



Scanning Manholes with CleverScan



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1 Technical overview

CleverScan is an intelligent manhole scanning system. The camera head hosts a processor with a fully loaded operating system that can analyze and preprocess a massive volume of high quality image and sensor data. CleverScan is the result of several years of joint research & development of two companies: The company KEP SO (owned by Peter Kessler) develops the hardware and electronic components whereas the company CDLab Ltd. – the producer of the pipe inspection software WinCan - is responsible for the development of the CleverScan control software.

The CleverScan system provides the user for a very interesting price the best trade-off between high mobility and simplicity on the one hand as well as speed and high image quality during the manhole inspection process on the other hand. Lots of manholes are located in areas where they cannot be accessed easily and directly from a TV truck with a complex camera equipment.

CleverScan is extremely mobile as it weighs only around 17.2 kg / 38 lbs and it is approximately 1.10 m / 3' 7" high and therefore can easily be put in a compact van and carried around by one person:



The camera system is fast and easy to handle and use as the software is perfectly integrated into the hardware: push a button and the camera automatically moves down from the cover to the bench/channel and back again. Afterwards the scan data are finalized within a few seconds before you're off to the next manhole. The image quality is one of the best on the market and can be obtained with a 5 HD camera system that creates a high resolution video, a 3D view of the manhole as well as an unfolded view of the manhole wall used for direct damage reporting.

1.1 Hardware

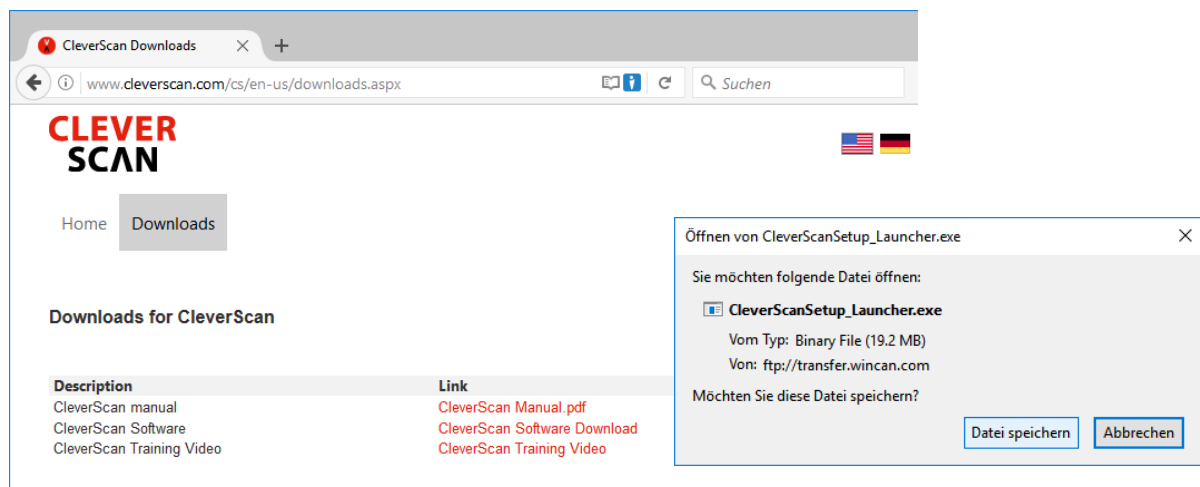
- Portable manhole inspection system (weight app. 17.2 kg/38 lbs; height app. 110 cm/3'7")
- 5 HD cameras (4 side & 1 front camera)
- 4 Laser sources for geometry measurement
- Powered with a battery (lasting for approximately 1 working day in full inspection mode)
- Built-in cable drum providing 10 m of cable length.
- Adjustable tripod for quick setup on the manhole (diameter range up to 2 m)
- Linux-based processing unit inside the camera head for flexible preprocessing of the raw data.
- Automated inspection process with a minimum of user interaction (Duration app. 5 min).
- Protection Class: camera head = IP67; control unit = IP54

1.2 Software

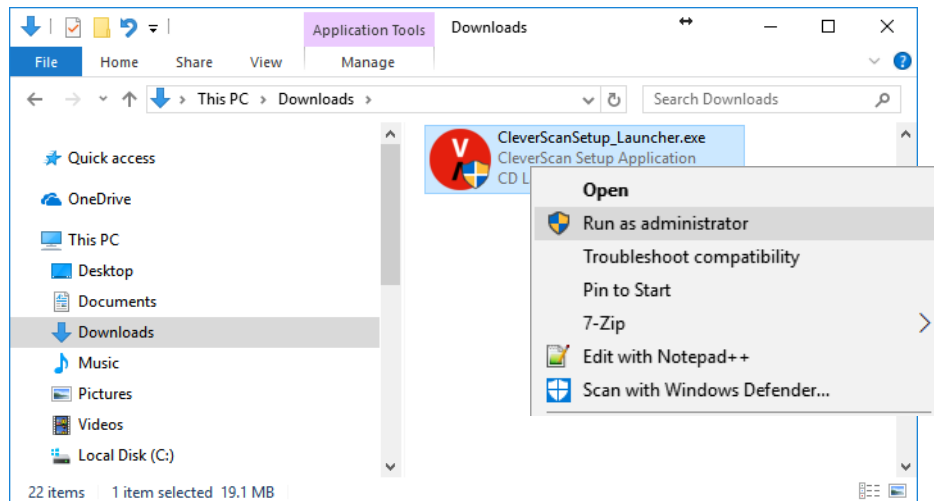
- Full integration into the damage reporting with WinCan
- Availability of all official manhole inspection standards world-wide
- Full integration into ESRI GIS systems
- 3D-view of the manhole
- HD Front Video
- HD unfolded view of the manhole wall

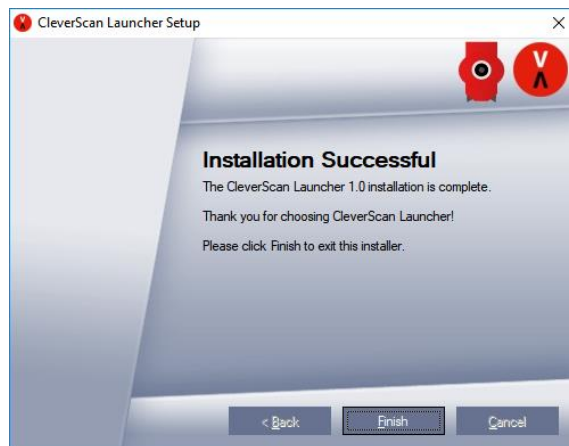
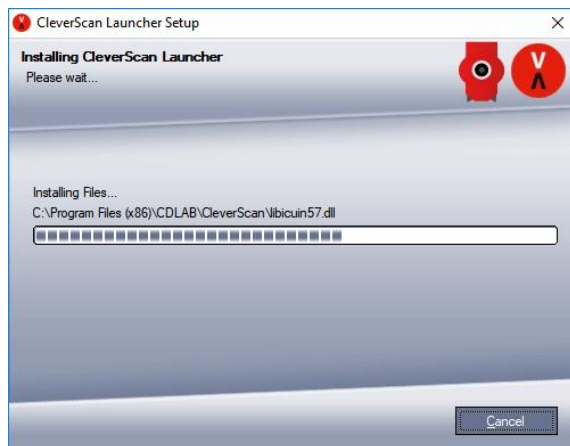
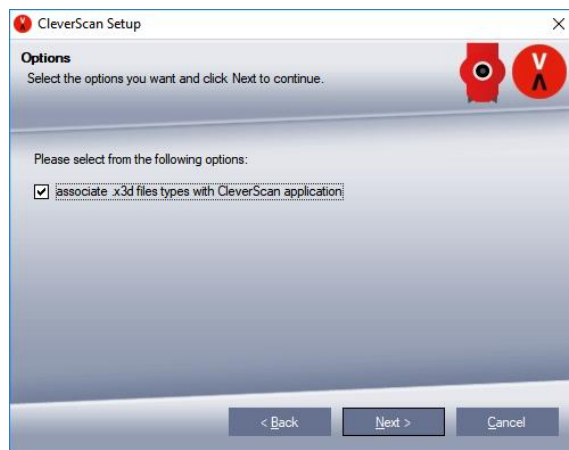
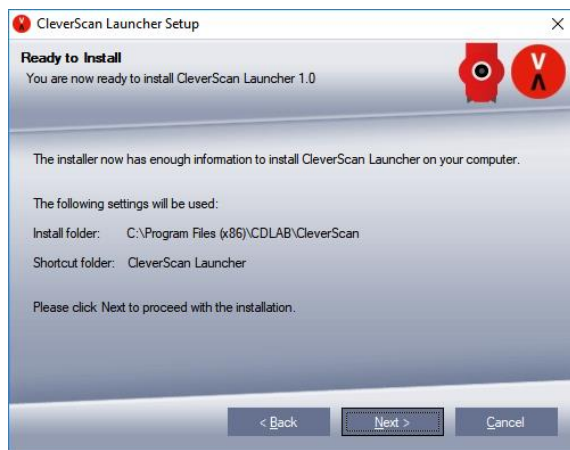
2 Software Installation

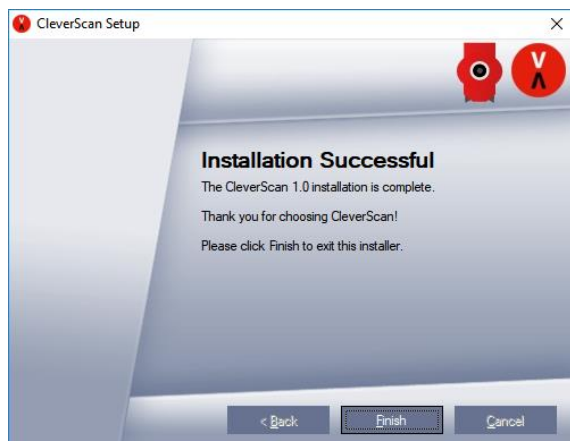
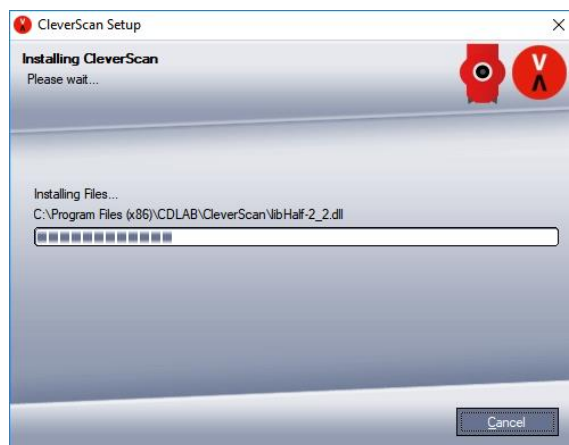
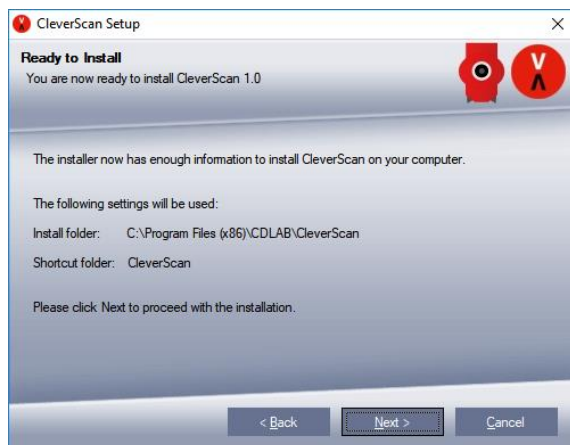
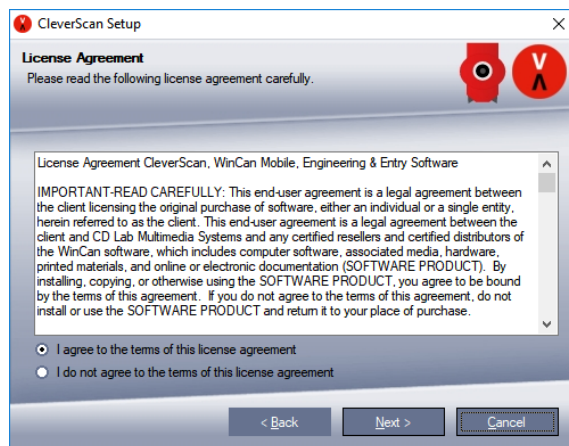
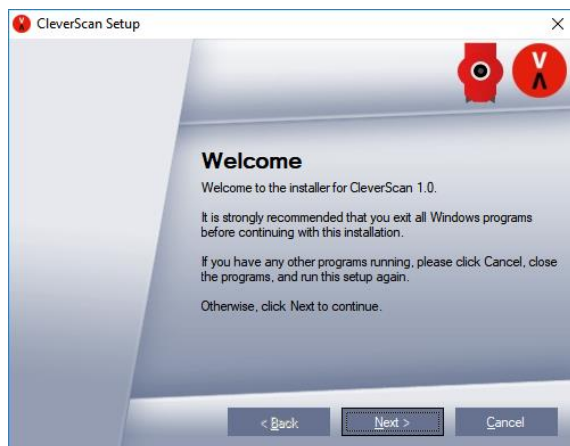
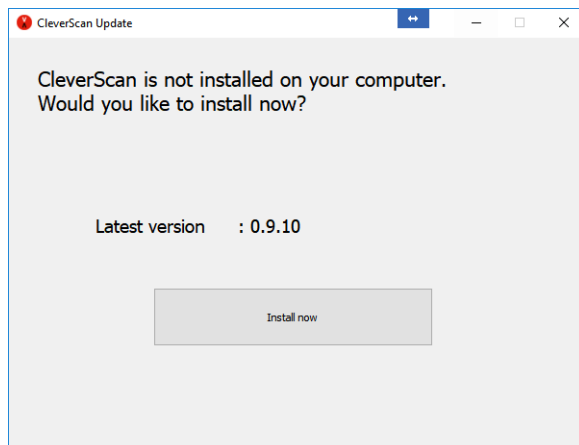
The camera is delivered to the user in a ready-to-run state. The software installation package can be downloaded from the website www.cleverscan.com:



Right click on the icon *CleverScanSetup_Launcher*, hit the command *Run as administrator* and follow the steps given by the wizard in order to have the software properly installed:







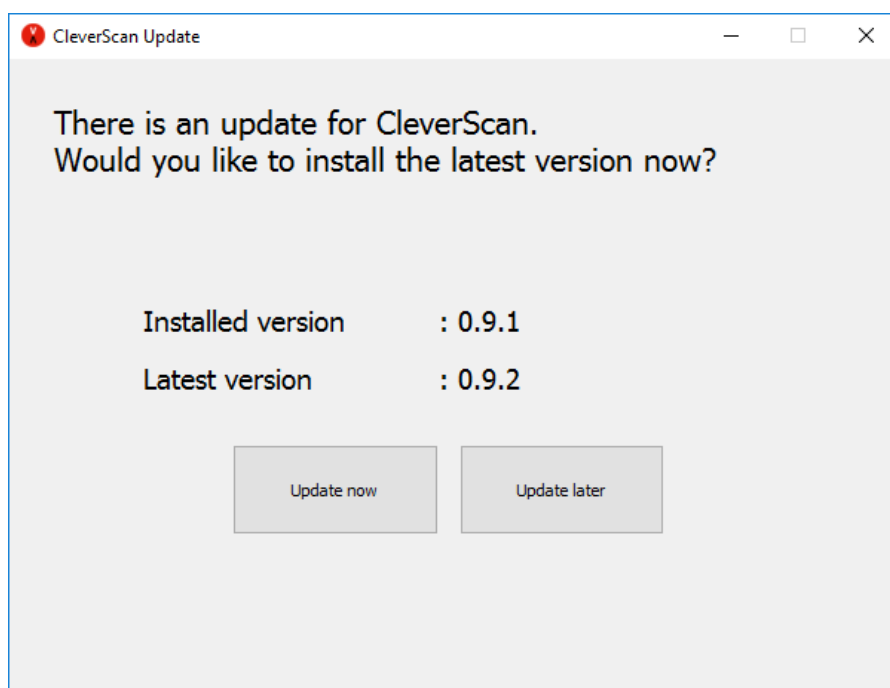
Once the laptop software is installed, all the user needs to do is to connect laptop and camera via Ethernet (RJ45), turn on the camera, and launch the CleverScan software.



2.1 Software Update

2.1.1 Laptop

The CleverScan software checks for updates automatically and always suggests the user to update to the latest version as soon as available:



2.1.2 Camera

Each time the laptop is going to be connected to the CleverScan system, the camera checks whether there is a new version of the **camera software** available and suggests the user to update to the latest version.

2.2 Licensing

CleverScan is a registered trademark of KEP SO and CD Lab Ltd.

3 Software parts

The CleverScan software has been designed and developed by CDLab, Switzerland and can be sub-divided into a camera part and a user interface part:

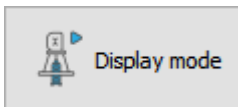
- The camera software part is responsible for setting the scan parameters and controlling the cameras during the scan. It receives commands from the laptop and executes them.
- The user interface itself supports two modes: **scanning** and **displaying**. During the scanning phase, the laptop software lets the user adjust the scan parameters, track the scan progress with live feed from the front lens and post-process the scan images. Afterwards the user may switch to the display mode to look at the results.

The commands and panels provided by the user interface are described in detail in the following chapter.

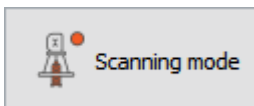
4 User Interface

When hitting the CleverScan desktop icon the software always starts running in the scanning mode.

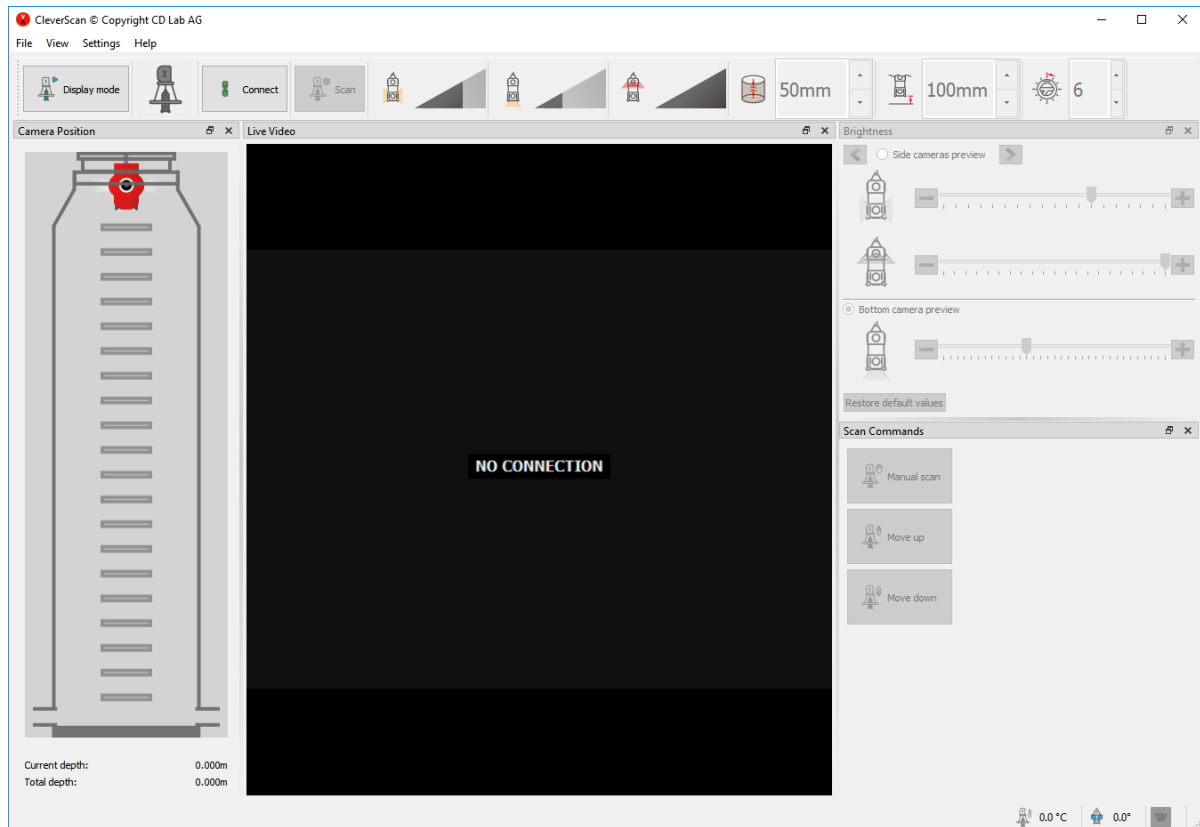
- Hit the button *Display mode* in the toolbar to switch from Scanning mode to Display mode:



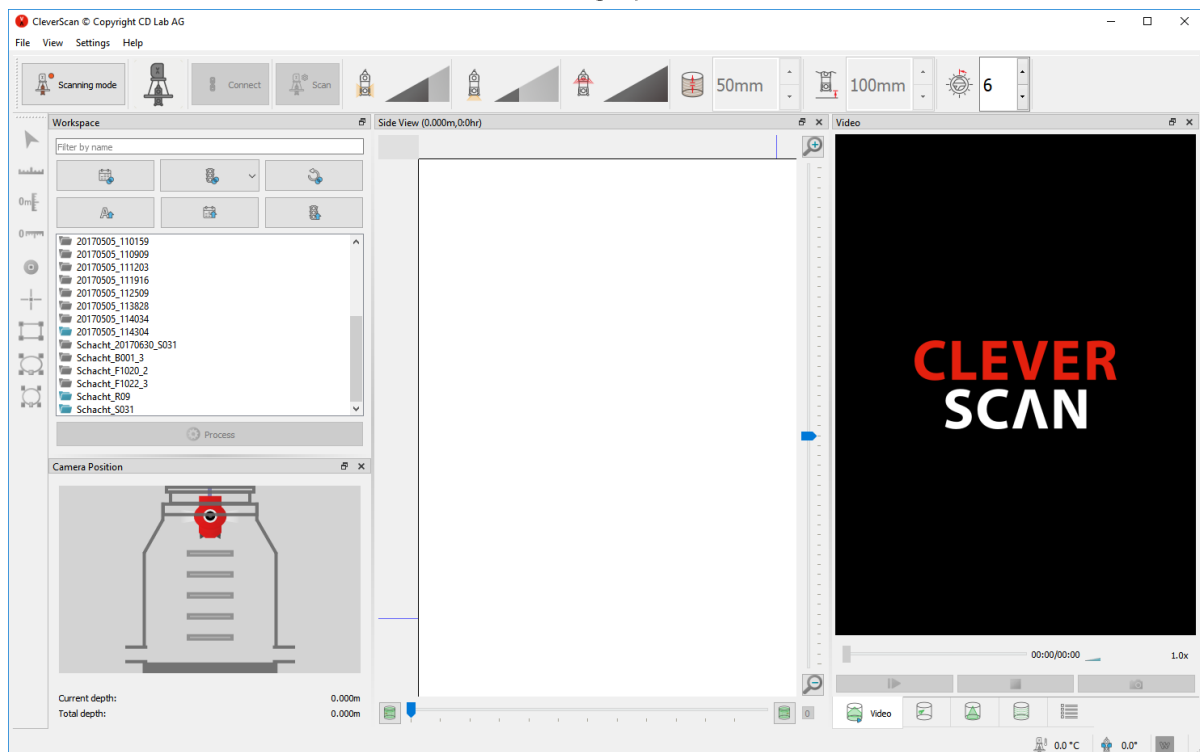
- Hit the button *Scanning mode* to switch back from Display mode to Scanning mode:



CleverScan user interface in scanning mode: use this mode to scan a manhole



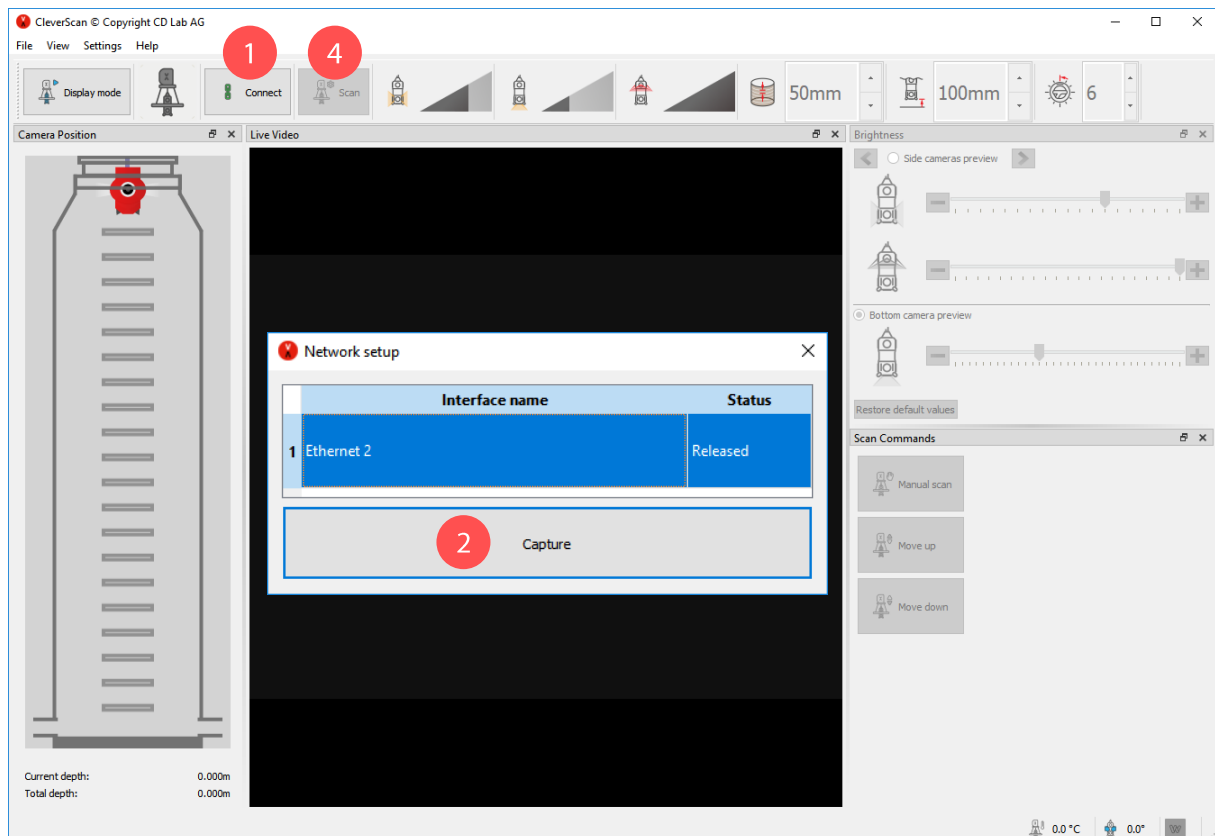
CleverScan user interface in display mode: use this mode to view the manholes that have been scanned and to enter observations with a set of graphic tools:



4.1 Running a scan

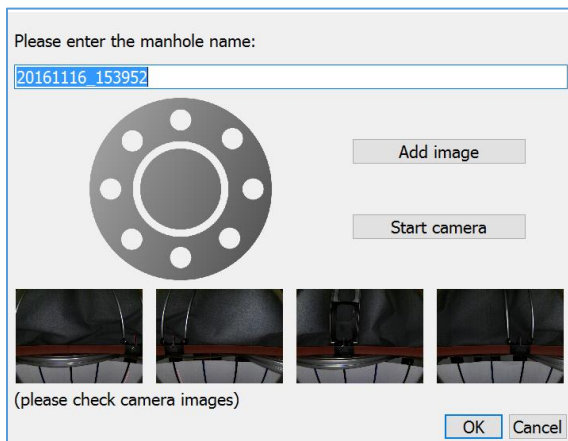
Mind the following steps in order to get a proper scan result:

1. Remove the manhole cover and place the camera tripod on the manhole ring.
2. Turn on the camera and turn the camera head in order the vertical laser points at the position of the main outlet. Connect the camera to the laptop, using the Ethernet cable provided with the camera equipment.
3. Mind that you place the camera equipment, such as the **Laser dot points to a solid surface** on the manhole ground. The perpendicular Laser is unable to return a reliable manhole depth value in case it falls on a water surface.
4. Run the CleverScan software in scanning mode and hit the command button *Connect* in the toolbar. Click on *Capture* in the message box to get connected to the camera device:



5. Make sure the camera settings have been adjusted accordingly and run the scan via the corresponding command (4).

You will be asked to enter a name for the manhole and to add a picture of the manhole cover (optional). Confirm with the button *OK* to start scanning:

The screenshot shows a software window titled "Please enter the manhole name:". It features a text input field containing "20161116_153952". Below the input field is a large circular icon representing a manhole cover with eight holes around its perimeter. To the right of this icon are two buttons: "Add image" and "Start camera". Below the circular icon are four small, square thumbnail images showing a camera's view of a manhole. Underneath these thumbnails is the text "(please check camera images)". At the bottom right of the window are "OK" and "Cancel" buttons.

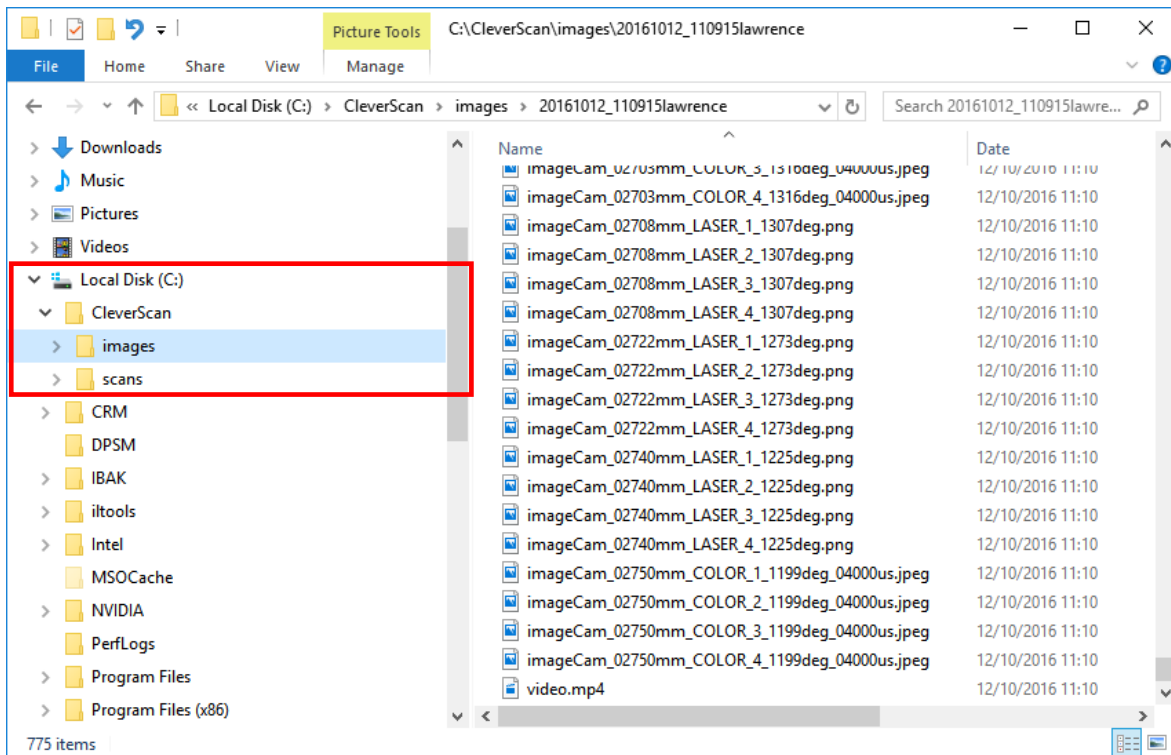
The scanning procedure is fully controlled by the camera device and doesn't require any additional manipulation from the part of the user

Wait for the scan to complete. In the meantime, you may watch the progress through the live video and the camera position panel which shows the total and the current depth.

The raw data (images and other data files) obtained from the scan process in the field are saved to the default directory `C:\CleverScan\images\[scan_name]`.

5 Scan Data, File Structure

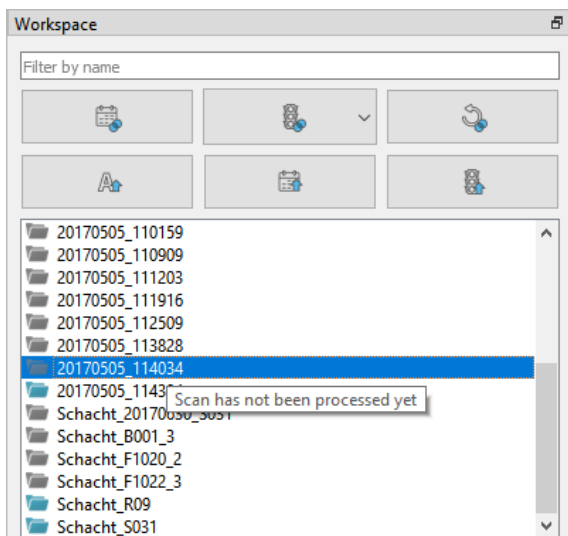
The raw data for one manhole created during a scan in the field consist on a series of images and a video file:



These data can be copied on any office computer, post-processed and finally be imported into the inspection software WinCanVX.

Mind the folder structure as highlighted above in order to be able to post-process a scan. The software *CleverScan* strictly uses the corresponding file paths:

- 1.) Check the availability of the main folder `C:\CleverScan`
- 2.) Create as sub-folder `C:\CleverScan\images` where you have to copy the raw data obtained from the scans in the field. When opening the software *CleverScan* the manholes are thus automatically listed in the panel *Workspace*:

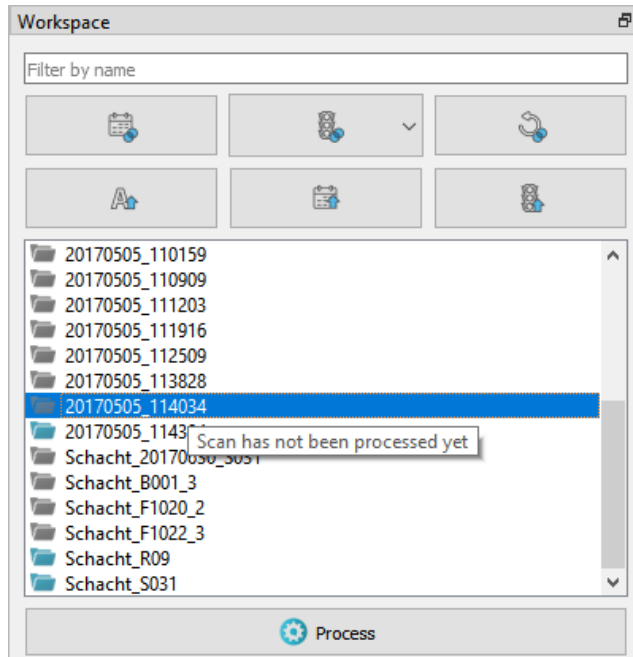


- 3.) Create a sub-folder `C:\CleverScan\scans` where the scan data will be put automatically after post-processing.

6 Post-processing a scan






The post-processing can be performed automatically each time a scan is completed if the option *Auto process* is enabled under *Settings>Options>Processing*:

On the other hand the user can also select the scan to be processed from the list of manhole scans shown in the workspace panel and press the button *Process*:



The list shows all manhole scans imported into the workspace folder: re-processed manhole data are marked with a BLUE folder icon whereas unprocessed scans get a GREY icon.

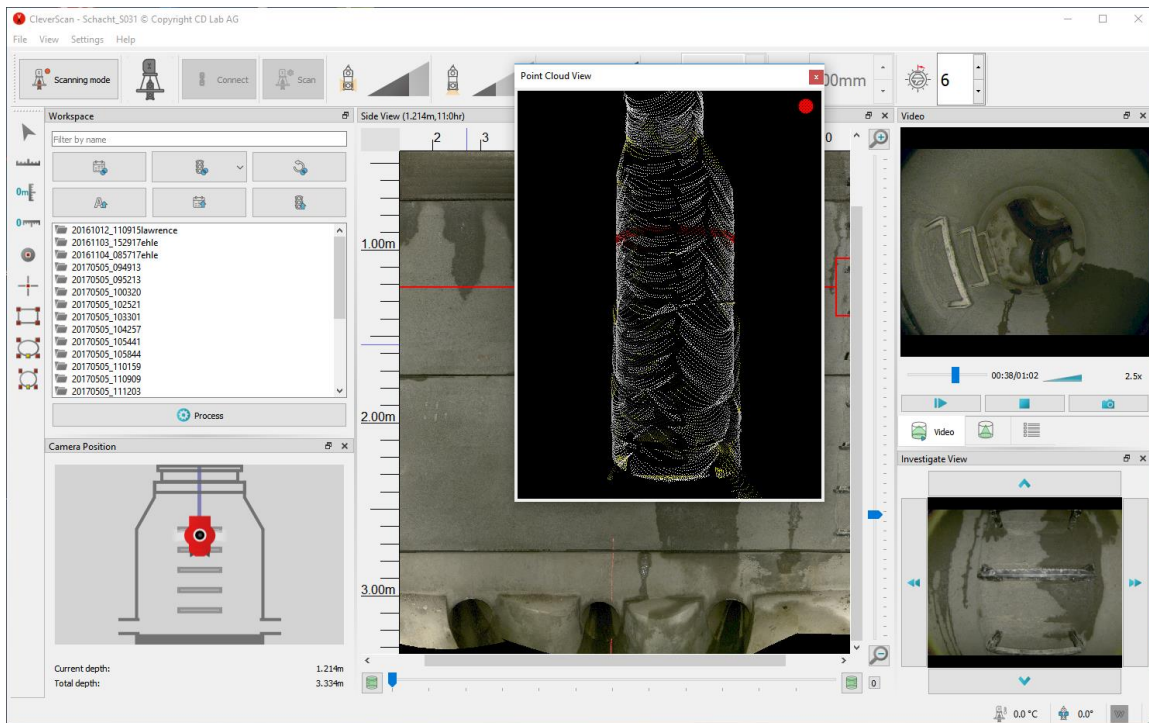
Simply double-click on a re-processed scan to get the result displayed on the different view panels:

-  20170505_112509
-  20170505_113828
-  20170505_114034
-  20170505_114304
-  Schacht_20170630_S031

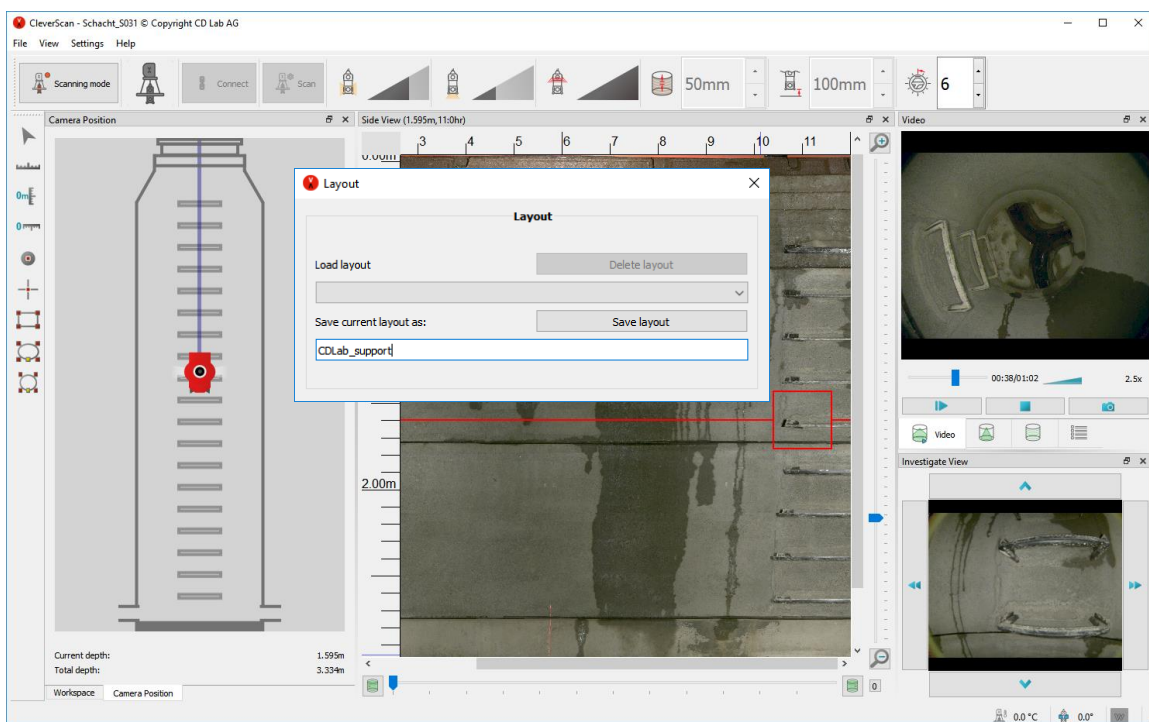
7 Toolbars and panels

The CleverScan main interface provides two toolbars and a group of floatable panels that can be docked to and undocked from each other or arranged as tabs. You may move around, hide or unhide panels in order to get an individual view that finally allows you to work comfortably and efficiently. Simply use the menu *View* to show hidden panels again.

Below you can see a sample layout where the *PointCloud View* is used as a floating panel whereas the front view and the observation list panel are minimized to tab size. The rest of the panels are docked individually:



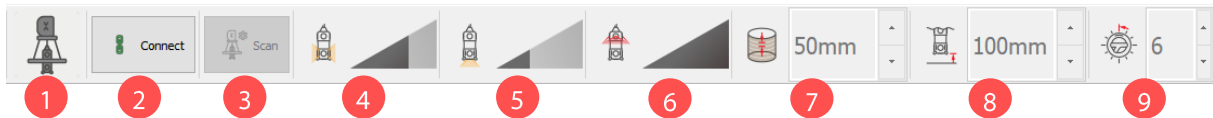
Grab each panel on the title bar, keep the left mouse key pressed and drop it wherever you prefer. A blue rectangle shows you the target area the panel finally is docked to. The result may look as shown below:



Changes on the panel layout can be saved as a specific user profile using the menu command *Settings>Layout*. On the following pages we will take a closer look at the toolbar buttons and the view panels.

7.1 Toolbar buttons

The **horizontal toolbar** (activated in scanning mode) provides command buttons in order to quickly adjust the camera settings prior to scanning:



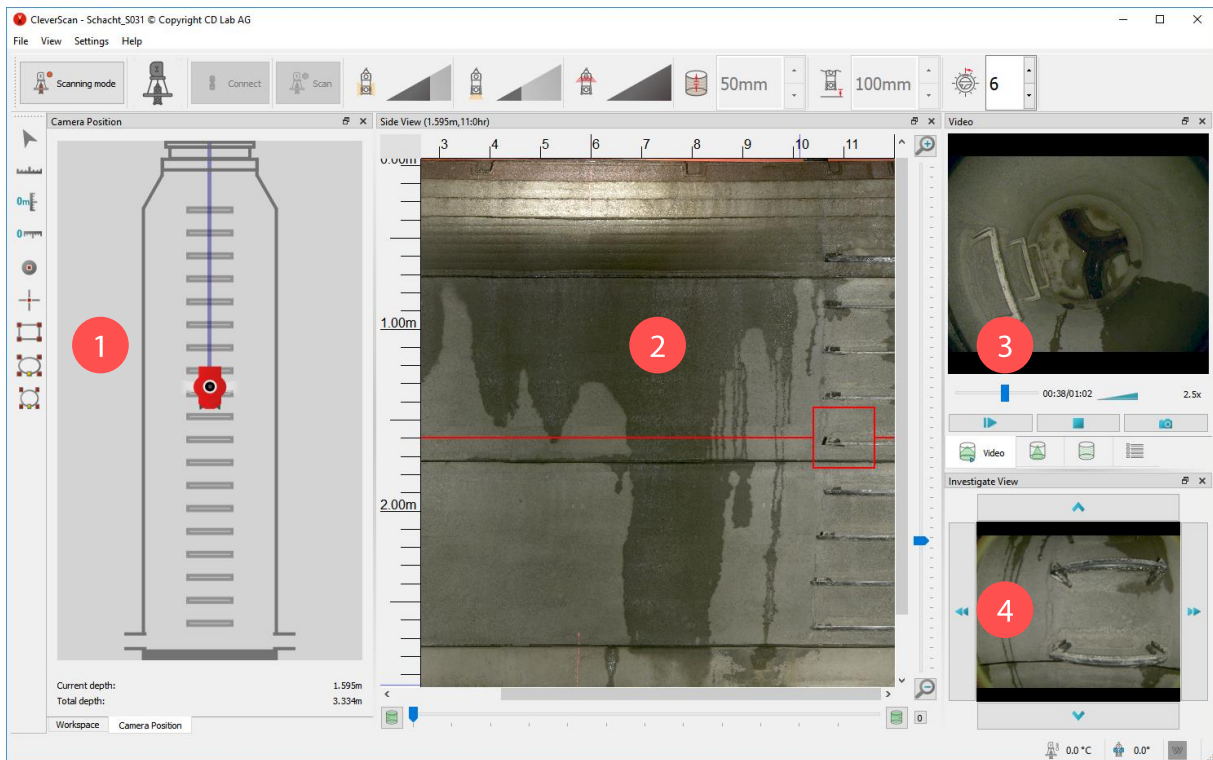
1. This icon shows the vertical movement of the camera
2. Hit this button to establish a connection to the camera device
3. Start scanning
4. Adjust brightness of the lateral cameras
5. Adjust brightness of the bottom camera
6. Adjust brightness of the laser
7. Set the frequency of snapshots (e.g. 50 mm = 1 picture/5 cm)
8. Set the minimum distance between bottom camera and manhole ground
9. Set the cutting position when unfolding the manhole wall


The **vertical toolbar** (activated in display mode) provides specific commands to precisely describe the extent of an observation or a damage directly on the *Side View*:

	Select this icon to highlight an observation graphic
	Select this icon to measure the extent of a damage or an object
	Change the direction of the vertical measurement bar
	Change the direction of the horizontal measurement bar.
	Select this icon to highlight a larger point damage
	Select this icon to highlight a smaller point damage
	Draw a rectangular observation/damage extent
	Draw an elliptical observation/damage extent
	Draw a circular observation/damage extent

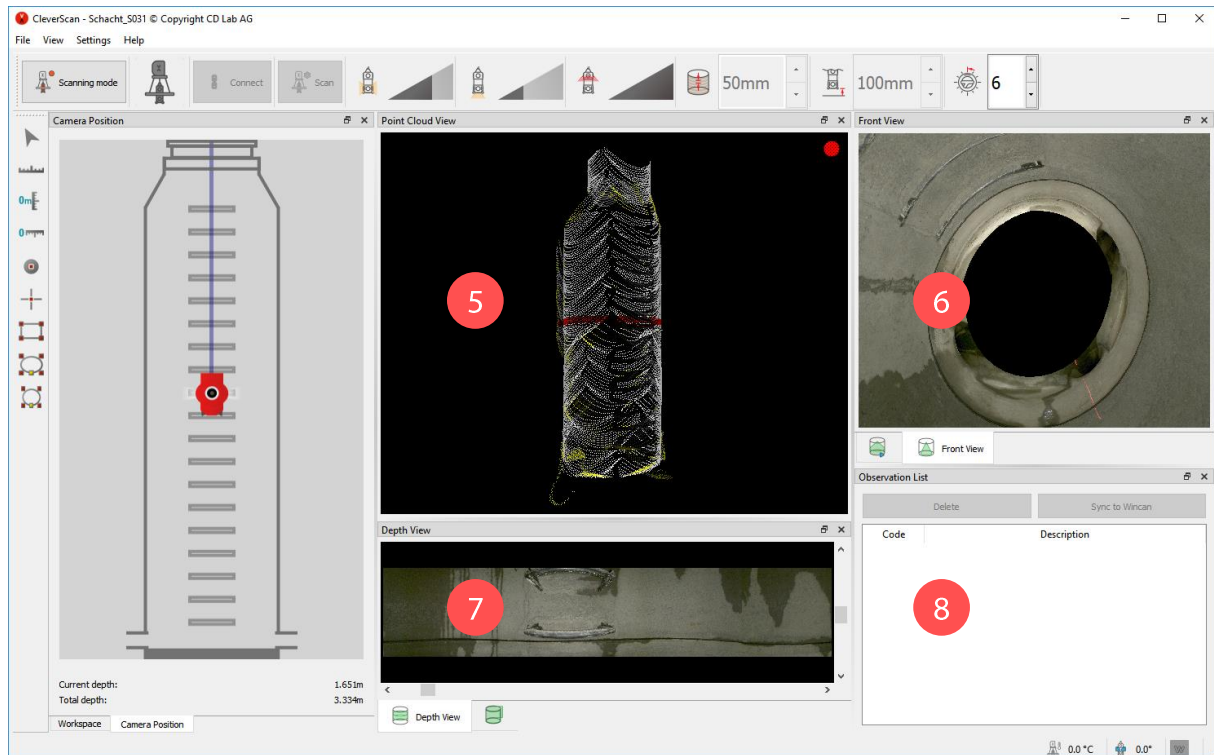
7.2 Panels

The menu *View* provides 7 panels that can be individually activated or deactivated moved and resized within the interface or docked to each other. The following pages describe the scope of each panel in detail:



1. The **camera position** panel helps to track the current depth in the display as well as in the scan mode. The display mode in addition allows the user to grab the camera icon directly on the panel and move it inside the manhole sketch. At the bottom of the panel the total and current depths are displayed.
2. The **side scan view** shows the unfolded manhole wall and allows you to mark observations and take measurements using the provided toolbox. The vertical ruler is measuring the depth whereas the horizontal ruler determines the clock position of the observation. The red line on this panel shows the current depth position and is synchronized with the other panels (i.e. front, depth, investigate and point cloud view): as soon as you move up or down within one of the synchronized panels the other panels automatically scroll up or down to the same depth level as well.
3. The **video panel** shows the live feed recorded during the scan. The user can scroll through the video using the navigation bar at the bottom of the video and take snapshots using the snapshot button (). The snapshots are saved at C:\CleverScan\scans\<scan_name> (default location).
4. The **investigation view** shows the view to the manhole wall taken at the current depth. The user can pan from left to right hitting the corresponding arrow icons or scroll up and down with the arrow icons at the top or the bottom. Navigation inside this panel can also be done with the mouse wheel or the cursor keys.

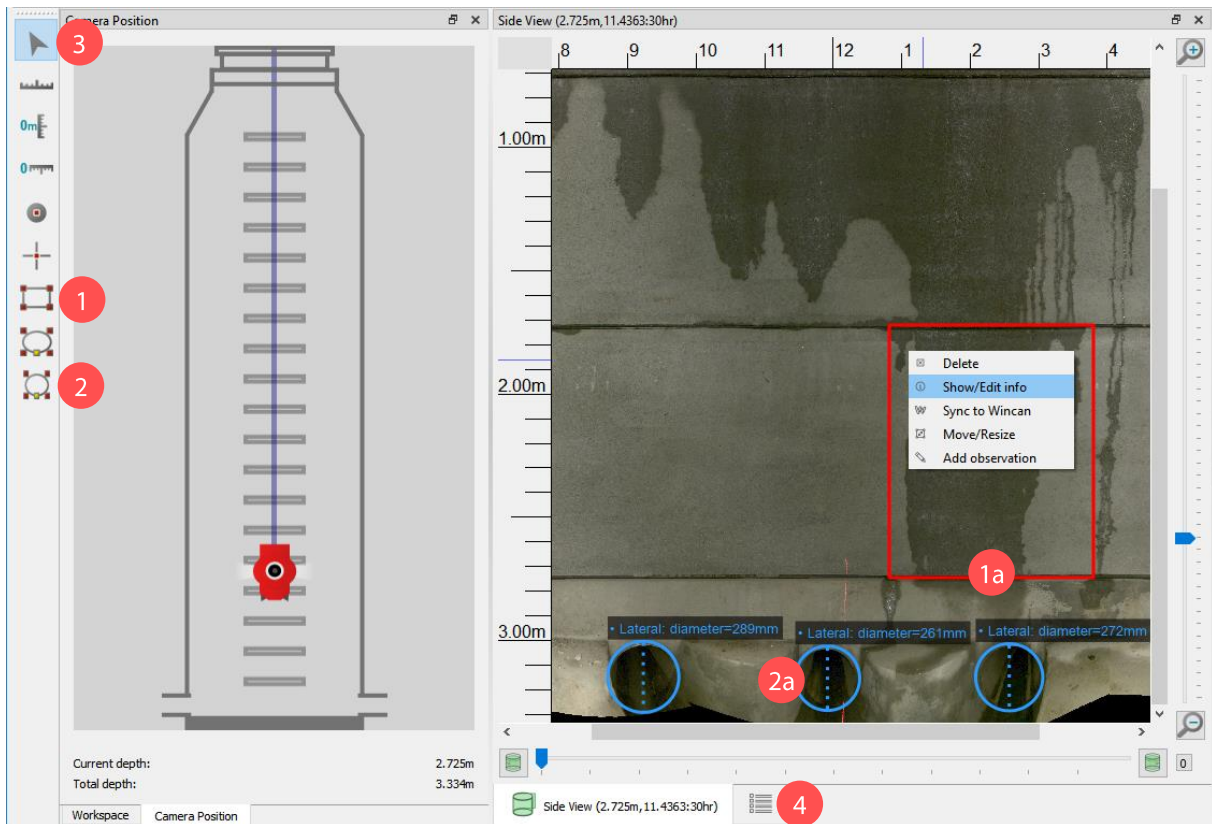
The interface depicted below shows a layout using the rest of the panels:



5. The **point cloud view** shows the points used to draw the mesh structure during post-processing. The user can move the point cloud up/down, back/forward and rotate around its vertical axis, and go back to the initial orientation by pressing the SPACE key at any time. This panel can be helpful to further investigate the structural defects.
6. The **front view** shows the mesh from top and lets the user scroll in and out with the mouse wheel and look at the walls again by using the mouse dragging while holding the mouse left button down. The user may go back to the initial orientation by pressing the Space key at any time. The observations marked on the side view are displayed in this panel as well.
7. The **depth view** shows four images taken at the current depth by the side cameras and stitched together. The user can change the cutting position using the horizontal scroll bar at the bottom of the panel, and move up and down in the manhole using the vertical scroll bar. Navigation via mouse wheel is also possible within this view.
8. The **observation list** shows all observations that have been drawn directly on the SideScan panel with the corresponding toolbox icon.

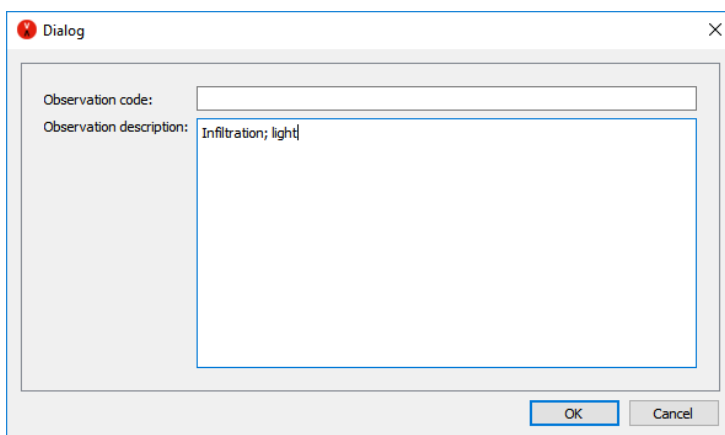
7.3 Creating and editing observations

Use the buttons on the vertical toolbar to mark observations on the SideScan panel. It is possible to mark either an observation spot, the extent of an observation/damage or to measure the dimension of manhole parts and intruding objects:



Select a graphic tool (1, 2) and draw the graphic over the corresponding damage location on the SideScan view (1a, 2a):

Select the pointer icon (3) and click on graphic which will then be highlighted accordingly. Right click on the highlighted graphic and select the context menu command *Show/Edit info* to describe the observation:

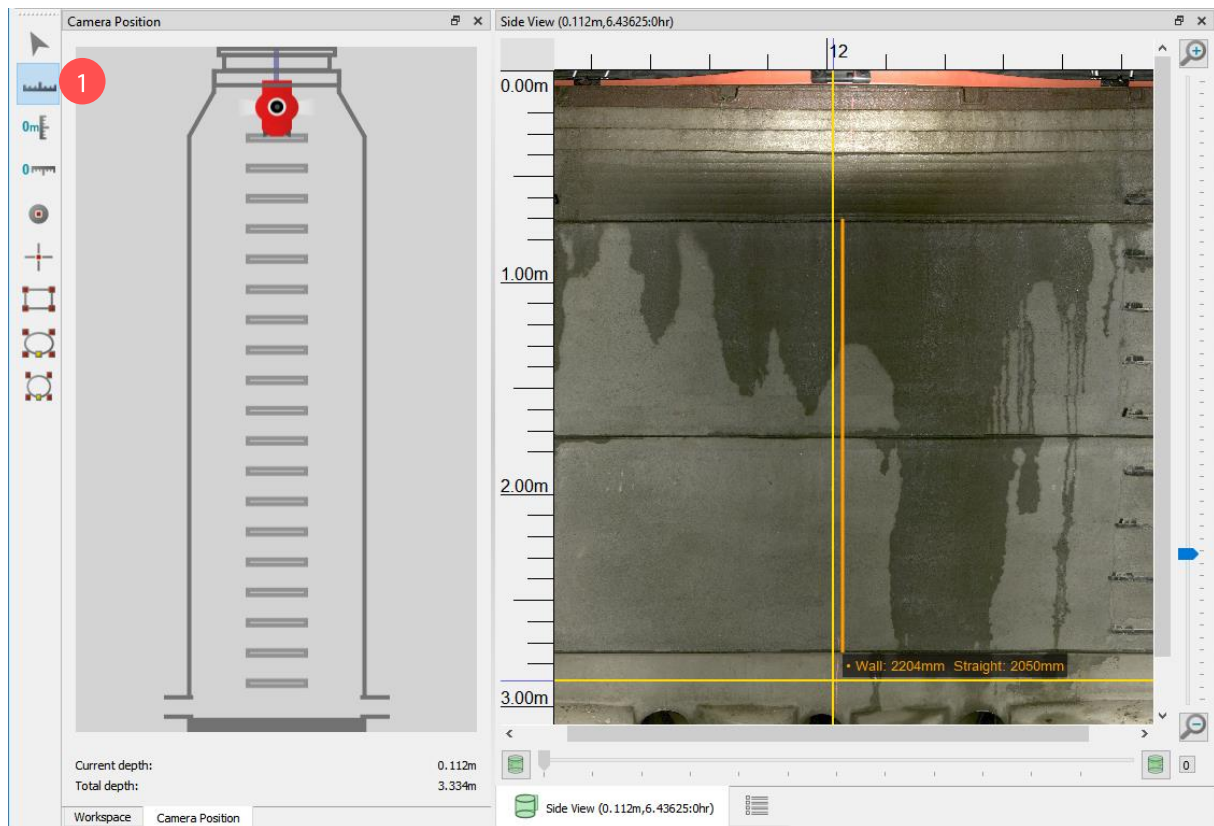


Observations are listed on the observation panel which can be reduced to tab size (4) right to the SideScan panel and opened whenever needed.

In order to move, resize or delete an observation, right click on the highlighted graphic and select the corresponding context menu command.

7.3.1 Measurement of object dimensions:

Manhole parts or objects inside the manhole can be measured using the bar icon in the toolbox (1). Select the icon and draw a measurement line over or around the desired object structure which is displayed in the SideScan view. The calculated value appears directly in a new field:

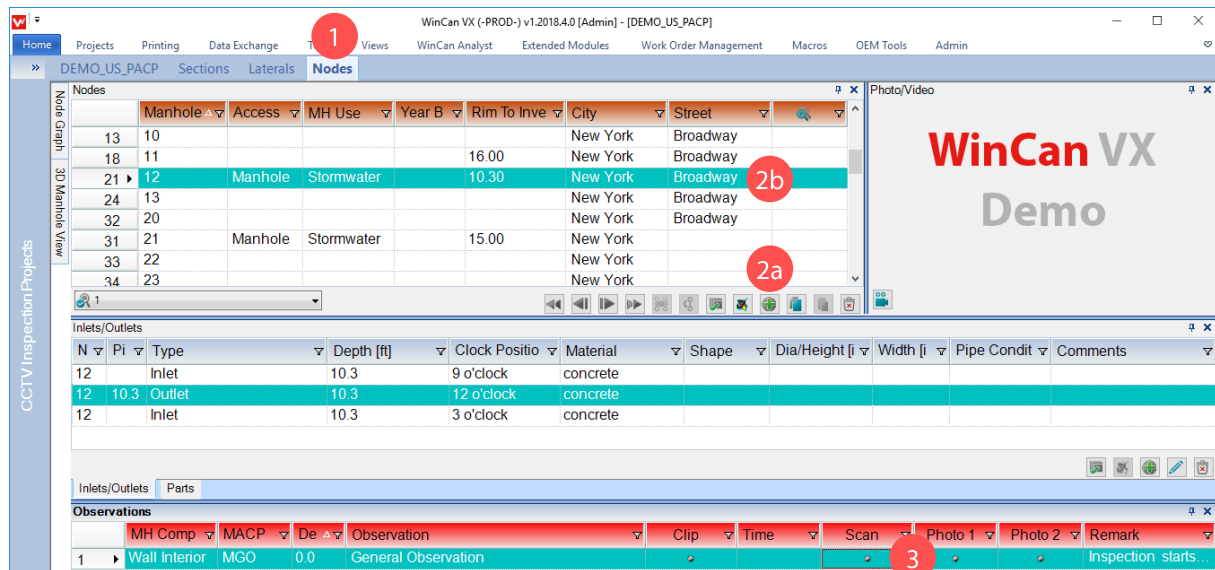


The unfolded wall is always shown as a rectangle, regardless whether there is a manhole with or without a cone. Different circumferences above and beneath a cone are taken into account and will return reliable values when measured on the SideScan view.

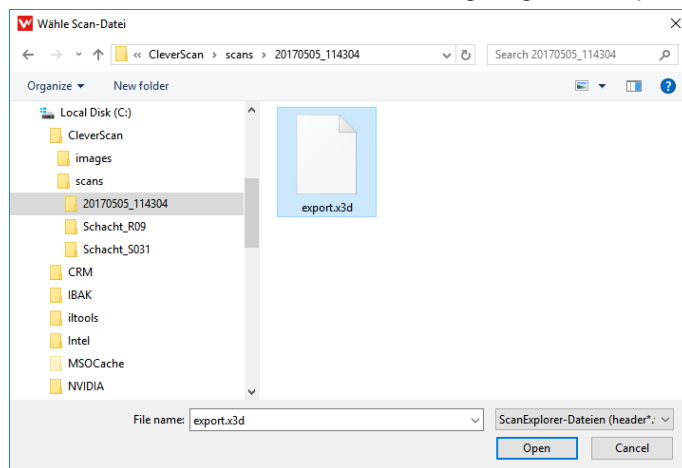
8 Import observations from CleverScan into WinCan VX

In order to import Clever Scan data into a WinCan VX project the user needs to follow the steps described below:

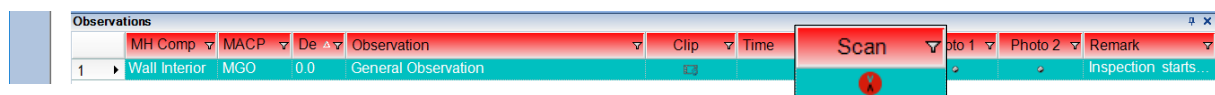
1. Create a project in WinCanVX, switch to the tab *Nodes* and create a new manhole (2a) or select an existing one (2b).
2. Create a first observation using the predefined text *General Observation* (e.g. MGO in PACP 6) and write the text *Inspection starts...* into the field *Remark*.
3. Go to the column *Scan* and double click on the grey bullet in order to import the CleverScan data into the project and to link it to the current observation:



4. Browse to the folder *C:\CleverScan\scan* within the Windows dialog box, search for the subfolder with the name of the desired manhole and select the file *export.x3d*.
5. Push the button *Open* in order to import the manhole data into the WinCan project. So the grey bullet within the Scan column is going to be replaced by a Scan icon:

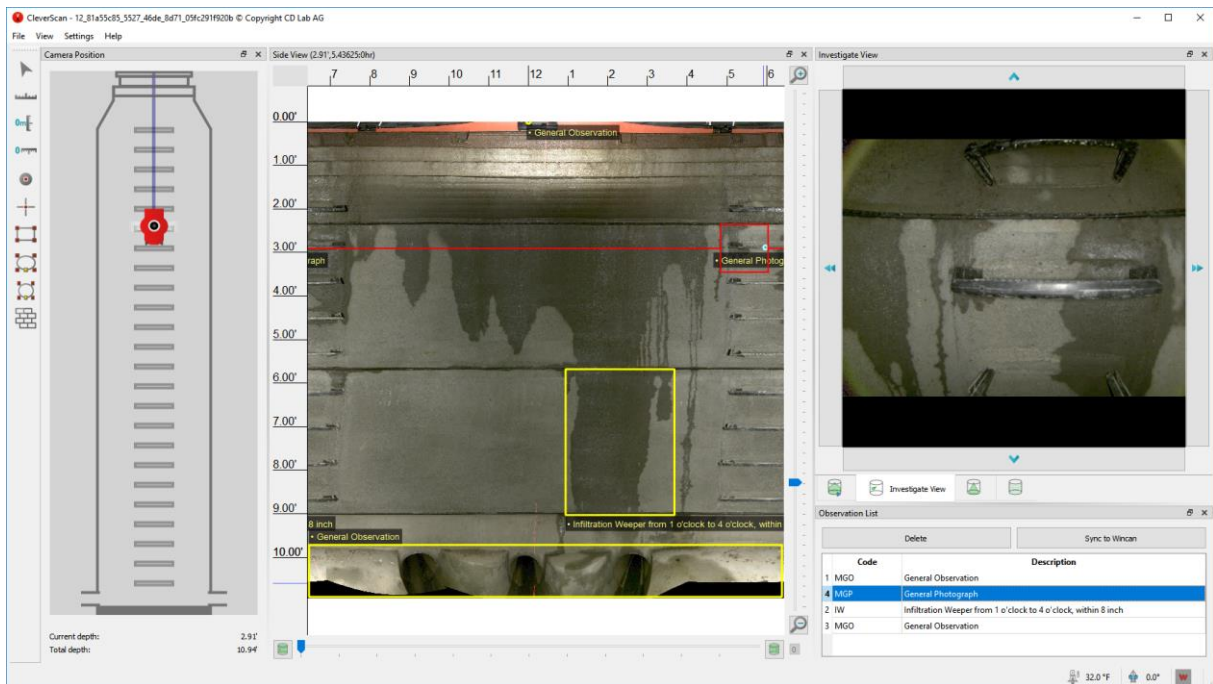


6. Double-click on the CleverScan icon to load the imported manhole data in the *Display mode* of the CleverScan software:

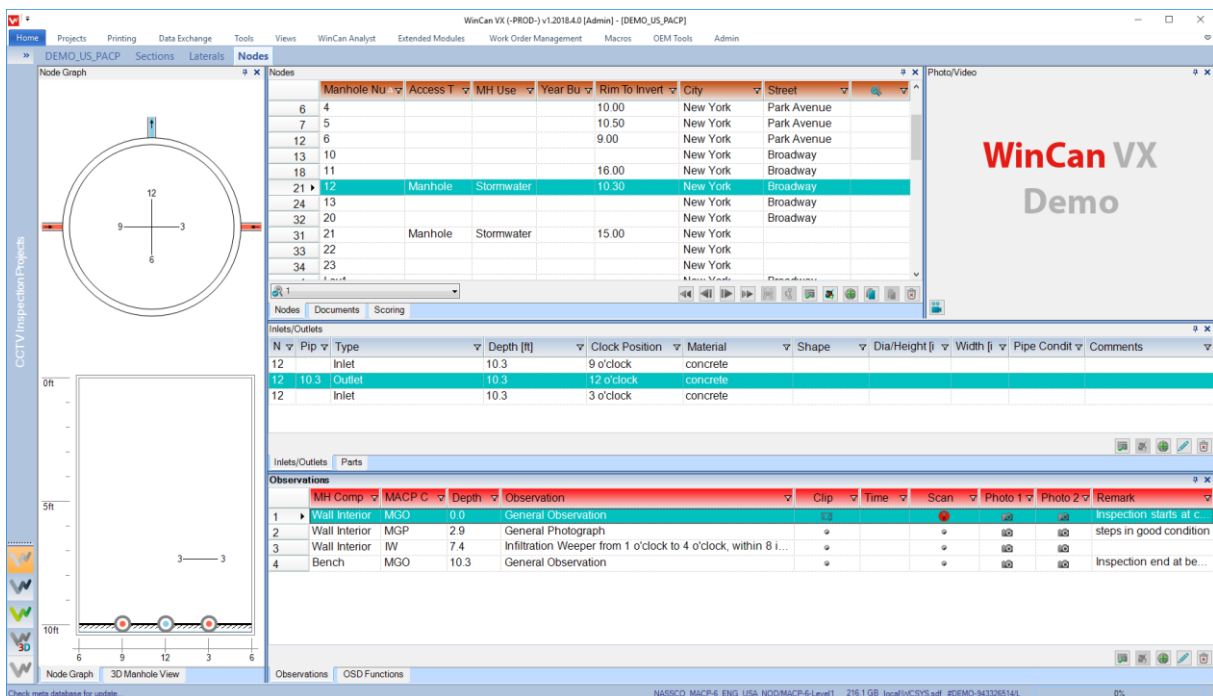


8.1 Describe observations and damages

Description of the observations is done via CleverScan: mark the damage on the *SideScan* view using a suitable icon from the toolbox (vertical toolbar). WinCanVX then is going to open the damage catalogue that provides the predefined descriptions.

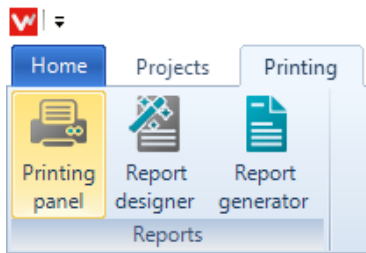


Depth value and clock position of an observation are transferred automatically from the CleverScan software to WinCanVX whereas the photos are taken from the *SideScan* and the *InvestigateView*, copied to the project and linked to the fields *Photo1* and *Photo2*:

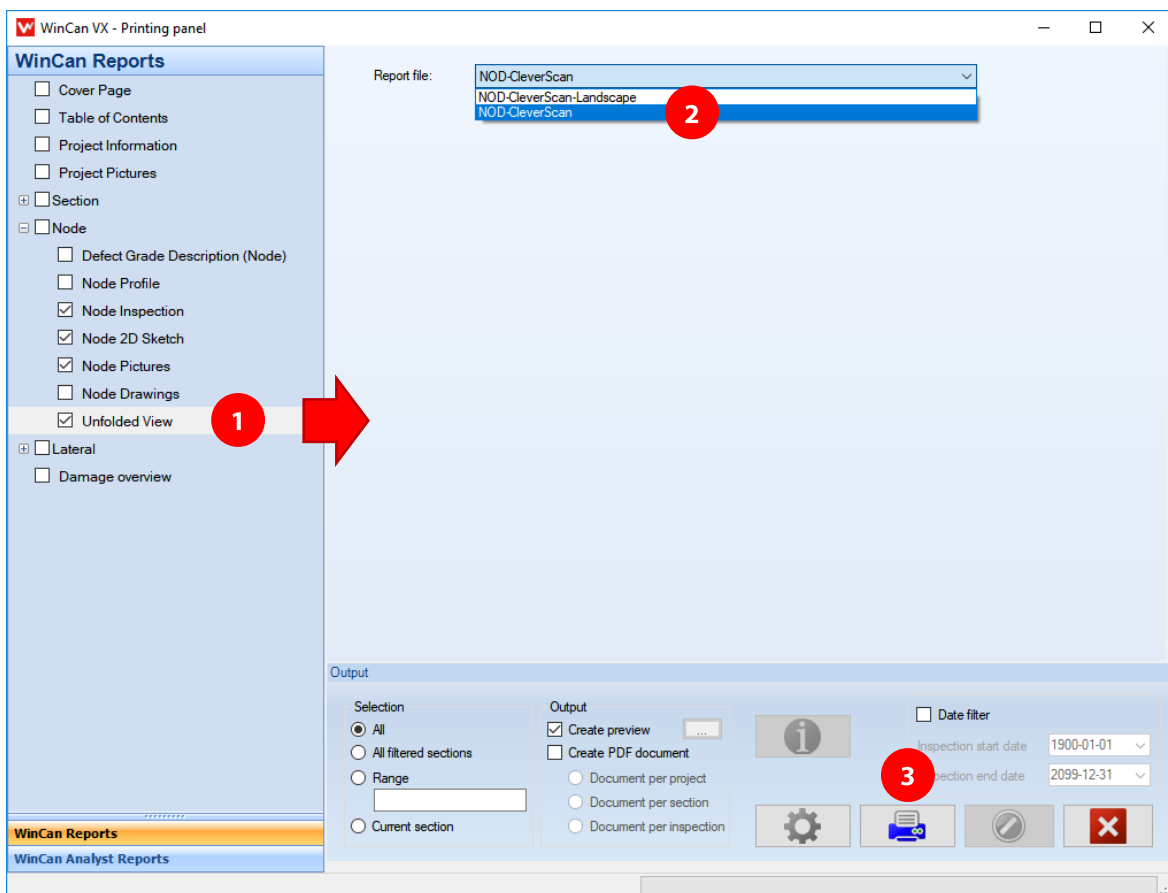


8.2 Print Manhole Reports with CleverScan Data


Activate the tab *Printing* and press the icon Printing Panel in order to print a CleverScan report from WinCan VX:

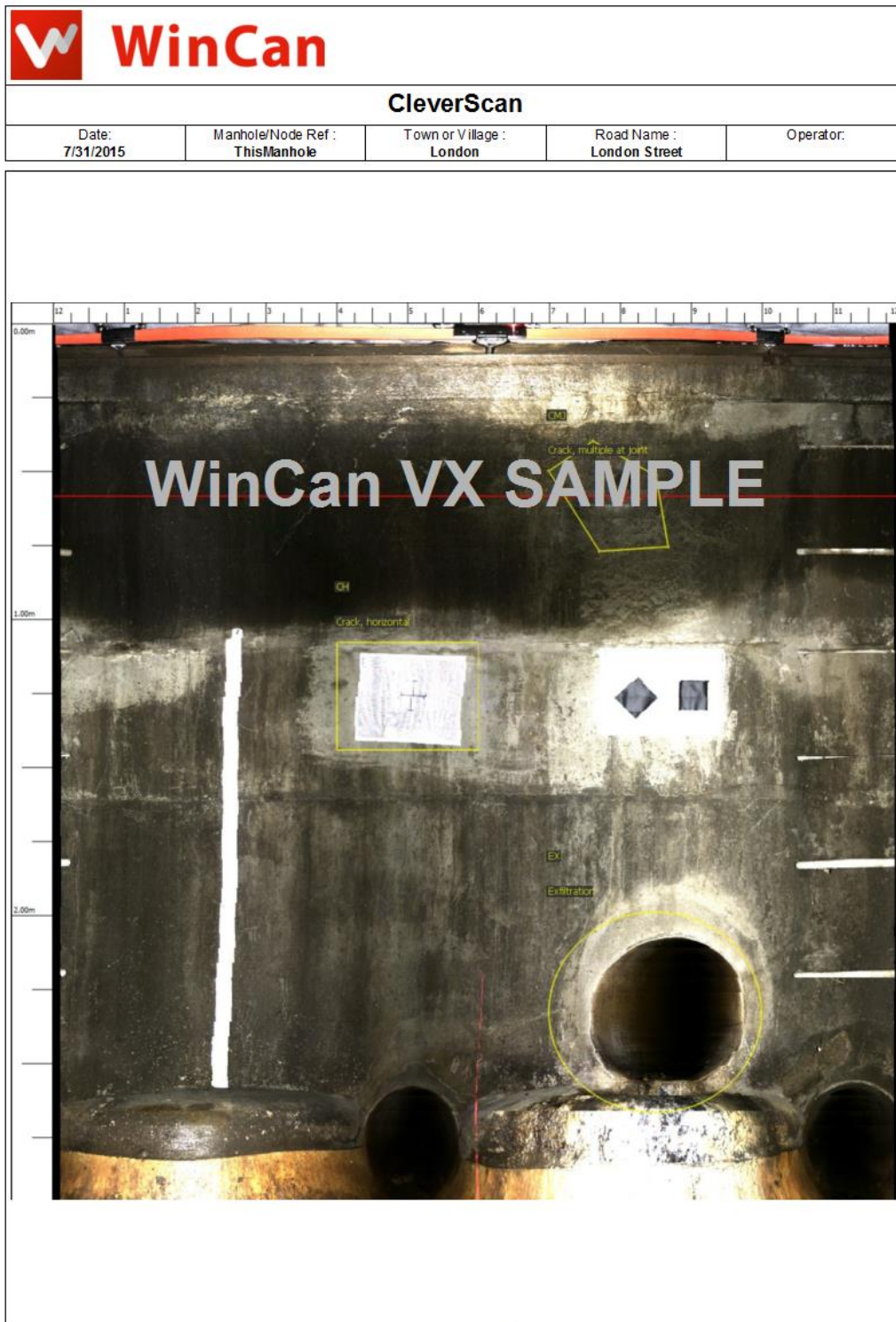


Check the report types *Node Inspection*, *Node 2D Sketch*, *Node Pictures* and *Unfolded View* in the report list on the left hand side of the dialog box. Selecting the report *Unfolded View* allows the user to select the page layout of the *CleverScan* report on the right hand side of the printing panel:



The *Unfolded View* represents the manhole wall that has been cut virtually at a certain clock position and rolled out to a flat surface.

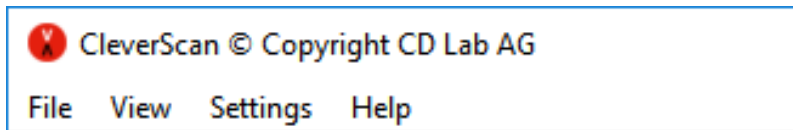
Finally press the print button  to create the report with the selected options. A sample *CleverScan* report page would look as illustrated below:



CleverScanDemo // Page: 4

9 Menu bar

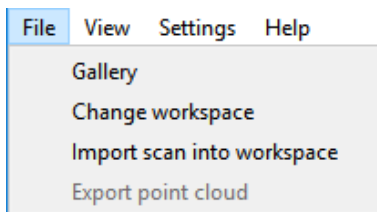
The menu bar at the top of the CleverScan interface is sub-divided into 4 groups:



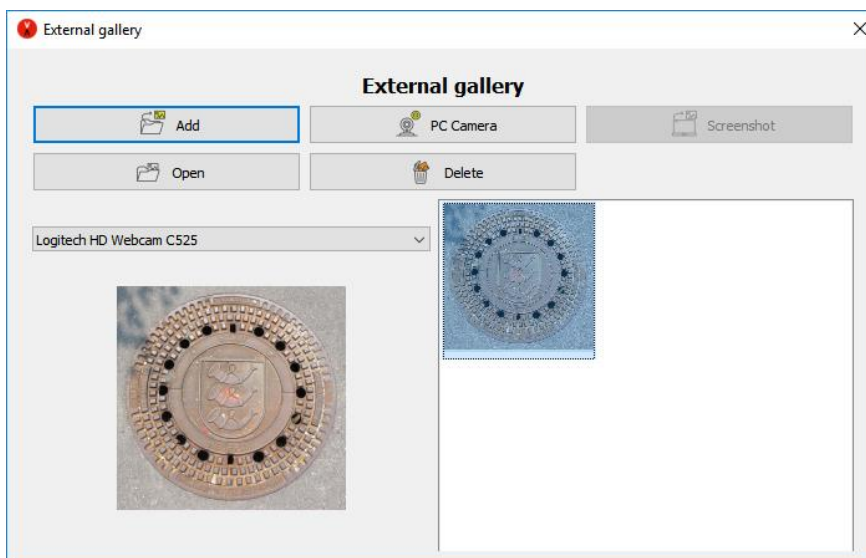
The commands of each menu group are explained in detail on the following pages

9.1 Menu FILE

This menu group provides commands for file management:



Gallery: Open a dialogue and add a picture of the manhole cover to the current scan for quick identification:

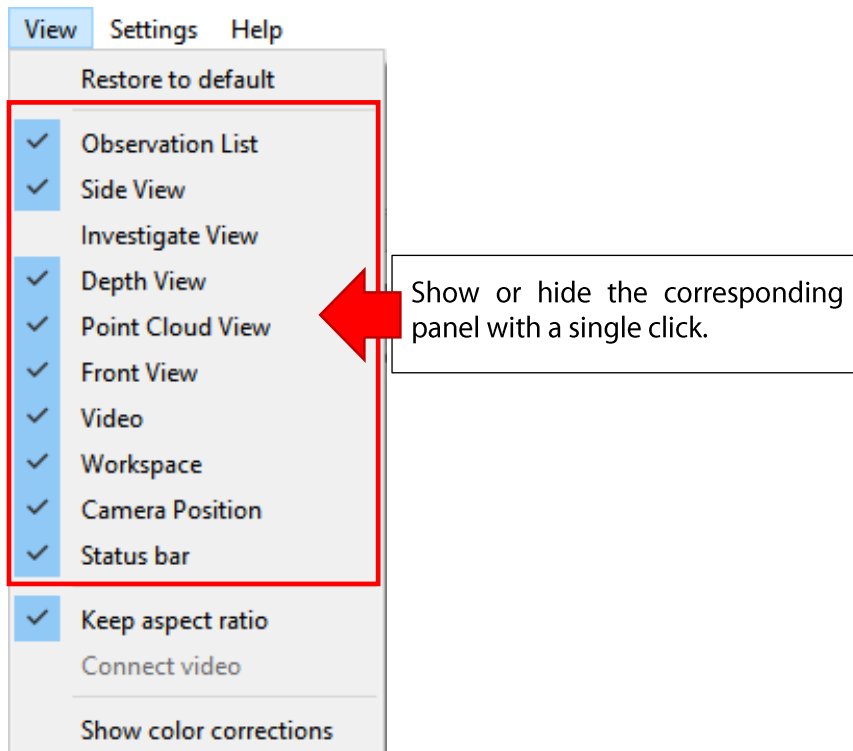


Change workspace: Open a Windows dialogue and set the sub-folder the raw data are copied into after scanning (e.g. C:\CleverScan).

Import scan into workspace: Open a Windows dialogue and browse for the scan data you want to copy into the workspace directory.

9.2 Menu VIEW

This menu group allows the user to directly hide or unhide any view panel provided by the CleverScan software.



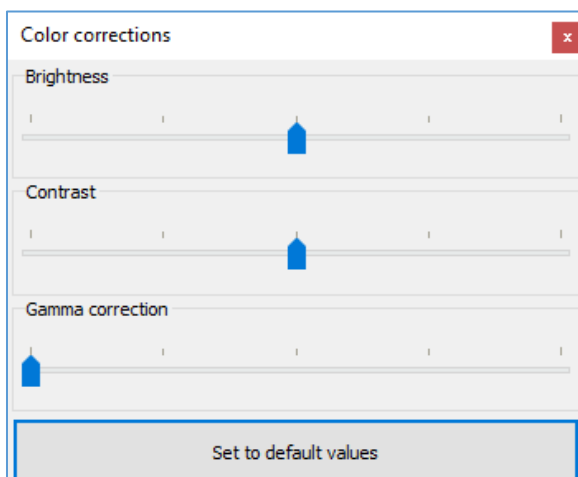
Restore to default: Decline any customized changes in the panel layout and set it back to default.

Keep aspect ratio: The user may choose whether he wants to keep the aspect ratio in side and depth views leaving spaces at the sides or at the top/bottom, or whether he prefers the image to cover the whole panel area using this option.

Connect video: The panel views are synchronized; so each of them shows the corresponding spot at the same location except the video panel. Synchronization of the video is switched off by default as it would slow down the performance of the software. The user may activate this feature whenever needed.

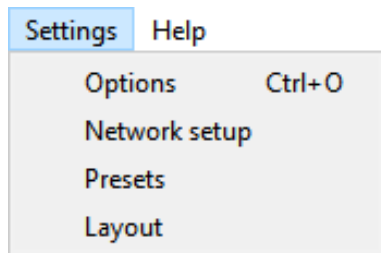
Color corrections: This command opens the dialogue box below, used for fine tuning of *Brightness*, *Contrast* or *Gamma*.

The latter one allows automatic *Brightness* and *Contrast* corrections for each color value detected on the picture.

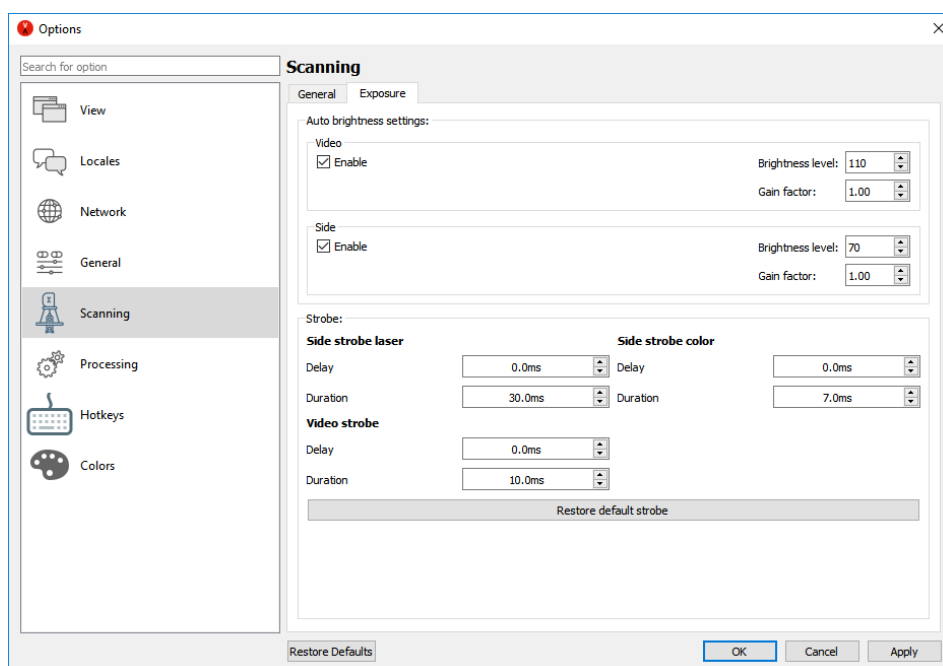


9.3 Menu SETTINGS

This menu group provides commands to check all kind of scanning options or camera settings and to change the panel layout of the user interface.

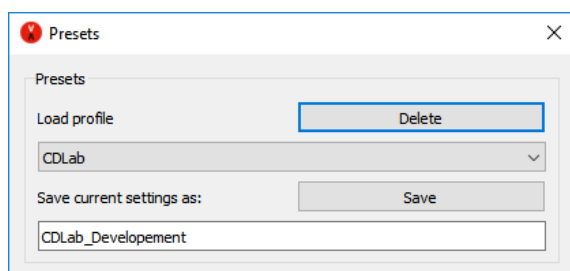


Options: Open the option panel in order to check or uncheck the most important scanning and camera parameters. We recommend to use default values and to have automated procedures enabled.

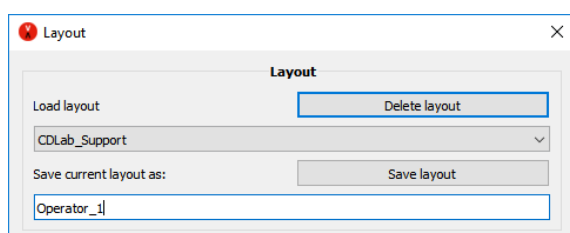


Network setup: Connect to or disconnect from the CleverScan device

Presets: Create a new settings profile or load an existing one.

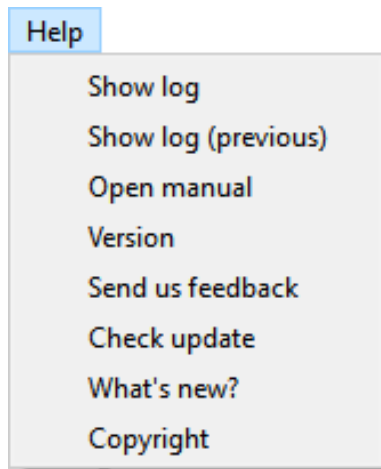


Layout: Save a new panel layout and load or delete an existing one.



9.4 Menu HELP

This menu group mainly provides commands used in case of trouble shooting. In addition the user can also get detailed information about the software and corresponding updates:



Show log: Show event protocol of the **current** CleverScan session.

Show log (previous): Show the event protocol of the **previous** CleverScan session

Open manual: Open the manual in the PDF-format. Make sure a PDF-reader (e.g. *Adobe Reader*) has been previously installed.

Version: Display the number of the current CleverScan software version.

Send us feedback: Report bugs using the predefined form in the dialogue

Check update: Download and install available update packages

What's new?: Show all new features added to the latest version

Copyright: Get copyright info about the CleverScan software

10 Troubleshooting

Below you can find a list of problems that may occur when working with the software module CleverScan:

Connection to the camera is not possible

1. Check whether network cable is connected
2. Check whether camera is turned on and has enough power
3. Check network setup and that network connection is captured
4. Restart the camera and the software

Camera does not move or scan fails

1. Try to move the camera up and down using the buttons on the camera unit
2. Make sure the depth sensor does not touch the water surface
3. Make sure the depth sensor reads sensible values, if not move the camera head slightly to see if you can get sensible values
4. Restart the camera

Post-processing fails

1. Restart the software and try to post-process again
2. Repeat the scan

Visualization fails

1. Repeat post-processing of the scan

CleverScan cannot connect to Wincan VX

1. Quit the software if there is already running another instance of CleverScan
2. Restart Wincan VX

In case of further or different problems please contact CDLAB support (support@wincan.com)