LM2500 assist-S (v1.0)

Datasheet

Contents

1. Introduction

Waygate Technologies' now offers the ability to exploit artificial intelligence (AI) technology to provide customers a solution for identification and classification of defects directly on their Mentor Visual iQ 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 LM2500 assist-S Analytic?

Waygate Technologies has developed an ADR analytic based on Machine Learning. The analytic was trained using thousands of representative images from LM2500 gas turbine inspections. These have been "characterized" to teach a neural network about items or areas of interest.

Once the model is trained, it is deployed for inferencing to predict indications on new images.

The LM2500 assist-S analytic was optimized to run on the Mentor Visual iQ borescope, but will also be available on the InspectionWorks cloud platform to enable analyses post-inspection.

This analytic is described as being a 'still' analytic. It is designed to operate whilst the device is presenting a still image. The Mentor Visual iQ device is capable of simultaneously operating one 'still' and one 'live' analytic at any given time.

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. Waygate Technologies USA, LP. cannot be held responsible for the accuracy nor outcome of any inspection. You must review this datasheet for intended use and limitations prior to use.

4. Prescribed usage

This analytic is based on ground truth data originating from the LM2500 gas turbine engine variant. 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 six characterizations:

1. Erosion

2. Rub

3. TBC loss
(Thermal Barrier Coating)

4. Dent/Nick

5. Tear

6. Crack

5. Accuracy metrics

	Identification		Identification + Classification	
	True Positive Rate	Precision	True Positive Rate	Precision
Total	84.6	82.7	80	77.8
Erosion	96.1	96	92.9	91.4
Crack	88	86.1	88	81.2
Rub	88.6	80.2	82.9	69.8
Dent/Nick	81.7	86.1	73.8	80.9
Tear	81.8	93.3	45.5	46.7
TBC Loss	72.7	68.5	67.8	66.1

Accuracy Metric Definitions:

$$\text{True Positive Rate} = \frac{\text{Indications Predicted Correctly}}{\text{Actual Indications}}$$

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

6. Dependencies

- Only operable on the Mentor Visual iQ (MViQ) Flame ("C" model) borescope

- Operating software version 3.60 or later

- Activated with LM2500ADR-S Feature Key (free trial or purchased)

- LM2500 assist-S analytic functions when MViQ is in one of the following two states:
  1. Freeze frame or 'FF' image
  2. Recalled image (from File Manager)

7. Operating instructions
(3.60 Mentor Visual iQ Release)

7.1 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 'LM2500 – assist-S' tile to toggle from 'off' to 'on'

4. 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 3.

7.2 Generating inferences

7.2.1 Freeze Frame Image Function

1. From the live video state, tap the touchscreen or press 'Enter' hardkey to activate the Freeze Frame (FF) state. "FF" should now appear in the top left status bar.

2. LM2500 assist-S analytic will now activate and analyze the image. "LM2500 assist-S v1.0" will now be visible in the top right hand corner of the screen to visually indicate its operation.
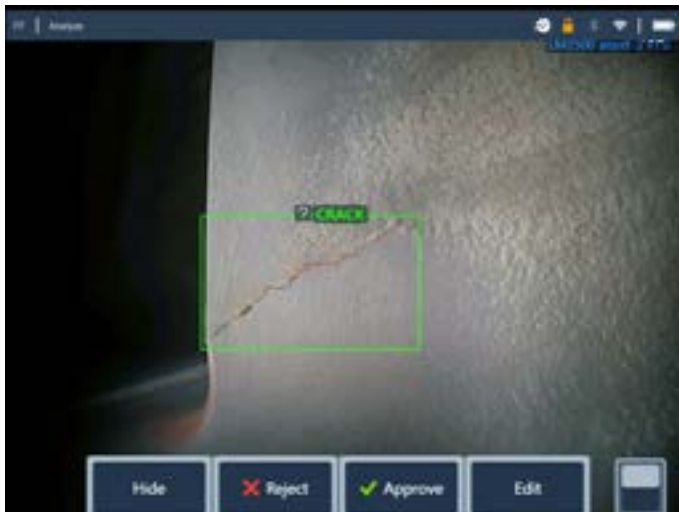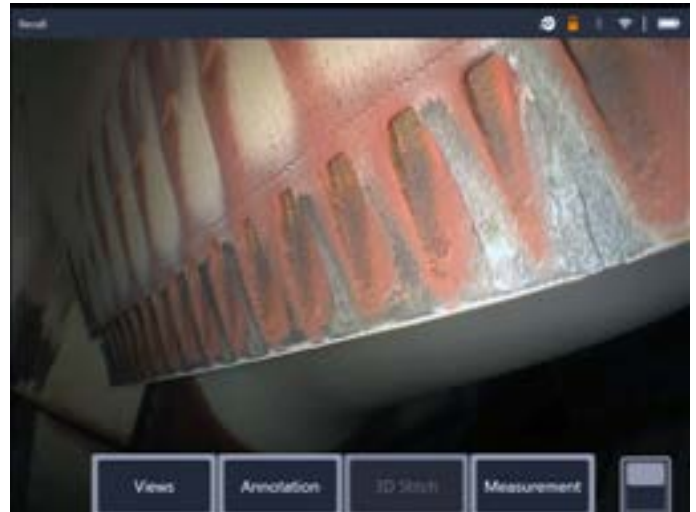

Initiate 'Freeze Frame' to activate LM2500 ADR-S Analytic.

3. Now save image containing inferences or alternatively cycle through the bounding boxes to 'accept', 'reject' and alter any classification(s) as desired.
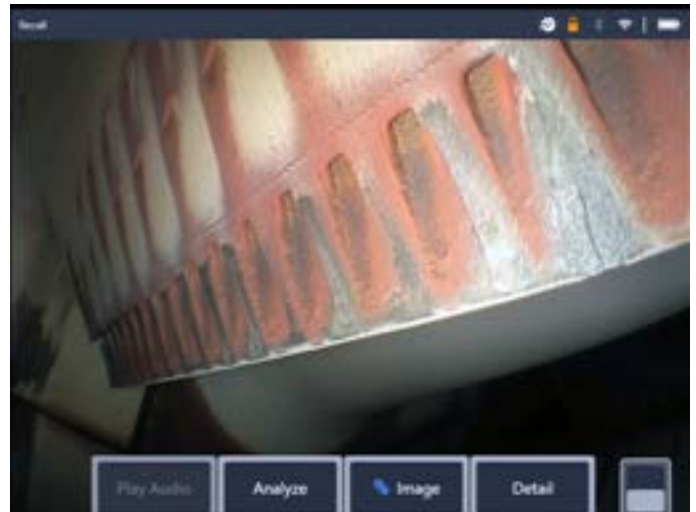
   Go to section 7.3 for more details.

7.2.2 Recalled image function

1. From the live video state, 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.

4. Now save image containing inferences or alternatively cycle through the bounding boxes to 'accept', 'reject' and alter any classification(s) as desired.
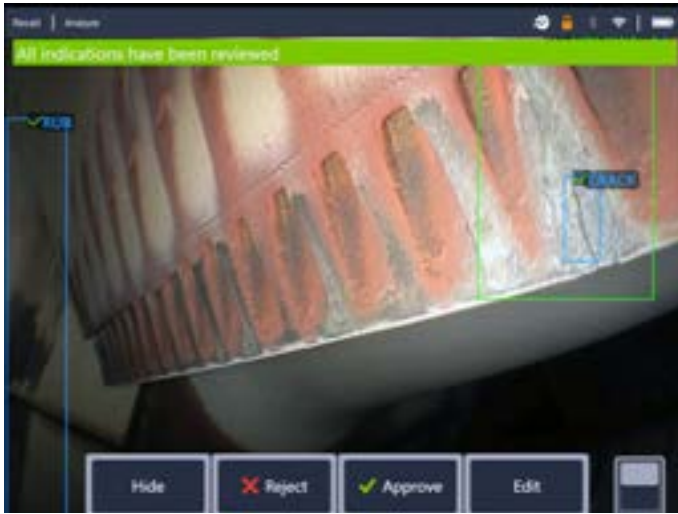
Go to section 7.3 for more details.

7.3 User functionality

It is possible to interact with all on-screen inferences generated by the LM2500 assist-S analytic.

- Hide / Show all inferences
- Accept – to agree and retain inference
- Reject – to disagree and disregard (not delete) inference
- Edit classification – to alter the defect category to another pre-determined type
- Hide / Show confidence value

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 are 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.

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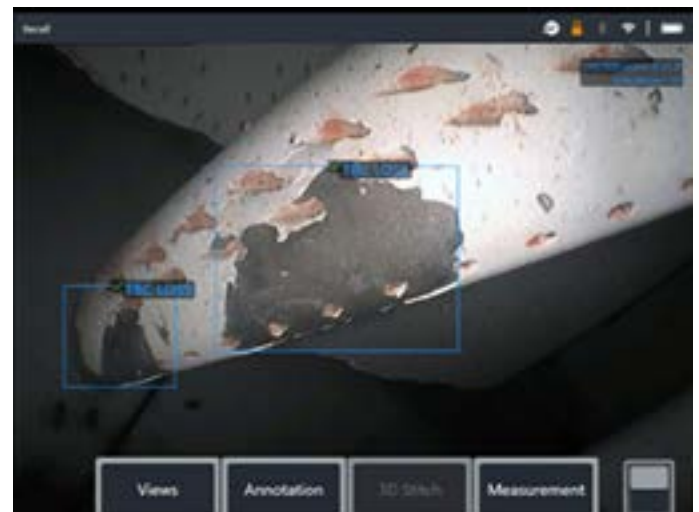
4. Confidence Values provide a percentage indication of the analytics likelihood of how similar the prediction is to the ground truth. 'Off' is the factory default setting.

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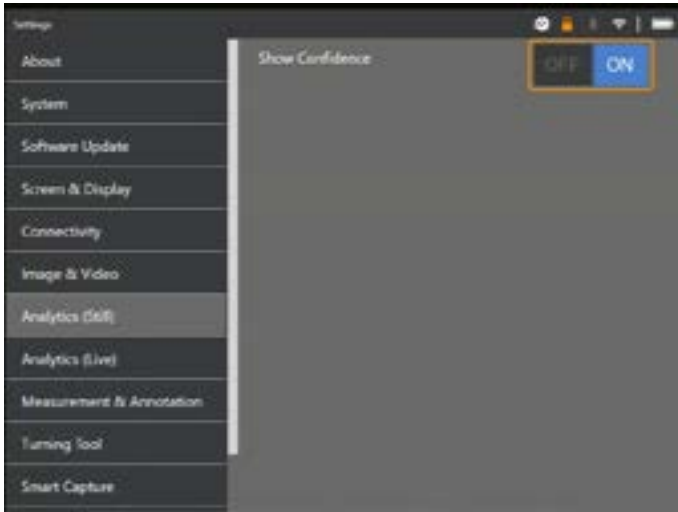
Now recall image and select 'Analyze' softkey or activate freeze frame (FF) to generate the inference. All bounding boxes will now be presented with the Confidence Value denoted as a percentage value.

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 LM2500 assist-S 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 two bounding boxes although the total number of indications is three.

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 LM2500 assist-S analytic is activated (see Section 7.1). This feature enables the current activated analytic to reanalyze the loaded image.
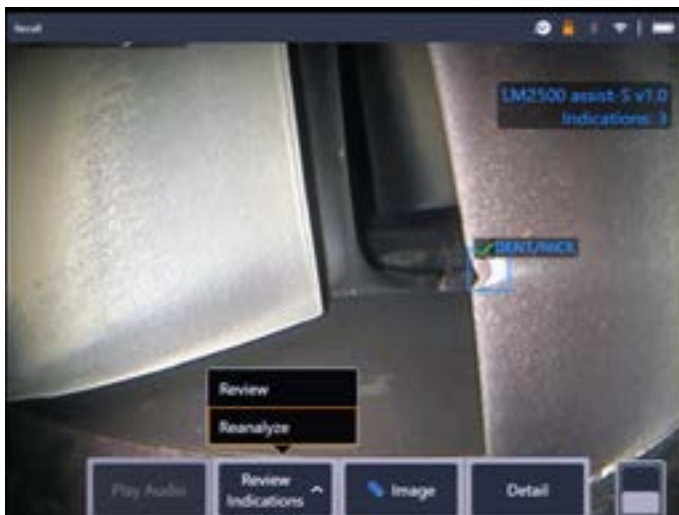
This is applicable if a different analytic version is now in-use.

1. This recalled image is displaying one bounding box although the number of indications found is three.
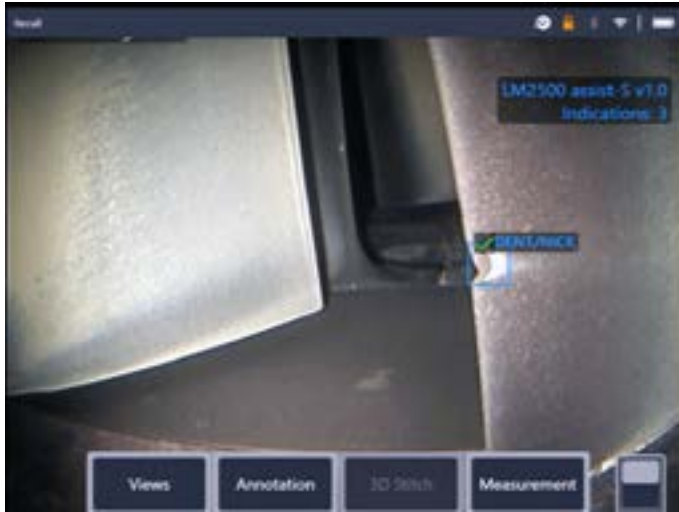
Note that Analytic is activated – icon on status bar is visible.

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
1.0	December 2021	Initial launch

10. Frequently Asked Questions (FAQs)

Q: How do I obtain this ADR analytic?

A: A free 90-day trial should be activated after installing 3.60 software. After that, contact your local Waygate Technologies sales representative, or visit www.waygatetech.com/MentorVisualiQ.

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.

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: Which engine components is it designed to operate on?

A: Gas turbine aerofoil within the LM2500 Compressor and Turbine systems

A: LM2500 combustion chamber hardware

A: Note that LM2500 is an aeroderivative of the CF6-6 aero gas turbine

Q: How was this ADR analytic validated?

A: Waygate Technologies has validated this analytic on 405 images from LM2500 inspections based on 4273 images within the training dataset. This analytic has not been formally validated by the LM2500 OEM.

Q: A: See section 5 How accurate is?

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: Erosion (which can sometimes be classed as 'oxidation'); Rub; TBC loss; Dent/Nick; Tear; Crack.

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 or some other device 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, but this functionality is planned within a future release.

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 borescope, the analytic results may be adjusted, hidden, or rejected. This will also be possible if accessing the file from Inspection Manager software and InspectionWorks cloud platform in the near future.

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 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

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