QUASAR

Product brief

v1.1

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1 Introduction

1.1 Objectives

Surface mount technology has brought about a paradigm shift in high-density design, opening new horizons. However, with its widespread adoption, ensuring the quality of SMT soldering has emerged as a significant challenge. To tackle this, a range of inspection technologies, including X-ray, optical, and thermal imaging, have been integrated to scrutinize soldering flaws. Yet, traditional human inspection methods for solderability testing and void detection suffer from drawbacks such as being time-consuming, error-prone, and inconsistent, largely influenced by the inspector's experience level.

Some existing x-ray inspection systems rely on void detection algorithms that demand meticulous fine-tuning to adapt across different devices and production lots. In response to these challenges, 7 Sensing Software presents Quasar: an AI-powered optical inspection Software as a Service (SaaS) tailored for non-wetted areas and solder voids detection.

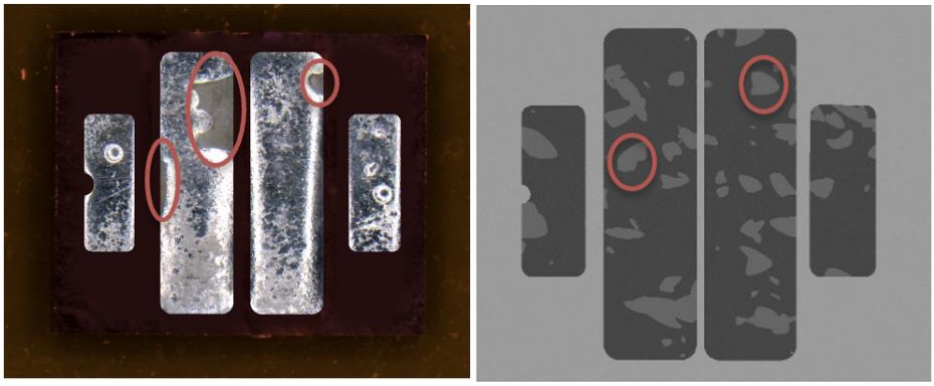


Figure 1 Example of non-wetted areas (left) and solder voids (right) in RGB and X-ray soldering images respectively

1.2 Overview

Quasar revolutionizes soldering inspection for Surface Mount Devices. It excels in pixel-level solder voids and non-wetted areas detection, ensuring meticulous quality control.

With Quasar, manual intervention becomes obsolete, significantly cutting down on non-quality issues and labour costs. Successfully deployed in automotive device production, Quasar offers rapid inspection, taking just one minute to process a set of 10 images and generate comprehensive technical reports compliant with JEDEC, IEC, and IPC standards.

Moreover, Quasar is device-agnostic, seamlessly integrating with various x-ray machines. Its intuitive interface is accessible from anywhere, catering to users of all expertise levels. Additionally, the batch-level analysis provided in the reports expedites root cause diagnosis, enhancing overall efficiency.

1.3 Key Points

This documentation will present in detail

- main features and functionalities of Quasar
- key technical specifications and requirements
- user guide of the web application
- how to deploy a model
- troubleshooting
- maintenance and updates
- support and resources

2 Product overview

2.1 Description

Quasar allows users to inspect soldering quality through a web application accessible from any computer (using the browser) connected to the internet.

Figure 2 Illustration of soldering quality inspection report generation flow with Quasar

Table 1 summarizes the key features of Quasar.

Table 1 Key features of Quasar

Feature Name	Feature Description
User authentication and service access	The user shall log in via its distributed account to access to the service landing page.
Non-wetted areas analysis	Non-wetted areas analysis for each image of a lot uploaded by the user. The results indicate several solderability quality metrics at the pad, device and lot's levels and their compliancy to quality requirements. Once completed, the user can download a PDF and an Excel report.
Solder voids analysis	Solder voids analysis for each image of a lot uploaded by the user. The results indicate several solderability quality metrics at the pad, device and lot's levels and their compliancy to quality requirements. Once completed, the user can download a PDF and an Excel report.

2.2 Specifications

Supported Platforms: Web-based, compatible with browsers Safari, Chrome, Firefox and Edge.

Languages: English

Version: 1.0.0

2.3 System Requirements

Hardware: Any device with internet access

Software: Modern web browser (Chrome, Firefox, Safari, Edge)

3 Getting started

3.1 Login

Before accessing the service, users must authenticate through a Single Sign-On (SSO) procedure. This section details the user authentication feature and provides instructions on how to access the service.

When entering the Quasar URL in the browser, the user will be directed to a login page if they are not authenticated.

3The user must click the "Login" button, prompting a pop-up window to appear, asking them to sign in with their account. Upon successful authentication, the user will be redirected to the landing page shown in Figure 4. The username will be included in all analysis reports initiated by the user.

3.2 Landing Page Overview

The soldering quality inspection using Quasar web application is straightforward and consists of four steps:

- Use Case Selection: Users can choose between WETTING (for inspecting non-wetted areas in RGB images) and VOIDING (for inspecting solder voids in X-ray images).
- Device Selection: Select a device, which is a group of products sharing the same geometry. If a template for the device exists in the database, a substrate drawing will be displayed, as shown in part 2 of Figure 4.
- Upload Your Files: Upload a batch of images for inspection by either browsing your folders or using drag and drop. The images in the batch must have the same geometry (as the device drawing if displayed).
- Run: Click the "Run" button to start the analysis.

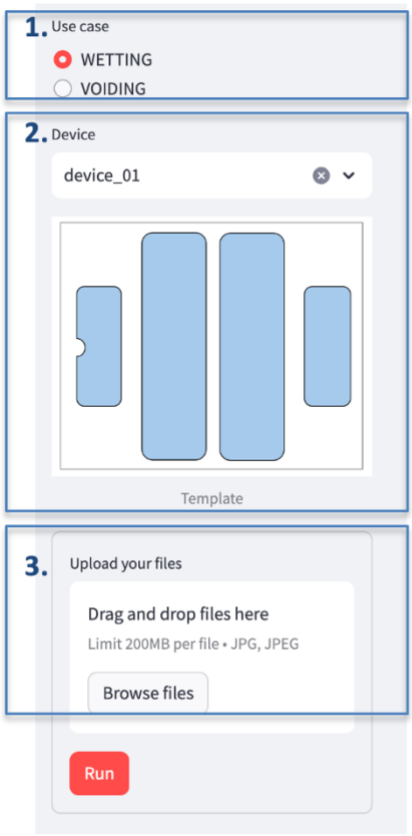


Figure 4 Illustration of soldering quality Inspection workflow

3.2.1 Use case selection

Quasar currently supports two use cases:

- WETTING: non-wetted areas detection and analysis in RGB images
- VOIDING: solder voids detection and analysis in X-ray images.

Users can select a use case by clicking on the desired box as shown in section 1 of Figure 4

3.2.2 Device selection

Users need to select the device type to assess for soldering quality inspection before uploading images and launching the analysis. Identifying the device type enables the web application to:

- Perform more accurate analyses, utilizing additional information associated with the device type, for example device's geometry.
- Include this information in the generated reports.

To select the device type, users can choose from a list of products populated from the database. This selection can be made using a drop-down list. If the user is uncertain of the device type, they can select the “Any other devices” option, as shown in **Error! Reference source not found.**. This selection will reveal an additional metadata field where the user can optionally enter a custom device type name, which will be displayed in the analysis results.

After selecting a device, a template substrate drawing representing the device's geometry will be displayed, if available in the database. This allows users to verify that the chosen device matches the images they plan to upload.

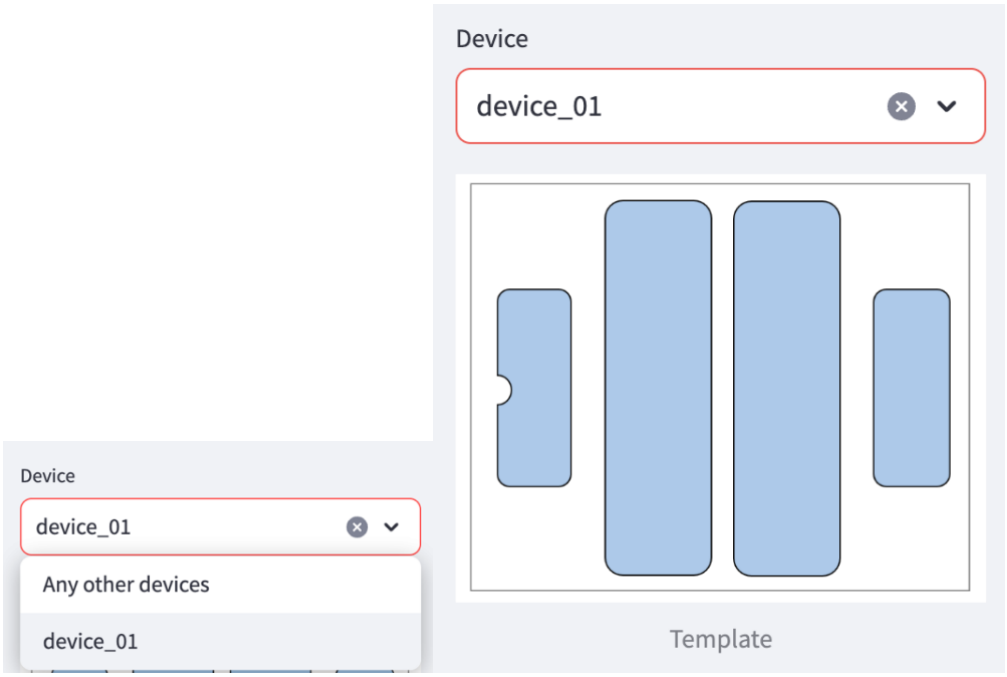


Figure 5 Illustration of drop-down list (left) and template display (right) for device selection

3.2.3 Upload files

Users can upload a batch of images for inspection by either browsing your folders by clicking on “Browse files” button or using drag and drop. The images in the batch must have the same geometry (as the device drawing if displayed). The accepted image format is JPEG and the maximal size is 200 MB per file.

The interface then expands to display the list of images being uploaded, along with a progress bar indicating the upload status. A small cross allows the user to remove files either during or after the upload process. Figure 6 shows an example of files uploading. The "run" button remains disabled until all files have been successfully uploaded.

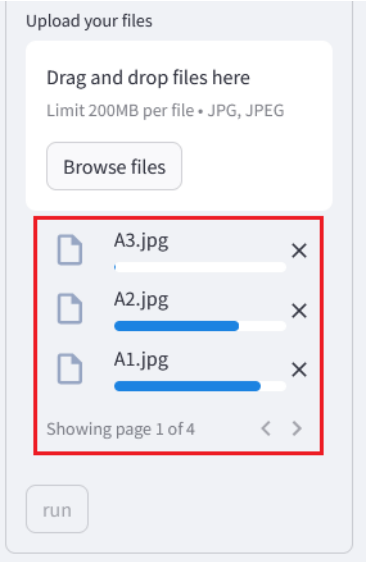


Figure 6 Example of files uploading

3.2.4 Run

Once all the images have been successfully uploaded, users can click the "Run" button, as shown in Figure 7, to start the inspection. A progress bar will then display the number of images processed.

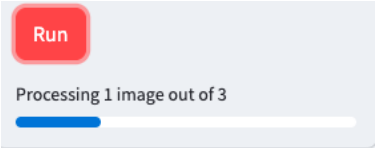


Figure 7 Illustration of progress bar when running the inspection on uploaded images

4 Inspection results analysis

Quasar detects pad and non-wetted areas/solder voids at pixel level for each image. A segmentation mask is generated for this purpose. Visual and statistical analysis is displayed for each pad, device (an image) and batch.

The inference results are displayed on the web application with the error code if any.

4.1 Definition of non-wetted areas analysis errors

Error raised by Quasar	Explanation	Error displayed to the user
UNKNOWN_DEVICE	The device is unknown: no template available	WARNING (the pad identification and void % may be wrong)
UNKNOWN_ROTATION_CONVENTION	the rotation convention is unknown: the image won't be rotated	
UNABLE_TO_PROPERLY_ROTATE	a rotation angle could not be found to match the rotation convention with confidence	
WRONG_TEMPLATE_ALIGNMENT	the intersection between the pads of the template and the detected pads is too small	WARNING (the template may be misaligned with the device)
TOO_MANY_PAD_DETECTIONS	too many pads detected compared to the template	
TOO_FEW_PAD_DETECTIONS	too few pads detected compared to the template	

4.2 Pad and image-level analysis

After an inference is performed on an image, the results are displayed in the right frame and contains:

- The image name.
- The status of the image analysis: OK or the error message.
- The original image.
- The image with the mask identifying the pads and the non-wetted/solder voids areas.
- The pad-level metrics for each pad and its compliance to the quality requirements.
- The image level metrics and its compliance to the quality requirements.

The results for each image are displayed one after the other as seen in Figure 8.

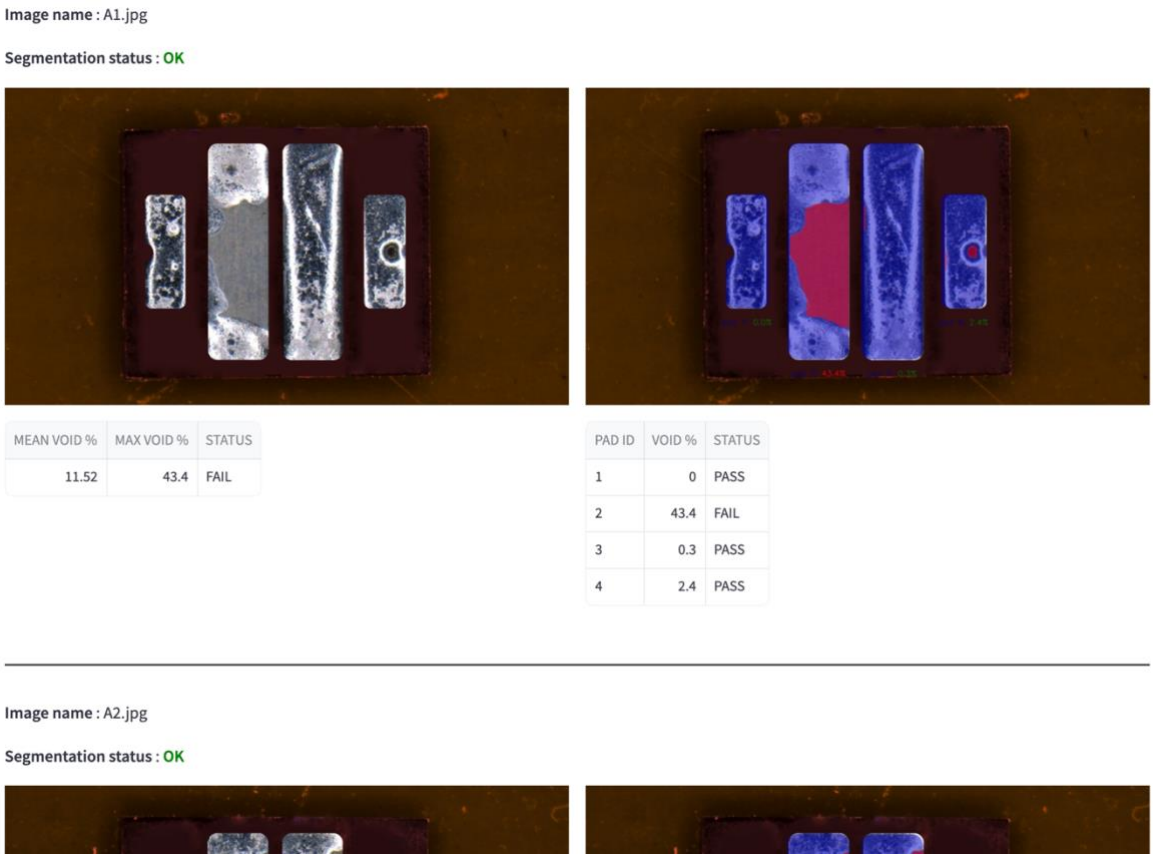


Figure 8 Non-wetted areas analysis results display

As shown in Figure 9, each pad has:

- PAD ID: the identification number of pad in the image.
- VOID %: non-wetted areas/solder voids percentage of the pad, which equals to non-wetted area/solder void area divided by pad area.
- STATUS: For non-wetting use case, if the VOID% is higher than **5%** (the threshold can be customized), then the PAD status is FAIL, otherwise PASS. For voiding (solder voids), if the VOID% is higher than **25%** (the threshold can be customized), then the PAD status is FAIL.

At image level, three metrics are defined:

- Mean void %: average non-wetted areas/solder voids percentage in the image, which equals to the overall void area in the image divided by all pads' area
- Max void %: the maximum non-wetted areas/solder voids percentage of all pads
- Status: if all pads pass, then the image status is PASS, otherwise its status is FAIL

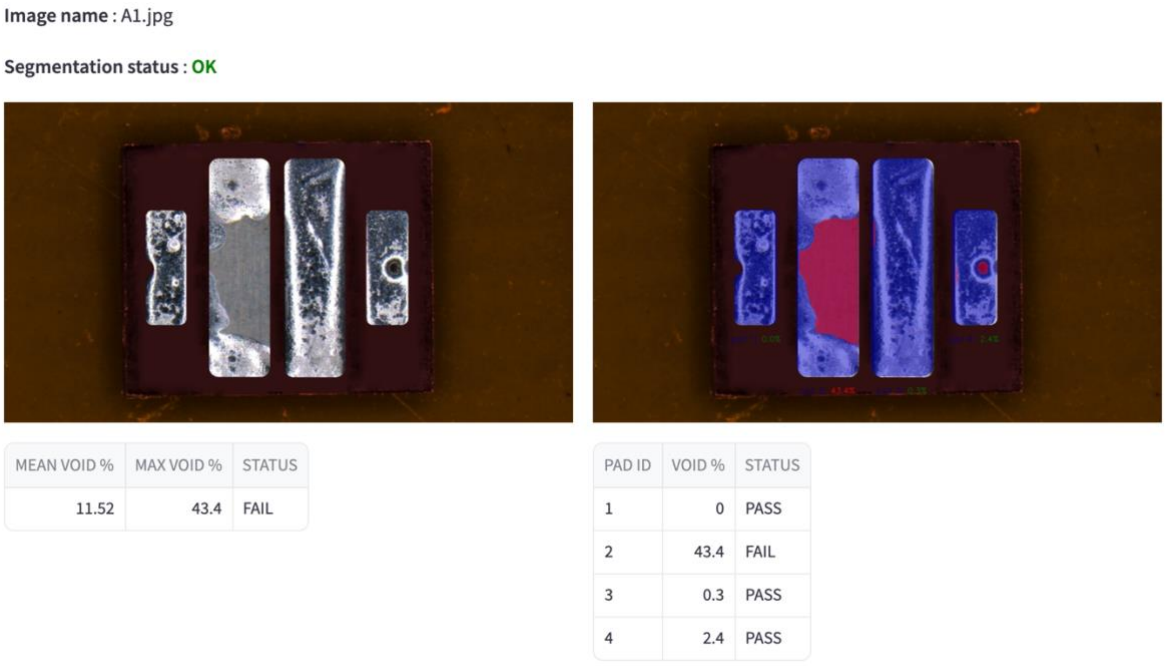


Figure 9 Illustration of Image-level and pad-level metrics definition for non-wetted areas analysis

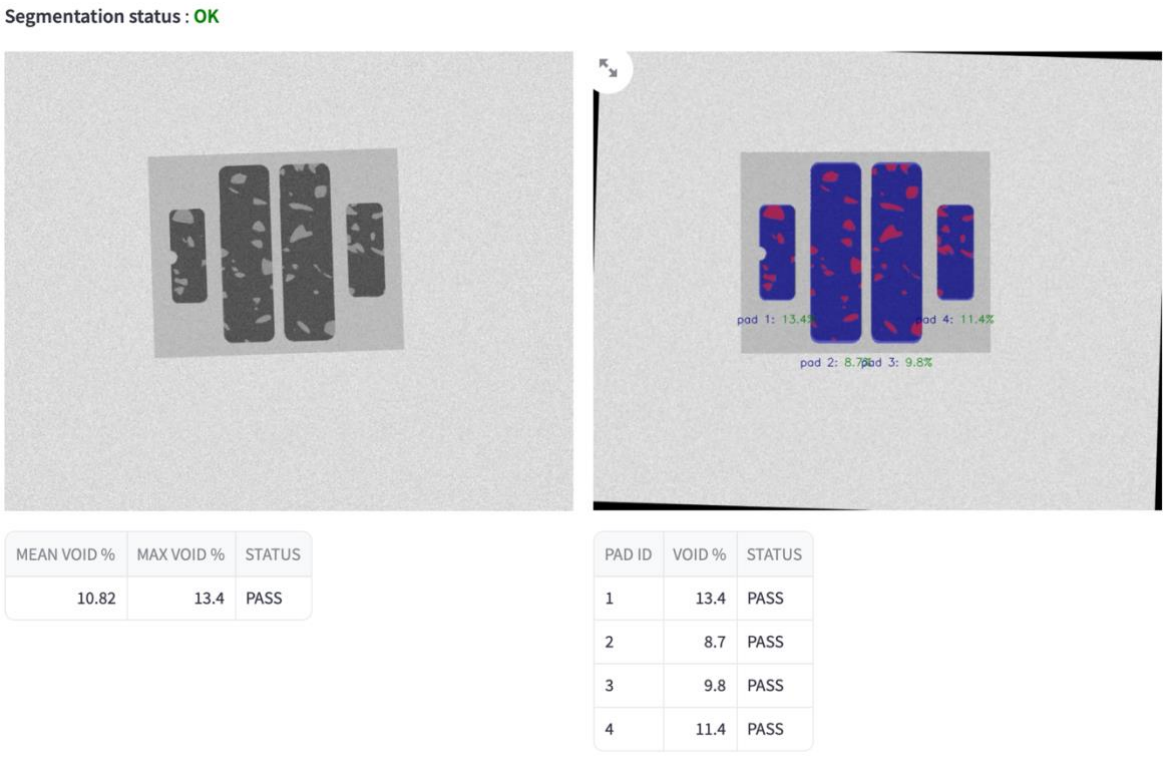


Figure 10 Illustration of Image-level and pad-level metrics definition for solder voids analysis

4.3 Batch-level analysis

Once all the images of a batch had been analyzed, Quasar computes batch-level metrics and a heatmap showing the occurrence of non-wetting in the device.

4.3.1 Batch-level metrics

The batch level metrics are defined as following:

- TotalMaxVoiding[%]: the maximum non-wetted areas/solder voids percentage of all pads in the batch
- AvgeVoiding all devices [%]: average non-wetted areas/solder voids percentage of all pads in the batch, which is calculated as the division of total non-wetted/solder voids area over total pad area
- Failed devices [%]: failed image number divided by number of images in the batch
- Failed devices [%]: failed pad number divided by number of pads in the batch

4.3.2 Heatmap

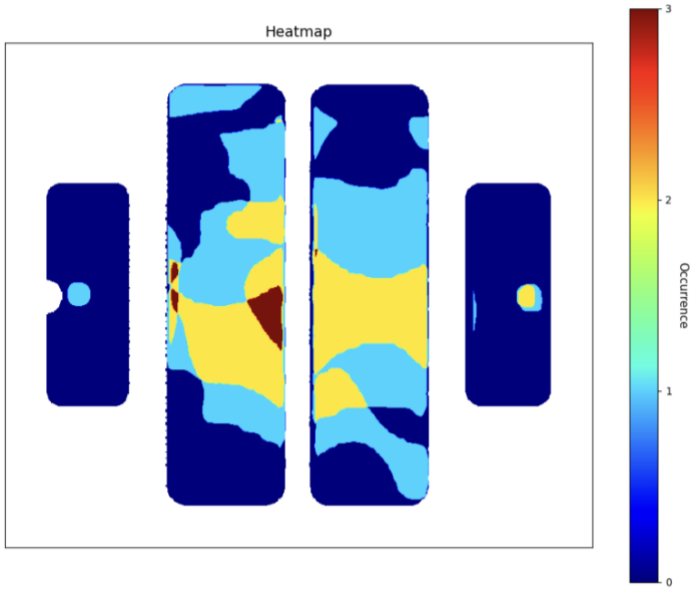


Figure 11 Non-wetted areas heatmap

Figure 11 show an example of non-wetted areas heatmap. It is built by counting the occurrence of each pixel of a pad in a void area in all analyzed images.

In case an image inference had generated an error different than UNKNOWN_DEVICE or UNKNOWN_ROTATION_CONVENTION, the image is excluded from the heatmap generation.

4.3.3 Analysis summary

A compliancy status of the batch is provided.

The metrics are encapsulated into a summary table containing additional information:

- The date of inspection

- The device name if filled by the user
- The username
- The device type
- The number of images
- The number of pads for the device type
- The threshold applied on the max acceptable non-wetted area/solder voids area ratio for each pad (5% by default for non-wetting, 25% for solder voids use case)
- Quasar version

	Overview
Date	2024-06-05
User	Unknown
Device	KW2 HIL532.TK
Number of devices	3
Number of pads	4
TotalMaxVoiding [%]	14.6
AvgeVoiding all devices [%]	4.72
Failed devices [%]	100.0
Failed pads [%]	41.67
Thresholds [%]	5 5 5 5
QUASAR release version	v1.0.0

Figure 12 Non-wetted areas analysis summary

4.4 Graphical and statistical reports

Below the analysis summary, a link allows downloading a PDF report and a link allows downloading an Excel report as shown in Figure 13.

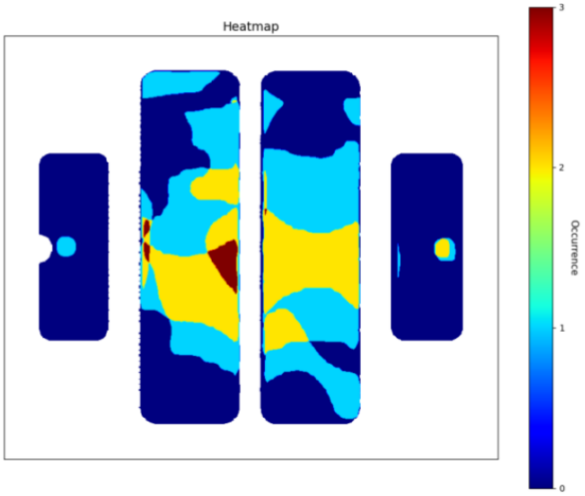
Figure 13 Reports download links

4.4.1 PDF report description

The PDF is composed of following information:

- Batch level analysis: a heatmap explained in section 4.3.2 and an analysis summary shown in 4.3.3 are summarized in the cover page of the report.
- Image level analysis: a dedicated page for each image in the batch is generated and it contains an original image, an image with segmentation masks, an image-level table and a pad-level table.

Automatic QUASAR 1.0.0 Report for device_01



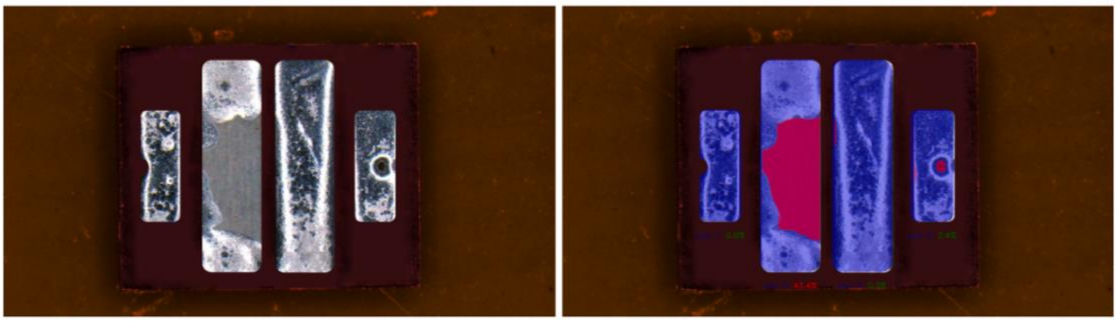
Batch segmentation status: OK

	Overview
Date	2024-06-08
User	Unknown
Device	device_01
Number of devices	5
Number of pads	4
TotalMaxVoiding [%]	52.2
AvgeVoiding all devices [%]	13.74
Failed devices [%]	100.0
Failed pads [%]	35.0
Thresholds [%]	5 5 5 5
QUASAR release version	v1.0.0

Figure 14 Example of cover page of the PDF report

	DeviceID	MEAN VOID %	MAX VOID %	STATUS
A1.jpg	1	11.52	43.4	FAIL

Segmentation status: OK



	DeviceId	PAD ID	VOID %	STATUS
A1.jpg_d1_p1	1	1	0.0	PASS
A1.jpg_d1_p2	1	2	43.4	FAIL
A1.jpg_d1_p3	1	3	0.3	PASS
A1.jpg_d1_p4	1	4	2.4	PASS

Figure 15 Example of image-level page in the PDF report

4.4.2 Excel report description

The excel file consists of 4 tables:

- **Overview**: table of analysis summary explained in 4.3.3.

	Overview
Date	2024-06-05
User	Unknown
Device	device1
Number of devices	3
Number of pads	4
TotalMaxVoiding [%]	14.6
AvgeVoiding all devices [%]	4.72
Failed devices [%]	100.0
Failed pads [%]	41.67
Thresholds [%]	5 5 5 5
QUASAR release version	v1.0.0

Figure 16 Example of Summary table

- **FullData**: a table contains detailed information of each pad (row) with following columns

- UniqueName: A unique name to identify a row, which is made up of OriginalName_DeviceNumber_PadNumber
- OriginalName: original image name without extension
- DeviceNumber: device number in the batch
- PadNumber: pad number in the image
- SolderJointArea_pixels: soldering area (in pixel) of the pad
- VoidingArea_pixels: non-wetted/solder voids area (in pixel) of the pad
- VoidingRatio [%]: non-wetted/solder voids ratio of the pad, which is VoidingArea_pixels divided by SolderJointArea_pixels times 100 (in percentage)
- BiggestVoid_pixels: biggest non-wetted/solder voids area in pixel in the pad
- NumberOfVoids: number of non-wetted areas/solder voids in the pad
- MeansizeOfVoids_pixels: average non-wetted areas/solder voids area in pixel, which is VoidingArea_pixels divided by NumberOfVoids
- Status: if the pad passes quality check. For non-wetting use case, when VoidingRatio > 5%, the status is FAIL, otherwise FAIL. For solder voids use case, when VoidingRatio > 25%, the status is FAIL, otherwise FAIL.

A	B	C	D	E	F	G	H	I	J	K
UniqueName	OriginalName	DeviceNumber	PadNumber	SolderJointArea_pixels	VoidingArea_pixels	VoidingRatio [%]	BiggestVoid_pixels	NumberOfVoids	MeansizeOfVoids_pixels	Status
Bild 001.jpg_1_1	Bild 001.jpg	1	1	56745	5047	8.894175698	2491	2	2523.5	FAIL
Bild 001.jpg_1_2	Bild 001.jpg	1	2	66277	0	0	0	0	0	PASS
Bild 001.jpg_1_3	Bild 001.jpg	1	3	68342	2272	3.32445641	2159	2	1136	PASS
Bild 001.jpg_1_4	Bild 001.jpg	1	4	58462	1040	1.778933324	1040	1	1040	PASS
Bild 002.jpg_2_1	Bild 002.jpg	2	1	56489	0	0	0	0	0	PASS
Bild 002.jpg_2_2	Bild 002.jpg	2	2	65008	3819	5.87466158	1486	4	954.75	FAIL
Bild 002.jpg_2_3	Bild 002.jpg	2	3	67988	5991	8.81184915	5991	1	5991	FAIL
Bild 002.jpg_2_4	Bild 002.jpg	2	4	58924	0	0	0	0	0	PASS
Bild 003.jpg_3_1	Bild 003.jpg	3	1	56653	0	0	0	0	0	PASS
Bild 003.jpg_3_2	Bild 003.jpg	3	2	65579	7726	11.78121045	4450	6	1287.666667	FAIL
Bild 003.jpg_3_3	Bild 003.jpg	3	3	66569	0	0	0	0	0	PASS
Bild 003.jpg_3_4	Bild 003.jpg	3	4	58248	8516	14.62024447	7162	2	4258	FAIL

Figure 17 Example of FullData table

- **DeviceSummary**: summary of a device (image), where each row represents an image, and it has following columns
  - OriginalName: original image name without extension
  - DeviceNumber: device number in the batch
  - Avge Voiding Ratio [%]: average non-wetted area/solder voids ratio in the image, which is total non-wetted/solder voids (overlapped with pads) area divided by total pad area in the image in percentage.
  - MaxVoidingPercent: maximum non-wetted area/solder voids percentage of all pads in the image
  - Status: if all pads in the image pass, the status is PASS, otherwise FAIL
  - Segmentation status: segmentation status of the image

OriginalName	DeviceNumber	Avge Voiding Ratio [%]	MaxVoidingPercent	Status	Segmentation status
Bild 001.jpg	1	3.48	8.7	FAIL	OK
Bild 002.jpg	2	3.68	9	FAIL	OK
Bild 003.jpg	3	6.6	14.6	FAIL	OK

Figure 18 Example of DeviceSummary table

- **PadSummary:** summary of a pad in all images of the batch, where each row represents a pad, and it has following columns
  - Pad: pad ID
  - VoidingArea pixels: sum of non-wetted area/solder voids area of THIS Pad in all images
  - Summe von SolderJointArea_pixels: sum of soldering area of THIS Pad in all images
  - Avge Voiding Ratio [%]: average non-wetted area/solder voids ratio in percentage, which is VoidingArea pixels divided by Summe von SolderJointArea_pixels and times 100
  - MaxVoiding Percent: maximum non-wetted area/solder voids percentage of THIS pad in all the images.

Pad	VoidingArea pixels	Summe von SolderJointArea_pixels	Avge Voiding Ratio [%]	MaxVoiding Percent
1	5047	169887	2.970798236	8.894175698
2	11545	196864	5.864454649	11.78121045
3	8263	202899	4.072469554	8.81184915
4	9556	175634	5.44085997	14.62024447
Total	34411	745284	4.617166074	14.62024447

Figure 19 Example of PadSummary table