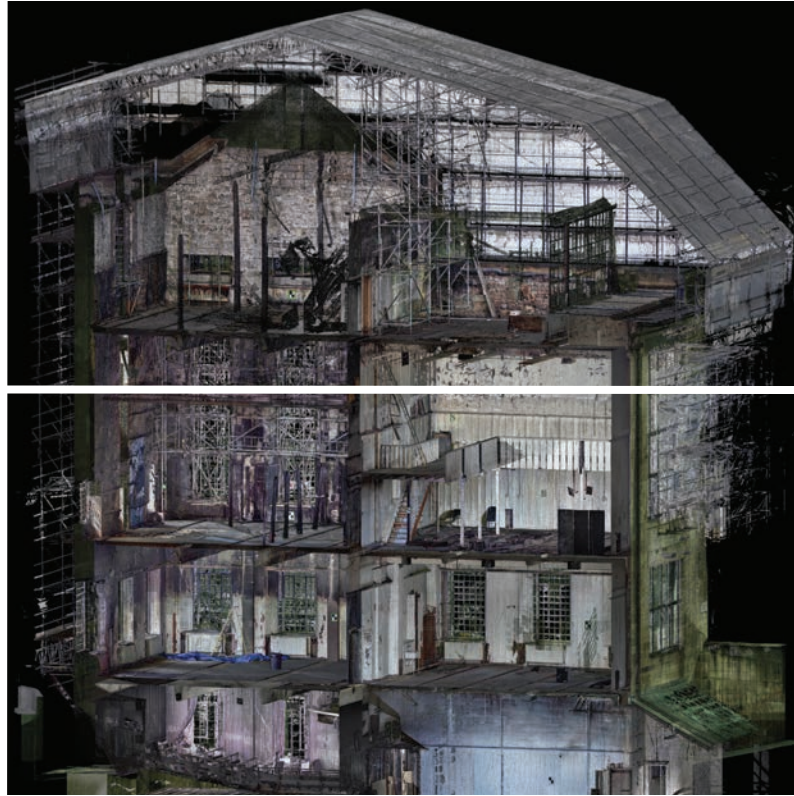


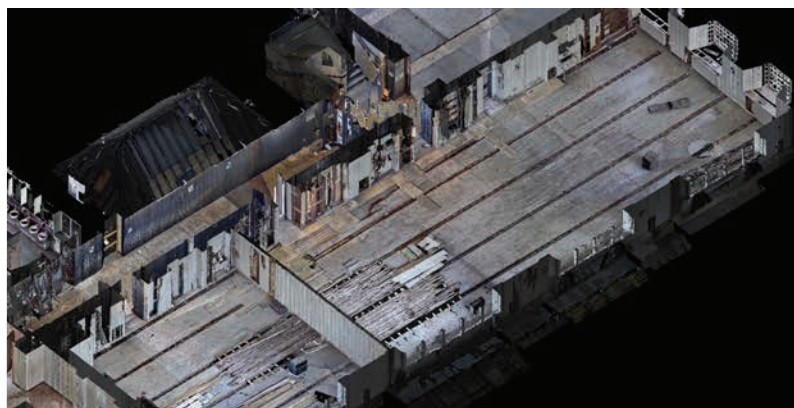
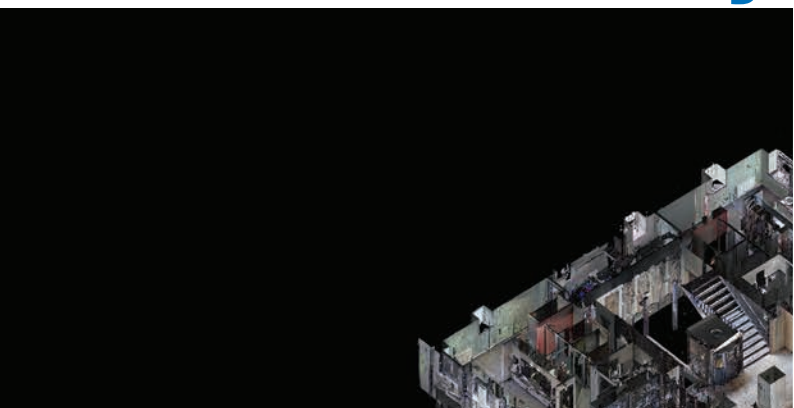


How we build reality



Case Study

The value of 3D data for restoration purposes
"The Mack" - Mackintosh Building
Glasgow, Scotland



Company Overview

Z+F is one of the world's leading manufacturers in the field of non-contact laser measurement technology. Due to years of research, development and numerous successful engineering projects, Z+F is the forerunner in this field with a wealth of knowledge, experience and success.

When it comes to implementing future developments Z+F has always encouraged innovative thinking and open-minds. Our loyal and long-standing customers appreciate our continual innovations, support and the services we provide.

[In cooperation with the Glasgow School of Art \(GSA\).](#)



*The Mackintosh Building in 3D
Picture: GSA*

Our Partner

The Glasgow School of Art (GSA)

The GSA is internationally recognised as one of Europe's leading university-level institutions for the visual creative disciplines. Its studio-based approach to research and teaching, brings disciplines together to explore problems in new ways to find new innovative solutions. The studio creates the environment for inter-disciplinarity, peer learning, critical enquiry, experimentation and prototyping, helping to address many of the grand challenges confronting society and contemporary business.

Since the School was founded in 1845 as one of the first Government Schools of Design, as a centre of creativity promoting good design for the manufacturing industries, our role has continually evolved and redefined to reflect the needs of the communities we are part of, embracing in the late 19th century fine art and architecture education and today, digital technology. Then as now our purpose remains the same - to contribute to a better world through creative education and research.

**THE GLASGOW
SCHOOL OF ART**

“The Mack”

The School was originally founded in January 1845 as Glasgow's Government School of Design. Forty years later in 1885 Francis Newbery became headmaster and under his energetic direction the Glasgow School of Art and Haldane Academy (as it was then known) expanded so considerably that a new larger building was required.

In 1896 an architectural competition took place for the building of a new Glasgow School of Art on a site offered to the School's directors by the Bellahouston trustees. Working to a budget of just £14,000, the Glasgow firm of Honeyman and Keppie submitted a design from the hand of one of their junior draughtsmen, Charles Rennie Mackintosh. Sympathetic to Mackintosh's intentions, the design was praised by Newbery and after being independently assessed by the educational authorities in London, was finally accepted.

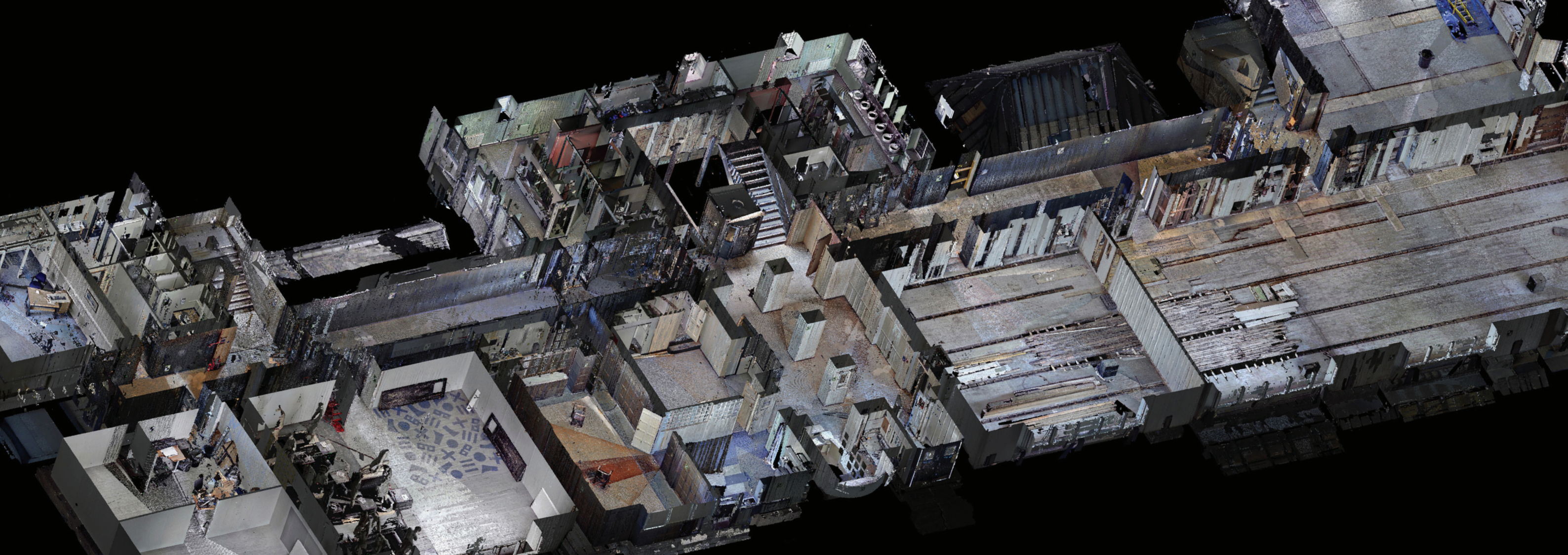
Building work commenced in 1897 and by December 1899 the first phase of the School had been completed including the Museum, the Director's Room and Board Room. It took Newbery and School's Board of Governors

a further eight years to secure the financial means to complete Mackintosh's scheme.

In the meantime, Mackintosh was invited back by the School to rework his original drawings and a series of alterations and extensions were made including the provision of a new second floor of studios and additional workshops accommodated into a sub-basement floor.

Work started on the second half of the building in 1907 and by December 1909 it had been completed. In total contrast to the earlier austere facades to the south and east, the west wing with its dramatic design and dominating windows heralded the birth of a new style in 20th century European architecture. Internally the most dramatic of interiors was reserved for the Library with its decorated balcony and central cluster of electric lights.

Today the Glasgow School of Art is widely considered to be Mackintosh's Masterwork.



Coloured pointcloud data of the Mackintosh Building
Picture: GSA

Project & Objectives

On the 23rd of May 2014 a fire damaged the west wing of the Mackintosh building including some studios, the Library and some archival stores. When the extent of the fire loss was known GSA's chair stated: "We will rebuild and rebuild well". Moving forward that commitment remains – the ambition is to achieve an exemplary restoration of the Mackintosh Building, using meticulous and detailed conservation, traditional craftsmanship and construction skills combined with technology, design innovation and robust functionality.

In the course of damage assessment, latest laser scanning technology was used extensively. The generated 3D data as well as the imagery served as a basis for appointing a main contractor for the restoration project.

Above all the commitment to the restoration must focus on the very highest standards of safety for the GSA's community while operating as a working art school, visitor attraction and jewel in Glasgow's architectural heritage.



The Mackintosh Building after the fire in 2014
Picture: GSA

Methodology

Damage assessment after fires is a very delicate task, since the acquired data not only serves as an asset for insurance purposes but also - and perhaps even more importantly - as a basis for restoration. Especially heritage buildings pose a special challenge due to their unique structures and materials which were used during construction. Documenting such buildings requires high precision measuring devices on the one hand and the allocation of additional information, such as colour or even thermal imagery, on the other.

Over the past few years, 3D laser scanning has become very common in the field of documenting and thus preserving cultural heritage sites. For the reasons mentioned above, GSA used a Z+F IMAGER® 5010C for scanning its precious Mackintosh Building.

A terrestrial laser scanner scans its environment by emitting a laser beam. The back-scattered beam is detected by the device as a measuring point. Since the Z+F IMAGER® 5010C acquires more than one million points per second, the result of one scan position is an accumulation of around

50 million points - a so called point cloud. By scanning multiple positions, those point clouds can be aligned to each other - the so called registration process - resulting in a three-dimensional „as-built“ model of the scanned environment.

This Z+F laser scanner is additionally equipped with an integrated HDR camera, allowing the user to capture colour information in one automatic process - even in challenging lighting conditions. During pre-processing the RGB values of each point can be mapped onto the greyscale laser scan data, resulting in a coloured point cloud.

In the course of 5 weeks, the entire Mackintosh Building was scanned from 520 positions from indoors and outdoors, allocating over 700 GB of data - including the colour images.



Z+F IMAGER® 5010C



3D model of various statues with different intensity levels
Picture: GSA

Results

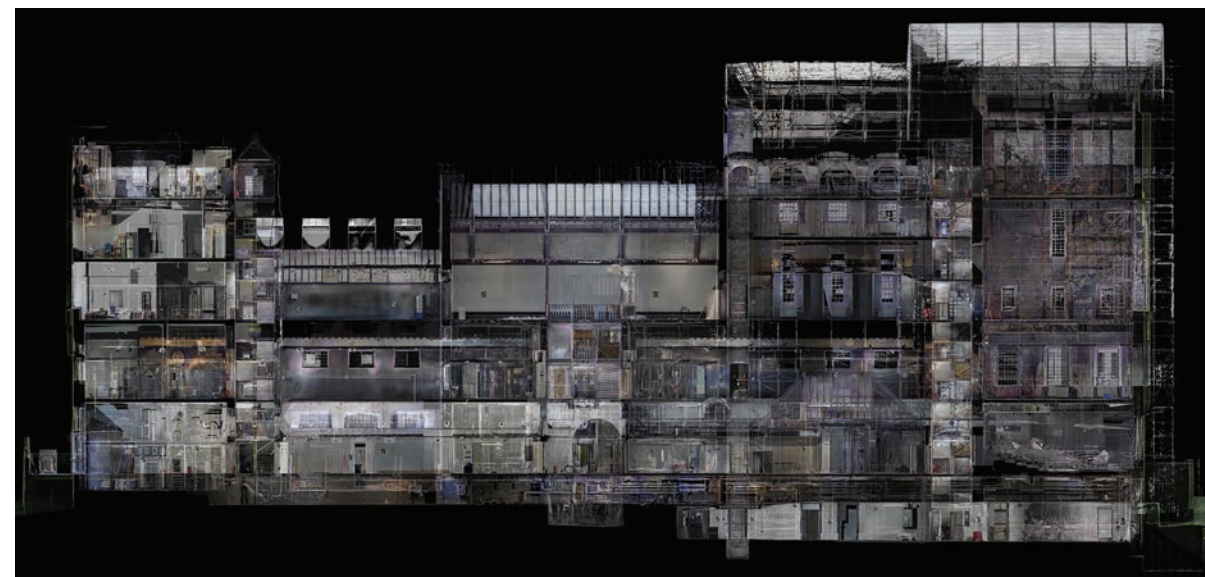
The data was processed, detailed floor-plans, cross-sections and three-dimensional models were generated, which all serve as a basis of a BIM (Building Information Model) allowing to plan and document every stage of the restoration.

GSA released some of the 3D images by its School of Simulation and Visualization in May 2016, looking to appoint a contractor for the restoration project. A final decision was made in the course of June 2016 and work started shortly after.

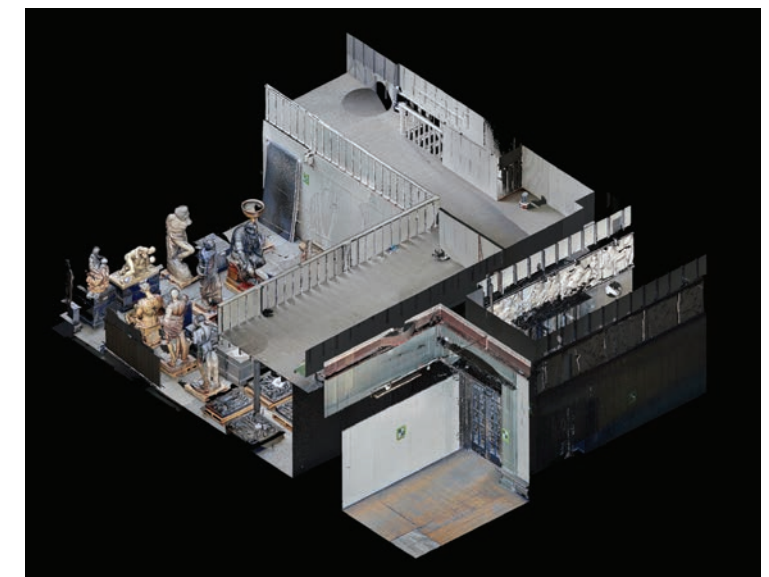
The Z+F IMAGER® 5010C proved to be the ideal solution for this project, due to its very high accuracy and its integrated HDR camera - delivering valuable colour information.

This approach on how to preserve historic structures as well as the detailed record of the work undertaken may be used both by the GSA and other organisations carrying out challenging restorations of heritage buildings.

Information on how to contribute to GSA's Mackintosh Building restoration may be found on www.gsa.ac.uk.



Cross sections of the building
Picture: GSA



Coloured 3D pointcloud
Picture: GSA



Head office – Germany

Zoller + Fröhlich GmbH
Simoniusstrasse 22
88239 Wangen im Allgäu
Germany
Phone: +49 7522 9308-0
Fax: +49 7522 9308-252
www.zofre.de
info@zofre.de

Subsidiary – UK

ZF UK Laser Limited
9 Avocado Court
Commerce Way
Trafford Park
Manchester M17 1HW
Great Britain
Phone: +44 161 8717 050
Fax: +44 161 3125 063
www.zf-uk.com
info@zf-uk.com

Subsidiary – USA

Z+F USA, Inc.
700 Old Pond Road
Suite 606
Bridgeville, PA 15017
USA
Phone: +1 412 257 8575
Fax: +1 412 257 8576
www.zf-usa.com
info@zf-usa.com