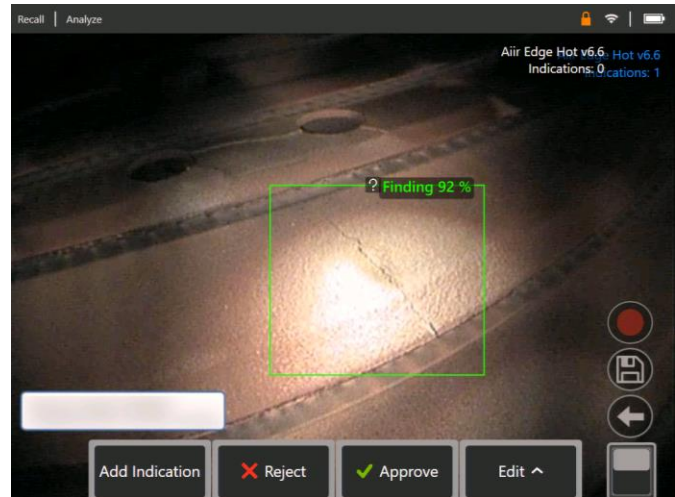### 7.4.1 Reviewing saved image(s)

It is possible to review all bounding boxes contained within a saved file from any MViQ Flame handset. The Aiir Edge Hot 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 zero bounding boxes although the total number of indications is one.
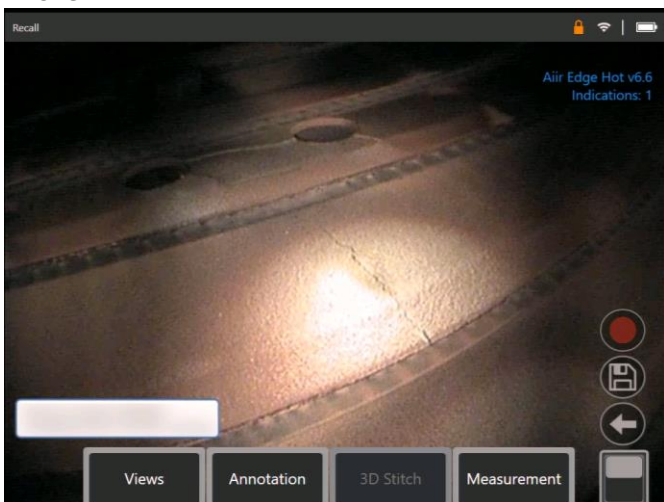
Note that no Analytic is activated – Analytics icon on status bar is not visible.

2. Select 'Review Indications' softkey to present all original indications i.e. making visible any 'Rejected' or unreviewed bounding box(es).

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 Aiir Edge Hot analytic is activated (see Section 7.1). This feature enables the current activated analytic to reanalyze the loaded image.
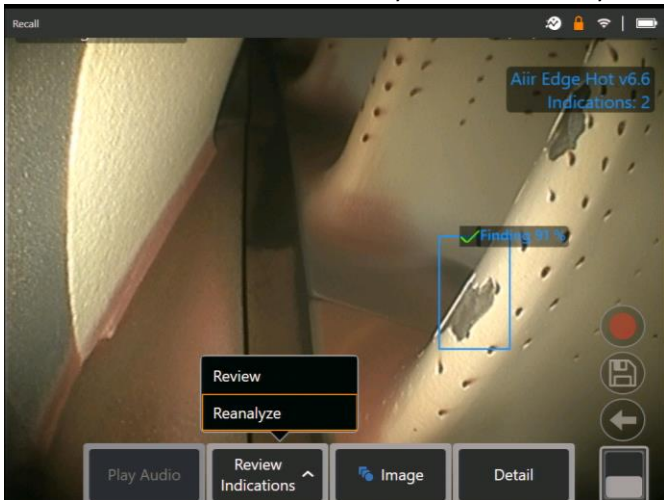
This is applicable if a different analytic version was now in-use.

1. This recalled image is displaying one bounding box although the number of indications displayed is two.
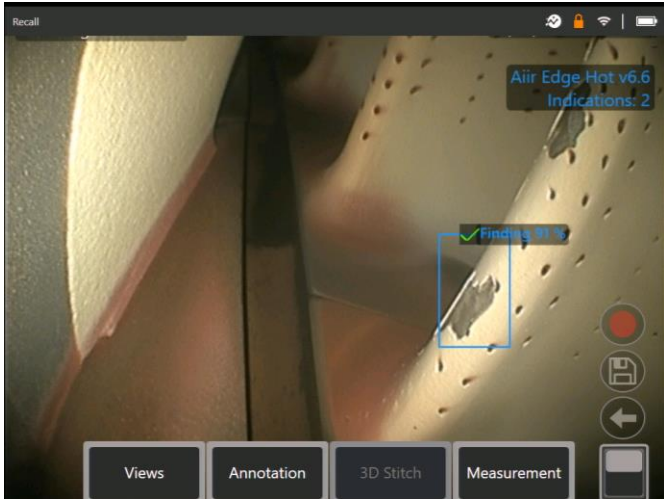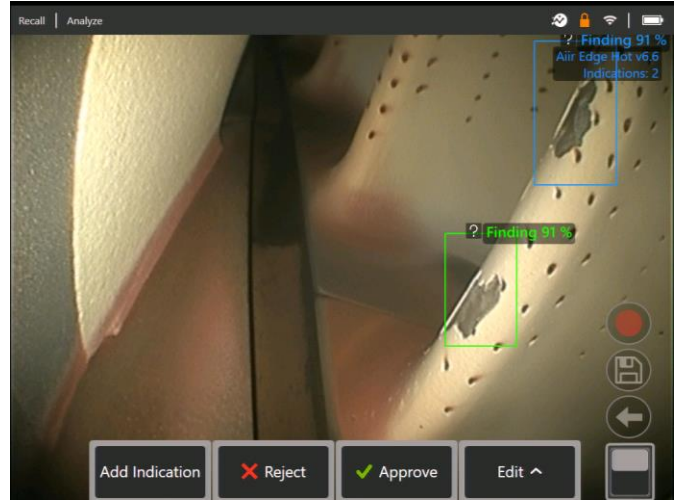

Note that Analytic is activated – icon on status bar is visible.

2. Select 'Review Indications' softkey and then "Reanalyze."

3. 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
1.1	July 2022	Update still image functionality
2	May 2023	Updated analytic, rebranded and now includes live video support

10. Frequently Asked Questions (FAQs)

Q: Who developed Aiir Edge?

A: The Aiir Edge analytic was developed by Aiir Innovations, an Artificial Intelligence company based in Amsterdam. Aiir specializes in the development of intelligent software for the aviation industry. More info at www.aiir.nl.

Q: Does Aiir Edge connect to the Aiir Inspection Cloud?

A: No, Aiir Edge is a stand-alone lightweight offline version of the analytic active in the Aiir Inspection Cloud software. More info at www.aiir.nl.

Q: What is an ADR analytic?

A: It is a type of Computer Vision model that predicts the presence of; and categorizes the detected indications contained within both 'live' and 'still' images or videos.

Q: Why should I consider using an ADR analytic?

A: It is a Computer Vision model that predicts the presence of indications contained within images or videos. The model was trained on over a thousand hours of video footage derived from a dataset from videoscopes used during actual in-situ inspections.

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

A: Combustor dome and high pressure turbine systems of gas turbine engines used in commercial aviation, including but not limited to CF6, CFM56 and V2500. See section 4 for the full list.

Q: How was this ADR analytic validated?

A: Aiir Innovations has validated this analytic on thousands of images from borescope inspections. This analytic has not been formally validated by engine OEMs.

Q: How accurate is this ADR analytic?

A: See section 5

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: Cracks, Missing TBC and Missing material (includes burned through material). See section 5.

Q: Will it measure indications?

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

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

A: No.

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.

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

A: No. The analytic operates entirely standalone within the device.

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

A: Yes. This ADR analytic can operate on recalled images within the MViQ 'Flame' handset. 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 for presentation or inclusion into the inspection report.

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

A: No.

Q: Do Analytics operate in conjunction with other Mentor Visual iQ features?

A: Image storage – Analytic results are stored in the still image file. This information is normally hidden when viewing jpg images on a standard consumer device like a laptop or phone. However when viewed on the MViQ

A: MDI – Analytics can be "prescribed" by an MDI template. At the time of writing, the MDI builder tool is not able to add analytics to an MDI template in a graphical fashion. The MDI template must be edited for you by Waygate Technologies. 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 languages
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
Crack	Localized separation of parent material forming a continuous linear indication
TBC loss	Localized removal of insulating coating from component revealing appearance of bare substrate. TBC: Thermal Barrier Coating
Missing material	Material missing from component as a result of impact or excessive temperature

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