# CIVIL ENGINEERING SURVEYOR

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Hydrography

CDM Regulations

Manual Monitoring

Extensions of Time

ices

# Our national flood risk assessment model now uses the DRN.

the DRN), monitoring pollution risk and identification and assisting in water resource assessments.

- One of the largest and immediately exploitable benefits of the Environment Agency owning its own river line (apart from any OS royalties) will be the capability to disseminate it in line with its own information access policies. In addition, it will license the product for wider re-use and derive further income to the organisation whilst not compromising its statutory and public task obligations.
- Environment Agency staff will have access to a scaleable, seamless data set, which is therefore easily navigable.

The project has run on time and to budget. By doing the work in a mix of in-house and contracting out, the capture work required, the Environment Agency has reduced the overhead costs of the project and minimised the risks during this basic, yet tricky, first stage.

## Availability of the data

The Environment Agency's charging and licensing policy means that all information provided outside of the organisation must be supplied under an appropriate licence. In addition, charges may be applied for the re-use of information, where appropriate, and third party royalties may be due (as is the case for DRN).

The purpose of the policy is to ensure the dataset is sustainable through future changes and that it is maintained at the highest quality. It will also further the dissemination of high quality information to inform a wide range of users about environmental issues. We carry this out within parameters set by the *Re-Use of Public Sector Information Regulations* 2005, competition law and our obligations to be fair, open and transparent as an accredited information fair trader. The DRN is now available for release under an appropriate licence.

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*For more information on the Environment Agency DRN, please contact e: rivers@environment-agency.gov.uk*
*For more information on the Atlantis Initiative, please visit w: www.projectatlantis.net*
*For more information the digital national framework, please visit w: www.dnf.org*











# Naica in 3D

## Laser scanning and post processing the Naica caves

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**IN MAY 2007**, our first official expedition to Mexico began, as part of the Naica project. The expedition involved researchers from ten universities, four companies and laboratories investigating the Naica hypogeal caves that are covered with selenite crystals.

Virtualgeo, a geomatics, software development and communication company, took part in the expedition to survey the caves' condition by laser scanning and created a 3D digital model of one of the caves, the Cueva de los Cristales, using CloudCUBE software. The University of Bologna work team is now applying 3D data analysis and operative strategies.

## Naica jewels

In Naica, a mining city in northern Mexico located 130km southeast from Chihuahua, nature offers a unique wonder of the world, not only in its beauty but also in its scientific significance. From 180m down to 300m deep into a mine, there are several caves covered with transparent selenite crystals. The Cueva del los Cristales (Cave of Crystals, Picture 1) and Cueva del las Espadas (Cave of Swords, Picture 2) are the biggest among the present caves. The caves include smaller cavities, among which the Ojo de la Reina and the Cueva del las Velas stand out. The caves are covered with selenite crystals, formed by plates merged into incredible shapes, which give the caves their particular names. In the most spectacular cave, the Cueva del los Cristales, crystals are some 14m in length. It is a forest of giant crystals.

## The project

The May 2007 expedition to the Naica mine was organised by the Mexican company Speleoresearch & Films and the exploring team La Venta (Italy). The Naica project's purpose is to realise a multidisciplinary campaign of research and documentation of the caves. In this way, it will be possible to explain the speleogenesis and minerogenesis processes as well as proposing hypotheses on how to preserve such a natural wonder and transfer this knowledge to future generations.

The first results from the Naica project were illustrated in December 2007 at the conference 'Naica caves: exploration, documentation, research' organised by Professor Paolo Forti from the department of earth and geo-environmental

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*Roberta Tedeschi*
*Paolo Mora*


*Picture 1: 3D laser scanning the Cueva de los Cristales in Naica (Mexico).*
Speleoresearch & Films©

sciences of Bologna University in Italy. Virtualgeo, which is a participant of the project, was present at the meeting with a report concerning the survey activities carried out with a laser scanner in the caves, as well as the outputs obtained from the elaboration of the acquired data. Moreover, it presented a device for stereoscopic visualisation that enabled viewers to 'virtually' visit, in three-dimensions, the Naica caves.

*Picture 2: 3D laser scanning the Cueva de las Espadas in Naica (Mexico). Speleoresearch & Films*

## 3D laser scanning survey

In the investigations concerning the caves' topography, surveyors laser scanned the cuevas de los Cristales and de las Espadas. The survey campaign phase, carried out by Roberta Tedeschi, took place in May 2007 during the first official expedition to the mine.

The survey's aim was to document the condition of the caves by constructing a high precision three-dimensional geometric database, including colour parameters, of the morphology and visual aspects of the caves and crystals. The 3D models obtained by the laser scanner are directed both to scientific purposes (for instance, to allow a specialised 'distance' study on caves and crystals) and information dissemination (virtual and semi-immersive access, also stereoscopic, for the public, site advancement and promotion, hypotheses simulation and evaluation for preserving the caves etc).

The Bologna University team is now analysing the collected three-dimensional data for operative strategies for the next 3D survey campaigns and also to verify the data accuracy.

## Morphometric acquisition of the caves

When surveying hypogeal cavities – such as caves – problems are connected with the irregular shape both of vertical and horizontal surfaces. Such surfaces are difficult to acquire (with a level of high detail), measure, compare and visualise with traditional survey techniques. It is hard to identify a morphometric survey method that can be more automatic and fulfil the requirements of each application, minimise measurement errors and reduce operative times and costs (both in the site and data elaboration phase), whilst increasing the quality and quantity of acquired information.

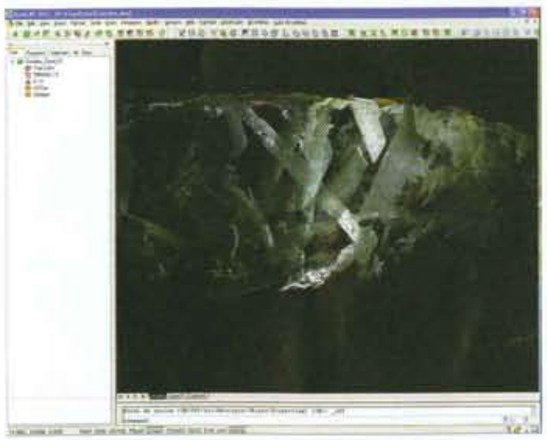
Laser scanning is a solution for the speed with which large complex surfaces are surveyed as well as for the density, precision and completeness of data, as compared to traditional topographic instruments. However, it has to be said, compared to other hypogeal cavities, the Naica caves have peculiar features that make them difficult to survey – whatever instrument is used.

## Prohibitive ambience

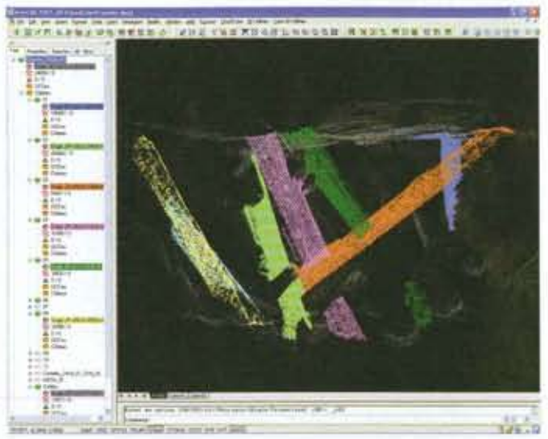
Survey operations in the Naica caves were carried out in adverse ambient conditions both for technicians' physiology and the laser scanner's functionality. (The temperature was 48°C and humidity close to 100% in the Cueva del los Cristales.)

The laser scanner used in the project was guaranteed by the manufacturer to work from 5°C up to 40°C of ambient temperature and, concerning the humidity degree, without condensation. Moreover, the other equipment necessary for surveying (laptop, cables, power supply devices etc) had to be set up on an uneven floor covered with crystals.

The prohibitive microclimate, with the limited risky mobility around the crystals, affected the activity of technicians who could work only wearing special suits and boots prepared by the La Venta team for the whole expedition.



*Picture 3: Cueva de los Cristales: Visualisation, on AutoCAD® platform with CloudCUBE software, of the point cloud.*

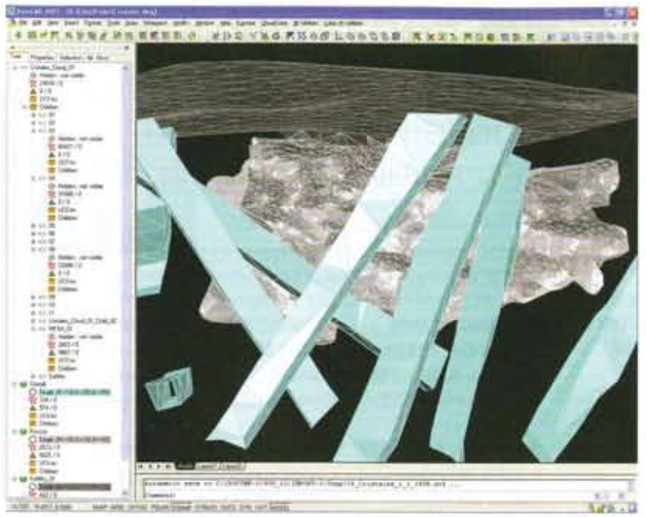


*Picture 4: Cueva de los Cristales: Organisation, on AutoCAD® platform with CloudCUBE software, of the point cloud in sub-clouds. Each sub-cloud corresponds to a selenite crystal.*









*Picture 5: Cueva de los Cristales: Three-dimensional model of the cave and crystals, visualised in 'shade' modality, obtained on AutoCAD® platform with CloudCUBE software.*

## Acquired data

The laser scanner used for the survey of the caves was based on 'phase shift' technology. It measures the distance of the surveyed object 'comparing' three pulses of different wavelengths reflected back to the scanner. Some technical data concerning such laser scanners is listed in Table 1.

In the Cueva de las Espadas and Cueva de los Cristales, four scans were carried out; acquiring spatial coordinates and RGB colour values of more than 43 million points. The colour values were collected from a camera incorporated in the laser scanner, which took 40 pictures (10 per scan). The total duration of all the necessary survey operations in the caves was three hours (over two working days), of which 15 minutes were taken for the scanning. The number of scans and the millions of points acquired by the laser scanner, the amount of pictures taken by the integrated camera and the full 'weight' of the digital data obtained from the survey campaign in Naica, divided for each of the two caves, are listed in Table 2.

## Data post-processing

After the registration of the Cueva de las Espadas scans, the data post-processing was performed with CloudCUBE, a software developed by Virtualgeo for the managing and 3D modelling of point clouds on an AutoCAD® platform.

| | |
|---|---|
| Laser Scanner | CAM2 LS 880 |
| Range | 0.6-76m |
| Measurement Speed | 120,000 points/second |
| Systematic Distance Error | ± 3mm at 25m |
| Vertical Field of View | 320° |
| Horizontal Field of View | 360° |
| Scanning Time | 2 million points in 20 seconds |
| Weight | 14.5kg |
| Camera | Nikon D70 |
| Range Pixel | 6.1M |

*Table 1: Technical data of the laser scanning instrument used to survey the Cuevas de los Cristales and de las Espadas in Naica.*

The work included the importation of the point cloud in AutoCAD® and, once the cloud had been visualised, careful cleaning and filtering to remove noise and non significant points. For the Cueva de los Cristales, the output of this preliminary phase is displayed in Picture 3. The following phase focused on the Cueva de los Cristales and consisted of organising the point cloud to obtain a basis rationally ordered according to the particular survey requirements. Picture 4 displays, for example, how a point cloud was divided into sub-clouds, each corresponding to a single selenite crystal and differently coloured.

## First outputs

The work proceeded to 3D modelling of the morphology of the cavity and its giant crystals. The 3D surface model of the Cueva de los Cristales is visible, in shade modality, in Picture 5. From the cave 3D model, it is possible to rapidly obtain dimensional information, graphic-numeric representations and sections (vertical and horizontal), axonometric projections and perspective cutaways.

## Conclusion

The Cueva de los Cristales 3D reconstruction is the result of a pilot investigation, which can be extended to the other Naica caves and, in general, to other hypogeal cavities. It can be extended to whatever context in which it is necessary to manage a remarkable morphologic complexity, a great amount of survey data and, also, particular ambient conditions, which can be important in the acquisition phase.

Starting from the need to document as fully as possible complex surfaces, Virtualgeo has found an

| | Cueva de los Cristales | Cueva de las Espadas |
|---|---|---|
| Number of scans acquired | 1 | 3 |
| Number of points acquired | 13.180.893 | 30.032.525 |
| Number of 2D images acquired | 10 | 30 |
| Amount of laser data acquired | 1GB | 3GB |
| Amount of 2D images acquired | 45MB | 135MB |

*Table 2: Number of scans and millions of points acquired by the laser scanner, amount of pictures taken by the integrated camera and full 'weight' of digital data divided for each of the caves surveyed.*

The use of a laser scanner enabled us to overcome the specific challenges of the project; surveying in a short time wide surfaces and compounded shapes — all impossible to fully survey using traditional instruments.

applicable solution in laser scanning technology and reverse modelling methodological approaches.

The use of a laser scanner enabled us to overcome the specific challenges of the project; surveying in a short time wide surfaces and compounded shapes – all impossible to fully survey using traditional instruments.

The use of post processing CloudCUBE software put at our disposal a set of tools for processing the millions of points acquired, for their optimised arrangement and for modelling, directly on the point clouds, a 3D model.

The 3D model now forms the basis of a large range of graphic representations (sections, axonometric projections and perspective cutaways). The analysis of the three-dimensional data acquired is being carried out by Bologna University, which is also working to plan the future laser scanning survey campaigns at Naica.

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# Weather events under JCT and NEC

*Rob Palles-Clark, Senior Managing Director, Brewer Consulting*

***Under JCT, the weather must be exceptional and it must adversely affect the works. Under NEC, a contractor must first establish that there was an effect due to weather and then determine if it was sufficiently rare and was of a type that amounts to a compensation event.***

**UNDER THE JCT** *Standard Building Contract* (SBC) 2005, a contractor is entitled to an extension of time (but not to loss and expense) for "*exceptionally adverse weather conditions.*" There is no clear definition of what this means or how the effect is to be quantified or assessed. Whilst any weather conditions may cause a delay, only exceptionally adverse weather will give rise to any entitlement. Whether the weather is sufficiently adverse to be a relevant event, and the extent of the delay it causes, is largely a matter for the discretion of the architect.

As will be seen, whilst the NEC approach to dealing with weather attempts to provide greater certainty, it still leaves much to be desired. NEC provides an entitlement to time and money for the effects of weather as a compensation event. The NEC approach requires the identification of a weather station for the recording of weather measurements. This could be any weather station, but it will obviously be best to ensure that it is close to the site.

The contract also identifies four standard measurements that are required to be recorded for each calendar month:

- Cumulative rainfall (mm).
- Number of days with rainfall more than 5mm.
- Number of days with minimum air temperature less than 0°C.
- Number of days with snow lying at a specified time.

These are defined as 'weather measurements', and these are the only weather conditions that will trigger a compensation event. There is space provided for additional weather measurements to be included, so if, for example, wind speed is likely to be a factor affecting crane utilisation, then it may be appropriate to make provision for the number of days with a wind speed above a specified level.

The term 'weather data' is defined as the historical records of each of the weather measurements for each calendar month recorded at a specified location and available from a specified body. Ideally, the location where the weather data is recorded should be close to the location at which the weather measurements are made. If no historical data is available, then it is possible to agree assumed values for the worst case over a 10 year period.

Clause 60.1(13) then provides a mechanism for the identification of a compensation event by comparing any of the weather measurements with the corresponding weather data for that measurement in any calendar month. A compensation event will arise if any of the weather measurements is shown to occur, on average, less often than once in 10 years. The use of the word 'average' here suggests that the weather data could embrace records that extend back beyond the previous 10 years.

For example, if in a month there is a total of 90mm of rain and the most that might be expected for that month in a 10 year period is 89mm, there will be a compensation event. The question then is, so what? The contractor has still to establish the consequences of the compensation event and the project manager must assess the effect of the compensation event upon defined cost and assess (by reference to the accepted programme) the effect upon the planned completion date.

In NEC3, it was made clear that only the difference between the exceptional weather measurement and the average one-in-ten-year worst case may be taken into account in assessing the compensation event. In the example above, the contractor would be entitled to compensation for the effect of 1mm of rain, provided it could show there was an effect.

Whilst the numbers of days of rainfall in excess of 5mm might seem more straightforward, the effect still has to be assessed and there is the unanswered question of which of the additional days are to be considered as part of the assessment and what effect they really had.

Thus, whilst taking away the need to speculate as to what is meant by 'exceptionally adverse', users of the NEC face the same difficulty as ever in determining the consequences of any adverse weather.

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