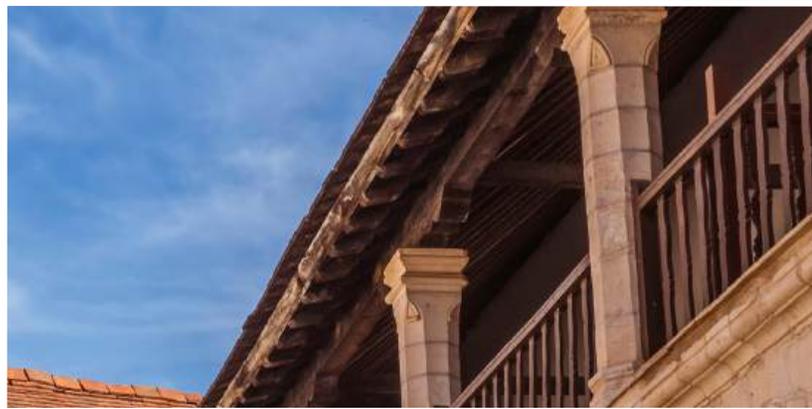




How we build reality



## Case Study

3D survey of the Cypriot monastery church Chrysorrogiatissa



## 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 innovation and open-minds. Our loyal and long-standing customers appreciate our continual innovations, support and the services we provide.

A project in cooperation with  
Dr. Marinos Ioannides / Cyprus University of Technology



# Digital Future of Europe

Europe's cultural heritage is the foundation of the European identity and characterizes our thoughts and actions every day. It is inextricably from the European values by which both, economy and society, live and act and is closely linked to Europe's cultural diversity. Reason enough to preserve it sustainably and to protect it from external threats. After all, our cultural treasures are increasingly exposed to natural and human-induced risks, from the fire, which caught the famous Notre-Dame cathedral in Paris to the regular floods in Venice and the vandalism at the Modern Theatre in Sofia, the capital of Bulgaria.

As of today, less than 20% of all collections in museums, galleries and libraries are digitized. Increasing climate change is affecting cultural heritage more and more frequently, fires and floods as a result of extreme heat waves and rain showers will unfortunately become the norm in the future. Therefore, at the end of 2021, the European Commission formulated a recommendation for a Common European Data Space for Cultural Heritage, which sets out a range of objectives in the context of digitization of cultural heritage.

The primary goal is to accelerate the digital transformation of cultural assets, especially in the areas of education, tourism and culture. In order to support this digital transformation and to take responsibility towards future generations, Dr. Marinos Ioannides of the CUT (Cyprus University of Technology) and the German Zoller + Fröhlich GmbH decided mutually to survey and digitize the Chrysorrogiatissa Monastery in Cyprus.



*Monastery Chrysorrogiatissa from the inside. Illustration: Markus Kresser / Zoller + Fröhlich GmbH*

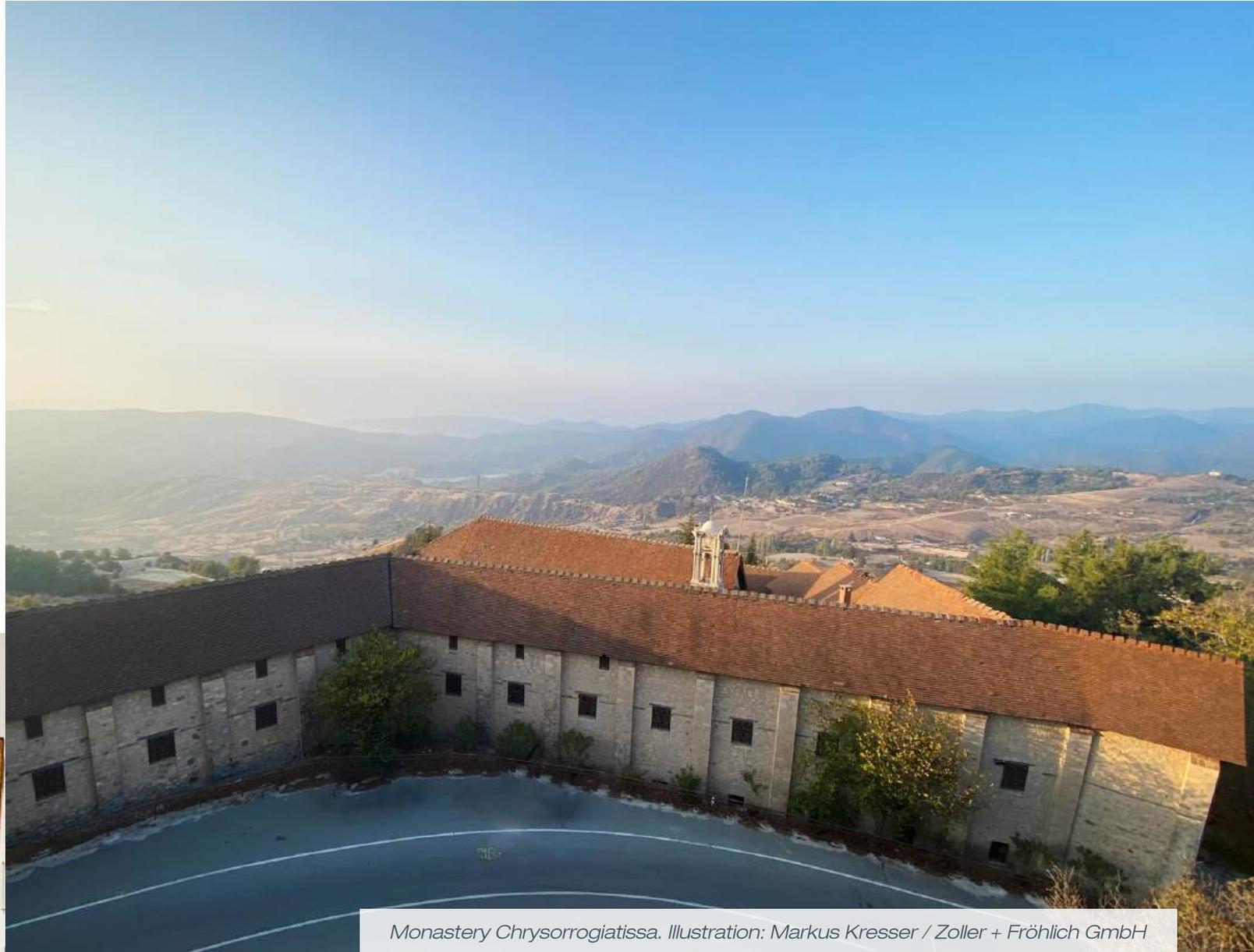
## Monastery Chrysorrogiatissa

Surrounded by peaks and valleys, vineyards and pine forests, the monastery of Chrysorrogiatissa is located at an altitude of 850 meters on a mountain crest. Chrysorrogiatissa was founded in 1152 by the hermit Ignatius and is today one of the most valuable monuments in Cyprus.

The name, which is somewhat difficult to pronounce, means something like „Our holy virgin of the golden pomegranate“. In 1770 the monastery complex was further expanded and in 1821 it was then almost completely destroyed by a devastating fire.

Today, one enters the monastery under a graceful shingle roof with decorative frescoes above a heavy old wooden door. From the green-covered inner courtyard, surrounded by two-storey arcades and porticoes, you can go to the monastery church. There is also the iconostasis of virgin mother, an image which is supposed to be painted by the evangelist apostle Luke and from which many pilgrims hope to see miraculous effects. In addition, the monastic treasury houses an important collection of icons and liturgical objects. The holy images as well as liturgical utensils are exhibited in a small museum, where they can be admired by visitors.

The winery processes some of the oldest grape varieties on the island, such as Xynisteri, Mavro and Maratheftiko. The best vintages of the award-winning wine are stored in the monastery's wine cellar or can be tasted in the tavern.



Monastery Chrysorrogiatissa. Illustration: Markus Kresser / Zoller + Fröhlich GmbH

# Cyprus University of Technology

This Mediterranean place of silence and contemplation, however, is also located in an earthquake zone where quakes that can reach values of up to 7 Mw (moment magnitude scale) occur from time to time. A series of these earthquakes caused damage to the northern wing of the Chrysorrogiatissa monastery in 2020 and 2021. The monastery's position on the slope, which probably slipped by millimeters or even centimeters as a result of the tremors, presents itself as additionally precarious.

As a result of these tremors, Dr. Marinos Ioannides, Director of the UNESCO Chair of Digital Cultural Heritage at the Cyprus University of Technology (CUT), initiated a project to record the damage caused using drones, system cameras and 3D laser scanners. The goal of this project was to digitally preserve the monastery's cultural heritage, as well as to renovate the buildings in a cost-effective and sustainable manner to ensure their continued existence.

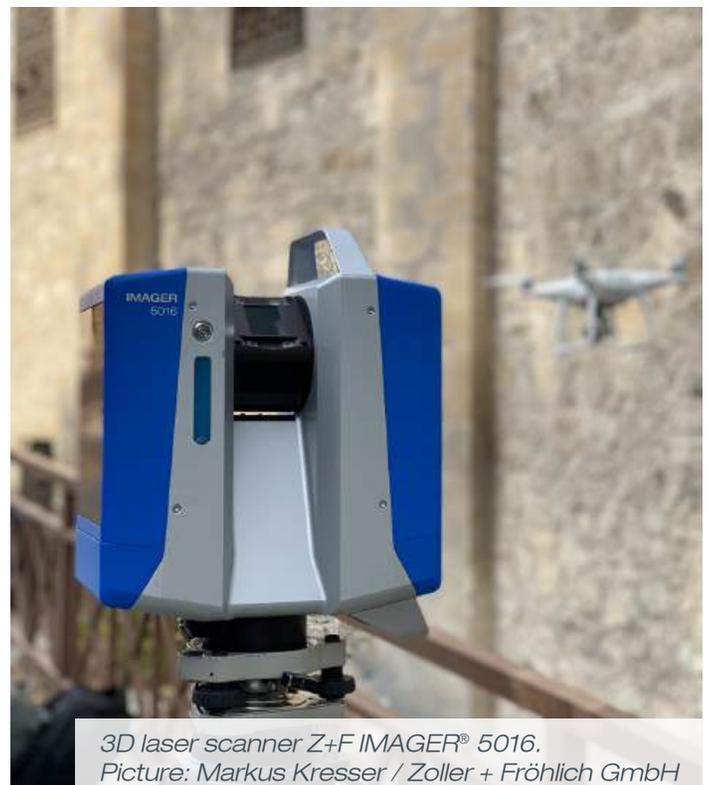
„Cultural heritage is a strategic resource for Europe with high cultural, social, environmental and economic value“ says Dr. Ioannides. The era of Digital Cultural Heritage is in full swing and the European research resources have grown significantly worldwide in recent years. The CUT has been a pioneer in this regard in the Eastern Mediterranean region and for Europe in general, especially through its leadership of key initiatives in research training and EU policy coordination and support.



## Data capture, equipment

In addition to drones for aerial photography and high-resolution system cameras for photogrammetric procedures, it was necessary to survey the plant with millimeter precision using 3D laser scanners. „These high accuracies at short to medium distances can only be achieved by laser scanners that work with a phase comparison method and have low measurement noise,“ explains surveyor Martin Reinköster, who is supporting the CUT’s non-profit project together with his colleague Mr. Markus Kresser and on behalf of Zoller + Fröhlich GmbH. The Z+F IMAGER® 5016, which was used for this project, can record up to one million measuring points per second with an accuracy of 0.25 mm.

Zoller + Fröhlich has been developing measurement systems since 1994 and is now one of the world’s leading companies in the field of non-contact laser measurement technology. The company regularly supports international research projects and contributes significantly to the further development of standards and basic research. „It is important for us to work closely with technical colleges and universities,“ says Dr.-Ing. Fröhlich, CEO of Zoller + Fröhlich, adding, „this always means gaining knowledge for us, where we leave familiar paths and head for new horizons.“



3D laser scanner Z+F IMAGER® 5016.  
Picture: Markus Kresser / Zoller + Fröhlich GmbH



Colored point cloud of the monastery complex. Illustration: Zoller + Fröhlich GmbH

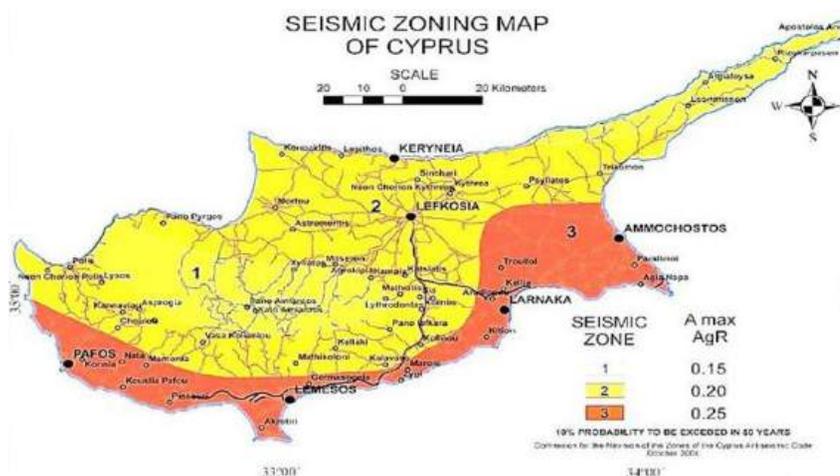


From left to right: Mr. Markus Kresser (Zoller + Fröhlich), monk of the monastery Chrysorrogiatissa, Mr. Martin Reinköster (Zoller + Fröhlich), Dr. Marinos Ioannides (CUT). Picture: Vassilis Athanasiou / CUT



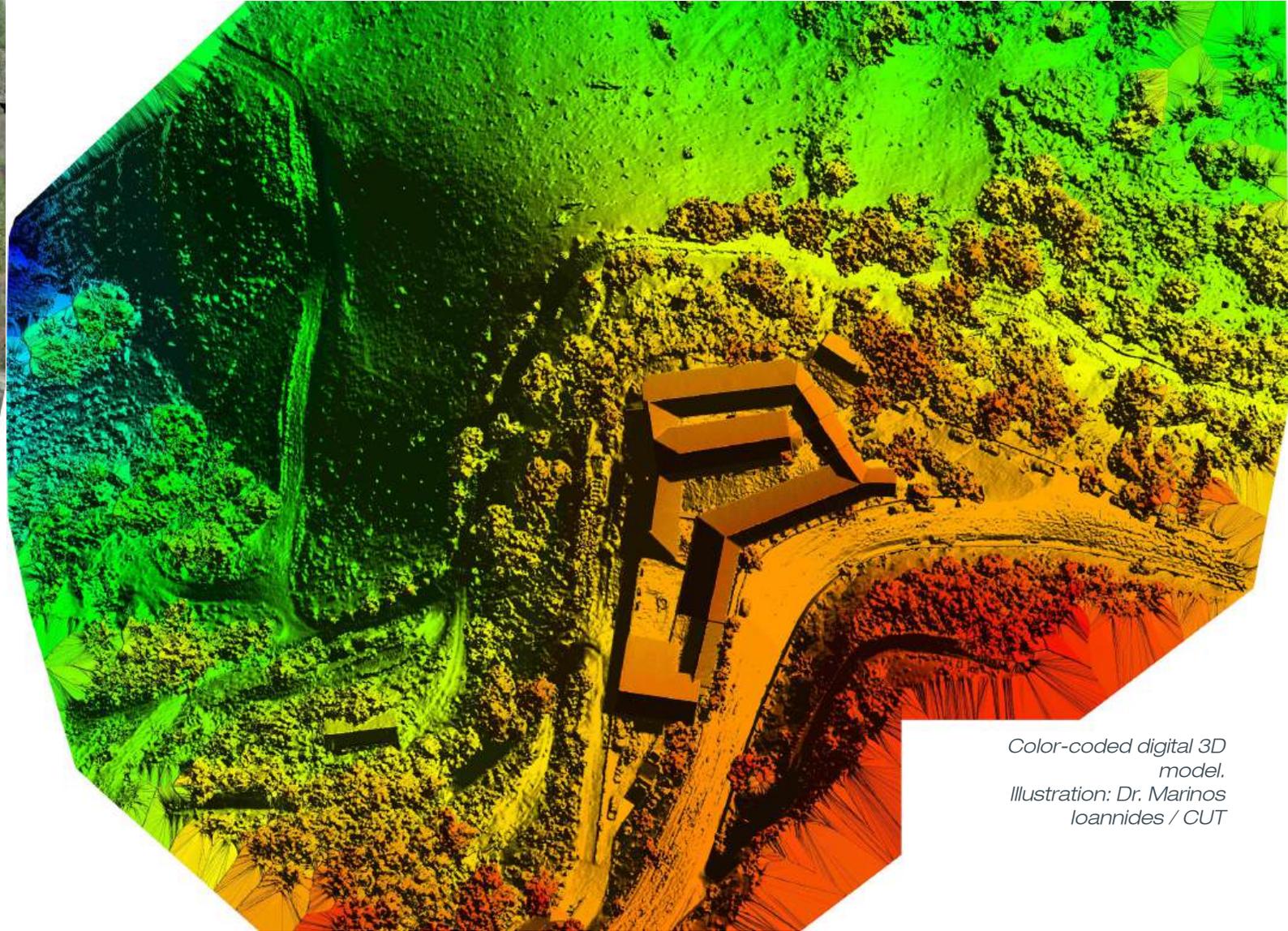
## Planning and implementation

In order to capture buildings and artworks in their entirety in three dimensions, experts must plan and determine several positions on site from which to scan, since the laser beam emanating from the scanner can't permeate solid objects. With only a few or poorly planned positions, shadowing occur in the 3D illustration. In the frame of this project, scanning was done from 390 positions. The resulting 390 point clouds were merged into an overall representation of the monastery complex while still on site. The LaserControl Scout software works here with a procedure called „blue workflow“. This term describes a series of optimized work steps in surveying and processing measurement data in the field. The fine registration of the point clouds as well as the coloring and filtering took place later in the office. The images which were captured by two other teams using drones and cameras, were later merged by specialists from CUT with the 3D data to create a model for building modeling and a nominal-actual comparison. In this way, the damage could be documented and analyzed with high precision.

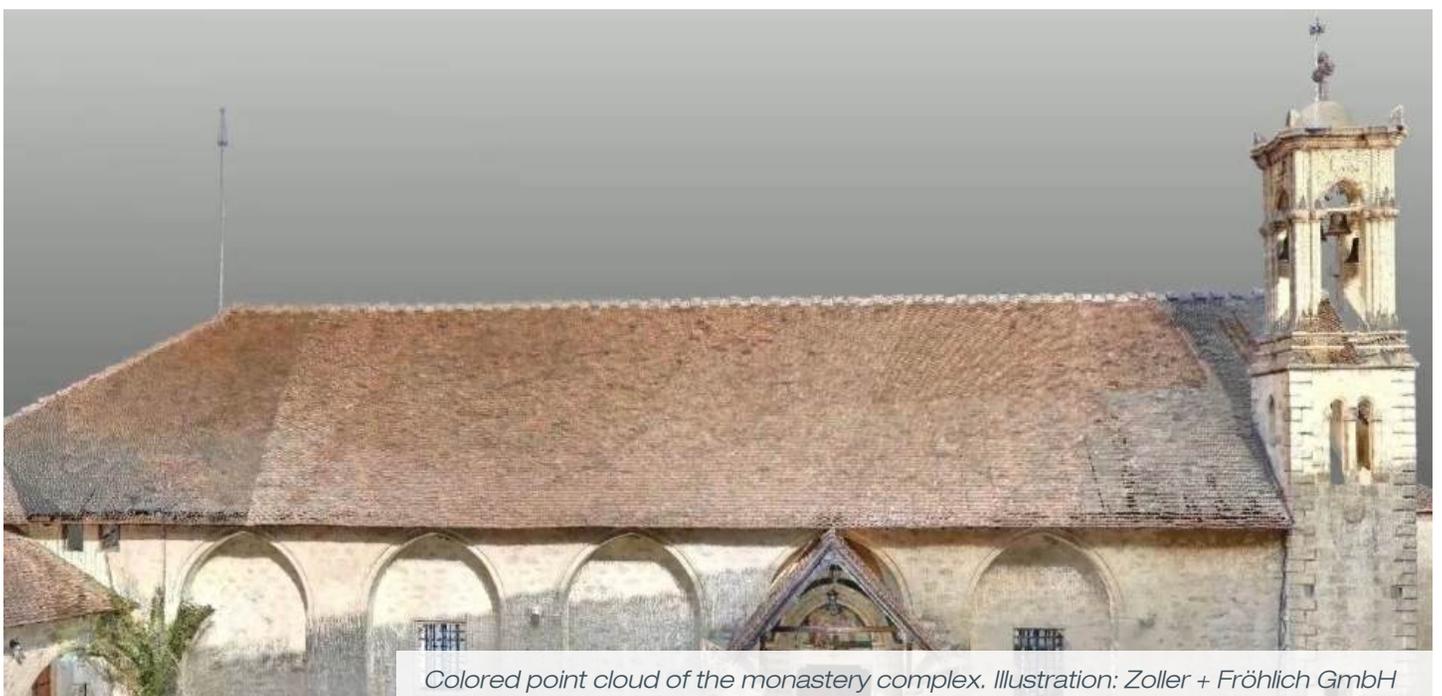


Natural hazards caused by act of nature are shaking Cyprus with increasing frequency. Earthquakes of various impacts and magnitudes occur regularly. These dangers are supplemented by human ignorance and inaction and finally cause structural cracks like the ones which were identified within the frame of the scan project of the Chrysorrogiatissa monastery.

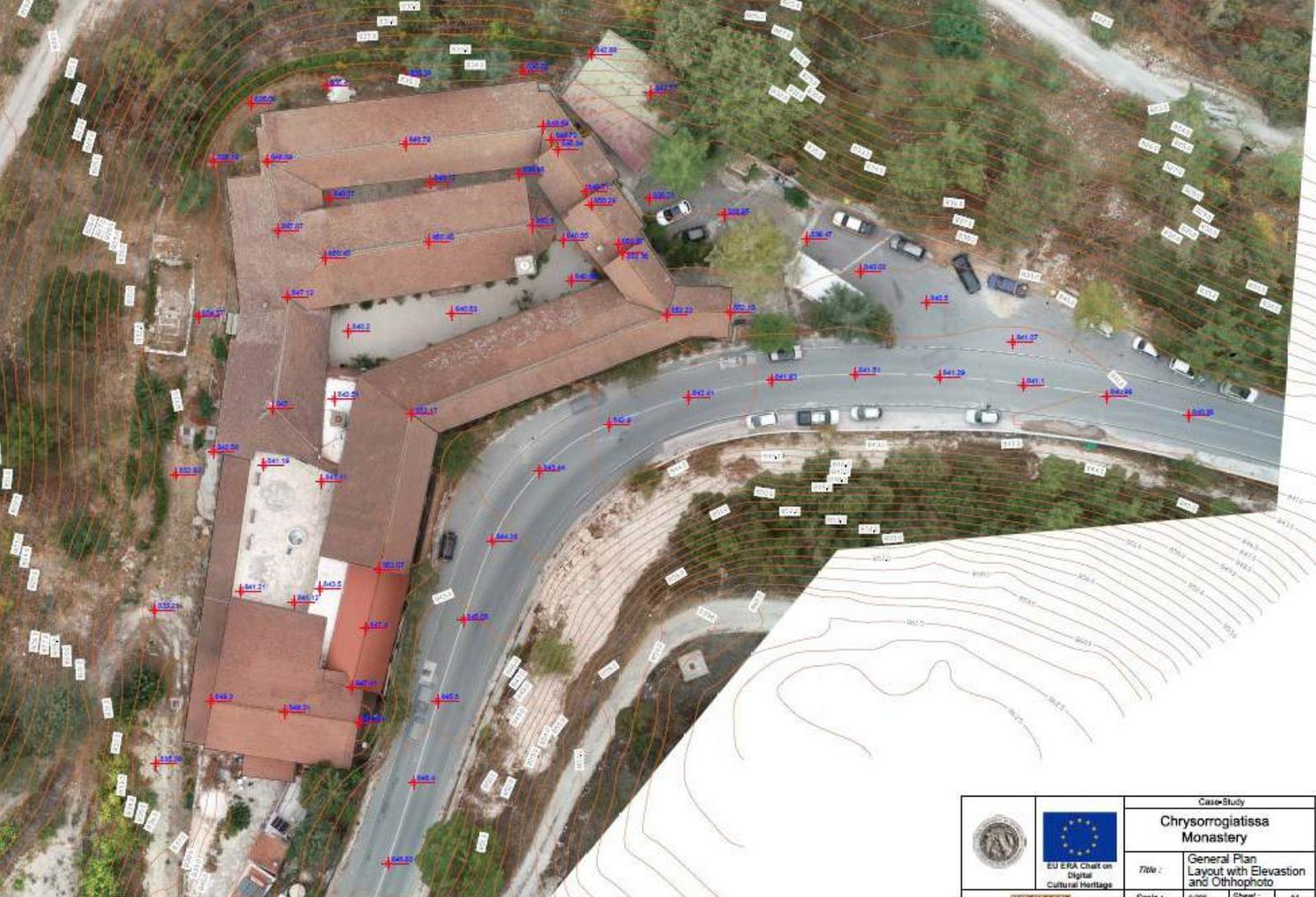
*Seismic zoning map of Cyprus*



*Color-coded digital 3D  
model.  
Illustration: Dr. Marinos  
Ioannides / CUT*



*Colored point cloud of the monastery complex. Illustration: Zoller + Fröhlich GmbH*



Entire monastery complex. Illustration: Dr. Marinos Ioannides / CUT

		<b>Case Study</b> <b>Chrysorrogiatissa Monastery</b>		
		<b>General Plan Layout with Elevation and Orthophoto</b>		
<b>MEMORANDUM</b> <small>The project has received funding from the European Union's Horizon Programme as Coordination and Support Action, under GA no 822817</small>		Title : Scale : 1:200 Date : 12/03/2023 Prepared by :	Sheet : A1 Dwg No : 03 Νικόλαος Δημητρίου <small>μεταλλικός μηχανικός, τοπογράφος</small>	

# Outlook

With the collected and compiled data, the team around Dr. Marinos Ioannides is now examining in a next step how the monastery can be better protected against geological changes in the future by structural measures. Furthermore it is considered how to renovate the treasures of the monastery in a cost-efficient and sustainable way. These are the upcoming major challenges for which the CUT project in cooperation with Zoller + Fröhlich has created a very good planning guide.



Orthophoto: Illustration: Dr. Marinos Ioannides / CUT



A crack running through the monastery church and the iconostasis of the virgin mother caused by earthquakes.  
 3D illustration: Zoller + Fröhlich GmbH



Orthophoto: Illustration: Dr. Marinos Ioannides / CUT



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