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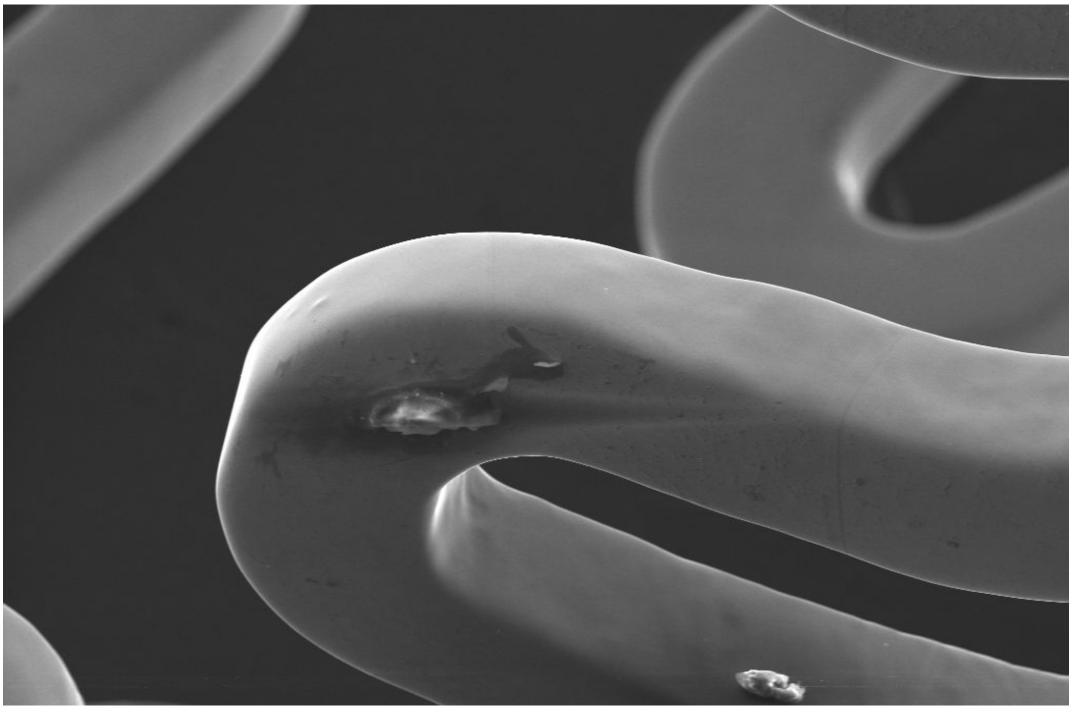

Data Management in Microscopic Analyses

Is Convergence Possible?

Master of Science Thesis in Biomedical Engineering

MARIE-LUISE PODLOUCKY

Department of Signals and Systems
Division of Biomedical Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2010
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Performed at:	**Carl Zeiss SMT Ltd** Cambridge, United Kingdom **Chalmers University of Technology** SE-41296 Göteborg, Sweden
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Cover:
A stent that has been used for a comprehensive analysis.

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Abstract

The content of this report concentrates on the workflow of organising, managing and storing data generated by different systems to achieve a comprehensive analysis. This comprises 2D scanning electron microscope (SEM) images, light microscope images, camera photographs, elemental analyses and 3D reconstructions. Finally the results shall be presented in a simple and clear way.

To date, the wide range of proprietary file formats complicates this process, requiring the use of a variety of software applications to present and report the information.

In this project, an extensive analysis of the existing file formats and their associated software applications has been accomplished, supported by a survey of the user requirements which has been done in form of phone interviews.

Based on the outcome, a proposal on how to organise and link the data, which simplifies the entire workflow follows.

Keywords: Sample Analysis, Data Management, Context View, Image Navigation, Microscopy, Reporting

Preface

This report is the result of my master thesis project at Carl Zeiss SMT Cambridge. Carl Zeiss SMT Cambridge is a manufacturer for scanning electron microscopes and additionally provides training rooms, where microscope systems are installed to conduct analyses for clients. While one complete analysis can take up to one week, with the option of returning or additional samples to be investigated, the wish is to organise and relate all data of one project to finally reduce the time needed for the result presentation. Having around four cases per month, a structured data organisation as well as result presentation is required. These needs raised the interest for this project, which has been supported by colleagues and external interviewees.

Special thanks go to Stewart Bean for his help and supervision of the project, Veronika Kugler for taking the time to explain the situation and especially aquire all the images. Roger Rowland for the cooperation and programming of a first prototype. The colleagues from product management for their constructive feedback and ideas and all other colleagues, enabling good times in the office.

I would also like to thank Professor Yngve Hamnerius for being my examiner and especially for his fast and helpful answers to my emails, which facilitated my work abroad a lot.

Special thanks go to Steffen Strätz for inspiring conversations and support during this project and my house mates and friends, who introduced me to the British culture and made a great time in Cambridge possible.

Contents

1. Introduction

"What is the problem with this stent?"

In medical research, microscopes are one of many devices contributing to the detection and analysis of diseases and fractures. They also play a large role in quality checks to analyse the conditions of surgical devices such as a stent. Using a microscope with different detector types allows not only to image the stent or parts of it, but also to perform an elemental analysis of the material and its composition using integrated X-ray detectors.

The digital aquisition makes it possible to automatise and capture several images of different regions from one and the same sample. Therefore, the amount of data can become large, complicating the presentation of the analysis results. Images are taken at varying magnifications with different detectors.

At the moment there is no option to visually relate several images and X-ray data taken with various detectors. Thus the difficulty to reconstruct where exactly the analysis has taken place and which spectrum belongs to which image is high. Furthermore, these results want to be presented to the client or patient in a clear and precise way, providing them with a report that gives all necessary information.

To date, it is more or less up to the user to organise the captured data in a way that results can be reconstructed and prepared for the presentation. This difficulty results in the idea to develop a solution to relate the data in a useful way. Ideally even follow-up studies of the same sample could be related to already existing datasets.

To get an idea of the current state-of-the-art and to develop a suitable solution, phone interviews with different user types have been conducted to elicit the user requirements. According to those, a selection of software applications has been evaluated. The outcome of these investigations has been used to suggest a solution to store and relate all images of one project, simplifying the data management and presentation of analysis results.

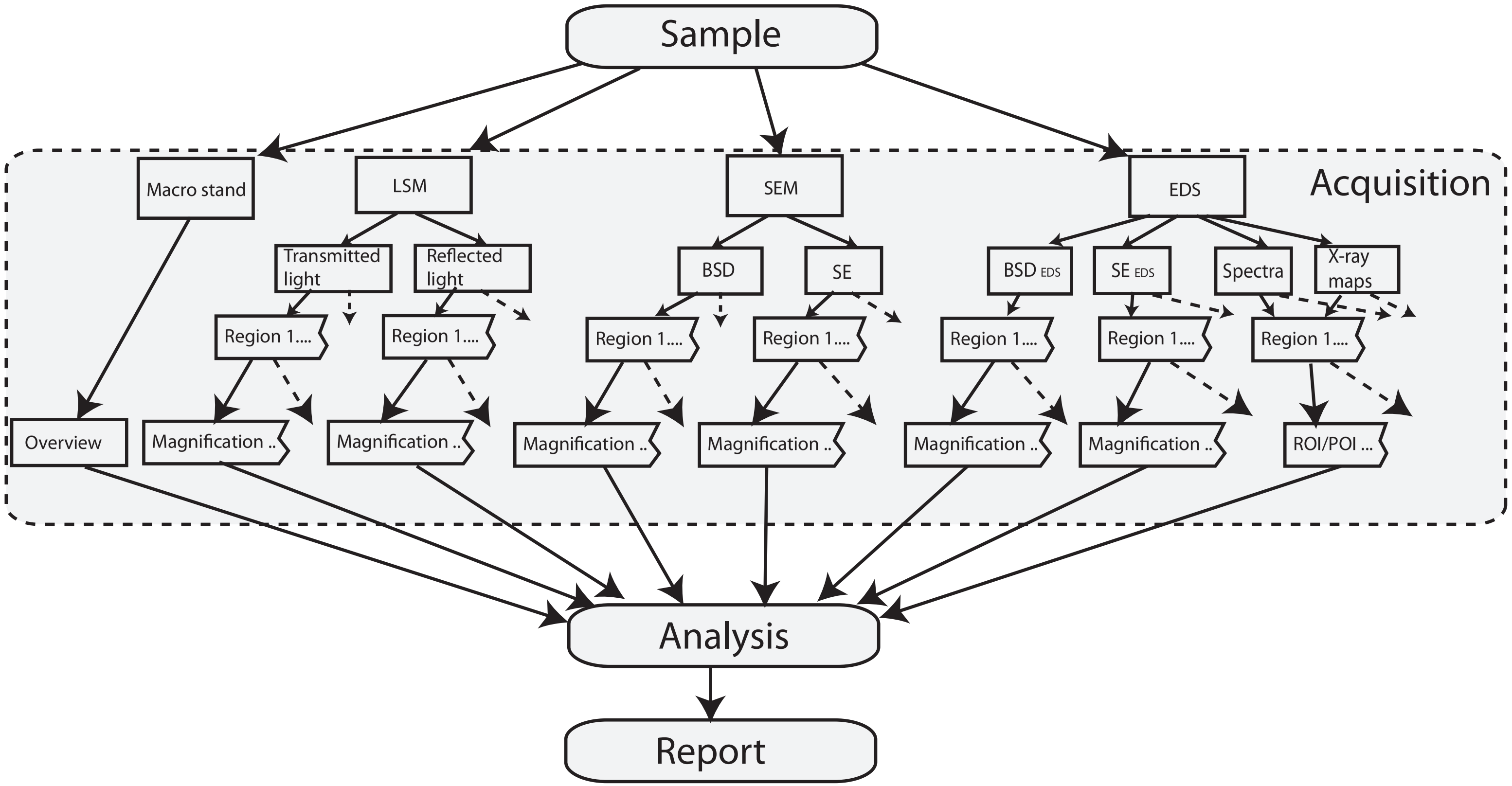


Figure 1.1.: Several systems and detectors contribute to a comprehensive analysis. This information needs to be analysed and presented in one final report. Abbreviations used in this figure are explained in the following chapter and at the end of the report.

2. General Concept

The main focus of this project is the development of a solution to manage and relate data aquired during a sample analysis. It shall provide the basis to facilitate the reconstruction of the image aquisition process and the file track-back through visual image navigation. Enabling the repetition of the aquisition process on a graphic model, helps to visually navigate to the needed information, which can then be further used for analysis and result presentation.

Figure 2.1.: Steps during a comprehensive analysis.

Analysis Process In this project an analysis basically refers to the process of investigating a sample under a microscope with focus on SEMs. A comprehensive analysis would start with an overview image taken with a macro stand, which is connected to the aquisition software of the SEM microscope. It can therefore be used as a reference to navigate the SEM stage to the desired position.

A light microscope analysis is helpful to detect and specify regions of interest for further analysis under a SEM. Depending on the SEM system, different detector types are available to produce the required signals. The secondary electron (SE) detector collects low-energy secondary electrons that result from inelastic scattering interactions of the beam electrons and creates a high resolution image of the sample surface. The backscattered detector (BSD) detects high-energy back-scattered electrons that result from elastic scattering interactions with the samples atoms. It is used to detect contrast between areas with different chemical compositions. Furthermore, a SEM can be equipped with an energy dispersive spectrometer (EDS) system, which analyses the elemental composition of a sample and characterises the relative concentration of materials and contaminants on the sample surface [1].

After the data acquisition is finished, the saved data needs to be organised and analysed, whereat each system provides its own associated software. Typical processing for the images is the general image enhancement, measurements on the sample and superimposing important annotations. The EDS analysis mainly results in spectra and numerical diagrams representing the elemental composition.

For the completion, relevant results are summarised and presented in a report.

Used Devices The data used in this project has been aquired by different systems, to simulate a real case situation.

Figure 2.2.: The EVO LS 15

The EVO LS 15 is a scanning electron microscope developed with the focus on life science imaging. It provides high magnification imaging, as well as the capability to maintain a locally high humidity to prevent water loss through cell membranes, which avoids de-hydration artifacts. An additional X-ray detector (EDS) by Oxford Instruments (OI), which is mounted to the system, has been used for elemental analysis, contributing to a more diverse investigation.

The SEM dual-channel mode enables to see images of two different detectors simultaneously on two separate screens to aquire two different analyses in parallel.

The OI EDS detector is connected to an additional computer communicating with the SEM system via a serial interface (RS232). This allows to capture the SEM image into the OI software INCAEnergy to specify a region of interest for an elemetal analysis. Depending on the sample, different scanning modes such as point or line scan can be chosen to aquire the according spectra. Once aquired, the data can be exported as a TIF file containing some of the basic parameters of the SEM aquisition settings.

The combination of these two systems forms a useful setup for the project and also represents a common system setup.

Another system, which has not actively been used in this project, is the Σigma which is a field emission scanning electron microscope (FESEM) that can handle objects up to a size of 250 mm diameter and 145 mm tall. It offers low voltage imaging and also allows the integration of X-ray detectors [2].

Carl Zeiss SmartSEM Carl Zeiss SmartSEM comes together with the Carl Zeiss (CZ) scanning electron microscope (SEM) and is the image aquisition software, providing control of all operating parameters. It is customisable, so that different users can be assigned certain levels of software control. “A secondary level even enables the user to change operating conditions and to write macros tailored to specific applications.” [3].

The images are exported in a customised TIF format (CZ TIF), which contains all metadata in the header. In addition to the raw image, an image of the same view, including all annotations that have been used during the analysis, is exported to a separate folder. Both files are created simultaneously, allocated with identical file names and containing the complete header information. Apart from visual observation, they can only be distinguished by their separated folders.

3. Understanding the User's Needs

One of the most important aspects for a user centered design in product and software development is to ascertain requirements to understand and characterise the users and their needs.

To get an overview of the use cases in image management and information presentation, phone interviews with different customers have been conducted as part of a direct observation. The general and common behaviours are of main interest with the focus on currently used software and the user requirements.

The varying application areas of microscopes, going from from medical research to quality analysis made interviews the most convenient solution to gather useful information. The direct contact with the user provides the flexibility to adjust questions for the specific interviewee according to the previously created interview guide.

Additionally, the design process was supported by regular meetings and presentations with colleagues from the product application management, the software development department and SEM application specialists.

3.1. Interviews to elicit User's Needs

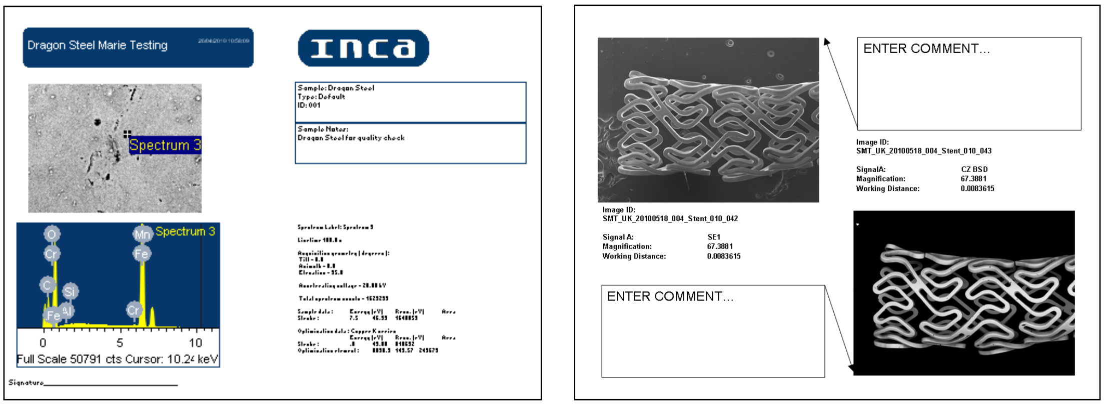
The selection of the interviewees was based on the variety of installed microscopes on-site with different capabilites and possibly from different manufacturers, which has been expected to give extensive information. For transnational results different countries have been selected. Among those were Sweden, Germany and the UK to get an overview, if certain solutions and requirements are dominant in one of the countries.

For a representation of different user requirements, interviewee groups are universities and research institutes, companies and also application specialists, performing on-site trainings for customers.

The focus of these interviews lies on the users' uses and skills with certain software and their solutions used for image analysis, image management and the presentation of results[1].

Use of Reporting and Presentation of Analysis Result Depending on the business, different features are required for the presentation of analysis results. Institutions dealing with e.g. forensic investigations or quality testing mainly need the images as a reference to the aquired elemental analysis of a sample. Creating analytical reports for elemental analysis is simpler in the way that just an output table or diagramm is needed, which

[1]This section is a summary of the phone interviews, which can be found in the appendix.



(a) In analytical reports, the actual SEM image serves mainly as a reference to locate the relevant areas.

(b) Result presentations display the actual images with their aquisition parameters.

Figure 3.1.: The figures show different report layouts dependent on the user's interest in the analysis.

is generally represented in the same way. This allows to create customised templates to automatically create a report.

On the other hand, most research institutes and medical institutions are more interested in visual results and analysis, thus the implemetation of images in the report is of high interest. This complicates an automatic report generation, since subjective analysis is required to include the required information.

Nearly every commercial software of a system provides a solution to report and present results, but only for its own produced data. This limitation increases the difficulty to combine and present a comprehensive analysis, which might involve data from different systems in an adequate and easy way. To overcome these difficulties, users export the data from all systems as common image files and prepare the presentation manually. The interviews show that Microsoft Office PowerPoint is the most commonly used solution, if a image-based result presentation is needed.

Out of 12 interviews, the universities and research institutes either used imaging software as ImageJ or Adobe Photoshop to process and prepare images for presentations in PowerPoint (PPT), or they did not have a need to present analysis results and left it up to the client. Application specialists either use PPT or other software, but there is no consistent solution.

INCAEnergy is widely used, but with varying extent concerning the implemented report generation module. One interviewee uses it as it is, whereas the other interviewees just create a report to access the data, which is then used for presentations created in PPT. This can be explained since the main interest of the former interviewee is the composition of the X-ray spectra, while the SEM image only serves as a reference to locate the tool markers.

The graphical user interface (GUI) of the INCAEnergy report generation is regarded as intuitive, but there are also some drawbacks concerning the design. Too little choice of parameters and flexibility when creating the templates influences the user experience. The fact that only one slide at a time can be exported highly limits the ease of use. This leads to the fact that users export the reports as HTML or Microsoft Office Word (Word) documents to further use the information in PPT presentations. In this case, a design update as well as the availability of PPT exports would be an improvement.

Having these facts in mind, the need to find a solution that handles all these concerns in an easy way, would be of common interest.

Software Used for Image Analysis In the area of image analysis, the choice of software varies a lot and depends mostly on the installed microscope system. Among commercial solutions INCAEnergy, SmartSEM and AxioVision by Carl Zeiss and GATAN's Digital Micrograph are mainly used. Additionally, freeware and open source solutions as e.g. ImageJ or NIH Image, developed by the National Institute of Mental Health (NIMH) [4], as well as a tendency to self-written software can be seen at universities (see interview A.2.4).

Until now, there does not seem to be a major solution since each individual has varying needs, which does not imply that there is no request. Generally, an interest in advanced stitching and 3D reconstruction can be observed (see interviews A.2.1, A.2.4), and a modular overall software interface, implementing all the desired features could be an appropriate solution.

Current Data Management Among the interviewees, the traditional Windows Explorer folder structure seems to form the basis for data management. Most of them store their data on servers, organised by locally determined rules, which often consist of a case/project number or the client's name, in combination with the date. In some cases this structure is supported by provided databases of software as INCAEnergy and the Carl Zeiss LSM Image Browser.

Some research institutes and universities do not store data at all, since they only provide the facilities and relinquish the analysis to the client, whereas others use larger database systems to organise their data. Among those are AnalySIS by Soft Imaging System GmbH and ImageAccess by Imagic (UK) Ltd.

3.2. Results of the User Interviews

Based on the previous results and some interviewees' opinions with focus on visual image analysis, an overall solution, including a database as well as functions for image analysis and reporting would be of high interest. Besides numerical reports for quality testing industry, the highest need for routine data presentation is at the application specialists, who not only perform on-site trainings, but also analyse samples that have been sent in by clients.

Still, it needs to be considered that people have difficulties switching their habits and they might want to keep their habits of creating reports and storing their data. Forcing them into predefined structures is not taken with delight. Thus if creating an overall solution, it has to be intuitive and highly customisable in an easy way [5].

A solution having all these aspects in mind would be desirable. The main aspects to be considered for a design proposal are:

- Export to Microsoft PowerPoint for the result presentation.
- A user interface which supports all file formats and allows to analyse the data.
- The solution should provide the facility to stay close to the user's previous file organisation for an easy migration.

4. Evaluation of Methods to Connect Data

In addition to the information that has been collected through the interviews in the privious chapter, a selection of individual software applications has been investigated to extract the relevant features and create a comprehensive proposal for data management.

As an application to visually relate images, Microsoft Photosynth (Photosynth) will be further investigated, while ImageAccess by Imagic (UK) Ltd. provides a solution for data organisation and storage, as well as analysis and reporting. It is capable of importing and reading all required file formats [6]. Furthermore, Carl Zeiss SmartTiffV2 is the stand alone user frontend for images taken on Carl Zeiss electron microscopes.

With the use of these programmes, a final graphical user interface (GUI) suggestion, relating and displaying all information associated to a sample, is developed.

4.1. Organising the Files

In addition to visual navigation, an underlying structured and elaborate file organisation is important to reduce the time needed to find and assemble the required information. For large amounts of data that shall be shared among several users, a database management system (DBMS) provides a suitable solution. It allows users to structure, control and maintain the data and to access it by different software applications. Other important features of a DBMS are the capability to protect data from failures and unauthorised accesses, to restore the database (DB) from backups and to present the DB information in a logical way to the user [7].

An application, providing these features is ImageAccess by Imagic (UK) Ltd. It is an image document management system, suitable for various application areas. It supports data aquisition and processing for a wide range of systems, from MRI and CT scanners, digital still and video cameras through to optical, confocal and electron microscopy [6].

The GUI allows to create a database structure according to the user's wishes. Additionally, optional functionalities as image analyses, measurements and annotations as well as image processing tools and enhancements are available.

Furthermore, a reporting module enables the creation of reports in Word or PowerPoint. Images can be organised in a lightbox and then automatically loaded into a previously created report template or they can be manually included using the drag-and-drop function.

Data present in the archive can be shared on a server using the “ims Publisher” module. It can be prepared for the download as a ZIP-file or as single files. A specific user/group can be defined and the sharing availability can be time limited and secured by a password [8].

Supporting 30 different image file formats, including the read-out of metadata and calibration information, it covers all requirements needed for this project. Files from several systems can be stored into one project case, maintaining the complete metadata for each file.

To test the suitability, the general DB structure has been set up integrating the current structure at Carl Zeiss SMT Cambridge, where a new project is created for each client that sends in samples. To date, the project name complies with the client's name and the project is first handwritten on a whiteboard, filling a set of category fields to specify the project. This is then additionally transfered to Microsoft Access. The DB in ImageAccess has been set up similar to the structure on the whiteboard. Small changes applied on the field categories for each project while the data storage structure has been completely overhauled. All images used in this project have been transfered and organised in the new DBMS.

4.1.1. Data Structure

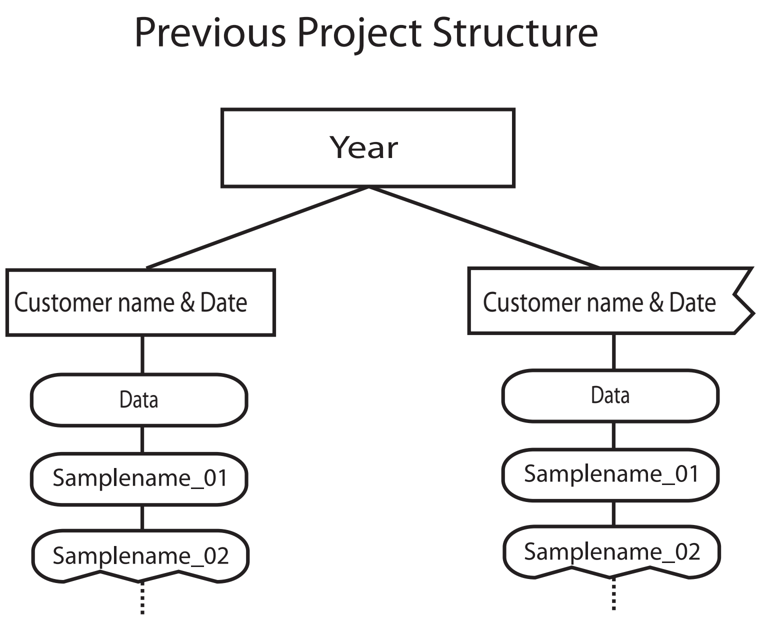


Figure 4.1.: The previous data management was mainly based on a folder structure, specifying the year and the customer as a subfolder, which then contained all data of the project.

Previously, files that were stored in a Microsoft (MS) Windows Explorer based folder structure, where all data from different sources is assembled manually, could be found either by date or the client's name. The user dependency of this structure implies a high risk for inconsistent file organisation. Furthermore, among the same user, labelling could differ for the same sample but different devices. Nevertheless, the main structure is composed of a main folder, specifying the year, which then contains a folder for each project named after the client and the date. The file names contain the sample name and a running number, while further optional information is not excluded (see figure 4.1). The new data organisation which is supposed to be operated only through the ImageAccess interface has therefore been set-up creating a four-layered DB structure.

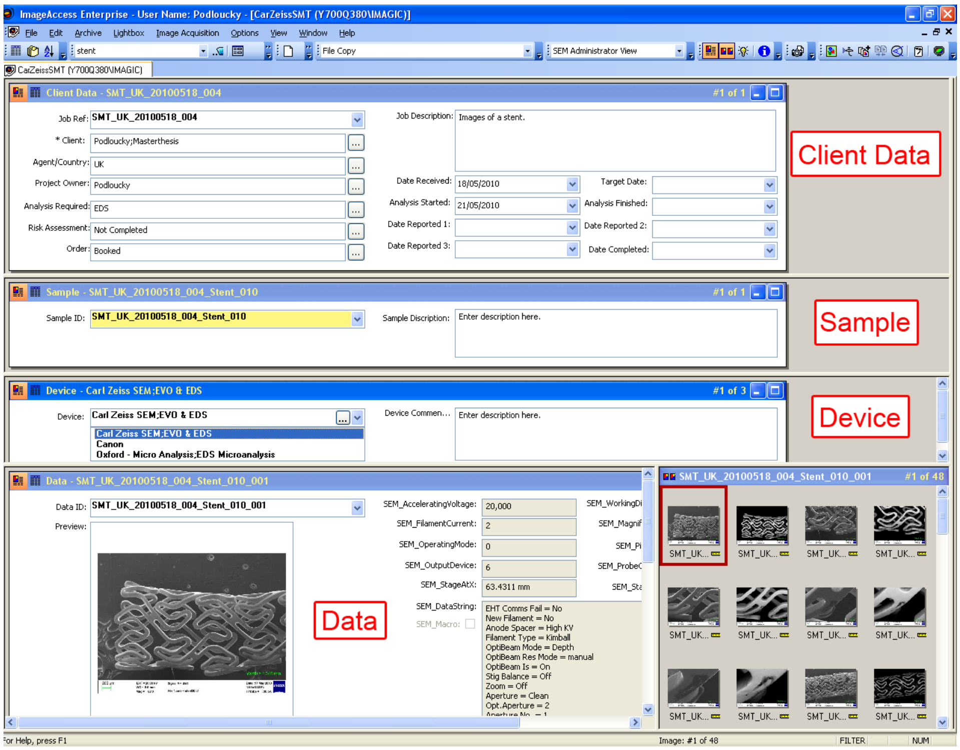


Figure 4.2.: The ImageAccess interface showing the four layered data organisation.

The first and second layer of a project are used to specify the client and sample information respectively with additional fields and comment boxes for optional information. Since a sample can be investigated by different devices, the third layer determines the used device, while the last layer contains the actual files (see figure 4.2).

4.1.2. Data Labelling

For a possibly global solution, an unambiguous identification of the files is of high importance. The new DBMS-based organisation automatically renames all files that are loaded into the archive and thus assures correct and consistent labelling for each sample among all users (see figure 4.3). To load data into the system, a new project needs to be

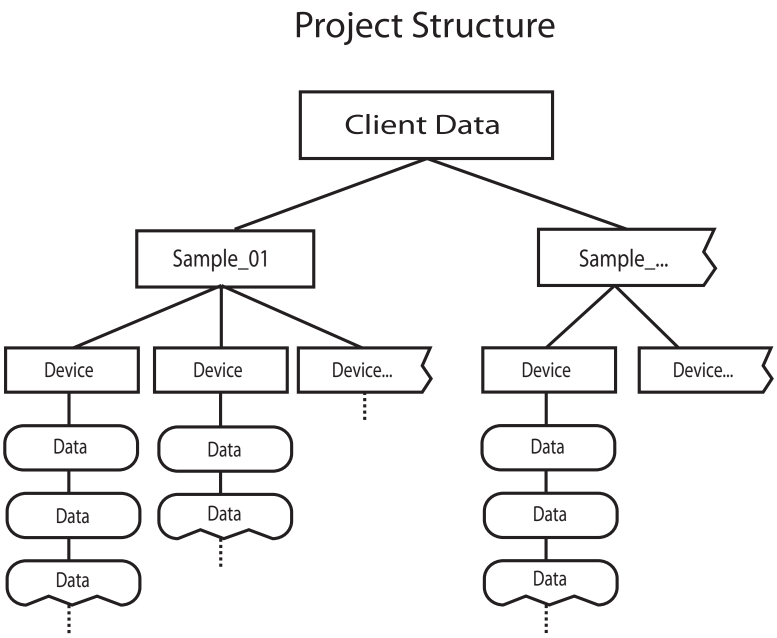


Figure 4.3.: The four-layered structure of the DB setup.

created, or an existing one selected. The project name for the first layer is automatically created and contains an identifier for the Carl Zeiss division, the country where it is located, the project date and a running number for uniqueness. The client name has been relinquished in the top layer to ensure anonymity for external data access. Instead, it is saved in one of the client data fields which are only displayed in the ImageAccess GUI (see figure 4.2).

$$\underbrace{\texttt{SMT\_UK\_20100618\_01}}_{project}\underbrace{\texttt{\_SampleName\_001}}_{sample}\underbrace{\texttt{\_001}}_{data} \tag{4.1}$$

Since the renaming of the files is the most significant change, the second layer contains the project label plus a textfield placeholder “SampleName”, which needs to be changed manually to the sample name, to keep parts of the previous user habits. An additional running number allows to have a unique identification for different samples within one project (see example 4.1). The device layer does not influence the labelling leading to the last layer that actually defines the name for the loaded files. Using the auto-save function in ImageAccess, each file is renamed according to the previously defined layer specifications, adding an additional running number to each file. Based on the layers in the ImageAccess GUI, folders and subfolders are automatically created to organise the storage of the files.

Even though the interface provides an extensive search function to filter all fields of a project and its samples, there is then a chance to access the files outside the interface using the MS Windows Explorer. This is not intended to be used, but gives the opportunity to access the data for users who do not have ImageAccess installed. In the MS Windows Explorer view a folder structure is created according to the DB's layer structure (see figure 4.3), creating a folder and subfolder for respectively project and sample, which then contain all the renamed files. In case the data shall be accessed externally, a copy of that folder should be created before external use, to avoid loss of data and inconformity of data used in ImageAccess.

Having in mind that users prefer to maintain their previous structure, data can also be loaded into the DB, maintaining its original filename. This keeps familiarity to the user, but does not ensure consistent file labelling. Especially for the current file structure of the CZ TIF files, where two images with the same file name seperated in different folders are exported for each view, it would not work out[1]. Since this folder structure is not preserved in ImageAccess, the SEM images from the two folders would be loaded into the same project and thus clash due to their identical filenames.

4.1.3. Discussion

The new data organisation involves some changes, which might cause initial discomfort for the user. Besides the renaming of all files, the idea of not being able to access the data at its storage location might cause a feeling of dependency and limitation. For the longterm, it can be assumed that the advantages of having a clear structure with full searchability among all fields will be appreciated.

Another benefit of the automated renaming is the fact that all files regardless of their origin would have the same labelling structure (see figure 4.4). On the other hand, a disadvantage of the automated renaming of the imported files is the missing ability of ImageAccess to recognise dublicates. If an image that is already present in the specific category is imported again, the software would not recognise it, but treat it as a new file and thus give it a new running number. This can cause confusion for the transition period from the old to the new system, but generally files should only be imported once into the archive for their further use.

Another aspect is that the current two folder structure requests to load the images sequentially, one folder after the other. This gives them sequent numbers, which breaks the link between the plain image and its related information image. They can then only be related either visually or by comparing their metadata.

Whenever the user is loading the images into the archive, it has to be verified that the correct sample of the project is selected in the interface to avoid images ending up in the wrong category.

[1]The current CZ TIF file structure is explained in more detail in chapter 2.

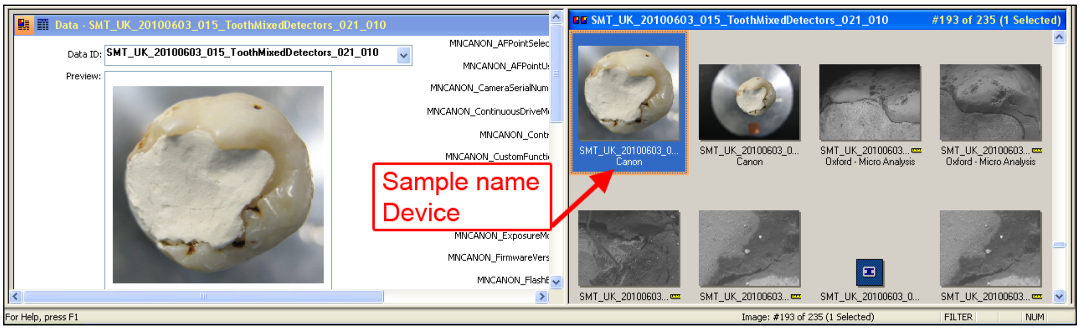


Figure 4.4.: In the ImageAccess GUI all files of a sample are renamed following the same structure. The name of the capture device can additionally be displayed below each thumbnail.

Having solved these adjustments, it can be said that the new structure would improve data management significantly and reduce the effort for the creation of reports and presentations since it provides a well-organised backend. Furthermore it shows that the current solution for the SEM file export needs a major overhaul. Not only for the new DB structure, but also to ensure unique file identifiability.

4.2. From Data Organisation to Visual Navigation

As described above, ImageAccess provides a customisable solution to organise, analyse and present the aquired data. All associated files of a sample are assembled manually under the same project number and can be filtered by various criteria. This provides a good backend, whereas the next step is to visually relate all images of one point of view with each other. In this case, the ImageAccess archive does not provide an automatic solution. However, it is capable of filtering all fields, including the metadata of each file giving the potential to add a common parameter to the metadata, that is specific for each view and identical for all related files. Another solution would be to manually enter keywords for each view which can then be searched for, but considering time and effort, this is not a realistic solution.

While Microsoft Photosynth uses a feature recognition algorithm to visually merge the images, another approach would be to look at the stage positions of the sample holder. They are stored in the metadata of the CZ TIF files and as long as the information is captured with the same device without removing the sample holder, they could be a criteria of interest to associate images of the same view. If all variables are combined, they provide enough information to reconstruct the exact stage position.

Difficulties arise for the combination of data taken on different systems or at different dates. There is no existent clue or calibration option that allows the merging of data sets to reconstruct the sample position. The stage coordinates only refer to a particular analysis and are not the same after a sample has been removed. Another difficulty is to merge files of one sample but comprising different analyses. Since they are taken on various systems from several manufacturers, the information is stored in different file formats, which do not necessarily store the required information in the same way.

4.3. Investigation of Existing Links

Based on the ideas of the previous section, a focus has been set on a solution to combine images based on their metadata. To achieve this, a solution that provides the same information for all different file types needs to be found. The following survey analyses the existing file exports to see if there already are common features that could be used to relate the data.

4.3.1. Relating Images of a Carl Zeiss LM and SEM

Being the only manufacturer for both light microscopes and scanning electron microscopes, Carl Zeiss released “Shuttle & Find”, an interface for correlative microscopy. It was designed for material analysis and allows to relocate a point of interest (POI) under an electron microscope, which had previously been selected using a light microscope and vice versa. It is based on a special sample holder, which contains L-shaped markers to calibrate the holder under each system, ensuring precise relocation [9].

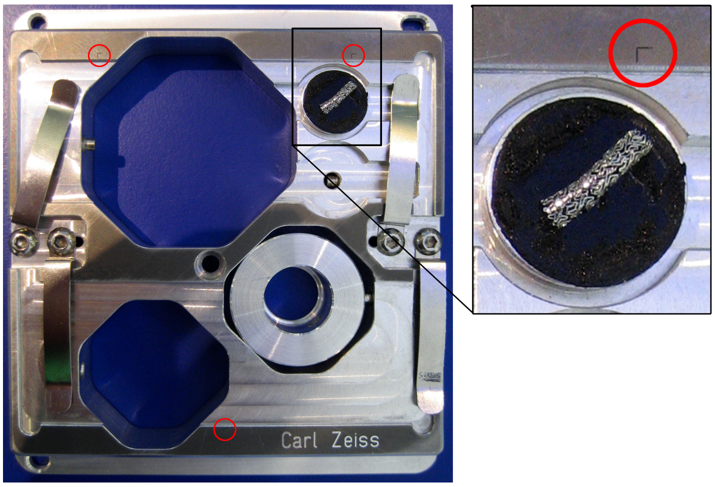
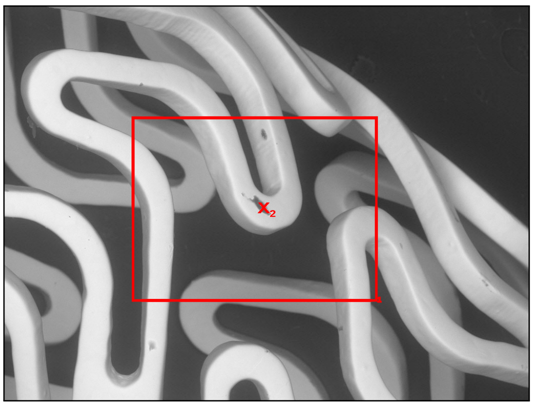
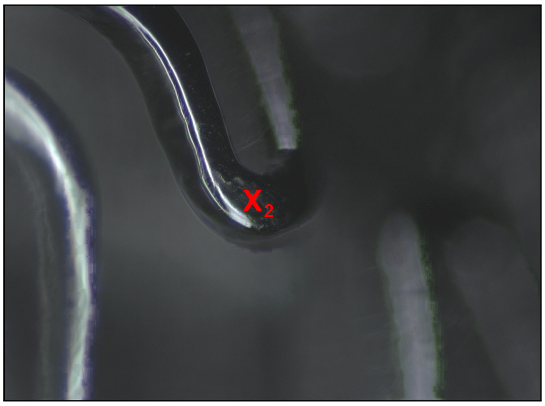


Figure 4.5.: The “Shuttle & Find” holder is specially designed to ensure precise calibration and alignment.

This interface creates a link between the electron and light microscopes, which is especially of interest to investigate samples at high magnifications, where visual relocation is impossible. A region defined under the light microscope can then be further investigated using the electron microscope. Subsequently, an elemental analysis can be performed to identify its chemical composition [10]. Those images can also be overlayed, giving comprehensive analysis results.



(a) The SEM view used to specify the region of interest.



(b) The LM image of the previously specified region under the SEM.

Figure 4.6.: Using the “Shuttle & Find” application creates a link between an SEM and the according LM image.

The application creates a good basis for further correlation of images since both systems originally have different stage positions, which then are related via the calibration process. The reference images are exported through the "Shuttle & Find" interface. While the LM images remain in their original Carl Zeiss Vision Image (ZVI) format, the reference images of the SEM are now also exported as a ZVI file, unfortunately not retaining their original metadata, which would be a good feature that enables to track-back the association of the images. To date, the link between the images is only present during the aquisition, leaving the later association up to the user.

4.3.2. Relating INCAEnergy and SmartSEM Files

During the investigation of current solutions, a comparison of the metadata showed that images exported from the INCAEnergy software contain certain parameters as stage coordinates and acceleration voltage, which are of interest to relate images.

They are directly imported from SmartSEM into INCAEnergy and then stored in the exported SEM reference images. Hence, they show the same information as the CZ TIF files which were directly exported through SmartSEM. This means that there already exists a link between those two systems which can be enhanced. Even though the values for the according parameters are the same, their units differ (see figure 4.7).

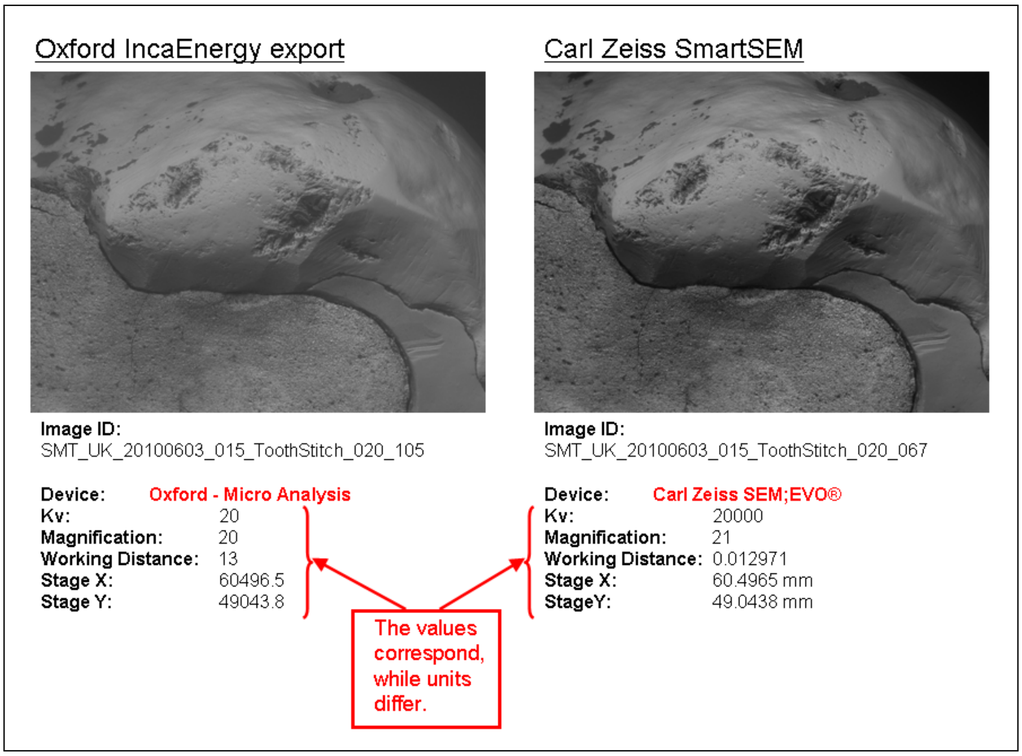
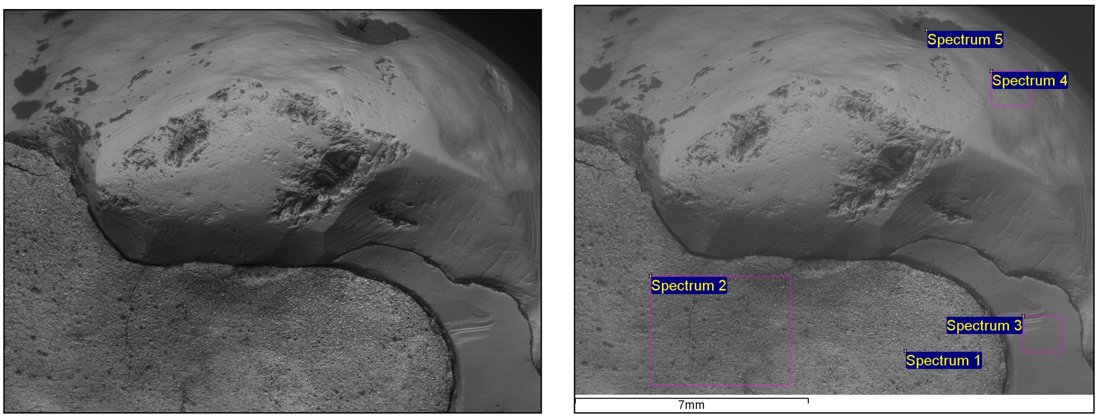


Figure 4.7.: Extracting the metadata from the SmartSEM image and according the INCAEnergy export shows that parameters correlate, whereas the units differ. The deviation at the magnification is caused by rounding differences.

There are two ways to export the images and spectra from the INCAEnergy software. While one solution exports the SEM images and spectra as a TIF file, a second option exports the complete project as a webpage, with each image as an individual BMP file. The TIF reference image contains the relevant header information, whereas the BMP file displays the analysed regions of interest, but does not contain any metadata (see figures 4.8). This complicates the relation of the spectra to the reference images outside the INCAEnergy software. Since the spectra files do not contain any metadata either, the only way to visually link them to the reference image is via the exported BMP file. Each spectrum has a numbering label which is also indicated in the BMP reference image and thus allows them to be matched to the according region of interest.



(a) The reference image used for the elemental analysis, exported as a TIF file, contains the relevant metadata.

(b) Exporting the whole elemental analysis project as a HTML provides this BMP reference image without any metadata, but displaying the analysed regions.

Figure 4.8.: The two export options for the reference images.

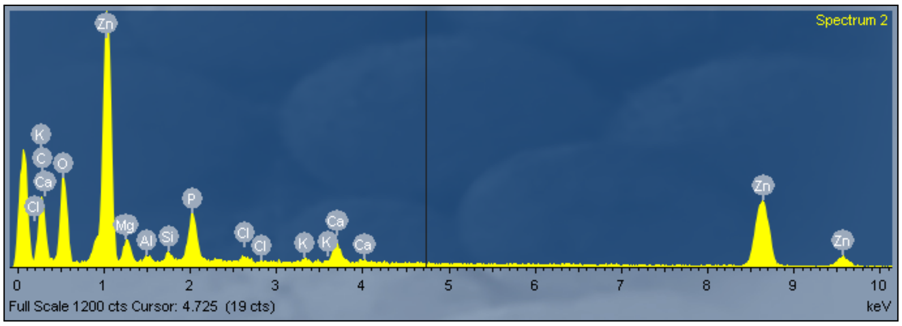


Figure 4.9.: The exported spectra do not contain metadata but outside the software, the label in the top right corner allows to relate them to their origin in the exported BMP reference image (4.8(b)).

So far, this can only be done manually, raising the need for a reference image export that contains both, metadata as well as the option to superimpose the regions of interest. The ideal solution would provide a reference image with related images of the spectra, where each spectrum contains the coordinates for its region of interest. Additionally, the units between the SmartSEM and INCAEnergy export images should be adjusted so that either of them could be used to locate the regions where the spectra have been aquired. The following sections give an insight into software applications with the potential to create the required links to visually navigate through the images.

4.4. Image Matching in Photosynth

Microsoft Photosynth is a software application, that merges a collection of images taken of the same scene, but from different perspectives. It is the result of a cooperation between Microsoft Research and the University of Washington, released for public use in August 2008. Its technique is based on a feature recognition algorithm. It is capable to create a 3D model of the 2D images of an arbitrary object [11].

Initially, the software was released to present photographs in an exeptional way, creating 3D reconstructions without any knowledge about the imaging device or capture settings. A completed 3D reconstruction is denoted as a Synth and can be viewed in different modes such as 3D models, a 2D view, displaying the containing images as thumbnails or as a 3D point cloud. It provides the possibility to navigate through a completed Synth, to select a thumbnail in the 2D view, or to “fly around” in the scene and zoom in and out of a picture as well as looking at the object from different perspectives in the 3D view. It enables to see, where the pictures were taken in relation to the complete scene and therefore creates a potential for enhanced user experience. First ideas to use this application as a forensic tool, utilising the point cloud as a free 3D scanner, have already been tested by AI2-3D, a company specialising in 3D forensic measurements and visualisations [12]. Furthermore, the implementation into Microsoft Bing Maps allows a realistic drive through the streets [11].
In this section, the functionality of Photosynth for microscopic images has been investigated. To get a comprehensive result, a variety of samples has been used to create challenging tasks. They aim to create a 3D model of a sample and to combine images of different magnifications to allow a subsequent investigation of the sample starting from an overview perspective. The last and most advanced task was the correct combination of two data sets of the same sample, taken at different dates. Furthermore, a combination of image stitching using Microsoft Image Composite Editor (ICE) and Photosynth is used to fulfil the aquisition requirements for images to be used in Photosynth [13].

If not otherwise specified, the images where taken with the Carl Zeiss EVO LS 15 according to the given Photosynth instructions, which require an overlap of ideally 50% and an angular intervall of maximal 15° [13].

The Technology The process of merging the uploaded images involves an interest point detection and matching algorithm that analyses each image to identify unique features. A comparison of these features among all the images reveals similarities and thus matches the images together. With the information about the distance, shift and angle, the 3D position of each feature is identified, scientifically known as bundle adjustment[2].

To ensure a successful Synth, certain requirements apply for the objects and their aquisition. Too repetitive textures and the occlusion of large regions complicate the process. Additionally, for changes in distance or angle, images need to be captured at determined intervals, further specified in [13].

[2]Bundle adjustment is a technique to refine a visual reconstruction to produce jointly optimal structure and viewing parameter estimates [14]. It is almost always used as the last step of every feature-based 3D reconstruction algorithm, which evolved in the field of photogrammetry.

The Application Feature recognition and matching appears to be a possible solution for the aim to visually relate images and reproduce the aquisition process described in chapter 1. Therefore its functionality for microscopic images shall be tested, allowing the user to reconstruct a 3D model of the investigated sample as well as the advanced navigation “through” it at different magnifications.

Photosynth is based on a feature detection algorithm which is incapable to link certain objects and textures. According to the examples given in [13], those are large uniform areas, highly repetitive structures, as well as complex occlusions, which cause problems. Yet microscopy is used to examine a certain region of interest, where uniformity is unlikely to occur. However, repetitive structures and occlusions are more likely to appear.

A Synth that has been completed can be shared among others. This implies that clients, who request an investigation, can get a complete analysis of their sample. They are then able to simulate the previously conducted aquisition process.

Problems Since the application is in an early development stage, the analysis as well as extracting sample information of a completed Synth is not yet possible. Additionally, it is limited to the online presentation, since the functionality to export a Synth is not implemented. As a result, the approach is to find a solution to prepare the microscopic image files in a way that they can be used in Photosynth, allowing to have the information about the current image directly available.

4.4.1. Microscopic Samples Used for the Tests

The samples used in this project were chosen according to the needs to realise a comprehensive investigation of the individual functions of Photosynth. Not only objects from the life science area had been taken, but also objects of interest in material analysis. This has been done to have a wider variety of structures available. Refering to the Photosynth manual, highly repetitive features as well as coarse structures raise the challenge on the software.

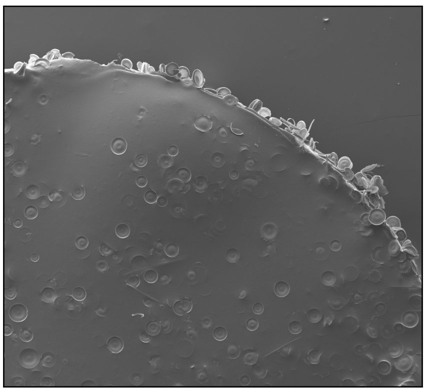


Figure 4.10.: Diatom captured with an EVO 15 using the SE detector.

A diatom had been chosen because of its repetitive circular features, which could influence the correct feature recognition in terms of localisation and scaling. Since the feature detection algorithm in Photosynth was inspired by the scale invariant feature transform (SIFT) developed by David Lowe at the University of British Columbia [15], the different sizes of the circles on the diatom itself should not contribute to the feature relocation.

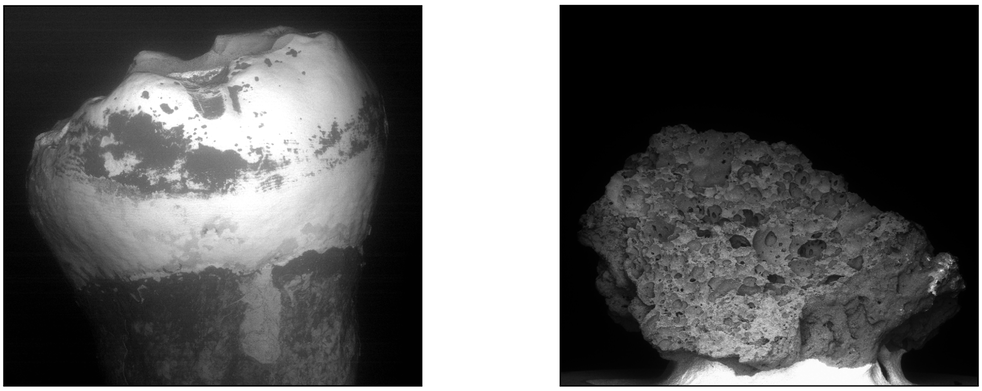


Figure 4.11.: Samples used to test the 3D reconstruction capabilities of Photosynth.

For the testing of 3D reconstruction, a tooth as well as a volcanic rock have been chosen because of their suitable 3D shape and size. The volcanic rock has been selected because of its coarse structure to challenge the application. According to the Photosynth manual, after which it could be categorised as “Unsynthy”, it is assumed to cause difficulties [13].

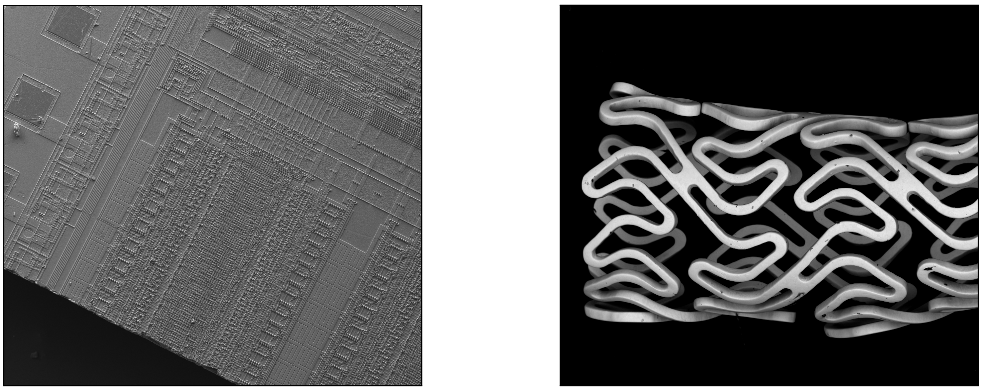


Figure 4.12.: An electric circuit and a stent, chosen because of their repetitive structure.

As samples with very regular and periodic structures, an electronic circuit as well as a stent have been selected. The circuit’s regular lines, as well as the stent’s partial occlusion of the reverse side, shall further investigate the algorithm’s reliability.

4.4.2. 3D Reconstruction

As the initial idea of Photosynth was to present photographs in an advanced way, creating 3D models of 2D images, this function shall be tested on microscopic images. A 3D model of a tooth and a volcanic rock which have been chosen for their good characteristics for 3D modelling shall be constructed. For the tooth, 24 images has been taken to fulfil the Photosynth requirements for "shooting a 3D-Object" with an even surface [13]. For the coarser texture of the volcanic rock, 36 images have been taken every 10 ° to ensure a successful Synth. Additional close-up images on a specific region of interest had been aquired in both cases and the respective final Synths were completed succesfully.

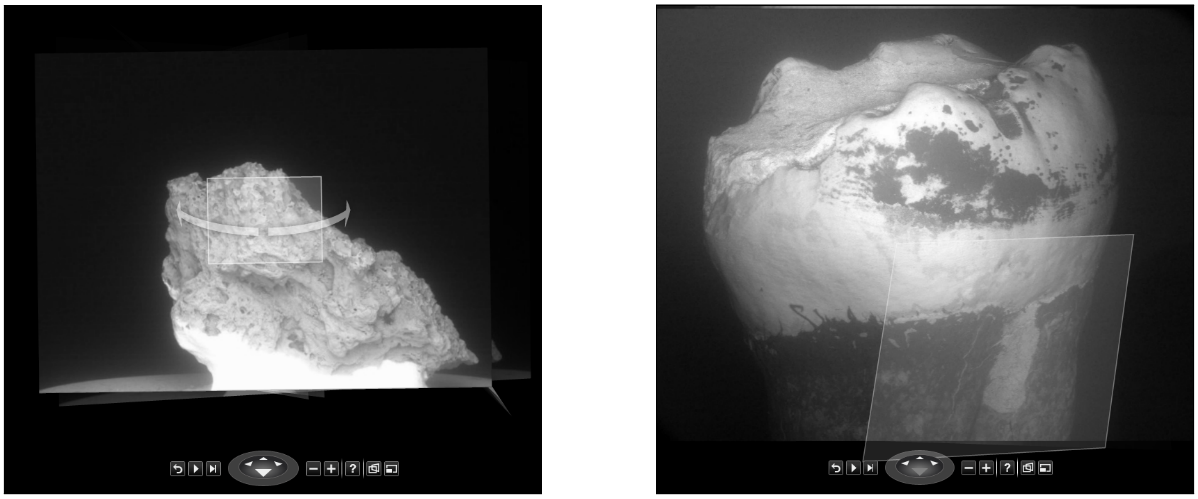


Figure 4.13.: The successfully completed Synths show the 3D models of the samples, while a white frame indicates an additional view.

Provided with a rotational view of 360 °, the chance to find the region of interest is still not obvious, but the optional 2D view in Photosynth enables to select the desired thumbnail image and then switch back to the 3D view (see figure 4.14). The navigation then starts at the selected perspective and the context view is attained by zooming out.

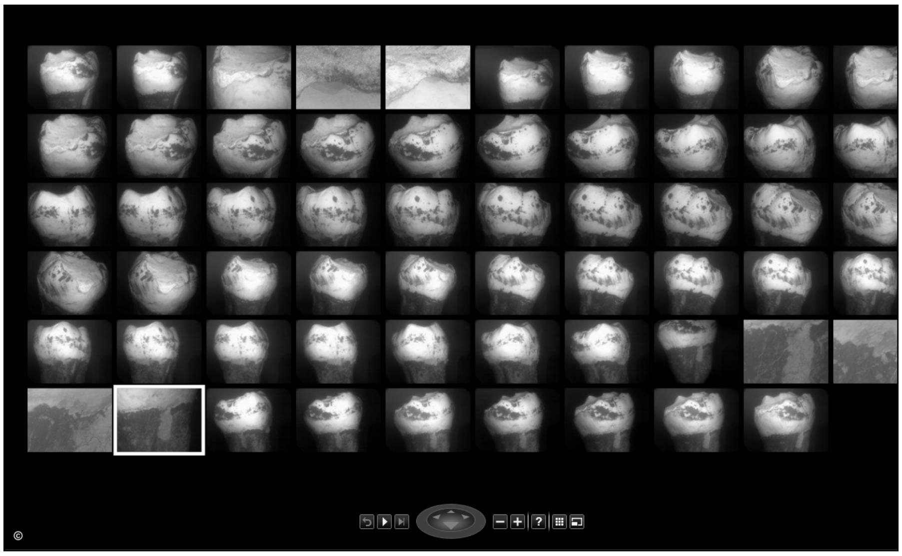


Figure 4.14.: The 2D view provides the option to choose the desired perspective, from which the navigation starts as soon as the 3D mode is chosen again.

4.4.3. Navigating through Images at Different Magnifications

The second task focusses on the functionality to match a common image set of a sample under consideration of the Photosynth requirements. Images have been taken at different magnifications to simulate a realistic analysis. The aim is to get more detailed information about a specific region by gradually zooming into the region of interst.

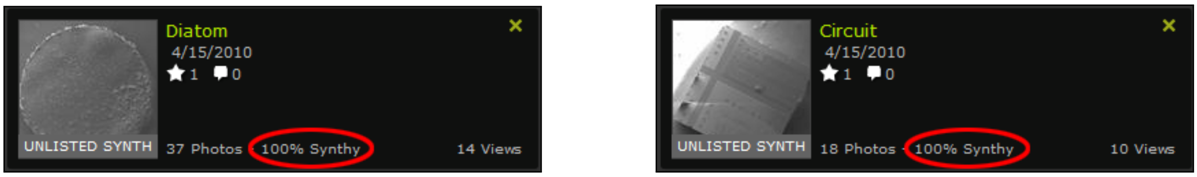


Figure 4.15.: Summary of the Synths. Besides the number of involved images, the result of the Synth is specified as "100% Synthy" [3].

This task has been performed on the diatom, the electric circuit and the stent, challenging the software by their repetitive structure. While the diatom contains several circular features of slightly different size, which are spread over the whole surface, the electronic circuit is composed of a range of parallel leads. Still, in both cases all images could be linked, resulting in a successful Synth (see figure 4.15).

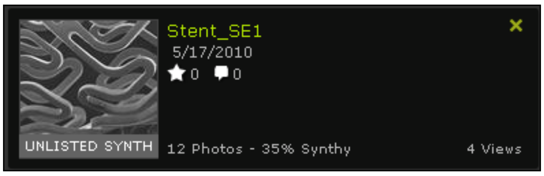


Figure 4.16.: Summary of the stent, which only achieved a "35% Synthy" result.

In contrast, the matching of the stent images resulted in a very incomplete Synth even though images were taken according to the requirements (see figure 4.16). The problem is that the material of the stent is a mesh, which causes false structures caused by the overlap of the back and front layer.

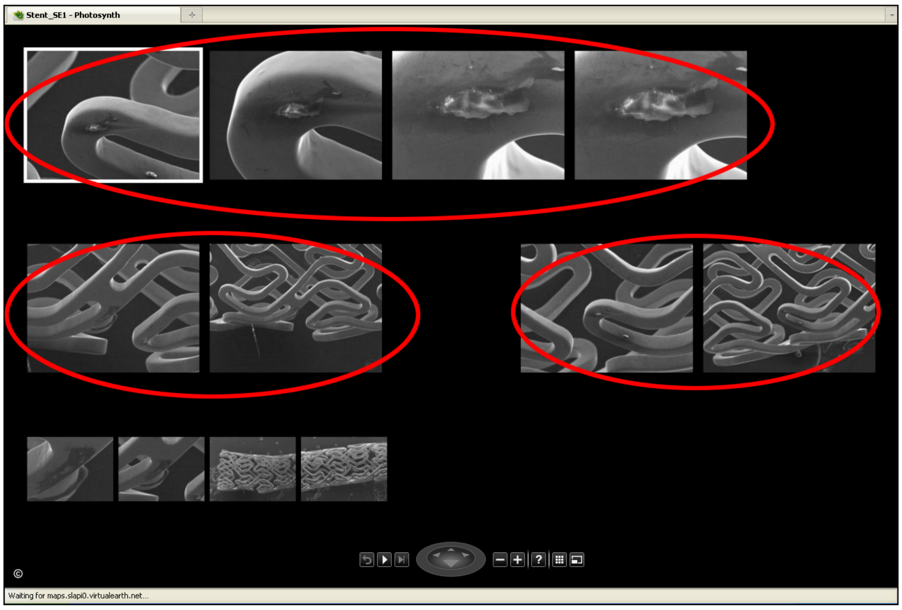


Figure 4.17.: The 2D view gives further details about the Synths. In this case the groups show where images could be merged in the otherwise unsuccessful Synth.

4.4.4. Tracing Back the Point of Interest

This task deals with the case of analysing a same sample on separate occasions. In this case a comparatively large sandstone sample has been used to create a stack of 399 images. They have been aquired using the “Stage Scan” function in Carl Zeiss SmartStitch (SmartStitch)[4] , which creates images with a slight overlap to stitch them to a large overview image of the sample.

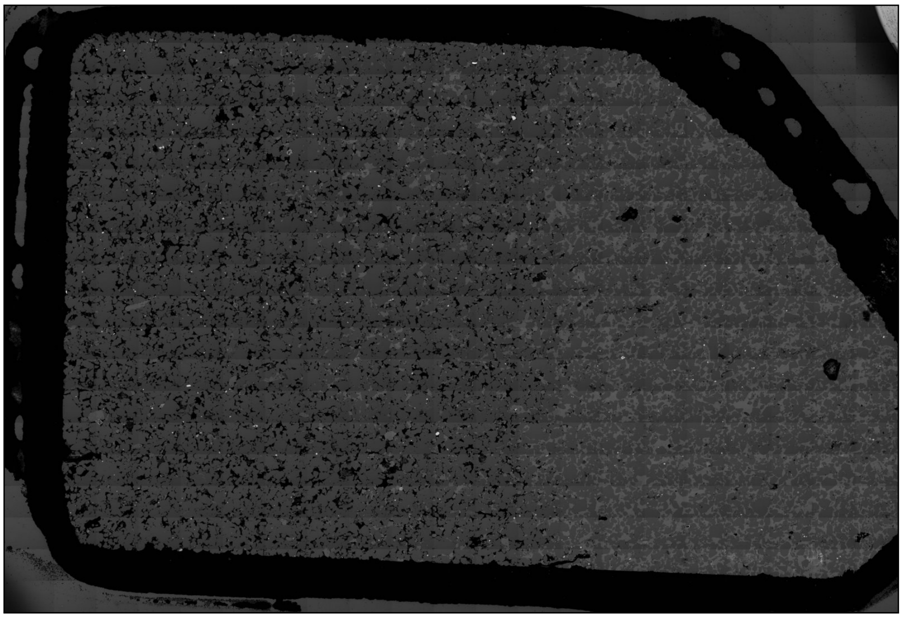


Figure 4.18.: This stitch is composed of 399 images with 1536x2048 pixel each, stitched together in the SmartStitch software, resulting in an image size of 25037x36864 pixel.

A couple of weeks later, additional close-up images were taken of the same sample, to investigate a specific region. The lowest magnification image of this analysis is about the size of one single tile in figure 4.18.

The goal was now to find this region in the stitched overview, which shows the whole sample. Since the first linkable image (2304x3072 pixel) only covers approximately $1/12 = 3072/36864$ of the overview, a solution to approach the guidelines for the creation of a successful Photosynth needs to be found. As the requirement is one image after increasing the focal length by a maximum factor of 2, the approach was to create sub-stitches of the 399 images to integrate the two image sets.

In addition to the complete stitch of 19x21 images, four sub-stitches of 11x11 images (allowing some overlapping) and eight sub-stitches of 5x5 images have been created in Microsoft ICE, an additional software by Microsoft Research which is designed to stitch large sets of overlapping images together. It is unlimited to image sizes which enables to stitch large panoramas. Again it uses the feature based analysis to discover the necessary correlations [11]. It produced a satisfying result without any tiling artifacts unlike the

[4]Carl Zeiss SmartStitch is a software application to stitch images together using the stage coordinate information, which is stored in the CZ TIF header.

SmartStitch application. The drawback is that the metadata is not retained. However, this is not relevant here, since the stitch will be further used in Photosynth, where no metadata is retained either.

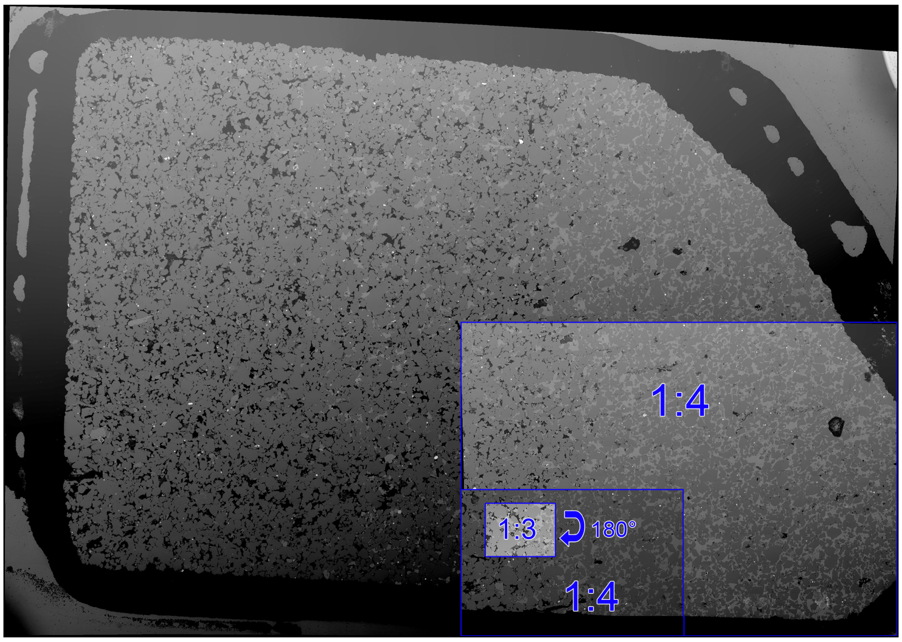


Figure 4.19.: The aspect ratios of the overview image composed of the 399 images, its sub-sets, created to integrate the new image set and the lowest magnification image of the new set which covers $1/3$ *of the smallest sub-stitch. This could only be reconstructed with the assistance of Microsoft Photosynth, which even recognized that the new set had been rotated by* $180\,°$.

The new image set, composed of the complete stitch, sub-stitches as well as the recent close-ups has then been uploaded to Photosynth. Even though the last gap between the sub-stitches and the new image set was still about 1/4th instead of the required 1/2, the region has been correctly located, additionally recognising that the sample had been rotated by $180\,°$ when the new image set had been aquired.

This result does not only show the high potential of Photosynth to present images in their context, but also the rediscovery of a region of interest, which had been captured completely independent of the previous image set. To the human eye, the texture of the sandstone appears similar all over the sample, whereas it still provides enough significant features to be merged in Photosynth.

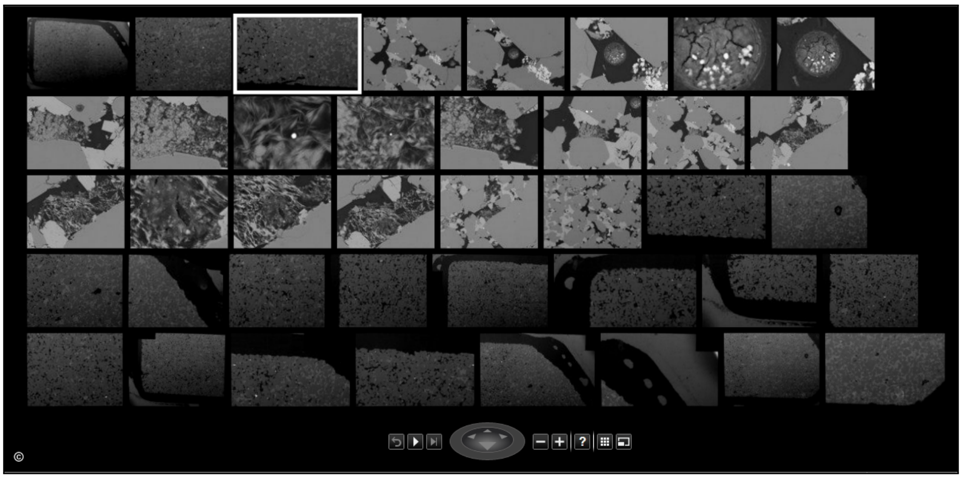


Figure 4.20.: All images have been successfully related, since no separate groups are displayed as in 4.17. The set of 399 images has been replaced by its stitch followed by sub-stitches and all close-up images of the second analysis.

4.4.5. Relate Images Aquired on Different Systems

Depending on the analysis, a common workflow would start with an overview image of a sample taken on a macro stand, followed by a light microscope, before the detailed analysis with an electron microscope. This can either be done to specify the regions of interest, or to completement a light microscope study with an electron microscope, which provides even higher magnification and a variety of detectors for different needs, including the option for an integrated EDS detector, which analyses the elemental composition of a sample.

Linking images from different systems created another task in Photosynth. The combination of macro stand images with SEM images, which were taken with a backscattered (BSD) and secondary electron (SE) detector, has been tried. Even though the similarity of these test images was visually obvious, the assossiation in Photosynth did not succeed (see figure 4.21).

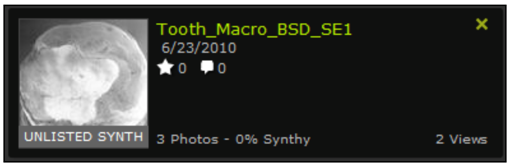


Figure 4.21.: Matching images from different sources yielded in a "0% Synthy" result. Manually creating 100% overlaps, did not trigger the feature recognition.

Although the Photosynth instructions advise the user not to scale or crop images, some processing has been applied, with the attempt to support the recognition. The image size has been adjusted in Adobe Photoshop so that they all have the same angle of view. Additionally, the colour image has been converted to greyscale to further reduce obvious differences. However, the recognition did not improve. Presumably, reflections and different contrasts between those images are too strong to achieve proper results.

Based on the idea to use markers to relate the regions of interest in MRI and CT images [16], a small marker representing the company's logotype, has been added to the different detector images to trigger recognition. This approach has not been tested extensively, because the current navigation of Photosynth is not suitable for layered views, where images cover exactly the same region. This makes the selection of either of the images nearly impossible.

But even with the markers, the different detectors could not been linked. Increasing the marker size might give better results for different detectors, but on the other hand it influences the original feature recognition. In the example shown in figure 4.22, the marker is already too strong for images of the same detector, presented in the first row, causing false links between the two sub images. While each of the subimages is correctly matched to the overview image, they are again linked at the logo position, which obviously is not correct. As a result, for situations where the marked images comprise different points of view, the chosen marker has been too strong causing false matches between unrelated images. Hence, the idea to use markers to assist the recognition is not suitable.

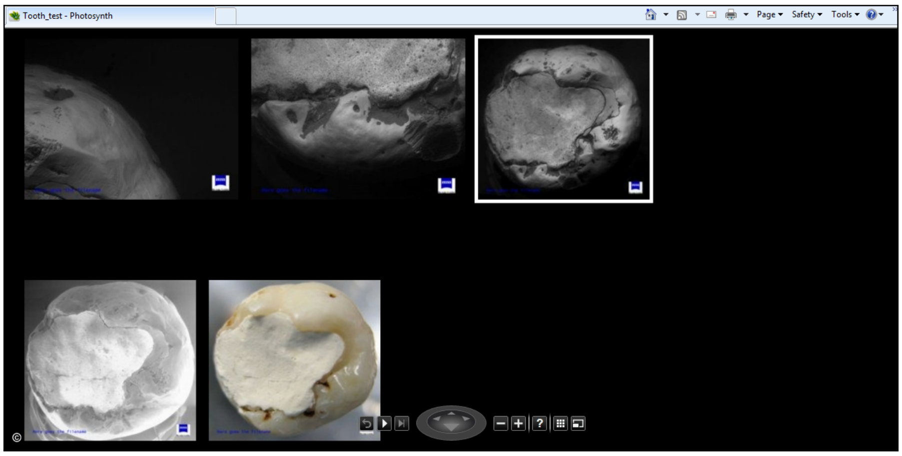


Figure 4.22.: This 2D view shows again clearly that the different detectors could not been linked, although the marker had been used to trigger recognition.

4.4.6. Information Presentation

During the aquisition of data with a SEM, two images are stored for the same point of view. While one is the plain raw image, the second one contains a data zone presenting the most important aquisition settings as well as annotations added during the analysis. As the metadata is not maintained in Photosynth, the first attempt to solve the problem

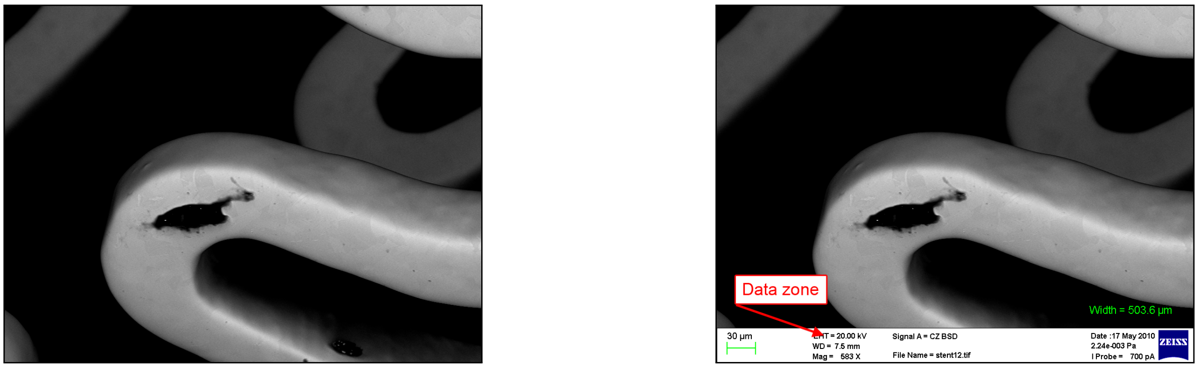
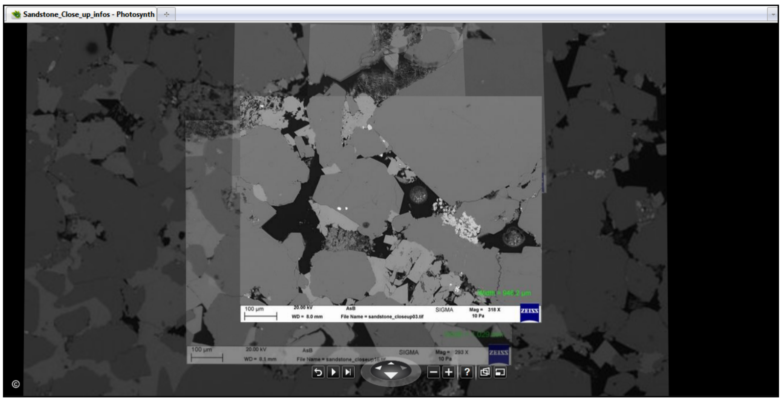


Figure 4.23.: During the SmartSEM analysis two files are exported. Both contain full metadata, whereas one displays an additional data zone, containing the most relevant aquisition settings.

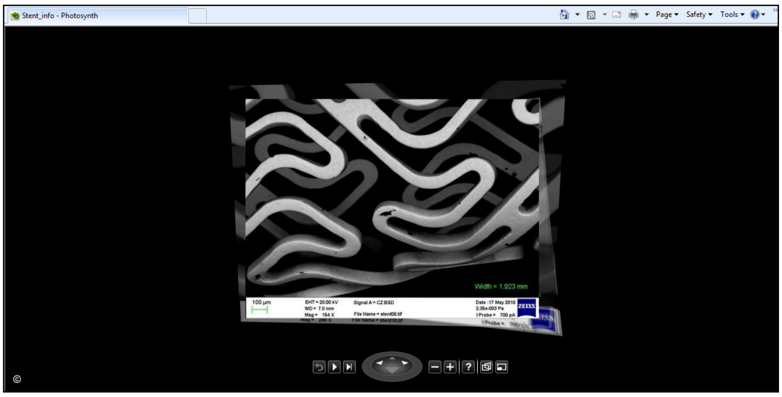
of losing all aquisition information was to use the data zone images for close-up views in a Synth. This way, does not require additional preparation of the files and all important information is directly provided. The idea functioned properly for the sandstone, which has an uneven and distinctive structure. Whereas the circuit, as well as the stent have too weak textures, resulting in mismatches as the data zone has been interpreted as the major reference feature. As a conclusion, this attempt to maintain the aquisition information is not reliable.

To exclude the risk of mismatched results, a more reliable solution would be preferred. For file identification, the filename is the most obvious representative of an image. It provides a reference to the original image to access all the metadata. A considerable solution would be to only use the filename as an annotation in the synthed images instead of the entire data zone. Additionally, this function could happen to be a future feature in Photosynth, since it is not just useful for microscopic images, but for users in general. Compared to the bold data zone, a single text string is less noticable and assumably reduces the influence on the matching of the images. Displaying the filename in the Synth allows the user to track-back to the file and obtain the full aquisition information.

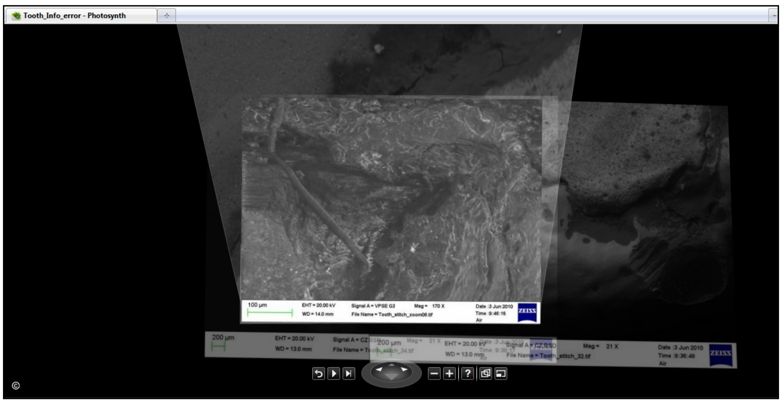
This attempt improved the Synth for the tooth but still showed that the sample texture itself has to provide strong enough features. For the stent, the Synth improved significantly compared to the data zone images, but still among images with no or little feature matches, the filename has been mistakenly used to link images.



(a) Successful integration of the data zone for close-up images.

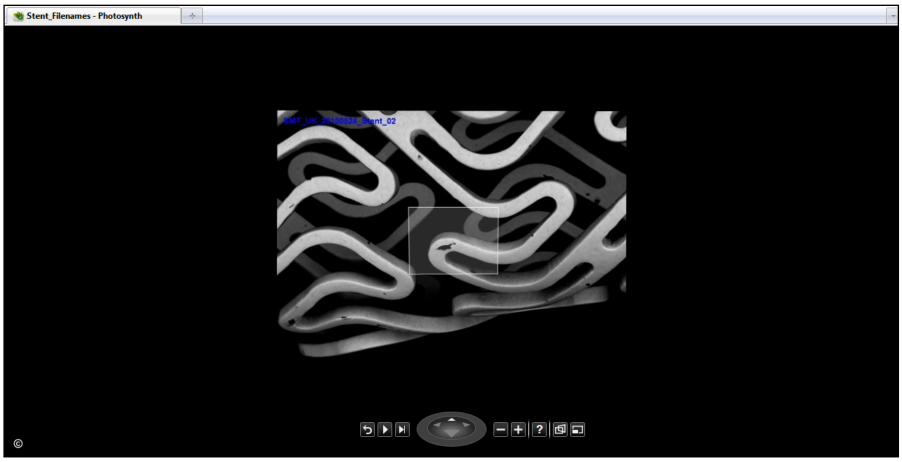


(b) The ambiguous texture of the stent in addition to the high contrast of the BSD images, provides too little feature reliability, joining all images at the data zone.

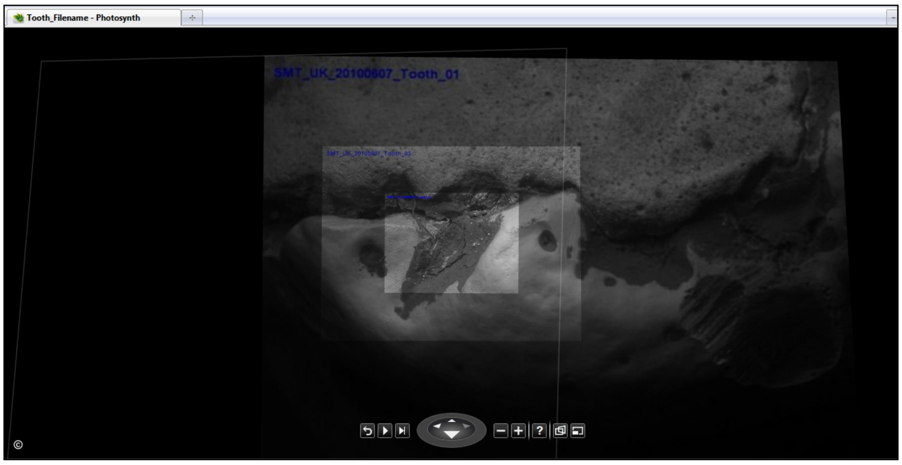


(c) The rather weak texture of the leads cause misinterpretation of the data zone.

Figure 4.24.: The figures show the influence of the sample's texture for the integration of the data zone.



(a) Matching of the images improved, but still caused errorneous links for images with weak matching features.



(b) Using only the filename for the tooth images resulted in an errorless Synth

Figure 4.25.: The figures show the improvements of exchanging the data zone for the filename in the images as described on page 32.

4.4.7. Discussion

The investigation of the capability to use Photosynth for microscopic images showed a wide range of image sets that could successfully be matched.

Against the expectations, which were based on the instructions given in [13], samples where the textures seemed to be too regular and repetitive, as e.g. the diatom, functioned well. In contrast to that, the tooth and stent images, taken with different detectors, could not be linked, even though their similarity was graphically obvious.

The periodic structure of the stent, which additionally causes occlusion of the reverse side is too complex to be matched correctly (see figure 4.12). For the tooth, the different detectors produce notably diverging images with changing contrast and reflections. In both cases, the inability to link these image sets can be understood with instructions given in the manual [13]. Examples for too complex occlusion problems are given and it is said not to apply any kind of filter on the images, which explains the failure to connect the different detector images.

The 3D reconstruction succeeded for both samples and even matched additional close-up images correctly (see figure 4.13).

As a solution to elude the fact that all metadata is lost in the final Synth, filename annotations could be added to the images used for Photosynth. As long as the sample texture is strong enough to be synthed, this gives the option to navigate to a certain view of interest and then search the given file name in the database. This file then contains all metadata and hence allows further analysis.

4.4.8. Conclusion

The chosen tasks show a high potential for the advanced use of Photosynth in terms of visual navigation and information presentation. As long as Photosynth was used for its intended purposes, with the minimum capturing conditions held, the Synths were 100% successful. Yet the stent caused problems because of its complex and repetitive structure, which can be considered to be part of the "Unsynthy" textures, displayed in [13]. On the other hand, the diatom did not cause problems eventhough it is covered with similar objects at different scales. Assumably, there are still sufficient features to allow a succesful Synth, correctly locating all regions of interest.

Photosynth is independent of any image aquisition settings to link the images, which permits to take images of a sample over a period of time. Even the combination of images taken on different systems with the same detector type is possible, without the need to calibrate the stage to get proper stage coordinate data. The 2D view allows to select the image of interest getting the desired context view, when switching back to the 3D mode.

3D reconstructions and more advanced uses as the matching of regions which had been taken completely out of context in the stitching task, show persuasive results. They exceed the intentional use of Photosynth, since the track-back of related views taken on different days is of high interest.

Apart from the reconstruction, the opportunity to share a Synth online is a convenient way to bring the information to the client. So far, a drawback are security concerns as well as the storing location. A copyright notice can be added to the Synths and they can be hidden from public presentation ("unlisted synth"), but there is no encrypted access provided [12]. This leads to the next aspect, comprising the fact that Photosynth does not allow to export or save the Synths on a local system, which could be useful for sharing information on an own server, being able to set up individual access restrictions.

To date, the user has to rely completely on the Photosynth system since the information is stored in the cloud. Generally speaking, this is a secure solution to store the data, but nonetheless secure encryption and determined access restrictions should not be neglected.

As long as Photosynth is used for its purposes, combining images of an object taken with the same system at certain magnifications, the results were mainly successful. During the trial to extend the functionality by including additional information in the images, difficulties occured. This is not surprising, since the manual requests to "be very careful with watermarks" [13]. Even though Synths were categorised as 100% Synthy, the results were errorneous.

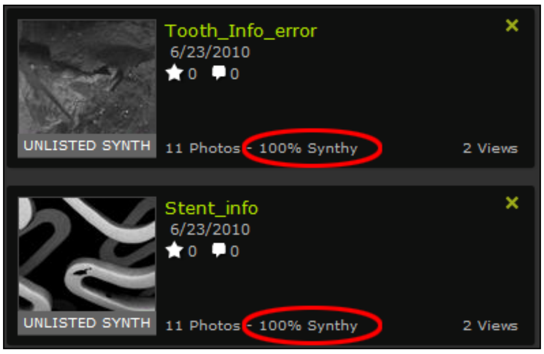


Figure 4.26.: Although the Synths 100% Synthy, they contained errorneous results.

For the whole investigation, it needs to be considered, that the problems occuring in 4.4.6 are beyond the scope of Photosynth. Still, they reveal the need to review all Synths carefully to exclude falsy Synths.

4.5. Conclusion of Methods Evaluation

The idea to organise all data in a DB did not show many drawbacks, besides the fact that the user needs to adapt to the new structure. This then provides far easier file access and organisation than previous solutions.

For the visual frontend Microsoft Photosynth has been investigated to show the principle of visual image navigation, based on a feature detection algorithm. The attempts to trigger recognition for differing image types in Photosynth with the use of markers did not succeed.

To date, the automatic file assembly to relate separate data sets remains to be achieved. The sandstone test further emphasises the need to develop a method to easily match various image sets captured on different systems at different times and angles. Assuming that this is solved, arbitrary images can be set into context.

5. Graphical User Interface Proposal

After the detailed investigation how to organise and present data of an extensive analysis, this part concentrates on the idea of developing a user interface that presents related images and additional information separately in a graphical context view based on a comprehensive database structure. Additionally, reversible search options and filtering for certain features shall enable datamining functions. Besides the viewing and organisation part, the data shall be analysed and processed for the reporting.

5.1. The General Idea

Based on the customer interviews, different software and their features have been considered as a solution to fulfil the requirements. Photosynth allows a highly advanced navigation seeing the images in their context. ImageAccess by Imagic (UK) Ltd. provides a complete DBMS to store and manage data on a highly customisable basis, as well as providing processing tools and a reporting solution. Furthermore, the main advantage of ImageAccess is that the metadata of all relevant manufacturers are supported. This creates a basis for further approaches to cluster all images of one sample and considerably simplifies the creation of comprehensive reports.

Furthermore, CZ SmartTiffV2 is an image viewer, which can be used off-line to process and analyse CZ TIF files captured with SmartSEM. It comes along as a free viewer with the Carl Zeiss electron microscopes and thus adresses even more customers for its use. Additionally, SmartTiffV2 has been designed to handle images of arbitrary size and has been tested for images larger than 4GB [17].

After having investigated each software for its convenience, the idea is to extract the best features and merge them into one overall user interface.

5.2. Conceptual Design of a Graphical User Interface

Bearing in mind that an overall solution for data management is not existend yet, users have most likely already developed their own compromise solutions to manage their data. Therefore a high recognition value for the future GUI is preferable to meet the customers' interest and reduce the constraints to change to a completely new solution. The close design of SmartSEM and SmartTiffV2, which are the currently provided software applications for image aquisition and viewing respectively, is already familiar to the customer and shall therefore create the basis for the new design.

The customisability of ImageAccess allows the customer to create a database structure, close to their previous solution. Additionally, the reporting function allows to compose individual templates according to the needs and therefore provides the preferable flexibility for the customer.

The new design is based on the use of a dual-screen mode, presenting the DBMS interface on one screen and the viewer interface on the other. This allows parallel data navigation in the DB as well as the graphical representation. Furthermore, only the design of a front-end solution is considered, assuming that the file organisation is already provided.

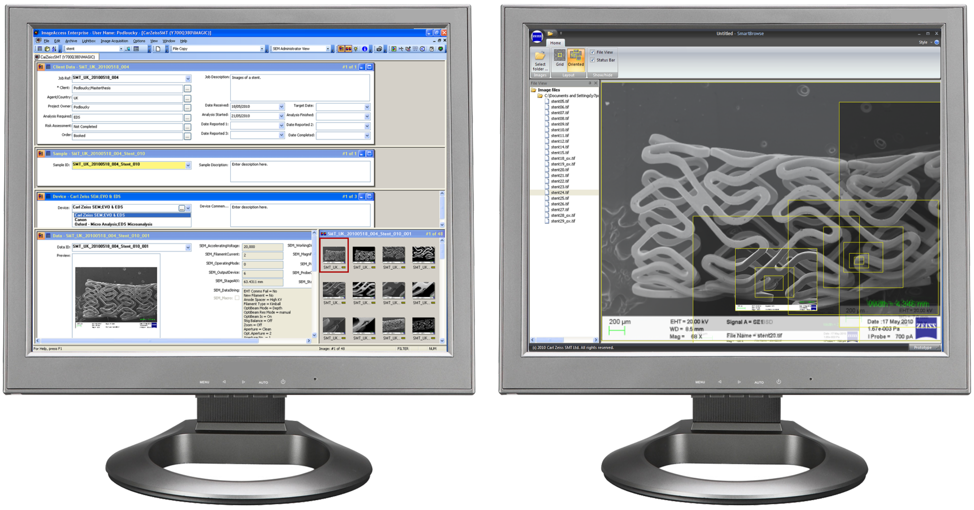


Figure 5.1.: The dual-screen mode facilitates parrallel navigation in the DB and the graphical representation.

The current design of SmartTiffV2 comes with a toolbar that provides a range of functions to process and analyse the images. Additionally annotations and SEM parameters can be added and stored as presets for reuse. Several files can be opened simultaneously, while the navigation between them is organised in tabs. An optional "Browse Images" window can be used to directly display all files of one folder and thus simplify the navigation. The metadata for the currently shown image, which is stored in the CZ TIF header, is incorporated in a sidebar (see figure 5.2).

Based on this design, modifications have been done to develop a conceptual design for an interface that visualises the content stored in one project in the DB.

The image browser has been modified to present the same data as the related project in the DBMS. Additional categories have been added to sort and group images by their filetype, as well as stage coordinates and image width, which are important parameters to specify the field of view (see figure 5.3).

The tab organisation of the opened image files is a space saving solution to represent several files simultaneously. Furthermore, it provides a basis that can easily be extended and has therefore been retained. However, it has been changed to display all associated files of one specific sample. After a project has been selected, the tabs indicate the existence of further analysis data from various systems. If information is present, the

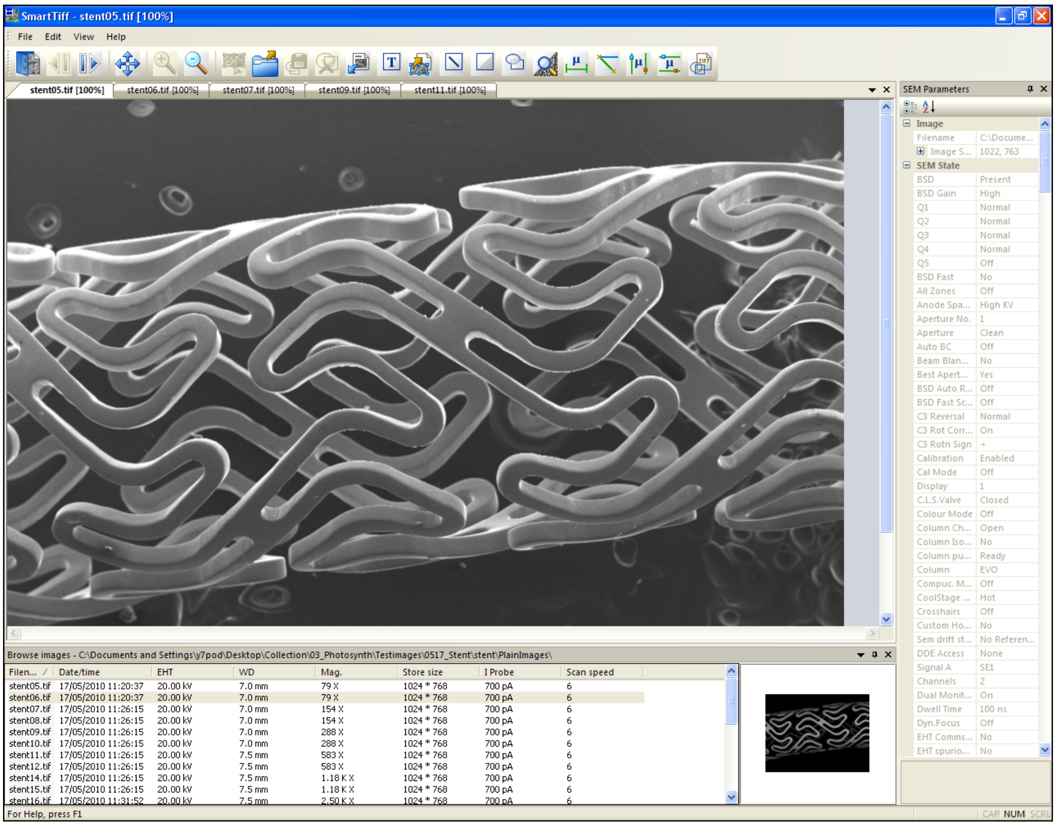


Figure 5.2.: This is the current layout of the SmartTiffV2 GUI, where the metadata of the image is presented in the sidebar. The optional "Browse Images" window below the image displays all files contained in the selected folder.

according tabs are highlighted and a bracketed number shows the number of analyses, else the tab is grayed-out. The tab order starts at the lowest magnification view, followed by more detailed analysis, to finally result in a 3D Photosynth summary that visually presents all images of one system in context.

The sidebar has also been modified to display the essential information which changes depending on the currently selected view and analysis system.

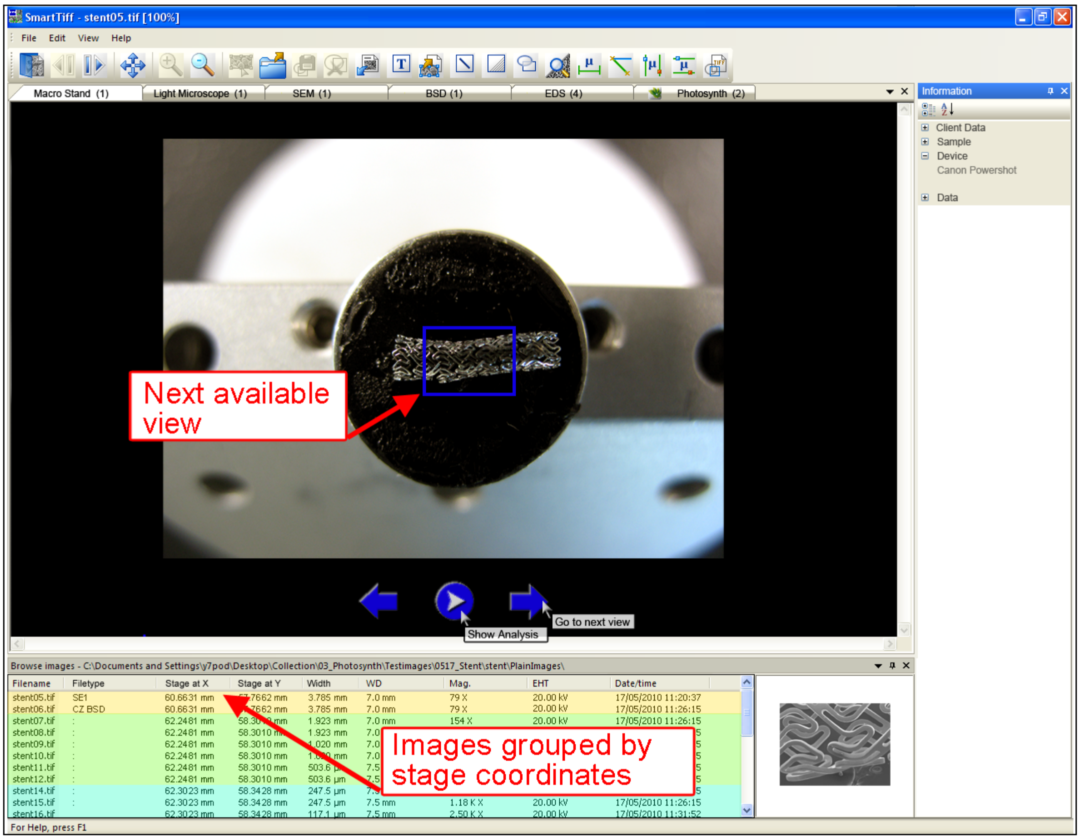


Figure 5.3.: By default, the navigation starts on the lowest magnification image, which ideally is taken with the macro stand to give a natural overview of the sample. The blue frame indicates the next available view, in this case taken with the LM.

The macro stand perspective is the lowest optional magnification image, to give an overview of the sample. If it has been taken, it defines the default starting perspective of a project. The additional arrows below the image navigate through the tabs of different analysis data. The play button automates the presentation of available analysis data. Starting from the lowest magnification image, it plays through all tabs giving an overview of the existing information. Blue frames on an image indicate if further analysis is available. They either lead to a higher magnification image of the same system or the next highlighted tab (see figure 5.3).

In this perspective, sidebar displays the general information about the project, which is extracted from the according project in the DB. The different colours in the "Browse Images" window indicate related images by stage coordinates (see figure 5.3). This implies that they show exactly the same region of the sample, probably at different magnifications.

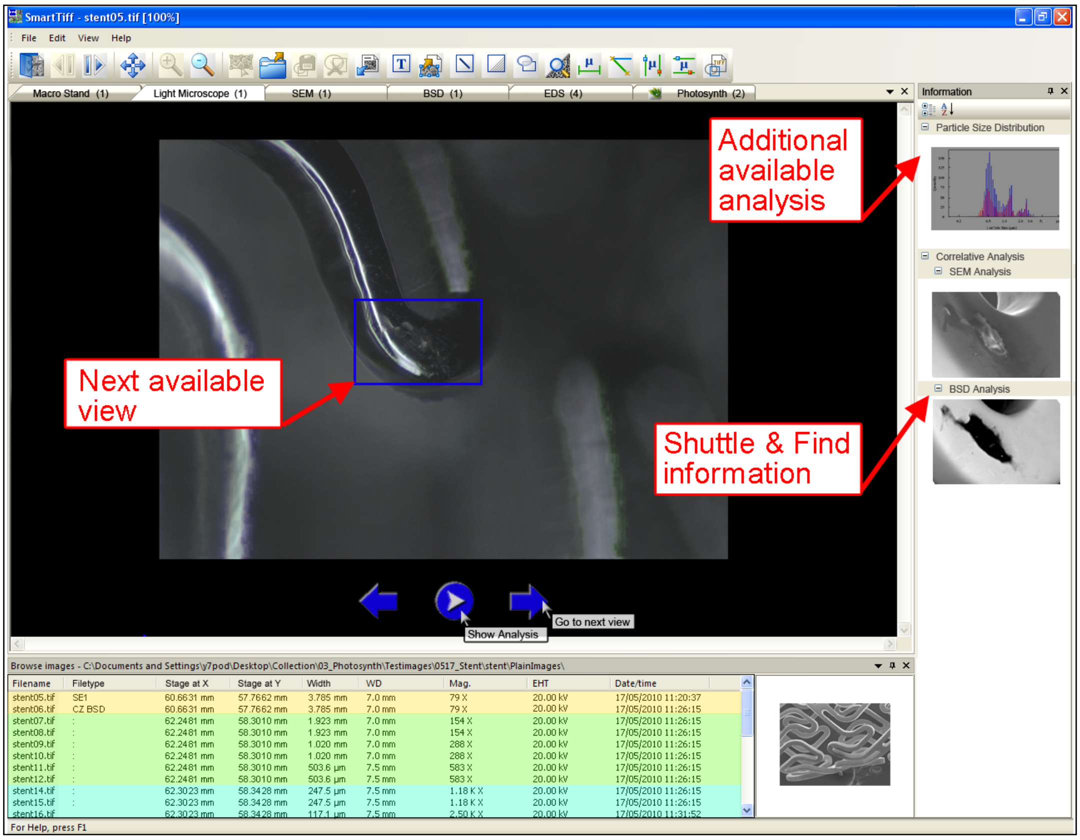


Figure 5.4.: The LM view gives more detailed information about the sample, while the blue frame indicates keypoints of the "Shuttle & Find" application. It can be chosen to continue directly with that perspective.

The following tab shows the next step of the analysis, depending on the scope of each study, this can be taken with a light microscope followed by some further SEM analysis, or directly with the SEM. The sidebar displays related results as e.g. the particle size distribution. Objects from the sidebar can easily be dragged into the main window for an elaborate analysis. The advantages of the new "Shuttle & Find" application have already been embedded showing the analysed keypoints in the LM image (see figure 5.4). Clicking on them leads directly to the corresponding SEM tab.

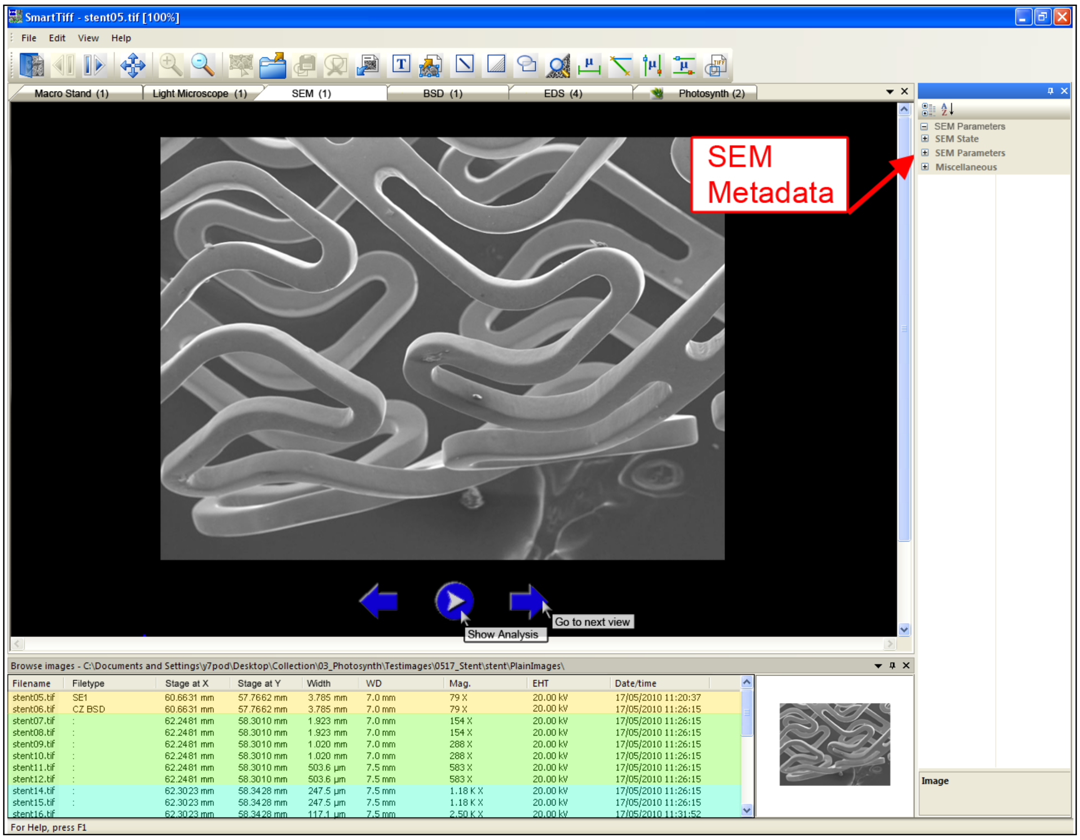


Figure 5.5.: Followed by the LM, the study is extended by a SEM analysis.

The capability to capture images at much higher magnifications with different detectors sets a high demand on SEM analyses. For this view, the sidebar displays the same metadata as the SmartTiffV2 interface. They are minimised by default to let the user choose which information should be displayed.

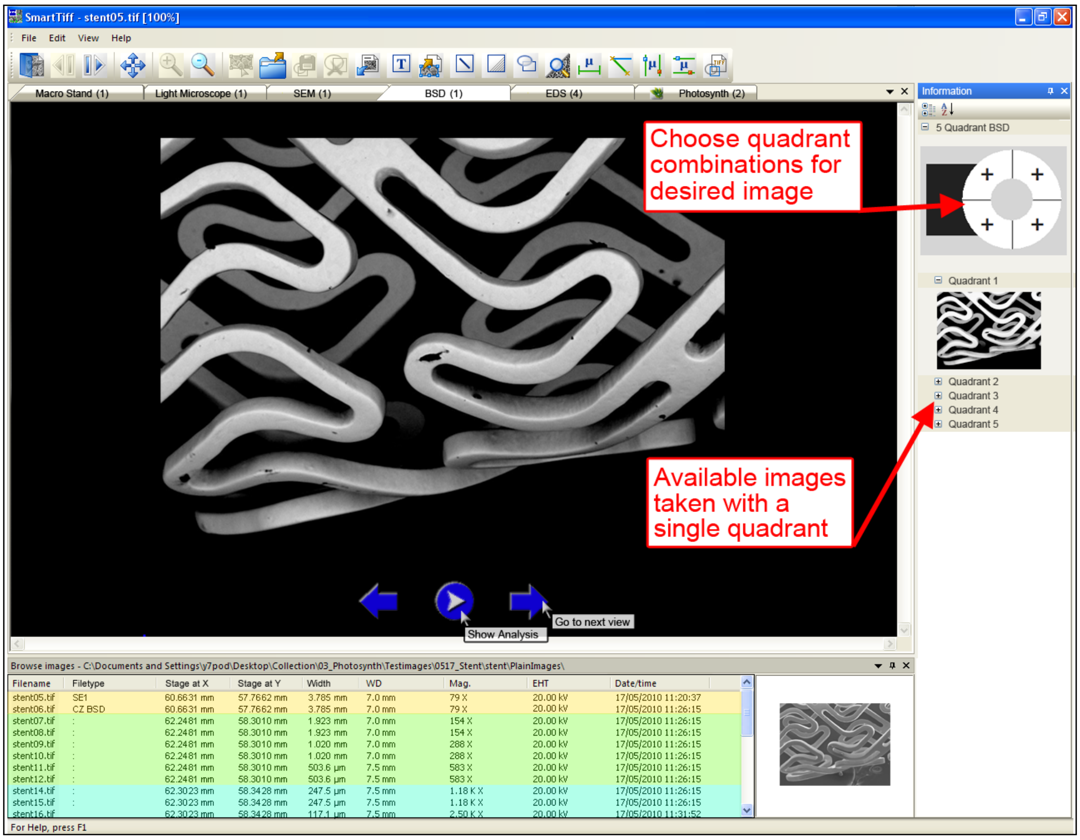


Figure 5.6.: If the microscope has been used in dual-channel mode, an additional image can be taken with a different detector, in this case a BSD, which extends the sample analysis.

In some situations, a backscattered detector (BSD) is useful to reveal additional information of the same perspective, representing the atomic number of the sample's composition. As the system involves a 5 quadrant BSD, the sidebar presents a similar navigation as the aquisition software SmartSEM. The graphic representation of the detector facilitates to select the desired image taken with all or the required combination of quadrants (see figure 5.6).

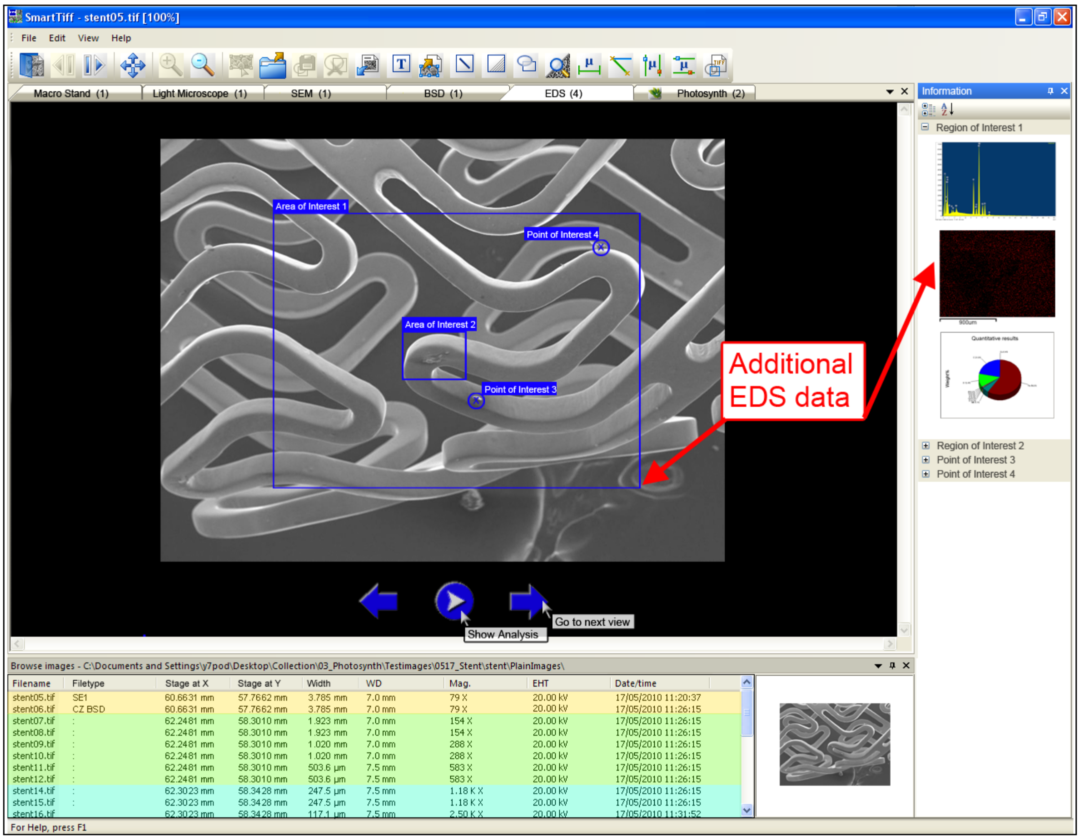


Figure 5.7.: The regions of the elemental analysis are indicated in the SEM image, which had been chosen as the reference image.

The previously taken SEM images provide the basis to specify regions for further elemental analyses. Frames on the SEM reference image signify the analysed regions. Additionally, the sidebar represents all aquired data to those specific regions. A mouse-over on either a thumbnail in the sidebar or a region frame respectively highlights the associated frame or thumbnail, whereas a single-click overlays the corresponding information onto the reference image (see figure 5.8).

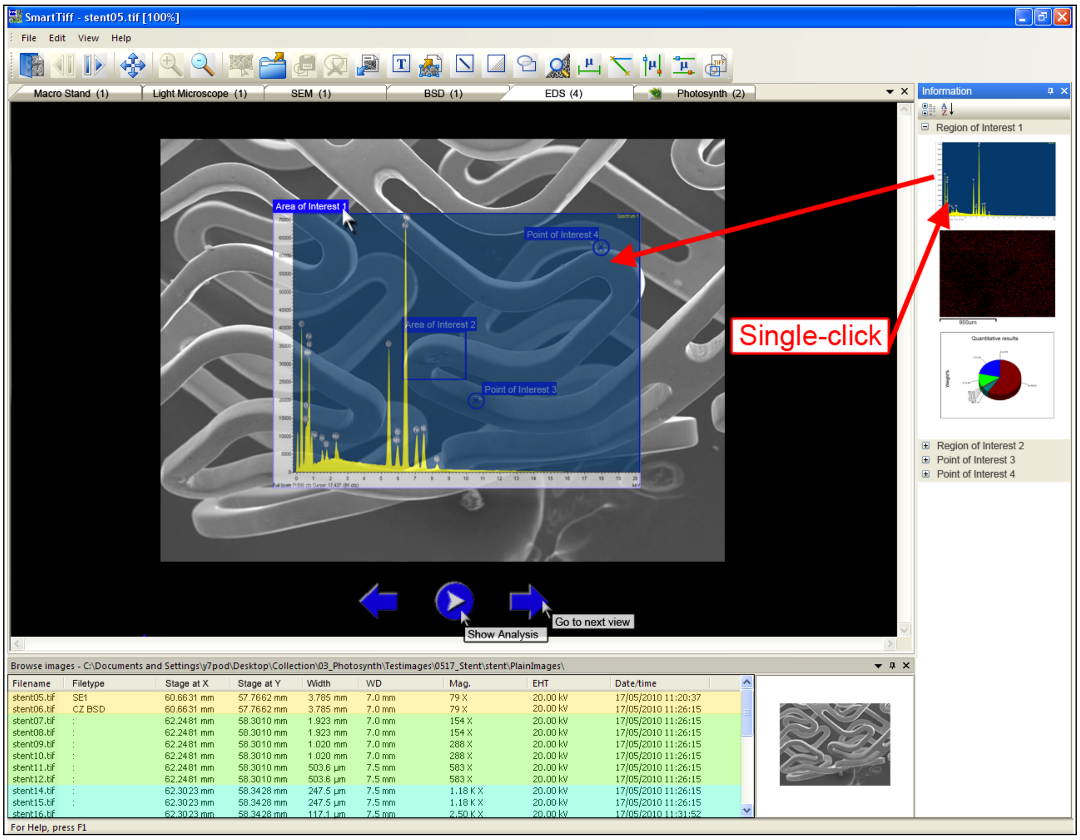


Figure 5.8.: A single-click on the region frames or thumbnails in the sidebar overlays a transparent preview of the related analysis data on the reference image.

For a more detailed analysis, spectra, maps and diagrams can either be double-clicked or dragged to appear in the main window providing the same analysis functionalities as its associated software during the aquisition process (see figure 5.10). While the spectra and diagram cause the reference image to move to the sidebar, the map is first superimposed on the reference image for a better context view.

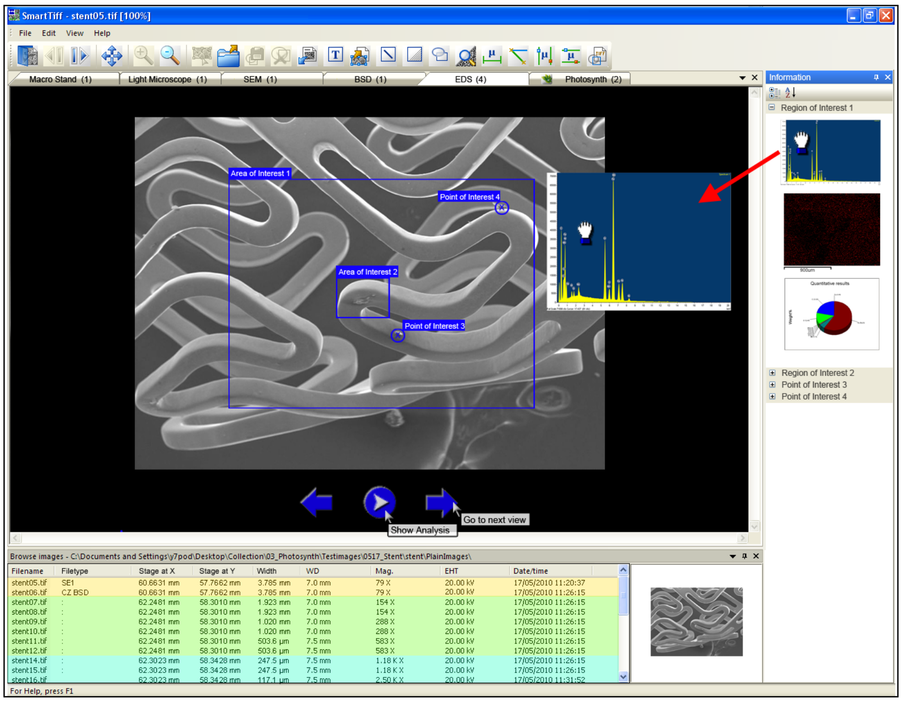


Figure 5.9.: The results of an elemental analysis of a certain region of interest can simply be dragged-and-dropped into the main frame, replacing the reference image.

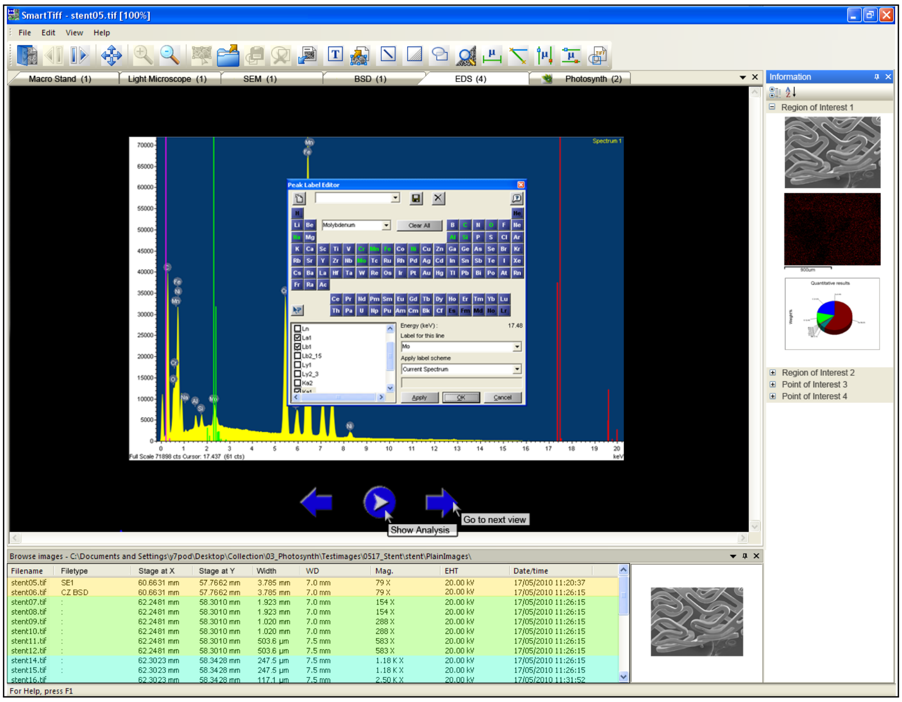


Figure 5.10.: The spectrum in the main frame can be analysed in the same way as during the aquisition process.

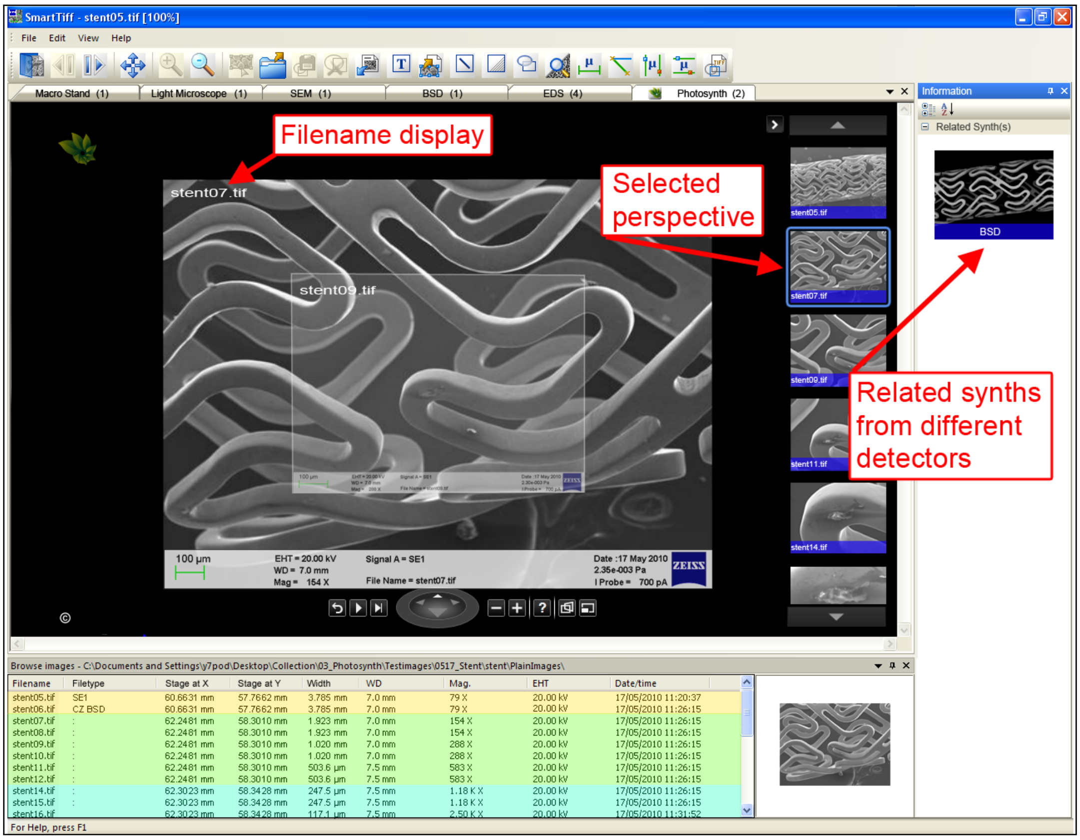


Figure 5.11.: Finally a Synth merges the images of one detector, enabling advanced visual navigation through the sample.

If it has been created, the analysis ends with a summarising embedded Photosynth that shows the images in context and even assists to create 3D models of the 2D images. Thumbnails at the right of the Synth allow to choose the desired perspective, while a light blue frame indicates the currently shown image. The sidebar displays all related Synths for the project that has been chosen in the "Browse Images" window.

6. Reporting and Presentation

After the organisation and visual representation the further use of the captured images varies, depending on users' needs. Besides image processing and image analysis, the presentation of results plays an important role. This chapter focusses on the reporting of results which are mainly based on images, whereas analytical reports rather focus on the numerical presentation in form of tables and diagrams (see figure 6.1). For a clear report and to better understand the images and their according information, it is essential to emphasise relevant features. This comprises the traditional highlighting, pointers to indicate the region of interest and ideally a zoom perspective of the focus area. Additionally, labels to add comments as well as parameter fields to display the capturing information are required to support the understanding. Referring to the interviews, there is no solution that suits all needs, therefore the flexibility to create own templates, which can be customised according to the user's needs, is of high relevance.

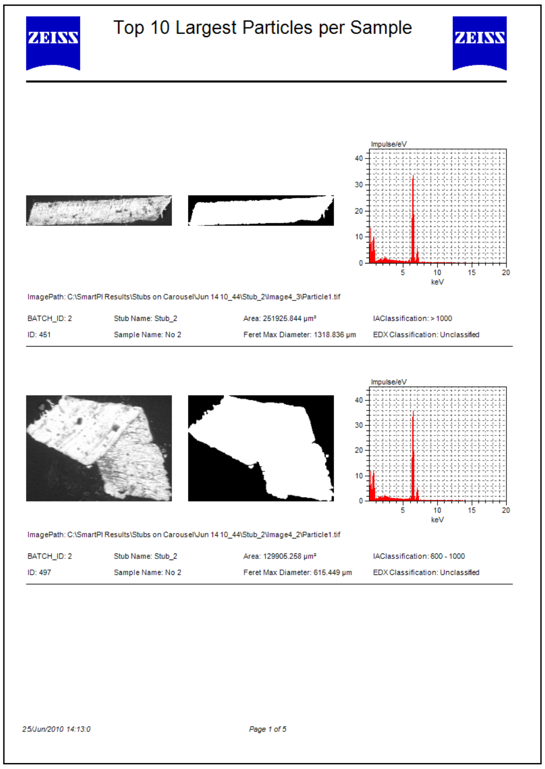
The final reports shall be manageable to do in an easy and fast way, ideally supporting all file formats including the read-out of the metadata.

6.1. Review of Current Software

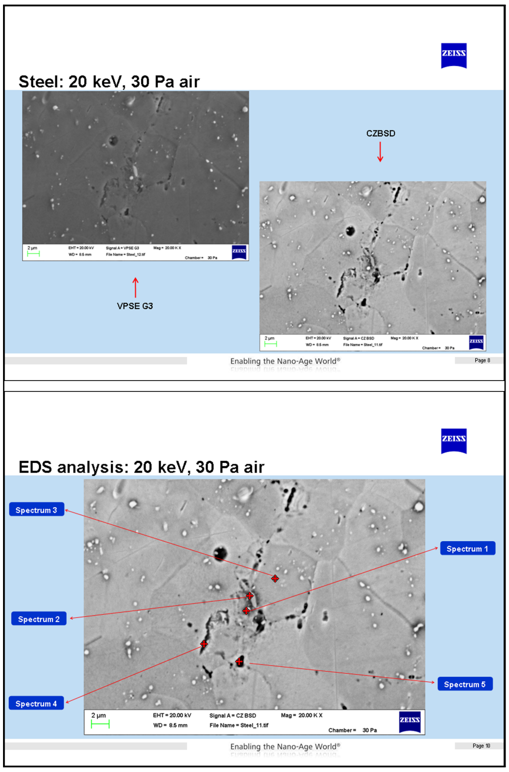
Having the determined requirements in mind, this part gives an overview of the current state of software with the focus on reporting. As part of the presentation preparation, image analysis and data managements are essential aspects, which need to be considered.

To date, customers may need to use an equal amount of software as the number of installed systems, to achieve their goals. This is because each of the manufacturers provides some more or less versatile solution.

Based on the outcome of the interviews (see appendix A.2) and own ideas, a list of required features has been created to evaluate the software applications. Each of them has been examined with the help of these guidelines to see if they could provide an overall solution.



(a) An analytical report mainly focusses on the numerical values, only using the images as a reference.



(b) Two slides of a PowerPoint report show that additional comments and highlighting of important regions, as well as the aquisition information are usually displayed in an image-based report.

Figure 6.1.: Depending on the scope of the analysis, the needs for result presentation differ.

Table 6.1.: Guiding points for the software evaluation.

Requirements
FILES
Support all image formats
Associate similar images of same object
TEMPLATES
Create customised templates
Include a start/introduction page
Apply a company logo on each page
Combine different template layouts, including individual views for images
Add additional images
Add additional images between existing slides
Move and replace images
Delete images
Highlight comments and parameters
IMAGES
Display capturing conditions
Superimpose measurements
Mark point of interest
Include zoom view for POI
PARAMETERS
Include parameters linked to an image
Add additional parameters to specific image afterwards
Highlight differences in parameters

6.1.1. Carl Zeiss AxioVision Rel. 4.8.1

AxioVision is the software solution that comes along with the Carl Zeiss light microscopes. The basic package provides functionalities for aquisition, image processing and complex analysis as well as archiving and documentation. Its modular structure allows to extend the functionalities by adding more extensive modules [18]. The focus of the investigation lay on the documentation module, as this is the reporting solution provided for the LM images. Besides some predefined templates, individual layouts can be composed. The enormous versatility for image analysis can also be seen in the documentation module, which in this case makes it difficult for a user to create a new template without the need to spend too much time and effort. The extensive toolbar and the need for more than 40 pages in the manual, explaining how to create reports, does not seem very user friendly (see figure 6.3). Instead of offering a large amount of options for each single textbox and image (see figure 6.2), a simple solution together with the appreciated drag-and-drop functions would be preferable. For an intuitive solution a manual should not necessarily be needed.

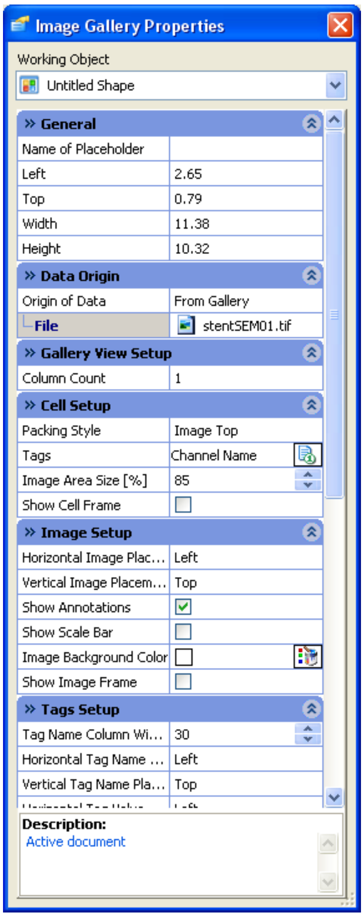


Figure 6.2.: The "Image Gallery Properties" window provides an enormous number of options.

A good feature is the preview function, but instead of using a page-wise view in the editing mode, it is split into sections which do not coinside with page breaks. Thus the user can not see or influence a page break without switching to the preview (see figure 6.3). Furthermore metadata of any other file than the ZVIs cannot be read.

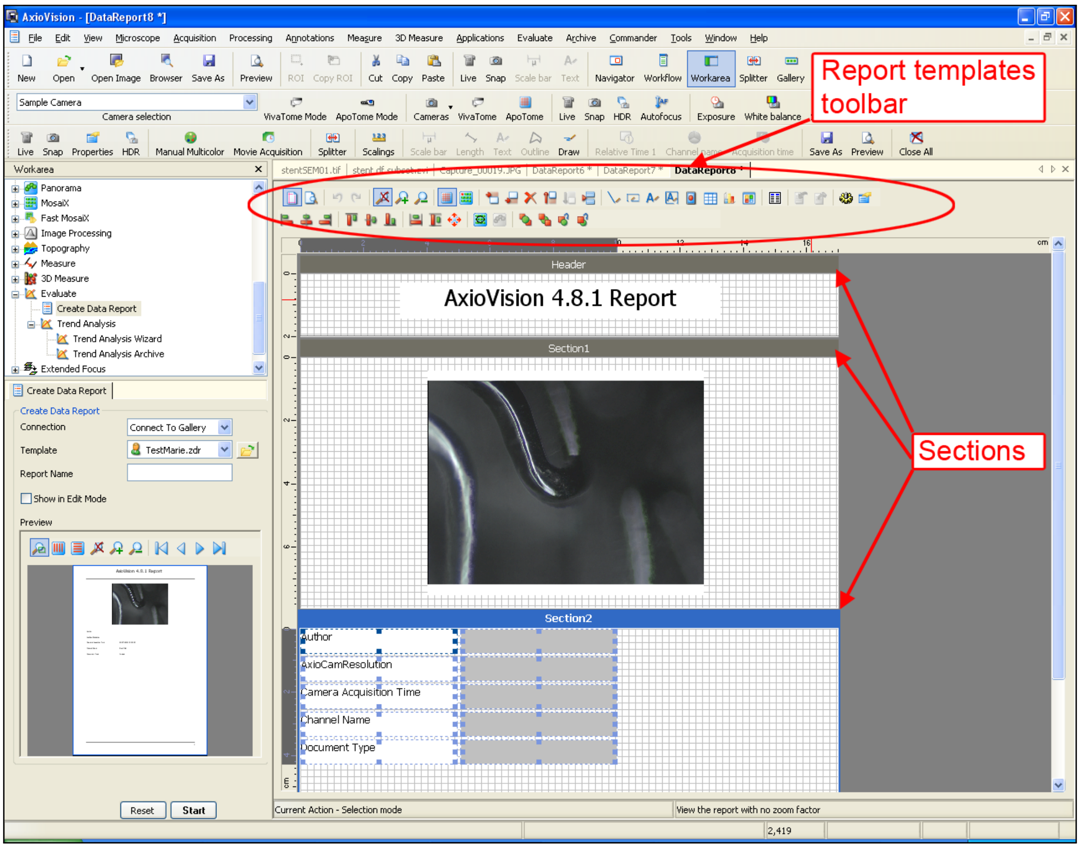


Figure 6.3.: The report templates toolbar offers a range of icons, whose functions are displayed in tooltips. The editing mode splits the template in sections, which do not necessarily signify page breaks.

6.1.2. ACD Systems FotoSlate 4.0

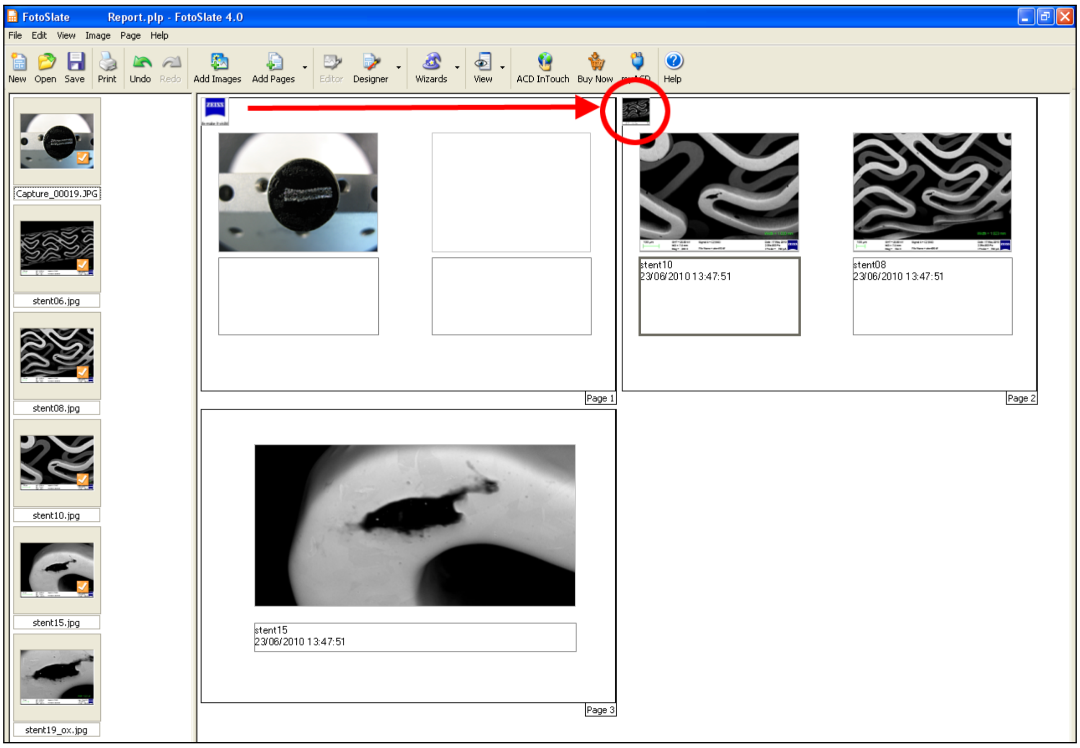


Figure 6.4.: The ACD Systems Fotoslate 4.0 allows to create and combine a selection of layouts. The drawback is that the company logo is interpreted as an image placeholder and thus by mistake replaced by another image.

ACD Systems FotoSlate 4.0 is a software package initially thought to prepare images for printing [19]. It is used by a Carl Zeiss application specialist in the United States, as being the best reporting solution so far. It is easy to create templates and multi-paged layouts can be combined. The basic metadata of a JPG file can be read and automatically loaded into the report if a textbox is associated to that specific image placeholder.

A sidebar allows images of interest to be loaded from different folders and also ticks those images that are already included in the report. They can easily be dragged into an image placeholder or replaced, using the right mouse function.

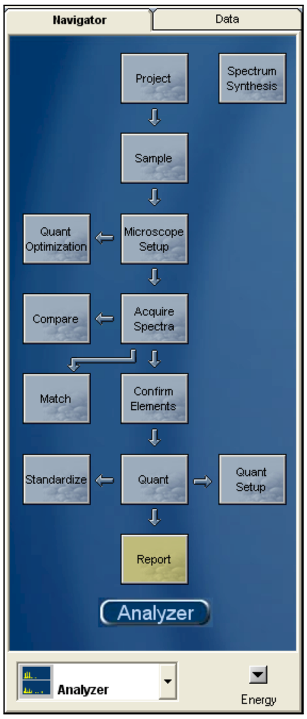
The main drawbacks are that images stored in a template are not embedded, thus they always need to be copied together with the template, whenever it shall be used on another system. This is of special interest, since the idea of a reporting solution is to have a global solution, which is used on several machines. If the number of images dragged into the template exceeds the number of pages, new pages are automatically added. Again, for the added pages, the company logo does not dublicate and instead of filling the designated image placeholder, the dragged images also fill the logotype position, since it is not recognized as part of the template but as an empty image placeholder (see figure 6.4).

It is not possible to add additional annotations and arrows to indicate a POI. This was not of interest for this user, since he usually describes the aquisition process in an introduction letter at the beginning of the report, but the need has been seen among other interviewees, where the aquisition data is needed. Since the SEM images are stored in TIF files, their metadata cannot be read and still needs to be entered manually. The project can only be exported in the application's own file format or as a PDF, which eliminates the opportunity to postprocess the report in another software.

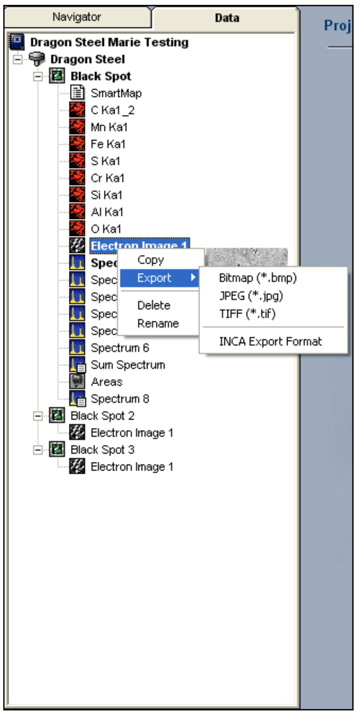
It needs to be kept in mind that this application has not been designed to create extensive reports, but to arrange images for a final print. Still, the convenient way to manually drag the images into the prepared template allows the quick creation of a rough report, including the best images, in parallel to a demonstration. This is an advantage compared to a standard PowerPoint template, which imports images at their original size, ignoring the designated placeholder. This causes an additional step to reduce the image to an appropiate size.

6.1.3. Oxford Instruments INCAEnergy

Oxford Instruments (OI) INCAEnergy is a software interface used for microanalysis. It is designed in a way that it guides the user through different tasks in a logical and structured way. Using the Navigator, the process is started with creating a new project, followed by different analyses. Changes to settings and additional analyses can simply be accomplished by moving around in the Navigator.



(a) The straight forward design of the navigator enables an analysis in only seven steps.



(b) The data tree displays all aquired information and allows the data to be exported in different file formats.

Figure 6.5.: The figures show the navigation menu of the INCAEnergy software.

The integration of the OI detector into the scanning electron microscope (SEM) makes it possible to capture the SEM image directly into INCAEnergy. It can then be used as a reference image to specify the region(s) where the analysis shall be done, while the X-ray detector only captures the elemental composition which can be displayed in spectra and X-ray maps and thus does not show a recognizable image of the sample. The analysis results are stored in a data tree, which is displayed in a second tab, and allows them to be exported in various file formats (see figure 6.5(b)).

The reporting tool allows to export the images and analysed data as Word and HTML documents. To create a report, provided single-paged templates can be used.

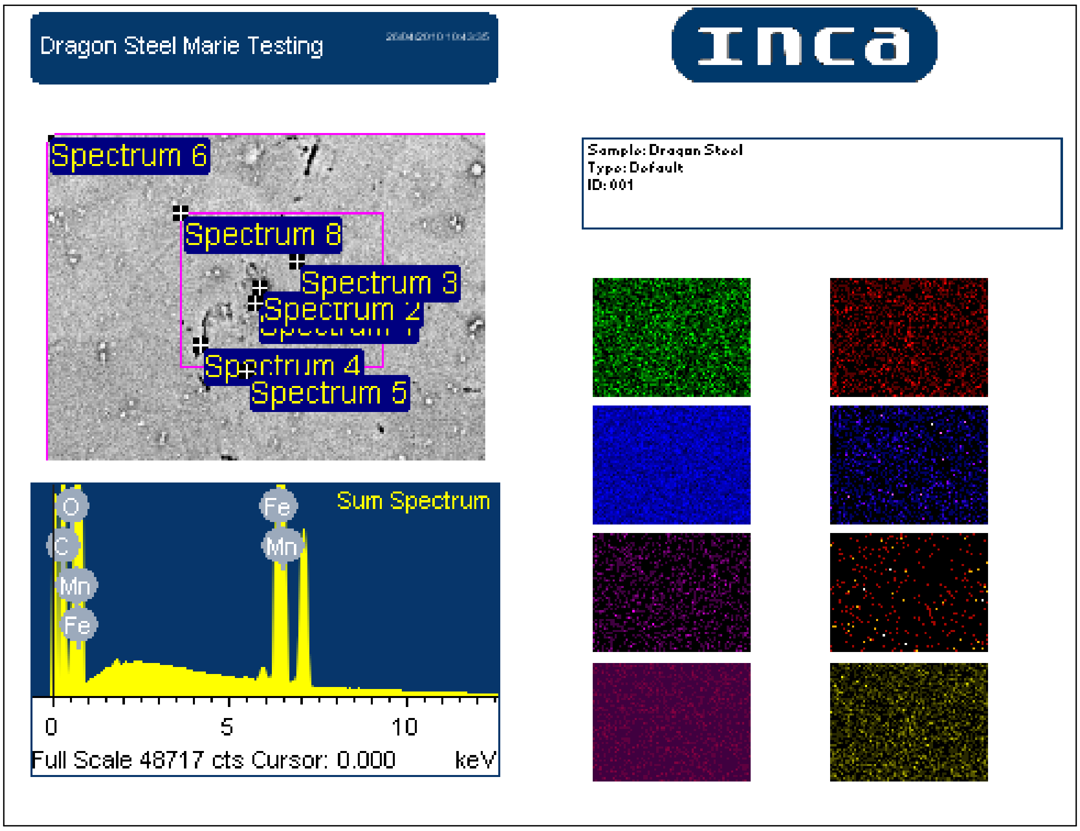


Figure 6.6.: The imported SEM image helps as a reference to locate the regions of the energy dispersive spectrometer (EDS).

Additionally, the report template editor allows to create and customise individual templates according to the user requirements.

Being one of the most used software applications among the interviewees, it has been evaluated in greater detail, to understand the users' viewpoints.

Evaluation With user requirements in mind (see table 6.1), the process from data aquisition until the finalisation of a report has been conducted, to get a comprehensive impression of the system with focus on report generation.

The first use of the user interface gives a very structured and straight forward impression. Following the main top-to-down line of the Navigator, it takes seven steps from the creation of the project to the final report (see figure 6.5(a)). Additional options are arranged in parallel branches, which do not need to be customised each time. The chance to navigate back and forth within these steps to apply changes without losing the previously entered information, is a convenient and user friendly feature.

Two different help options support the user with on-site information, either starting a tutorial about the selected function or explaining the function directly in the interface. The quick help is presented in tooltips, which can be further extended by pressing the question mark in the tooltip. This leads to the main help HTML file (see figure 6.7).

The simple and clear design in combination with the on-site help allows the user to start using the software directly without the need to read the manual.

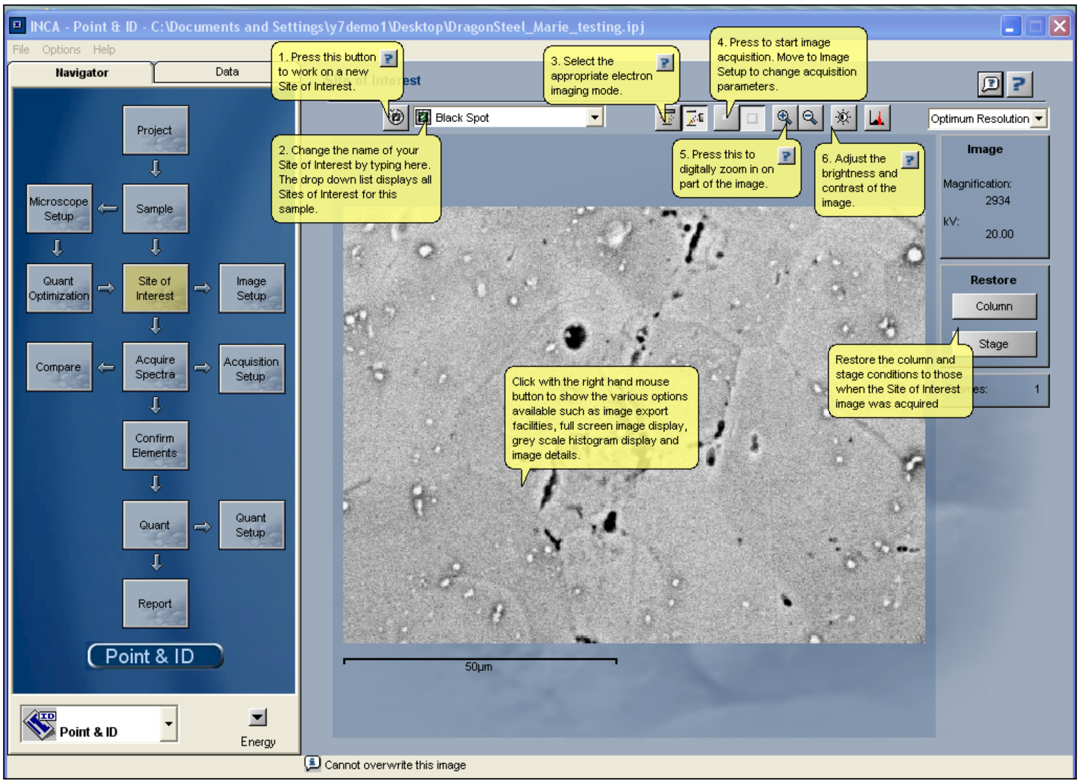


Figure 6.7.: The GUI provides a quick help function, using tooltips. Pressing the question mark in the tooltip leads to the main help HTML file.

Reporting When a new project is created, all project information can manually be added at the "Project/Sample" position. The "Site of Interest" button is used for image adjustments and to specify the used detector before starting the analysis. The desired spectra can be aquired in the next step, selecting one or several region(s) of interest in the imported SmartSEM image, followed by an automated scan of all regions. Changes or additional spectra aquisition can also be performed later on. For the elemental analysis, further information about the specific elements is presented in the following step.

All analysed data is stored in the data tab and can be accessed for the final report generation. Several templates are provided to present the desired information. Combinations of spectra and images, as well as elemental analysis, can be presented and exported on one slide. However, one of the main drawbacks is the limitation to only allow the export of single-paged reports. A combination of different templates or simply a generation of an automated multi-paged report is not possible and therefore considerably limits the report generation. A new slide has to be created and exported for each single sample or information. This means if a report shall present different images or information, the single pages have to be assembled manually. However, one does not have to go back to select the new site of interest, but can choose the required data directly from a drop-down list in the report preview, if a previous analysis has been done. This simplifies the process of exporting single slides.

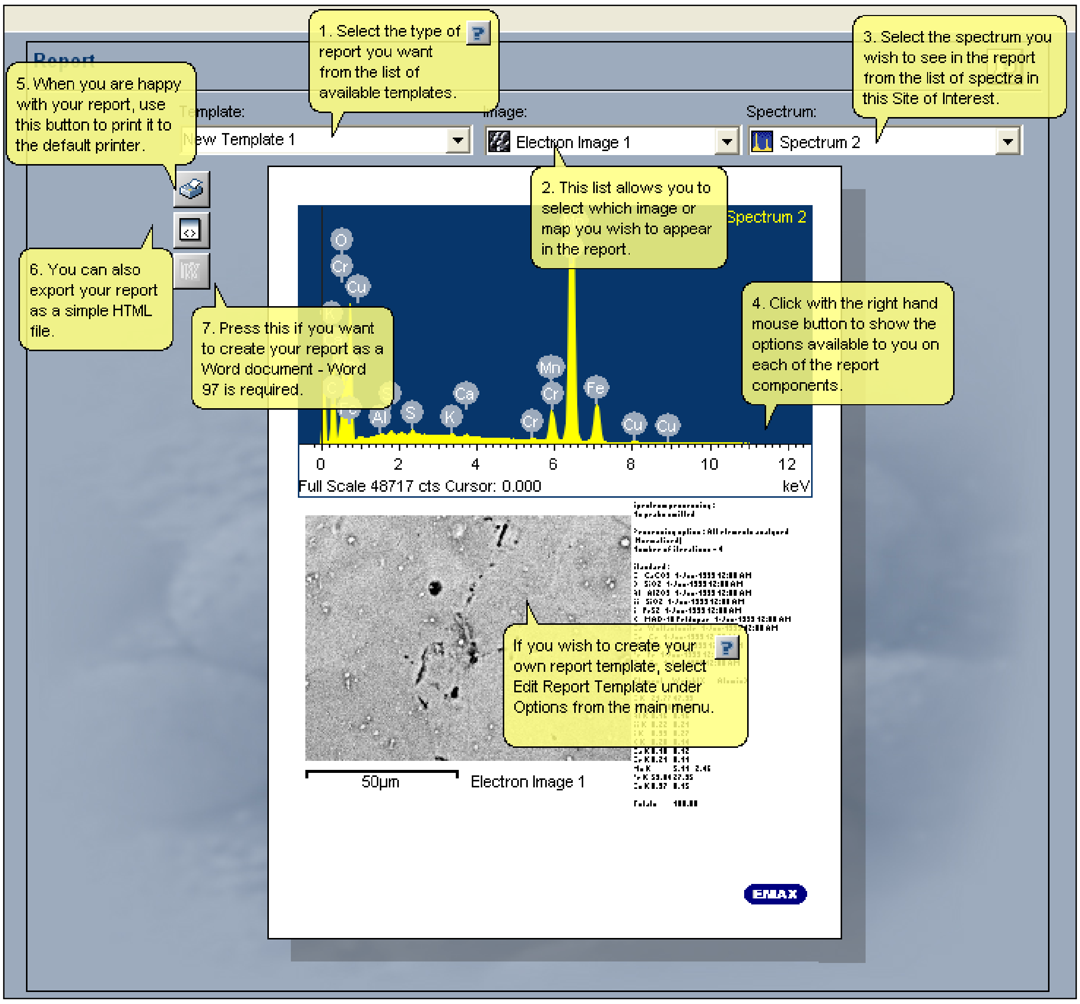


Figure 6.8.: During the report generation, the desired region of interest and its associated analyses can be chosen in the preview mode.

While the region for each spectrum is indicated in the SEM image, the reporting tool does not allow any further annotations. This needs to be done afterwards, either in the exported Word document or when creating a separate PowerPoint presentation.

Creating templates Assuming that the provided templates do not fulfil the user's needs, the creation of a customised template starting with a cover page and presenting the required information on the following pages is needed.

Choosing either landscape or portrait format, parameters are selected using tick boxes causing a place holder to appear on the slide. They can easily be moved around and adjusted in size supported by a background grid. The removal of an image parameter placeholder is rather inconvenient. They cannot be selected and deleted directly from the page, but the according tick box needs to be found and deselected in the parameter sidebar. To do so, one needs to know the name of that particular parameter (see figure 6.9).

An optional function to auto-align and scale the parameters as well as a snap-to-grid mode would simplify the layouting. The absence of a preview function requires to create a report first, in order to get an impression of the template. When the template is created, it can be saved among the other templates.

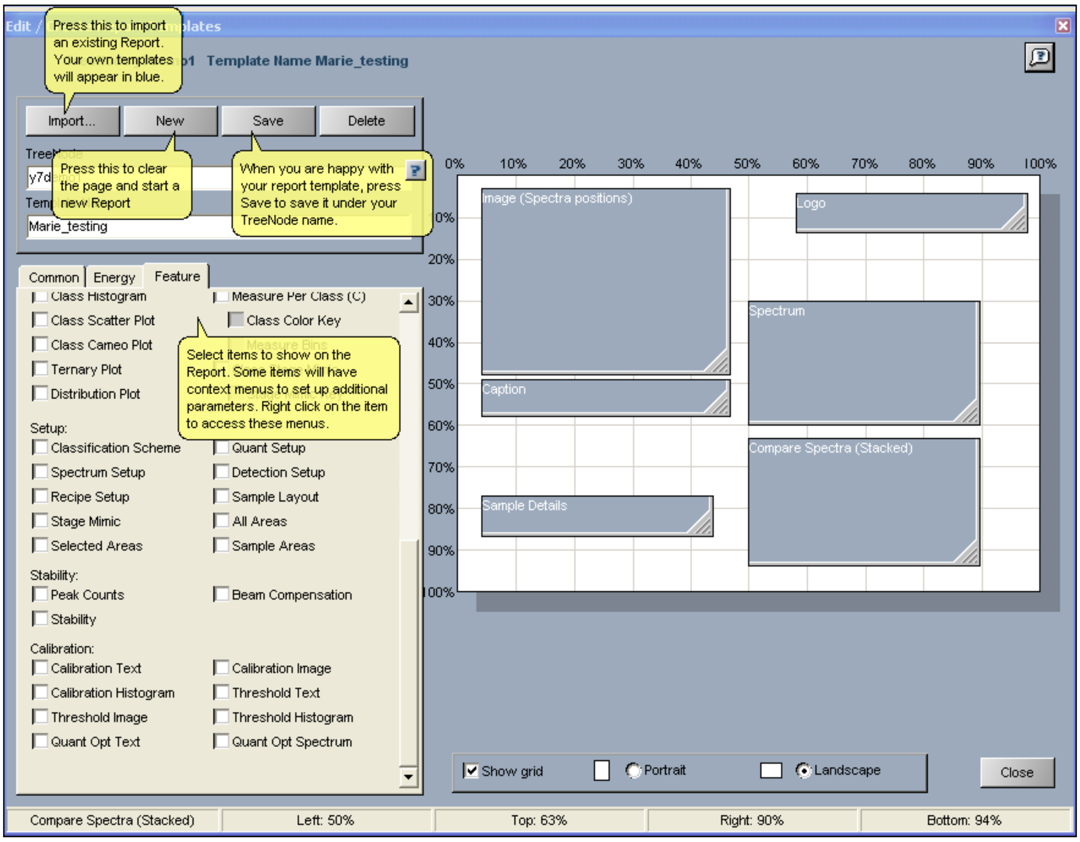


Figure 6.9.: The report template module allows to choose the required data from the tab-organised sidebar, resulting in a scaleable placeholder that appears on the page. To remove a placeholder, the according parameter needs to be deselected in the parameter sidebar.

Another aspect is that the design of the template editor tempts to just close the template without saving, because the position of the close button is in the down-right corner. Following the ideal visual flow for users of left-to-right speaking languages, this position would normally be the button for the next step in the process of the template generation [5](4.2.8). If pressed, the template is closed without saving or further warning.

Conclusion The GUI is well organised and structured and the intuitive navigation makes it a user friendly solution. Fast results can be achieved without reading the manual, using the on-site help functions if needed. Having the data directly available for the report generation to change and adjust it at the final step are highly appreciated.

A template presenting the needed information can be composed rather easily, as long as only one page is needed. Considering the fact that the application is used to analyse elemental compositions, a single-paged report is sufficient to present numerical data, using the image only for a reference. But when it comes to more customised needs considering image-based result presentation, it has several drawbacks and can be considered as insufficient in its current version. The single-paged mode imposes high limitations on the user, who generally wishes to create larger reports as it has been confirmed in the interviews. The INCAEnergy reporting has been used among the interviewees, but only few used it for the final presentation. In most cases it has been used to access the information and to create a basis for further processing in PowerPoint. A future feature could therefore be to allow an addtional PowerPoint export.

6.1.4. Carl Zeiss SmartSEM Reporter

The CZ SmartSEM Reporter is a software application which is still in development stage and therefore subject for deeper evaluation. It is composed of an Add-In for Word 2007 and an API that is used by SmartSEM to provide an integrated solution.

The idea is to provide a programme, which allows a report to be created in a familiar enviroment with the additional ability to read all data from the CZ TIF images [20].

CZ TIF images as well as live images from SmartSEM with all required aquisition settings can directly be included in a report.

Predefined templates facilitate to compile automatic reports, containing all important information. Furthermore, additional templates and modifications can be composed.

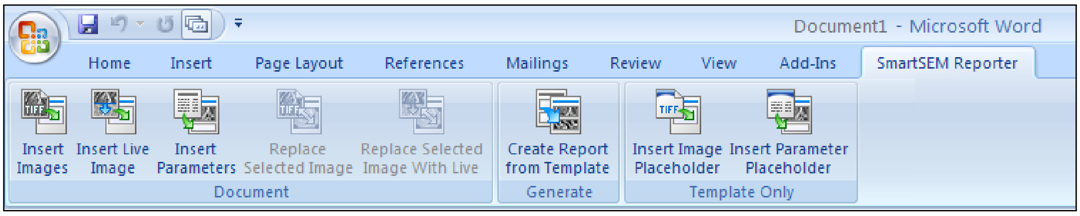


Figure 6.10.: In Word 2007 additional Add-Ins appear as an extra tab.

Evaluation Having these specifications and the user requirements in mind, this reporting Add-In shall be evaluated. In Word 2007 additional Add-Ins are represented by an additional tab in the toolbar, allowing the user to simply switch to the SmartSEM Reporter module.

The choice to use the Microsoft Office environment to create a reporting module is a convenient solution and assumably appreciated by customers, since they are already familiar with the interface and its basic functions. Depending on the user requirements, a PowerPoint solution might be more desirable.

Reporting After having selected the "Create report from template" button, a "Select image(s) for the report" window opens to choose the required images. Subsequently, a new document is created automatically and according to the number of selected images, new slides are added presenting the images and their associated parameters, which had previously been defined in the template.

Compared to the manual drag-and-drop composition of a report, this automated generation is timesaving, but on the other hand the user has no influence on the order in which the images appear in the report. Even though, images can be replaced later on by selecting the image frame to enable the "Replace Selected Image" button (fig 6.10). A new image can be chosen and thus replaces the previous one, which causes redundant effort compared to an option for prior sorting of the images. If one wants to add an image between already filled placeholders, the current mouse pointer position has no influence and the image always ends up at the end of the report, filling the next empty image placeholder. Thus the only solution would be to replace all images after that point, where the selected one shall be added.

If one wants to add additional parameters, a window opens showing a list of all the images present in the report. This is a good feedback on the one hand, but on the other hand one has to double check which image the parameters shall belong to since there is no indicator that highlights the currently selected image in the list. In addition to that, the list does not represent the filenames, but only the number of "CZTiff" images.

This could cause incorrect labelling of the images if the wrong parameters are selected. Some sort of highlighting of the associated image in the list of images, would be a useful feedback.

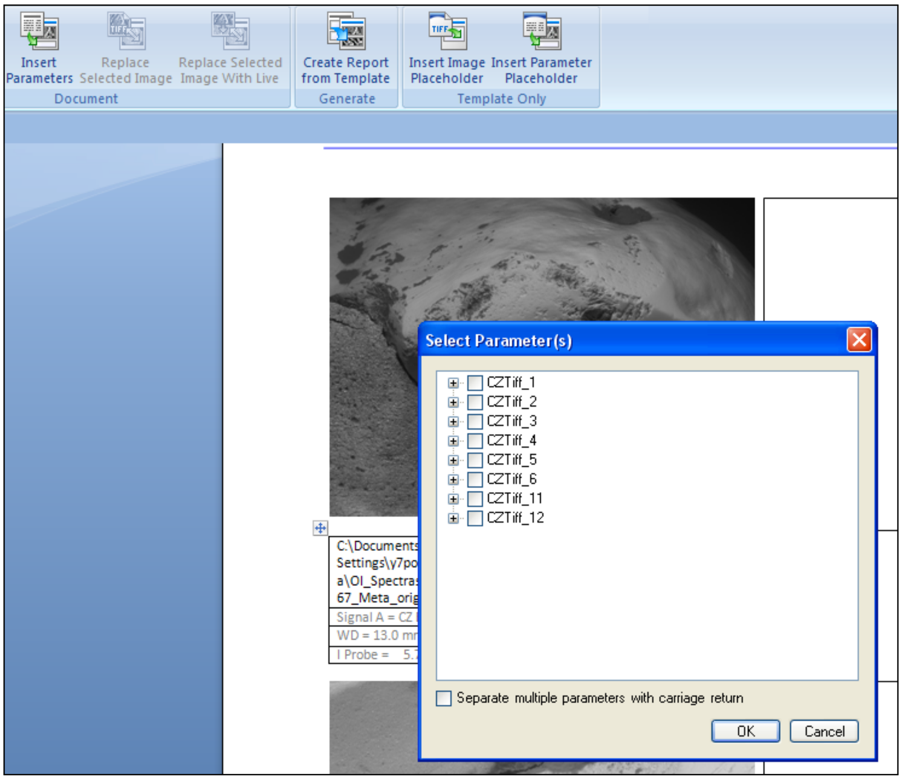


Figure 6.11.: To add additional parameters, a popup window opens with a list of all images in the report.

Usually, a report is used to show information and also gives a short introduction into the performed analysis after the cover page. The SmartSEM Reporter however does not allow different templates to be combined in one document. When using a double-image layout, it might be of interest to show a certain image in greater detail and thus present it in a large single-image layout. Attempts to overcome this by inserting an empty page and using the basic Word image inserting function, did not achieve satisfying results either.

Creating Templates Instead of using an existing template, one might want to create a new customised template. This can be done by adding SmartSEM Reporter image and parameter placeholders to a new Word document. A template including several different pages can be created, according to the user's needs.

Still the creation of the introduction pages that display the used systems and samples is difficult, since one does not have an influence on how the images are loaded into the report. Creating a blank page in the beginning of the template overcomes this problem and it can be filled manually after the automated process of loading the images is completed.

Since the Add-In does not support the combination of different templates, one has to specify beforehand how many pages the report will be, if the template contains several different pages. If the selection of images exceeds the number of determined pages in the template, additional pages are added in the end, restarting with the first page of the template. This means that also the cover pages show up again. As a consequence, the creation of templates containing different page layouts is only useful if the number of images is constant for each report. Else the process of automatically extending the report according to the number of selected images is pointless.

Another option to overcome this limitation would be to create a template with spare pages at the end to be on the safe side. After the report has been finished, all redundant pages can then simply be removed.

Unfortunately, pages of the same layout cannot simply be multiplied using the copy-and-paste function, since the links of the parameter placeholders to the according image are static. As a result the same parameters would then be presented for all following images. This means that they either need to be adjusted afterwards or each additional page has to be created from scratch.

Conclusion The idea to use Word as a basis is convenient, since most people are familiar with it, whereas the compability to only Word 2007 limits the target group. Furthermore, the interviews showed that the use of PowerPoint is of much higher popularity.

The automatic import of the images is useful as long as only images and their metadata shall be presented. As soon as the user wishes a certain order of the images and some additional annotations, the software limits the options. It can only read the metadata of CZ TIF files, which means that including third party images requires manual adding of all necessary information. Thus the idea to present them next to a CZ TIF image is not possible and they can only be added at the end of the report, since intermediate pages are not supported.

6.1.5. Imagic ImageAccess

The reporting modules in ImageAccess allow automated reports to be created in either Word or PowerPoint. The metadata can be read and presented for nearly all file formats involved in a typical analysis. This is one of the main wishes for a reporting solution since it also ensures correctly displayed aquisition information which is based on the direct linkage between the image and parameter placeholders. In addition, it immensely reduces the time effort of manually typing the important parameters. The connection to the archive allows to load images and their metadata directly into the template. Furthermore the QuickFind option can be used to track back images used in the report in the archive [21].

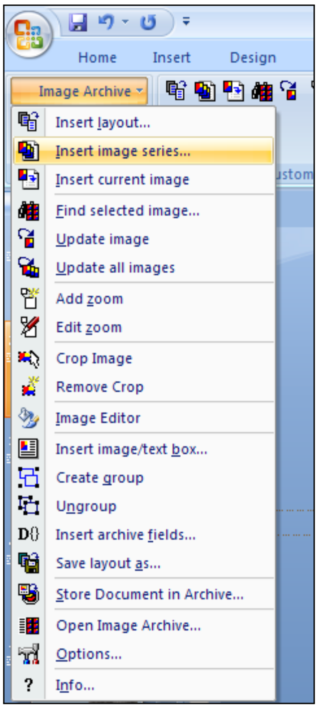


Figure 6.12.: The ImageAccess reporting module appears as an extra tab in the PowerPoint toolbar.

The Word module uses a proxy reference of the images and the required resolution can thus be specified when the report is printed. This allows to adjust a report to either presentations or hardcopies and also reduces the file size.

In PowerPoint, the resolution needs to be defined when the images are inserted. Thus the further need for the report should be known beforehand, as files can become huge if images are unnecessarily inserted at a high resolution. In both cases pre-defined templates, as well as user-defined layouts can be used.

The support of automatic report generation in Word and especially PowerPoint, in combination with an extensive DBMS, makes the software a subject of a detailed investigation. Additionally it comes with the unique feature being capable to access the metadata of nearly all file formats including SEMs, light microscopes and EDS packages.

Evaluation The ImageAccess reporting module appears as an additional tab in Word and PowerPoint, in addition to their standard tools to compose layouts (see figure 6.12). This allows the users to continue the work in a familiar environment and easily transfer previous templates according to the ImageAccess module. Based on the interview results and feedback, the evaluation focusses on the PowerPoint module.

Reporting To enable a report generation, not only the selected software (Word or PowerPoint) but also the ImageAccess archive needs to be opened. A lightbox in ImageAccess allows to select and arrange images from one or several projects to be included in the report. This lightbox selection can also be saved for further editing.

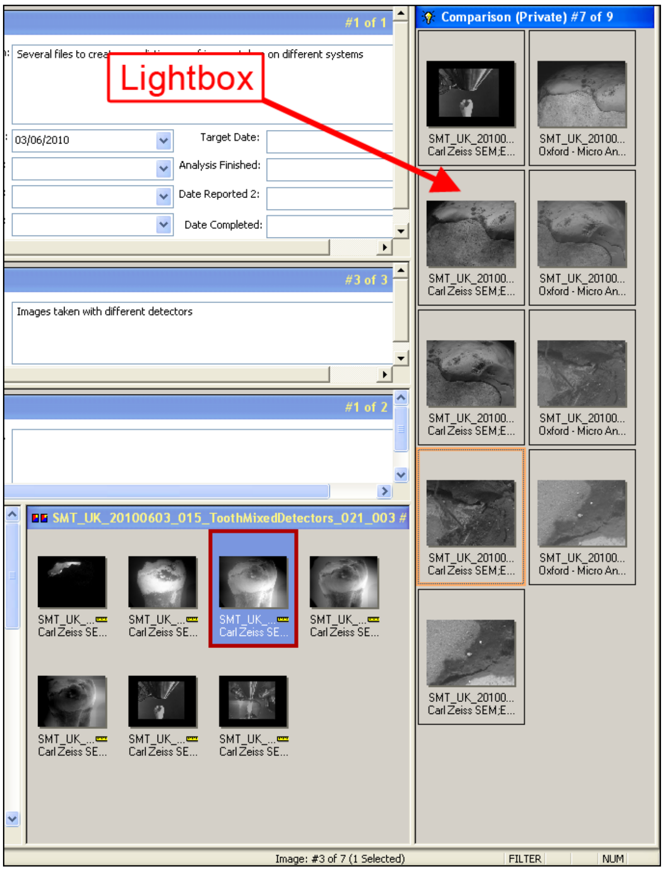


Figure 6.13.: The lightbox stores a selection of images that shall be used in a report. Files from different projects can be combined, while the image order defines the order in the report.

Starting the report by loading an ImageAccess template in PowerPoint, the integrated reporting module recognises the selected image(s) in the ImageAccess archive and imports either a selection or all images present in the lightbox (see figure 6.14). If a report is started without the ImageAccess archive opened, a popup window appears, asking to open the archive.

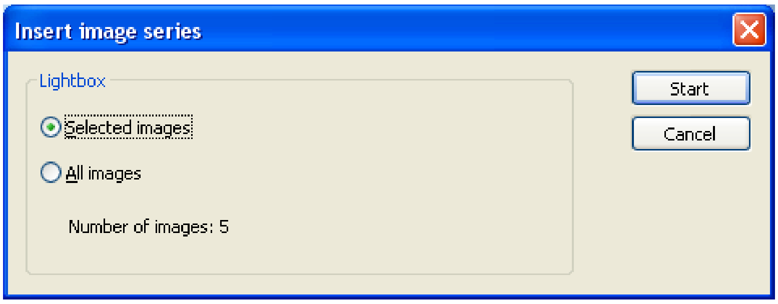


Figure 6.14.: In the insert images box either all images or just the selected ones can be chosen to be included in the report.

For an automatic creation via the “Insert image series” option, the order of the images in the lightbox defines the order of the images in the report. Images can also be inserted manually by drag-and-drop or the “Insert current image” button (see figure 6.12).

One of the reasons why an automated report generation had not been used by some of the interviewees were the varying needs, which make it impossible to have one template that applies to all. However, using the ImageAccess reporting module, the user can also choose to use the common drag-and-drop function to include images. Dragging it directly from the ImageAccess interface into PowerPoint, it is recognised to come from the archive causing the “Insert Image/Text Box” window to open. If additional metadata is desired, either an already existing template can be chosen for the import, or a new image/textbox group created.

In both modules a combination of different templates is possible and allows to create an individual report according to the user’s needs.

Images can be replaced by selecting the desired image placeholers and inserting an image. If the placeholder is already filled with data, a “Replace image” box appears and after the approval, the new image is loaded and the parameters are adjusted automatically.

In addition to the standard Microsoft Office functions, a specific zoom function allows to create a close-up view of an already inserted image, to underline the POI. The selected region of interest is framed automatically and an additional zoom image appears (see figure 6.15). It can freely be moved and positioned and after deciding to “finish zoom”, a magnification scale as well as a line, relating the POI to the new image frame are created (see figure 6.15).

If measurements and annotations have been added to an image in ImageAccess after the report had already been created, an “Update Image” function facilitates to update these changes in the report.

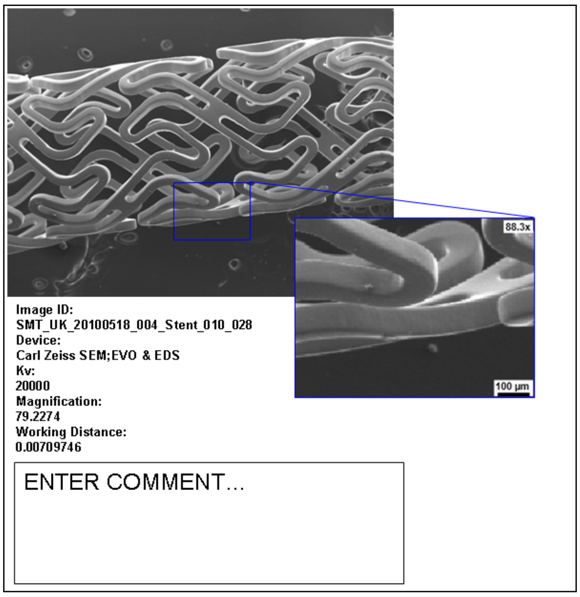


Figure 6.15.: The ImageAccess zoom function, enables to automatically point out regions of interest.

The use of the standard PowerPoint functions allows additional text comments and arrows to be added to the images and parameters.

After finishing the report, it can be printed and also stored into the project that is currently opened in the archive. This assists to easily assemble all project related information.

Creating Templates This part focusses on the template creation using the reporting module in PowerPoint. Starting from a blank page, the template generation works similar to creating a standard PowerPoint presentation. Instead of using the standard functions, the elements from the "Image Archive" tab, which is associated with ImageAccess need to be selected (see figure 6.12). One or several image and text boxes can be added to the slide. After selecting the "Insert Image/Text Box" option, the user can specify the image size and if previously performed, measurements and annotations can be loaded with the image.

A text box can either be empty and manually filled with information in the report, or it can contain image parameter placeholders, which refer to the image's metadata and automatically present the specified aquisition information.

To relate the parameters to a certain image, the image placeholder and the according textbox need to be grouped in the template, using the "create group" function under "Image archive" (see figure 6.12). If this is left behind, the parameters stay empty, when the automated report is done. This constitutes a error source, but if the template is done properly once, it is not a subject anymore.

Templates can be single- or multi-paged and thus allow high customisability for the report generation.

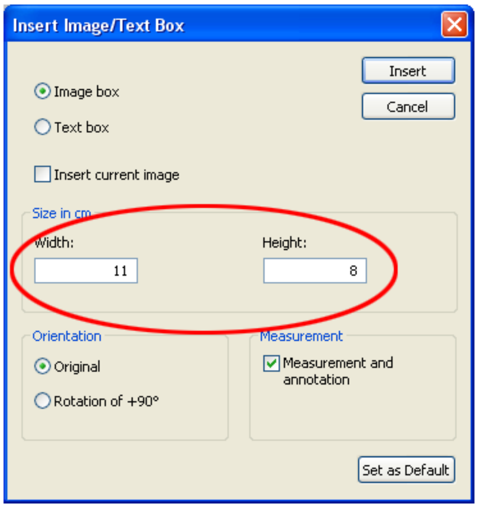


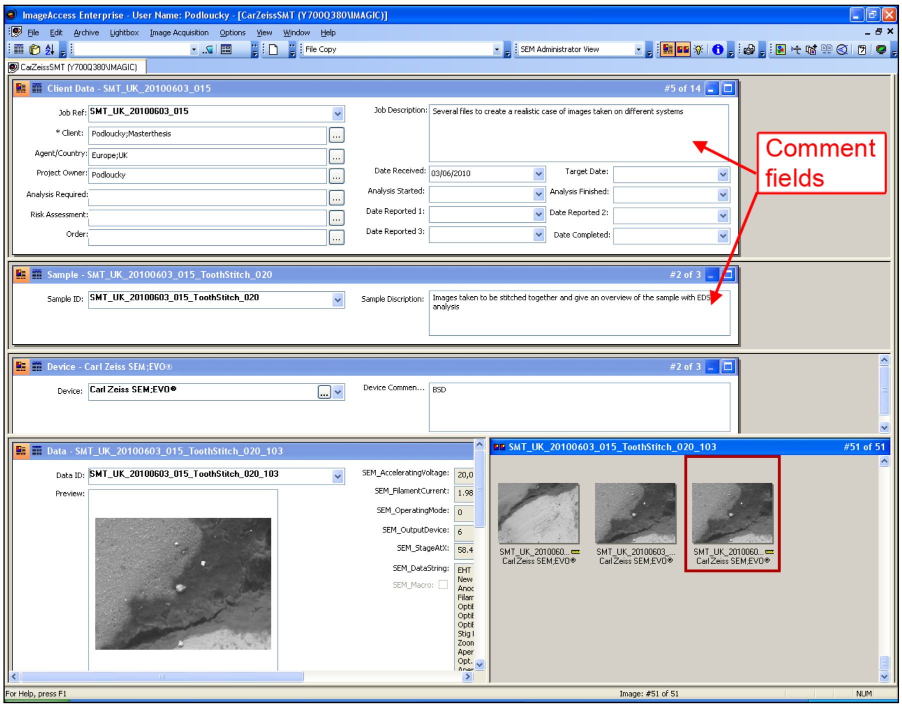
Figure 6.16.: The "Insert image/text box" option allows to add placeholders or the final image, directly specifying its size.

Conclusion The ImageAccess reporting modules fulfil all the requirements for reporting collected from the interviews in chapter 6 and listed in table 6.1. Furthermore, they offer some additional features, as the automatically created zoom image and the track-back of files in the archive.

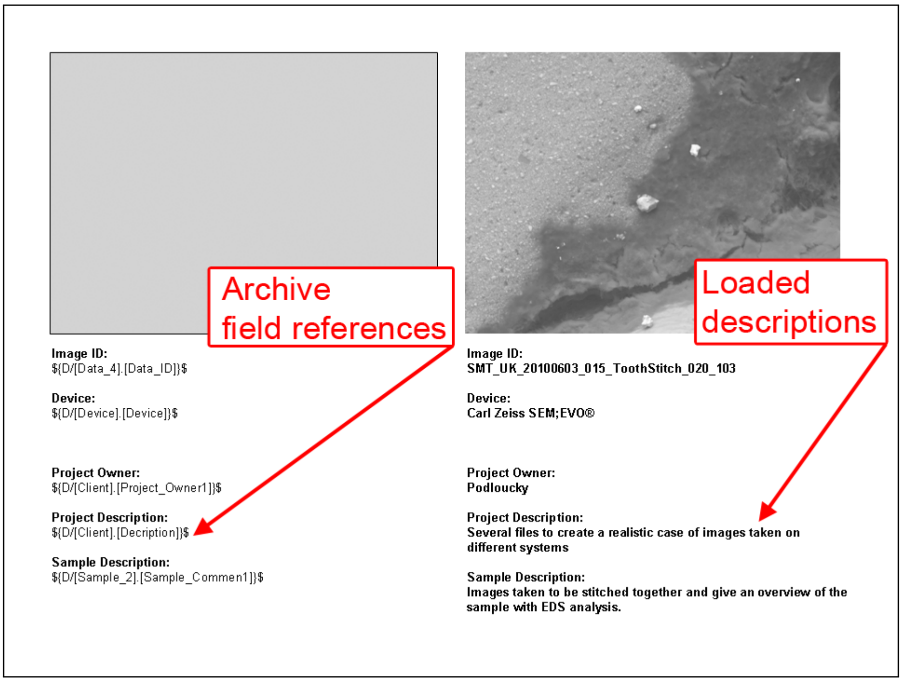
The option to either create a report in Word or PowerPoint sets a liberty to the user to choose the preferred format. While Word offers advanced options for printing, being more difficult in the template creation, PowerPoint is more user friendly in layouting but limits image quality to the resolution chosen when the image is imported.

An advantage to the standard PowerPoint tools is the drag-and-drop function for images. In the standard PowerPoint, images that are dragged directly from a folder either only show the directory path or they appear at their original size, which often is much larger than the PowerPoint slide itself. By contrast if the ImageAccess module is installed and images are dragged from the archive, the "Insert Image/Text Box" window automatically shows up and allows to choose an appropiate size and additionally keeps the file track-back function.

If all comment fields in the ImageAccess archive are filled properly it can greatly simplify the report creation. The project description can automatically be loaded into the report, if reference placeholders to that field have been included in the report template. They only need to be associated to one of the images. This saves the effort to manually type the project description during the report generation.



(a) Each project and sample has associated fields for further comments.



(b) Using the archive field references in the report template loads the associated descriptions directly from the archive.

Figure 6.17.: Filling the comment fields for each project significantly improves the automated report generation.

6.2. Reporting Conclusion

Considering the aim of the project to simplify the result presentation including all data from various systems and the wide usage of PowerPoint, most of the investigated reporting applications do not come up to the requirements.

The main issue is that each manufacturer only supports its proprietary file format, thus not allowing to present diverse information at once. Most solutions solve the task to create a report, but they have their drawbacks, mainly increasing the time needed to achieve the final report. While some create reports completely automated and fast, such as the INCAEnergy or the SmartSEM Reporter, their limitations lie in the customisability of the layout. On the other hand, programmes as the standard PowerPoint and FotoSlate by ACD Systems allow to customise a report and templates but additional information, as adding parameters and editing images has to be done manually. Apart from PowerPoint, the INCAEnergy reporting solution has been used by several interviewees to create and combine individual templates, but its report export is limited and it also only supports the proprietary INCAEnergy files.

Depending on what the customer expects, the individual programmes might solve their requirements. However, considering the time needed, the ImageAccess module provides the most comprehensive solution. It not only reads all proprietary image files including their metadata, but also uses a lightbox to organise and save images used in the report. The linkage to the original file in the archive is kept, which allows the track-back and simple update of images in the report. Providing an automatic storage option into the archive together with the associated project, further extends the advantages of the basic PowerPoint solution. Additionally, it follows with the ImageAccess package, which not only implies reporting but also a complete solution for data management.

Even though the need for the reporting of analysis results has not yet been mentioned among all interviewees, a user friendly solution could attract users and generate interest. Providing extensive templates that come with the final software package, could additionally trigger the use.

Table 6.2.: Overview of the reporting packages.

	ACD Systems Fotoslate 4.0	Carl Zeiss AxioVision Rel. 4.8.1	Carl Zeiss SmartSEM Reporter	Imagic (UK) Ltd. ImageAccess reporting module	Oxford Instruments INCAEnergy
Files					
Support of various file formats	✓	✓	×	✓	SmartSEM import image
Display metadata	JPG only	ZVI	CZ TIF only	all tested systems	own only
Reporting					
Create customised templates	✓	✓	✓	✓	✓
Post processing/ add notes	×	✓	✓	✓	×
Multi-paged export	✓	✓	✓	✓	×
PowerPoint	×	×	×	✓	×
Word	×		✓	✓	✓
Export formats	Own, PDF	Own, PDF, RTF	Word	Word, PPT	Word, HTML

7. Conclusion

The previous investigations and tests confirm the difficulty users experience to relate data aquired during a comprehensive analysis. Therefore, an elaborate database structure combined with an overall GUI that integrates various applications, are important key factors that add to a feasible solution. Based on the manual assembly of all data, they provide a basis for a universal solution even if the automatic relation of all data is not yet achieved. The different applications can then be accessed through the new GUI at full functionality, not opening a new window, but being represented in form of tabs.

The ImageAccess database management system (DBMS) provides a useful basis to assemble images for the final report. The high degree of customisability meets the user requirements which have been elicited from the interviews. In addition, the searchability of all fields and the optional lightbox facilitate to select and organise data from several samples and devices. It can read the metadata of nearly any file format, which considerably improves the report generation since it completely eliminates the manual adding of the aquisition settings.

The customers' interest in 3D visualisation of analysis results led to the attempts to visually relate data from various sources. Microsoft Photosynth has been tested for its suitability and showed impressive results. Several image sets including 3D models have been successfully merged. Still, the drawbacks of creating the links on a feature based algorithm could be seen for complex textures and data aquired on various analysis systems. As this was one of the main interests of the project, Photosynth has not been investigated in much greater detail.

In future, either conform metadata among all files or image registration could be a solution to relate similar regions. After the registration, an export of related images, that updates the matched stage coordinates for either of the data sets, would be a good feature to store the created relation for future use.

It confirms the need for an adjusted file structure. The results from chapter 4.3 show, that there are already some links between different systems but the implementation should be improved. The comparison between the INCAEnergy files and the original SEM outputs shows that the values for certain parameters are the same but at different units (see figure 4.7). Adjusting the units would create the required link. In addition, "Shuttle & Find" creates the link between the LM and SEM but does not export any related parameters yet, which disregards a high potential use.

Based on those links, a common file type with corresponding metadata fields could be a solution. As negotiations with third party vendors would considerably prolong the implementation process, another attempt could be to convert and export all files as CZ TIF files. The connection to INCAEnergy has already been established to import the SEM images into INCAEnergy and could therefore be inverted to export the OI data through SmartSEM. Furthermore, ImageAccess provides all necessary metadata of various files and could therefore create a basis to convert and export all files of a project as CZ TIF files, which would provide conformity among the data.

In this context, the current file structure has been reviewed. Storing the metadata in the TIF header and not in a separate file is a convenient solution and simplifies the data organisation. Since the datazone images are appreciated by customers (see interview A.2.3), they should be retained, but then their organisation needs to be changed. The two folder structure, which contains files with the same filename and metadata but different visual appereance is not an appropriate solution. Without looking at the image itself, the user cannot tell if the file contains the datazone or not. Furthermore, the use of the same filename does not ensure file uniqueness and can cause clashes if the files are moved. This has already been experienced, when the files were loaded to the DB without the automatic renaming. Since the DB does not retain the folder structure, the files clashed during the import. Instead of storing two files, another solution would be to save the datazone, which has been displayed during the aquisition, into the TIF header. A function “show datazone” could then be implemented in SmartTiffV2 to display the plain image and the datazone as an optional overlay. To reduce the additional effort for the user, an automatic batch function that “exports all images with datazone” as a separate file would be useful.

The implementation of these results would provide an elaborate and unique datamanagement solution, enabling visual image navigation and fast reporting. Similar to the individual parts in this report, these suggestions do not need to be implemented at once, but can be regarded separately. A thought through one by one implementation would also add to the customer satisfaction. As a first step for the proposed overall solution, the general file structure needs to be revised. Based on this, the DB can be created and the suggestions be implemented.

8. Acronyms

BSD backscattered detector

CZ Carl Zeiss

DB database

DBMS database management system

EDS energy dispersive spectrometer

GUI graphical user interface

ICE Image Composite Editor

LM light microscope

MS Microsoft

OI Oxford Instruments

POI point of interest

PPT PowerPoint

PS Photosynth

SEM scanning electron microscope

SIFT scale invariant feature transform

SE secondary electron

TIF tagged image file

ZVI Carl Zeiss Vision Image

Bibliography

[1] Siliconfareast.com, "SEM/TEM." Internet: http://www.siliconfareast.com/SEMTEM.htm, July 2010.

[2] Carl Zeiss SMT, "Maximum Information Maximum Insight - A Wide Range of Versatile Nano Technology Solutions," July 2009.

[3] Carl Zeiss SMT AG, Germany, "Scanning Electron Microscopes - Intuitive operation with Windows® based SmartSEM™ with multi-lingual task orientated GUI." Internet: http://www.meditec.zeiss.com/C1256E4600305472/Contents-Frame/03C8D322B730726AC1256E5C0050C6DF, June 2010.

[4] "About NIH Image." Internet: http://rsb.info.nih.gov/nih-image/about.html, June 2010.

[5] Tidwell, Jenifer, *Designing interfaces: Patterns for Effective Interaction Design.* Sebastopol, CA: O'Reilly, 2005. 978-0596008031.

[6] Imagic Ltd. (UK), "Imaging Solutions - Home." Internet: http://www.imagic-uk.com/, June 2010.

[7] Allen Kent, James G. Williams, *Encyclopedia of Computer Science and Technology*, vol. 38. New York, NY, USA: Marcel Dekker, Inc., 1998.

[8] Imagic Ltd. (UK), "ImageAccess For Life Science." Available: http://www.imagic-uk.com/pdfs/ImageAccess%20For%20LifeScience.pdf, June 2010.

[9] Carl Zeiss SMT, "Shuttle & Find, Bridging the Micro and Nano World." Available: http://www.bg-tech.co.il/App_Themes/en-US/Upload/Content/articles/Zeiss/Shuttle_and_Find_Flyer.pdf, November 2009.

[10] C. Scherrer, D. Lysenkov, H. Mantz, C. Thomas, "Microstructural Investigation of Austempered Ductile Iron (ADI) with "Shuttle & Find" Interface for Correlative Microscopy in Materials Analysis."
Available: http://www.zeiss.de/C1256E4600307C70/EmbedTitelIntern/AN_MicrostructuralInvestigationofAustemperedDuctileIRONADI/$File/AN_Microstructural_Investigation_of_Austempered_Ductile_Iron_ADI_Vers.4.pdf, November 2009.

[11] Microsoft Research, "Background Photosynth - How Does it Work?." Internet: http://photosynth.net/Background.aspx, May 2010.

[12] Eugene Liscio, P. Eng, "Microsoft's Photosynth: A Future Forensic Tool?," *DFI News Online*, March 2010.

[13] Microsoft Corporation, "The Photosynth Photography Guide." Available: http://mslabs-777.vo.llnwd.net/e1/documentation/Photosynth%20Guide%20v8.pdf, May 2010.

[14] B. Triggs, P. McLauchlan, R. I. Hartley, A. W. Fitzgibbon, "Bundle Adjustment: A Modern Synthesis," in *Vision Algorithms Workshop: Theory and Practice*, pp. 298–372, Springer Verlag, 1999.

[15] synthy, "Photosynth Blog - How to Succeed in Synthing a Car." Internet: http://blogs.msdn.com/b/photosynth/archive/2010/01/15/how-to-succeed-in-synthing-a-car.aspx, 15 January 2010.

[16] Beekley Corporation, "CT/MRI/Multi-Modality." Internet: http://www.beekley.com/products/cat_scan.asp, June 2010.

[17] Roger Rowland, "Re: Smarttiff description," 20th May 2010. Personal e-mail.

[18] Carl Zeiss MicroImaging GmbH, "AxioVision 4 - Perform to Perfection." Available: http://www.zeiss.de/C1256D18002CC306/0/11968EB5A1D4E9FFC12575D30046E4BF/$file/60-3-0019_e.pdf, April 2009.

[19] ACD Systems, "FotoSlate™ 4 Photo Print Studio." Internet: http://www.acdoffers.com/en/na/fotoslate/#fotoslate, June 2010.

[20] Nicholas Sharp, Carl Zeiss SMT, *SmartSEM Reporter Manual*, 2010.

[21] Imagic Bildverarbeitung AG, "ImageAccess Presentation." Available: http://www.imagic.ch/index.php?id=162\&L=2, June 2010.

A. Appendix

A.1. Trademark Notices

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A.2. User Interviews

A.2.1. Carl Zeiss Application Specialist, US, 2010-05-27

Background and Requirements for the Creation of Reports

- Does demonstrations for customers and preferably wants to present the results directly in a report.
- The most required format for reports is PDF
- Bruker as an example has the nice feature that analysis tools are still accessible in report generation as in the acquisition software.
- The user wants metadata and associated information to be presented in the report. ⇒ The TIF header information displayed on default is too long. ⇒ Earlier, the customer could choose which parameters to export. This was changed to exporting all fields to ensure that no relevant information is unintentionally neglected.

Current Solution to create Reports - FotoSlate by ACD Systems

- Created his own template in FotoSlate
- The first page is a cover letter to the customer, where he explains the performed analysis and used systems. It is written in Word and then copy-and-pasted into a textbox place holder in the template.
- The report then continues displaying two images per page while annotations and parameters have to be done manually.
- Pages in the template can simply be modified and duplicated using copy-and-paste. New pages with varying layouts can simply be added to the report.
- Images can be selected from a folder and are then displayed in a sidebar from where they can be dragged-and-dropped into the layout. Additional frames and shadows can be added.
- A tick on the sidebar thumbnails indicates images that are already included in the report.
- The final report can be exported to a PDF file at different qualities.

This solution allows him to do a report in parallel to a demonstration, dragging good images into the template and already print it at the end (without the customer letter).

Drawbacks

- Images are only linked and not embedded in the report.
  ⇒ Moving an image folder or renaming images affects report as long as it is not exported to PDF.
  ⇒ If a template shall be used on another system, all the associated image files (i.e. logotypes and fixed pictures) have to be copied to that system as well.

It would be good, if images were embedded and to have a solution, where images from several different folders could be stored.

File Organisation

- Simple without a certain structure using Windows Explorer. (Folder: "Images" → "Customer" or "Date" → "Device_CustomerReferenceOfSample_Counter.tif")

- Suggestion: If a sample has been analyseid on different machines, it would be helpful to assemble them. Then the stage coordinates would be useful in the file name.

Further Interest

- VE Viewer by Fibics, puts together the scan generator and stitches images. It first looks at the stage coordinates and then performes a more precise analysis based on feature recognition

- The interest in 3D reconstruction as i.e. Photosynth to navigate and investigate images is increasing. Especially in the area of tomography and material analysis.

- Sees potential in the convergence of SEM and micro imaging software.
  ⇒ Assumes that AxioVision could be the basis, since they have complex imaging tools, but their reporting is insufficient.
  ⇒ There exists already a NTS PlugIn to read SEM files in AxioVision

- Heard of a project in Germany where they try to bring those academics together that already write their own software, to develop a common solution. This is most about 3D reconstruction.

- "Reconstruct" and "Fiji" by HHMI are other open source solutions for stitching and 3D reconstruction.

A.2.2. Carl Zeiss Application Specialist, UK, 2010-04-20

Background and Requirements for the Creation of Reports

- Customers want to present the analysis results.
- Get samples from customers to investigate. The results of the investigation is sent to the user and presented in a clear and informative way.
- Ideally, the report should be created in a fast and easy way

Report Structure

- Introduction & Overview
- Give capture information
- Label images with parameters
- Indicate POI, Zoom

Current Solution to Create Reports Has created her own PowerPoint template, which she then just adjusts according to customer.

- 1st page:
  Introduction to the analysis, naming the used system and capturing conditions
- 2nd page:
  Displays an image of the sample(s) provided with numbers. The overview is used to refer to the according sample throughout the report.
  Include the customer's logotype and a "Strictly Confidential" note to show the customer that all data is treated confidentially.
  An outline of the process telling which analysis she did and the used settings (keV, VP etc.)
- 3rd page:
  Image of the investigated sample and the used settings.
  Sometimes the settings are also given in each slide's title.
- 4th and following pages:
  The following pages normally present dual channel images, comparing the results of different detectors or displaying a zoom view to highlight a region of interest. This could be:
  - 2 images of the same region with different detectors. A textbox is used with an arrow pointing at image, to label image detectors.
  - 2 images different magnifications. The POI is indicated with a rectangle and lines leading to the related zoom view.

- ⇒ This takes too long time!

This way of presenting the results indicates to the customer that Zeiss knows, what they are doing and thus increases their trust in the company.

Including X-ray Analysis The only way to include related X-ray analysis information, is to export a report as html to access the images.

- The idea is to present an SEM image and the according X-ray tables and maps on one slide

- So far, this can only be done by copying the data from the html/doc file into the PowerPoint presentation. The table is then edited in PowerPoint

⇒ Huge time effort.

Problems testing the SmartSEM Reporter

- It does not read any other file than the CZ TIF format. This still does not simplify the integration of third party information or even basic JPG files.
- When loading one of the provided templates, the parameter for the chamber pressure stays empty.
- Creating templates is more complicated in Word than PowerPoint. This takes again more time and causes frustration for the user. The result would be that no one uses it.
- If one selects images to be loaded into the the template, there is no feedback about the order of the images and their relations, meaning how they are loaded into the template.
- If an image is at an incorrect location, in PowerPoint one just needs to copy-and-paste the image to another location. In Word, all links are lost and just a small image place holder is left, when cutting wrongly located image from its position.
⇒ Suggestion: If an image is deleted, the following ones should move up, filling the empty space.
- Marking of the POI in images is much more complicated in Word than PowerPoint.
- There is no solution to "Replace parameters". If an image is replaced, the parameters remain and thus display wrong information about the newly added image.
- Changes applied on the first page of a template affect all the following added slides. If image is deleted on first side, the slides added afterwards also only have one image. ⇒ It seems as if the first page defines the template.

- The template is so limited, that there is no chance to include a cover- and introduction slide.

Aspects on INCAEnergy:

- The spectra image is too small and it does not take the customized spectra view, when it is exported.
- All images and information needs to be saved separately from the project.
- There is no chance to get the information before creating the final report to then copy-and-paste the information from the INCAEnergy report file into PowerPoint
- The basic reporting has not been used so far because the user wants no hardcopy but an electronic presentation.

A.2.3. Company Interview - The Usage of ImageAccess (2010-05-21)

Database (DB) Structure

- The DB consists of 4 layers:
  1. Field name: Customer's country
  2. Study layer: Date of analysis
  3. General Information: Age of Rocks, name of client
  4. Sample layer: Is categorised by the depth, type, unit, age
     The name of the sample is just the depth
- The captured images are automatically stored using the AutoSave function.
- The name is based on the field, study, sample plus a sequencial number. Using the "\" in the AutoSave setup creates a new folder for each project on the server. This is used so that customers without ImageAcces can still access the images, using common software although the Idea of ImageAcces is that images are only stored in the DB and not accessable outside the archive interface

Image Aquisition

- Uses the regular software to aquire images and saves them into a certain folder.
- The ImageAccess polling function collects the images into the database, and renames them according to the AutoSave setup.

Used File Formats

- JPG, CZ TIF and occasionally ZVI
- Optical Zeiss microscopes save JPG + metadata file
- Scanned images are stored as JPG
- Oxford,EDS information: The spectra are saved as TIF

The Use of the ImageAccess Reporting Module

- It is not really used.
- Drags-and-drops the images into a customised template in PowerPoint
- Defined parameters are automatically loaded in the PowerPoint

- Types the parameters manually
- Customers are not that interested in the capturing parameters, but in the information about the sample.
- The most important capturing information for the customer is in label.
  ⇒ Keep the 2 files export
- INCAEnergy:
  Creates an Oxford Instruments INCAEnergy report exported as a Word file and adds it to the database. The solution is not great at the moment. Either each single spectra has to be saved to the polling folder, or the whole analysis has to be saved as a Word report.

A general problem in reporting is that no template would fit all requirements. A flexible output is needed depending on the customer and therefore he preferes to use the drag-and-drop.

How are Images Related?

- By detector type and sample type
- So far there is no chance to see/relocate where an image was taken.
- The only chance is if the sample is placed in the system exactly as before and then reconstructing the stage coordinates.
- The association of images is not of interest, since regions of interest are rather obvious and thus easy to reconstruct.

A.2.4. Phone Interviews

Date:	2010-04-23
Institute:	**Research Institute 1**
Country:	Sweden
Number of Microscopes:	In total 8 Microscopes (Only light microscopes).
Manufacturer:	2 Bio-Rad Photon 200 (from 2003 but already too old) → They will be replaced by Zeiss Palm Olympus Coming soon: 3 new ZEISS microscopes (Meta, Axio 100)
Number of images taken and stored:	Images are only taken by customers only. They take them home.
Type of images:	Customer dependent.
Use/Analysis of images:	Customer dependent.
Used Software:	They only recommend software to the customers: • ImageJ • LM Image Browser: Only to open LM images and store them as regular TIF files
Storing/Management:	No database or storing done on-site. They only offer the facilities and training for customers. Customers take images home If they do their own research, they just store them in the according software database (LSM Image Browser).
Information presentation:	No need for presentation, since the customers take the images home and do it independently if needed. All important information about the aquisition is stored in the files and thus can be seen in the corresponding software.

Date:	2010-04-23
Institute:	**Research Institute 2**
Country:	Germany
Number of Microscopes:	4 TEM
	2 REM
Manufacturer:	**TEM**
	Analogue:
	Philips 402
	Zeiss EM10ZR
	Zeiss 902
	Digital:
	FEI Techna G2T20
	Coming: New FEI in summer
	FEM
	Philips
Number of images:	User/Project dependent. This could be either for the institution, or Life Science investigations.
Type of images:	User dependent:
	Fundamental research
	Medical virology
	Pathology (seldom)
Use/Analysis of images:	User dependent
Used Software:	Analogue:
	Flatfilm (6,5x9) → develop → scan in negatives
	Digital:
	Morphologic analysis
	Tables etc are done in Adobe Photoshop

	Analysis in done in the provided software, where only the FEI is a digital microscope so far. 3D reconstruction is of importance. → Amira, Imod (Open Source) Stereology
Storing/Management:	No database or storing Customers take images home <u>Digital</u> They have one computer, from which everybody should take the images home. → She sees a need to find a better solution, since the hard-disk is often full. E.g. the Techna produces files up to 5GB. Users organize their files on their own. <u>Analogue</u> They use a file cabinet. A protocol paper is filled by the user, using an archive number. The metadata, as archive number, magnification and acceleration, is exposed onto the images.
Information presentation:	There is no need, since the users take the images home and do it independetly if needed. The interest is rather in what the sample image shows. If a presentation is needed, images are prepared in Adobe Photoshop, and the presentation is done in PowerPoint.

Date:	2010-04-26
Institute:	**University 1**
Country:	Sweden
Number of Microscopes:	2 SEM, 3 TEM, 1 Sip SEM
Manufacturer:	Zeiss FEI a digital LM
Number of images:	Customers dependent.
Type of images:	Digital and analogue.
Work:	Research and visitors
Use/Analysis of images:	Done individually by customers.
Used Software:	Many different types: NIH (freeware) MSpex Digital Micrograph (GATAN)
Storing/Management:	Images are stored on a server but no database.
Information presentation:	Internal/external reports. Journals PowerPoint They use Word or PowerPoint because they want to be flexible.

Date:	2010-04-27
Institute:	**Museum**
Country:	United Kingdom
Number of Microscopes:	In total 6 microscopes: 1 TEM 1 EM Probe 2 VP SEM 2 FE Gun 1 Confocal (Leica)
Manufacturer:	3 Zeiss 1 FEI 1 Hitachi 1 Camica 1 Leica(confocal)
Number of images:	Approx 360/day at maximum capacity.
Type of images:	Varying images depending on sample and needed investigation.
Use/Analysis of images:	User do it individually, using Imagin, ImageJ or Photoshop.
Used Software:	Imagin, ImageJ, Photoshop INCAEnergy by Oxford Instruments AnalySIS by Soft Imaging System GmbH (SIS)
Storing/Management:	All images are stored. The data captured via INCAEnergy is stored in a project and backed-up by the IT. Users export their data as a back-up on tape. All other data in organised in the AnalySIS database.
Information presentation:	Uses the INCAEnergy reporting module and exports the final report as html.
Oxford Instruments INCAEnergy:	Highly appreciated, but one needs to export each single report for a project slide by slide. The web export allows to export all images in a html file.

Date:	2010-04-27
Institute:	**Research Institute 3**
Country:	Germany
Number of Microscopes:	In total 8 microscopes: 5 EM (1 TEM ordered) 3 LM more on webpage
Manufacturer:	Zeiss Leo Phi Nikon Infinity
Number of images:	Right now still withing the limits, but it will highly increase, when the third TEM is installed. • Now: max 100 files/day → (2-3GB/day) • Future: 72-140 images/series at 5-10 series/day → 20GB/day
Type of images:	Different: Images and spectra
Use/Analysis of images:	Many images go to customer without analysis those are images from scanning microscopes. TEM/Spectra will be analysed. Much data is discarded.
Used Software:	Digital Micrograph (GATAN) ITEM (Olympus) EDAX Spectroscopy More detailed analysis is done using: • Photoshop • ImageJ • Digital Micrograph (GATAN)

	Spectras are analysed with: • Self-programmed solutions • Matlab • OriginLab, Data analysis and graphing software.
Storing/Management:	All images are stored. Images are deleted locally, but synchronised with a server. No Database → classical structure in a filing System. • They have a list with cases: One file for each case with a labeling regulation. • Each user has his own directory and own responsibility for he data.
Information presentation:	They do little reporting.
	He is unsastisfied with having so many different software that does not cooperate where each has his Pros and Cons
Oxford Instruments INCAEnergy:	Is frequently used to extract the aquired spectra and maps in common image filetypes, which enables to review them on other machines, where the INCAEnergy software is not installed. Pros: • Good and intuitive flowchart Cons: • It does not have a good interface to connect to other programmes. • It has a bad data management system, which makes the data export complicated. • The design is old fashioned. → He never uses the Word export as it is, but post processes it before it is sent to the customer. → This is too time consuming • A Word and PowerPoint implementation with good design would be good.

Further tested/used software:	• Digital Micrograph: does not do reporting. • Osis: Has a database system but many other disadvantages. • ITEM is good for reporting, but many other disadvantages → not used • Leginon™ Used for data management. Acquisition software for microscopes. Database storage.
General Information Experiences:	Tried to get a overall interface solution. His experiences show: • A professional IMS provider would be too expensive. • It needs to be flexible and easy. • It does not make sense to force users into a predefined system. • The more rules user gets, the less he cares about them. • Tried to implement ITEM as a overall interface, but already the step from WinSEM/WinTEM to ITEM was too much for the users. They rather stick to their file structure. ImageAccess: Read about it but it did not seem sufficient. Did not get information if there is a chance to control the microscopes as e.g. the LEO SUPRA55

Date:	2010-04-28
Institute:	**Laboratory**
Country:	Sweden

Number of Microscopes:	In total 2 microscopes: 1 Zeiss EVO 5x VP (3years) 1 Leo (13 years)
Manufacturer:	Zeiss
Number of images:	10 images/day
Type of images:	Elemental analysis
Use/Analysis of images:	No analysis performed. The interest lies in the overview of the X-ray spectra and how it is composed.
Used Software:	SmartSEM®to get an overview of the sample INCAEnergy to perform the elemental analysis. Everything is done in the Oxford software.
Storing/Management:	Cases are stored on their network.

- The storing structure is related to cases.
- They always also use the BSD detector to see the contrast. Those two images of the same probe are stored under the same case name, which is also displayed in the captions on the printed hardcopies.

Started using SIS Scandium by Olympus Soft Imaging Solutions:

- It followed with the microscope.
- The main application is stitching to get an overview of the tool marks. It is able to stitch 10x10 images.
- If SmartSEM®images are printed tool marks can get lost. Therefore it is important to be able to cover a larger area.

Information presentation:	External reports are seldom needed, but else they use PowerPoint.
Oxford Instruments INCAEnergy:	They use the "Point&ID", "Site of interest" Reporting module: • Export reports as hardcopies and store them with case files. • For the hardcopies, the report template Picture& EDX results is used. Template creation: • It would be good to be able to do more changes in the templates. As to include more parameters and specifications. • The captions could be improved. Many are not needed and others are too unspecific. INCAGSR (GunShot recidue) • Runs automatic analysis of particles. • It needs improvement since one has to do a lot to achieve the results. → Simplify procedures.

Date:	2010-04-28
Institute:	**University 2**
Country:	Germany
Number of Microscopes:	In total 12-15 microscopes: Light microscopes 1 EM
Manufacturer:	Zeiss Leica
Number of images:	Approx 30-40/day
Type of images:	
Use/Analysis of images:	
Used Software:	AxioVision to control Zeiss microscope. ImageAccess for: • Database • To control the LEICA microscopes. • In principle it is possible to control all microscopes through ImageAccess, but the use with Zeiss is difficult and not as described. Partly AxioVision & ImageAccess SmartSEM® INCAEnergy: High relevance
Storing/Management:	All images are stored using ImageAccess. They are sorted by case numbers.
Information presentation:	They have no standard template and use PowerPoint to present their results. Word has only little use.
Oxford Instruments INCAEnergy:	Used to create reports, but only to access the data and import the files into PowerPoint.
Wishes:	One solution that does everything (Database& Image analysis) would be great, but seems to be an illusion.

Date:	2010-04-28
Institute:	**University 3**
Country:	Germany
Number of Microscopes:	In total 3 microscopes (Only light microscopes).
Manufacturer:	2 Zeiss
	Till Photonics
Number of images:	Approx 200-300/day
Type of images:	s/w bitmap
Use/Analysis of images:	
Used Software:	Self written image acquisition software based on C.
	Self written digital reconstruction for evaluation.
	Self written analysis software, based on PV-WAVE.
	Partly Photoshop, ImageJ, ACDSee.
Storing/Management:	Server with labelling regulation.
	Structure is based on cooperative partners and date.
Information presentation:	PowerPoint