Workflow Bulletin

GEOSPATIAL
FEBRUARY 2022

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Fabrication Workflow using Trimble Geospatial Technology

Purpose

In construction sites and prefabrication/precast factories, accurate setting out and QA inspection is important. Control points are defined and survey equipment is used to either define these control points in the real world or to verify that the construction or fabricated elements have been placed correctly. Reports are created and fed back to the office.

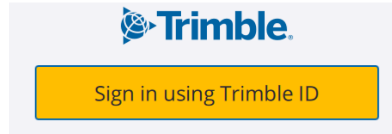
In this document, we will describe the general workflow, from the office to the field, that users can follow utilizing the Trimble Solutions for fabrication QA/QC. This workflow has been applied and tested with customers in the steel industry.

Current Trimble Geospatial Technology

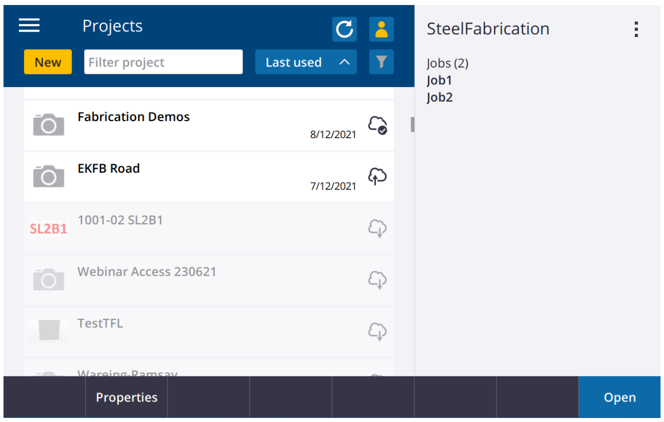
Loading Data

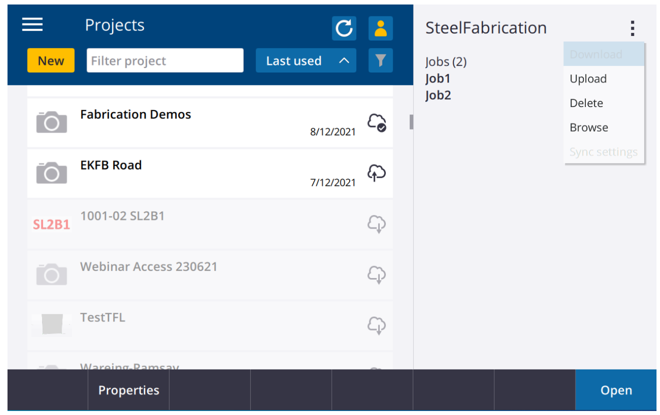
Trimble Access (TA) allows you to load the 3D model directly on the data logger via the cloud, without the need to manually transfer the data. Currently, Trimble Access supports IFC or TRB models. In some cases, where annotations are required (usually 3D dwg), that needs to be converted to a TRB model.

A user can export the 3D model(s) to Trimble Connect and load that model to Trimble Access. If a user uses Tekla Structures for creating the 3D models, then there is the capability to export the detailed steel model directly from Tekla Structures on to Trimble Connect, and then sync the data directly on to Trimble Access. The individual IFC files can be loaded through the Trimble Access Layer Manager. Trimble Access has a direct link to Trimble Connect so any model data that is required to be used for setting our and/or inspection on the data logger can be exported to Trimble Connect. Users will have to log in to the device with their TID. That is a quite seamless process that especially satisfies customers that already use Trimble Connect.

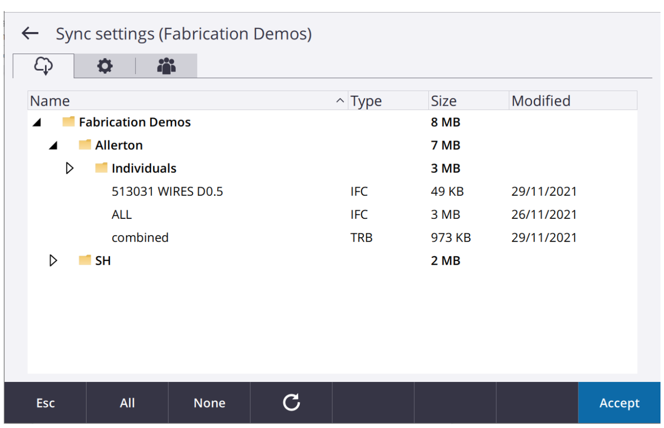


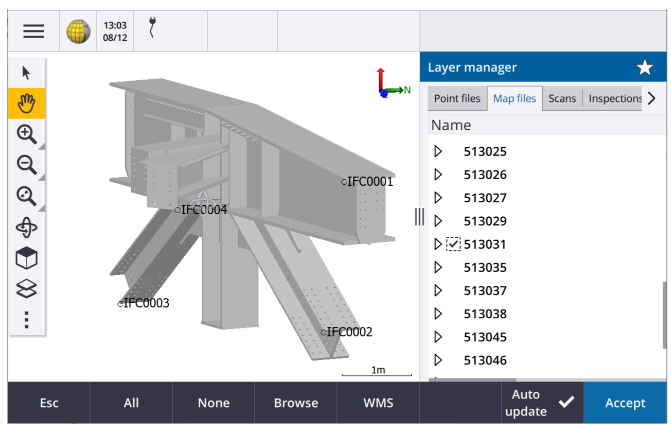
As soon as the user is online, any projects not downloaded to the logger can be seen. By selecting the project the user wants to work with, he/she gets access to the data that sits on Trimble Connect. That is depicted in the images below.





By pressing the download button users can select the specific file(s) they want to work with. The file will be downloaded to Trimble Access internally and users can manage which one to work with through the Layer Manager. Multiple model files can be used, if required - there is no restriction to only display one model at the time (e.g. 3D model and annotations, set out points, etc.).





Setting Up

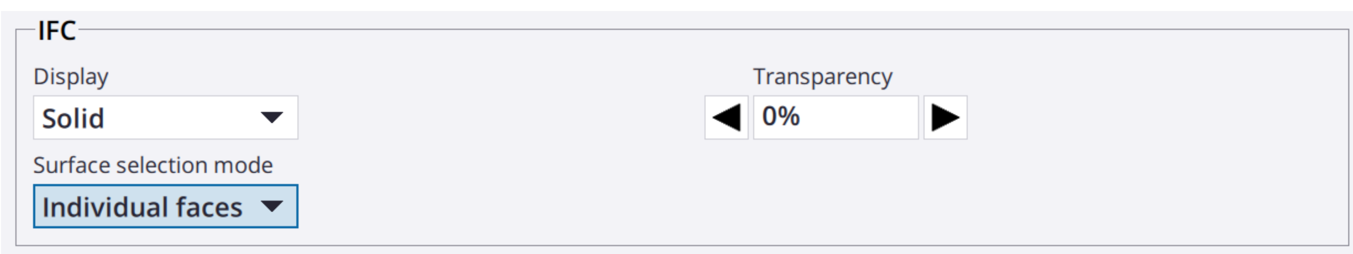
We have noticed that one of the main challenges in a fabrication scenario, when survey equipment is used for setting out, inspection, etc. is to align the digital design data to the actual fabricated element. Users would always need to do a station set up or a stationing to get the instrument to work in the given coordinate system. The main difference between a station set up for traditional construction work and a typical shop floor work is that a traditional set-up almost always is done relative to a flat grid that is leveled to the horizon. A set up in a fabrication environment can be done like that, but it can also be required to set it up oriented to a specific object instead of a given coordinate system. An additional challenge in using a 3D model for fabrication and especially when survey equipment is required, is the location and orientation of the element while it is being fabricated. The object that is to be fabricated is to be fabricated lying down and/or rotated and hence, it would need to be oriented within the station set up in such a way that it could be fabricated like that.

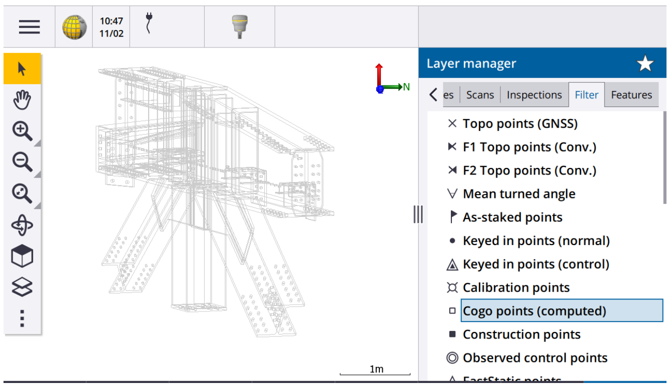
In the above section, the current practice was described, where the user had to measure some initial points in the shop based on the coordinate system of the shop, then go back to the office, translate the design data to those measured points, and then use those in the shop floor for setting out and inspection. However, it would be much more time efficient if the process of aligning the data to the real environment could be done directly in the field by using a “reference to object set up”.

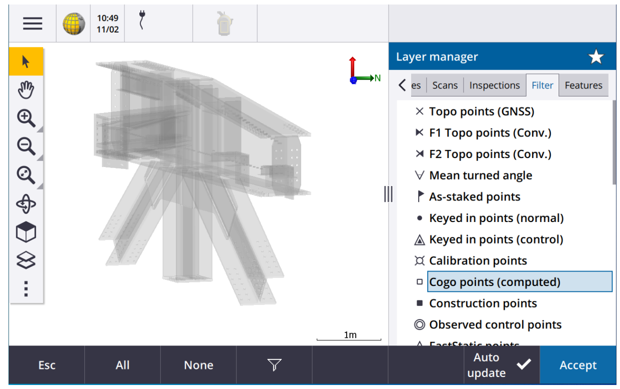
Currently in Trimble Access we support an “object oriented set up”, where users are not required to reference the total station set up to an outside coordinate system anymore, but they can reference the total station to three known points on an object they would want to work on. That object does not have to be the object they are about to build or assemble but it can be a reference object they build relative to. As soon as the station is correctly set up, every set out point or measurement point is relative to the reference object’s control points. This set up is also often referenced as an “unlevel set up”, since the reference coordinate system is not necessarily referenced to a level grid.

With the latest version of Trimble Access we can now do an “object oriented set up”, so instead of moving the model to a fixed coordinate system on the shop floor, or moving it every time it needs changing direction and orientation, the instrument can be stationed relative to the model itself. This is a big time saver as users do not have to “prep” the data in the office before they use it; it can be used directly in the field.

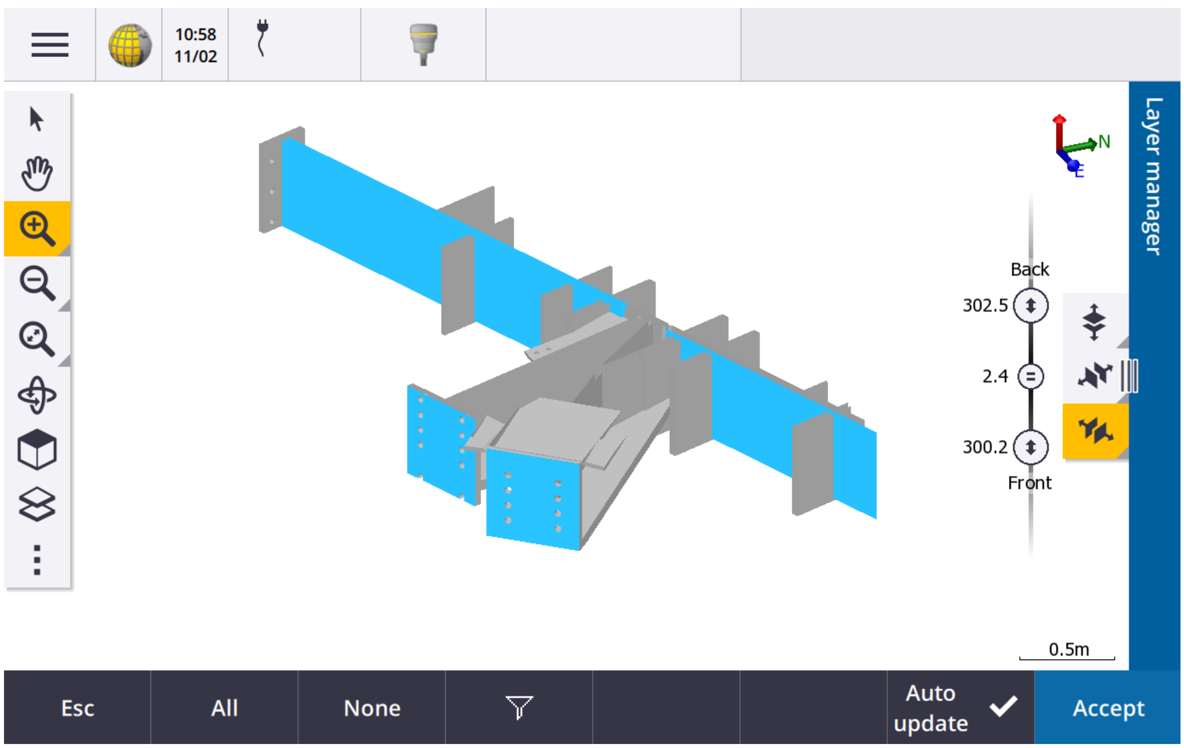
As soon as the file is active in Trimble Access, users can interact with the model directly. They can choose whether they want to work with the entire object or just individual faces of the object. This can also be controlled in the layer menu of TA if the IFC file is organized in such a way. The transparency setting is very useful if there is other data that would be useful to be displayed or users can choose to see the data in a wire frame. Examples are depicted below.



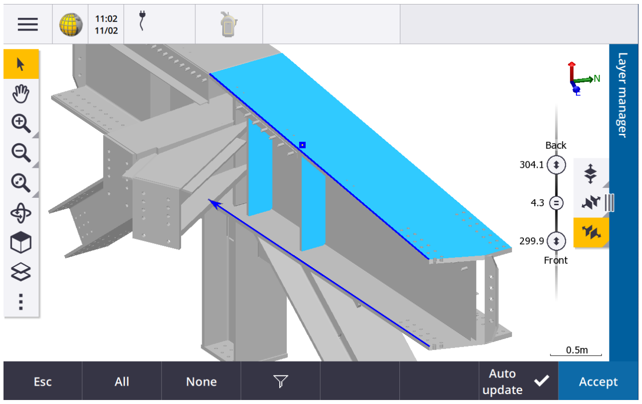


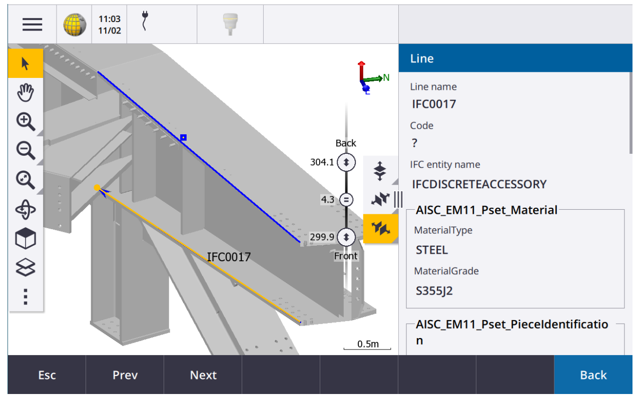


Trimble Access also includes a limit box functionality to section out specific areas of the model. This is very handy if only a specific part of the model is needed:

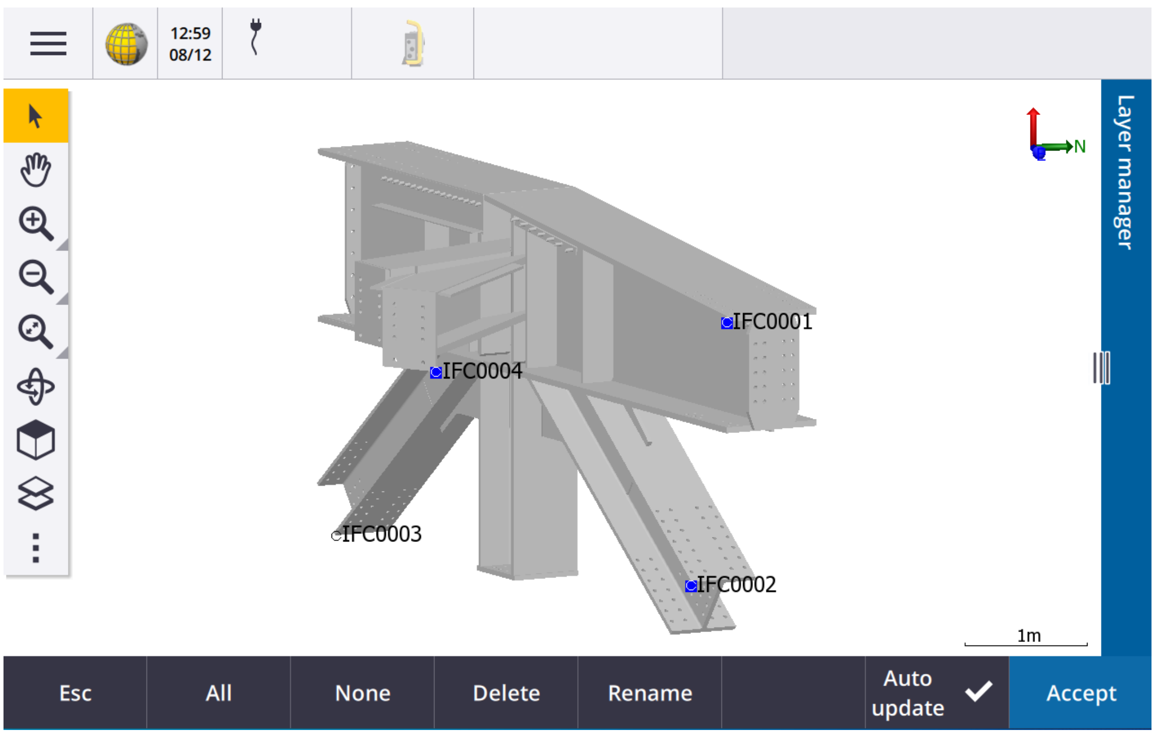


There is no need to first manually extract the set-out or calibration points in the office, as users are now able to extract required set-out points in the field directly from the model. Trimble Access allows users to extract points, lines or surfaces directly from the model. They can simply press an edge to get a line, or a corner to get a corner point, and it will snap to the given surface. They can also choose a specific surface or a number of surfaces they want to work with. Users can work with these points and lines directly. Examples are presented below:





In terms of the Object oriented Set-Up process, the user will need to pick 3 points and then observe each of these in order to get the set-up done. Users can either pick 3 points and store them and then select these as they observe. However, it's easy enough to pick a point in the model, then turn the Total Station to this point on the real model and observe. This needs to be done minimum of 3 times to get a solution.



The registration process is completed when 3 points have been captured. However, users can choose to add more points in order to build redundancy.

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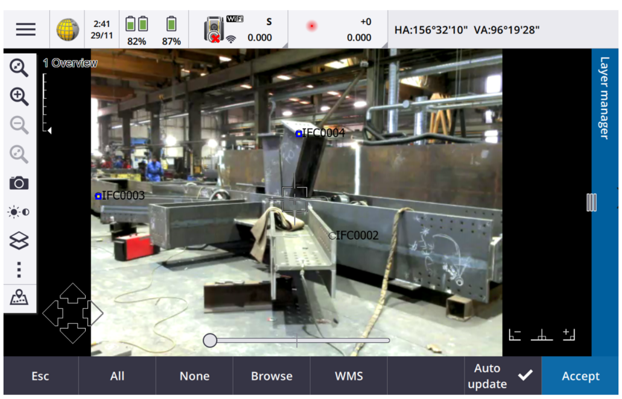
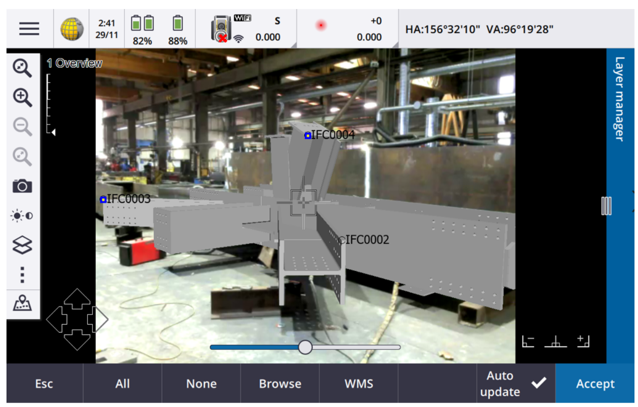
Station setup - Residuals

Point ^	ΔN	ΔE	ΔElev
IFC...	0.000m	0.001m	0.002m
IFC...	0.000m	0.000m	-0.002m
IFC...	0.000m	0.000m	0.000m

Setting Out and Inspection Process

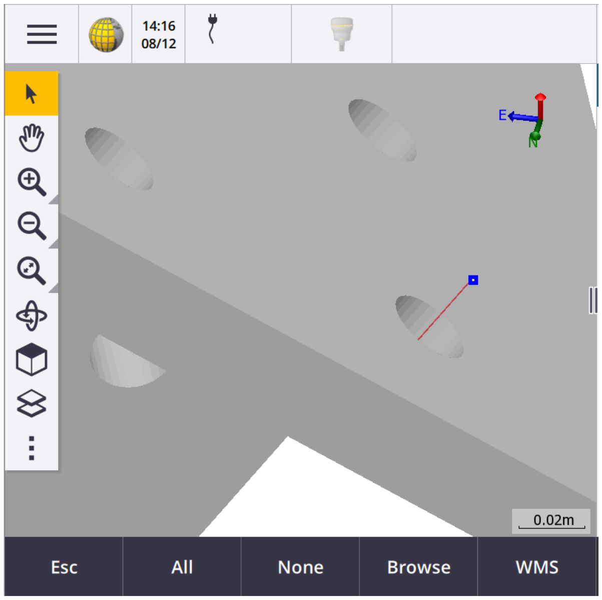
After completing the object oriented set up, the model and SX12 instrument will be aligned with the physical object. The SX12 Robotic total station is a revolutionary system that has all its viewing done through sophisticated camera usage. One of the big benefits of this, in combination with the way Trimble Access handles 3D models, is the capability to create an Augmented Reality (AR) based view of the 3D model onto the physical object in a mm accuracy. That capability (i.e. being able to see the model overlaid over the physical object) provides the means to visually check if the setting up process and the object oriented-set-up described above was conducted successfully. Additionally an AR based view facilitates data interpretation and enhances visual inspection for QA/QC purposes. It is also an excellent tool to guide the assembly process and communicate any discrepancies that might occur in a more intuitive way.





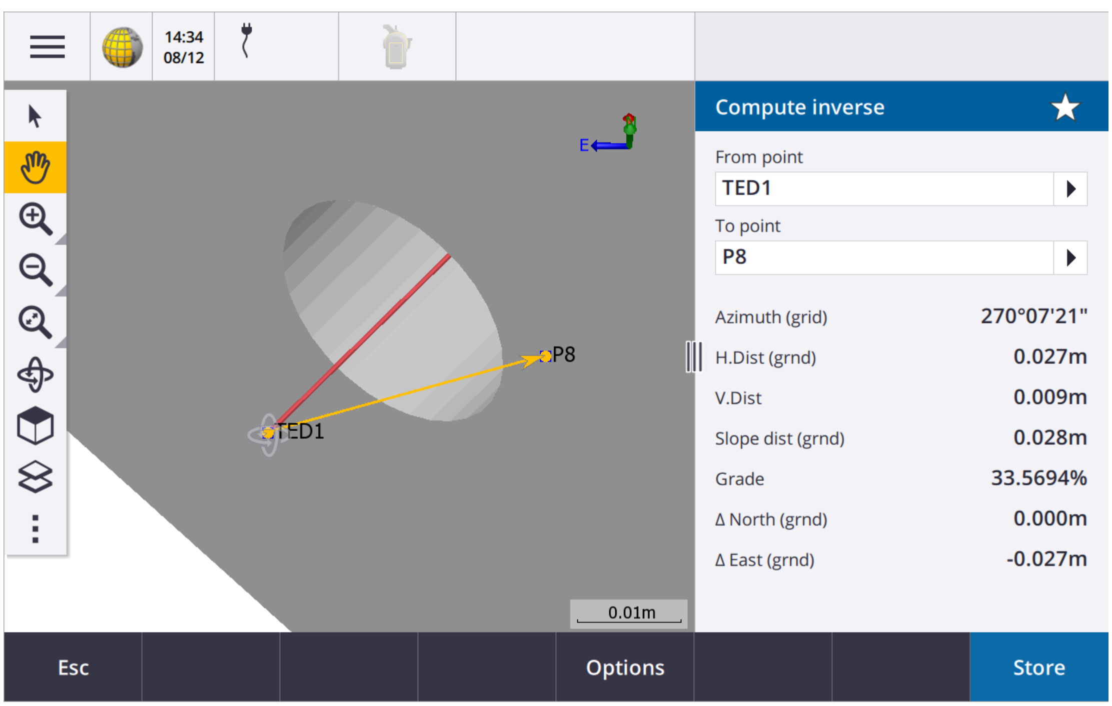
Once the user is satisfied with the object alignment the inspection process can start. There are a few ways this can be done. First, it can be done with individual point measurements to a selected number of points on the object. This is typically done with a prism ball, where the ball prism constant corresponds to pre extracted points. When an observation is taken, the deviation between the model and the as-built object is calculated. The process can also be automated through a style sheet generation where the software will run and compare the deviation between point pairs.

The fabricators often export offset points together with the model that correspond with the prism balls offset. This ensures that the correct distance is being applied when observing. Examples of this process can be seen in the following figures.



As soon as an observation is taken, the data is stored in Trimble Access. If the selected control points have been pre calculated and the user observes these, the deviation between the calculated and the observed point is automatically stored in the Trimble Access database and this can be exported afterwards as a report.

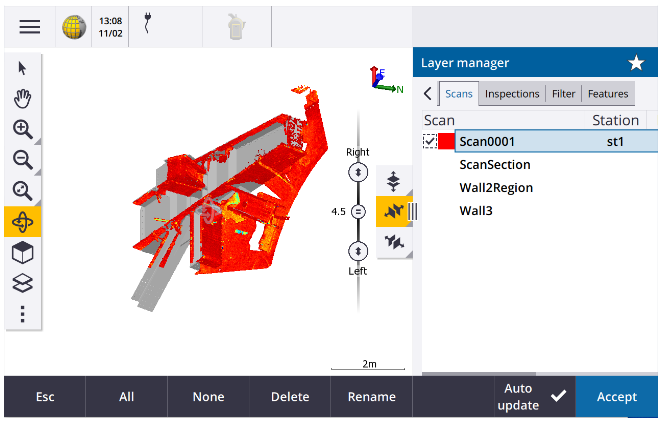
The operator can also inspect individual points as he/she makes observations. In the below example a deviation is calculated based on a chosen point in the model and an observation to the physical point. The result can be seen in the field screen where the user gets a graphical representation of the deviation as well as a numeric one.

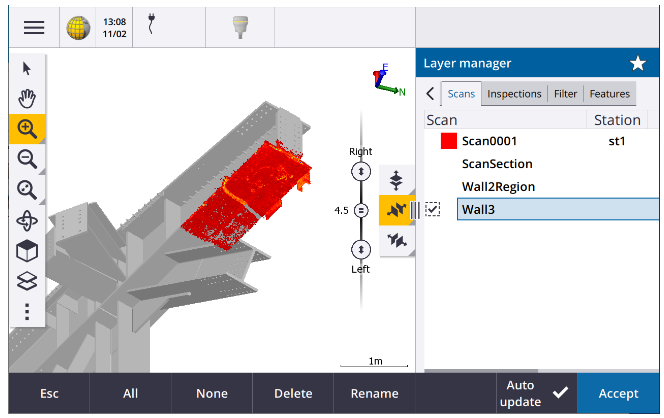


https://geospatial.trimble.com/

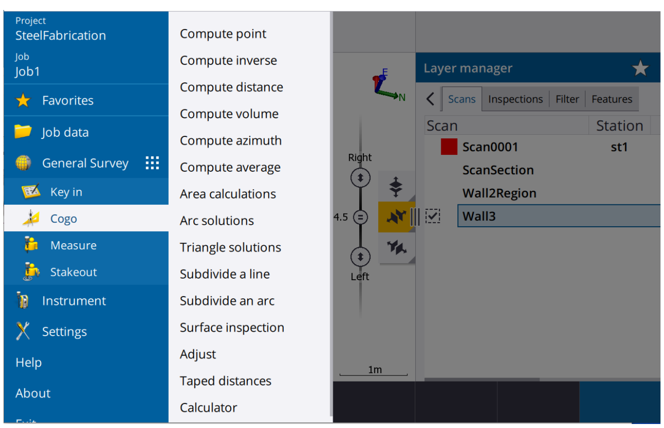
An alternative way is to use a combination of scanning and extracted points towards a surface. The SX12 is a total station with high accuracy scanning capabilities. Section-scan can be performed for a specific part (or the whole object) through a number of set ups and then a surface inspection can be conducted within the Trimble Access software to get a comparison between the scan (physical object) and the 3D model.

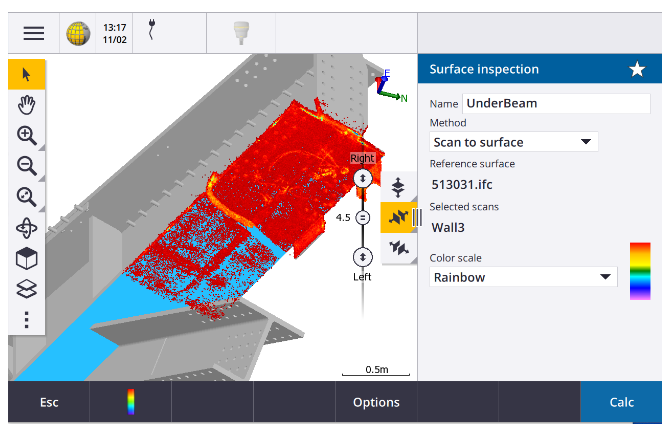
The SX12 allows a user to control the scan data in several ways. First, users can do section scans. So instead of doing a full 360 scan, users can select the object of interest through a polygon selection. When users have the data, they can either use the already mentioned limit box to section the scan data further, or they can select the area of the scan data by a simple square segmentation process. The segmented data can be stored as a separate section which again can be controlled in the layer menu.



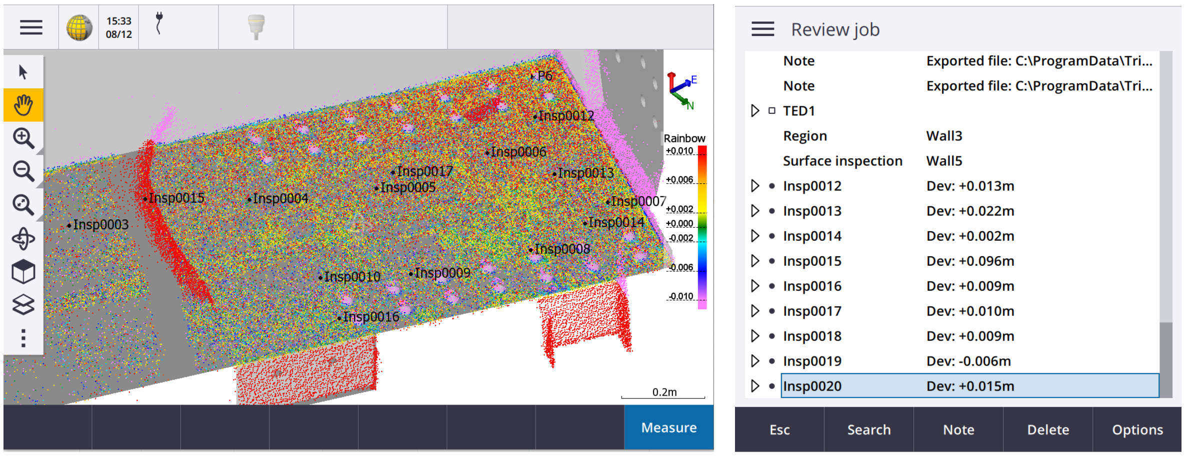


The scan-to-model comparison is a functionality that can be found under the COGO menu. Users can choose “Surface Inspection” and then pick the surface they want to inspect; that can be an individual surface or a whole object. Next, the inspection should be given a name and the map configuration should be chosen (this can be individually configured based on the needs of the inspection, required tolerances, colours of tolerances, etc.).



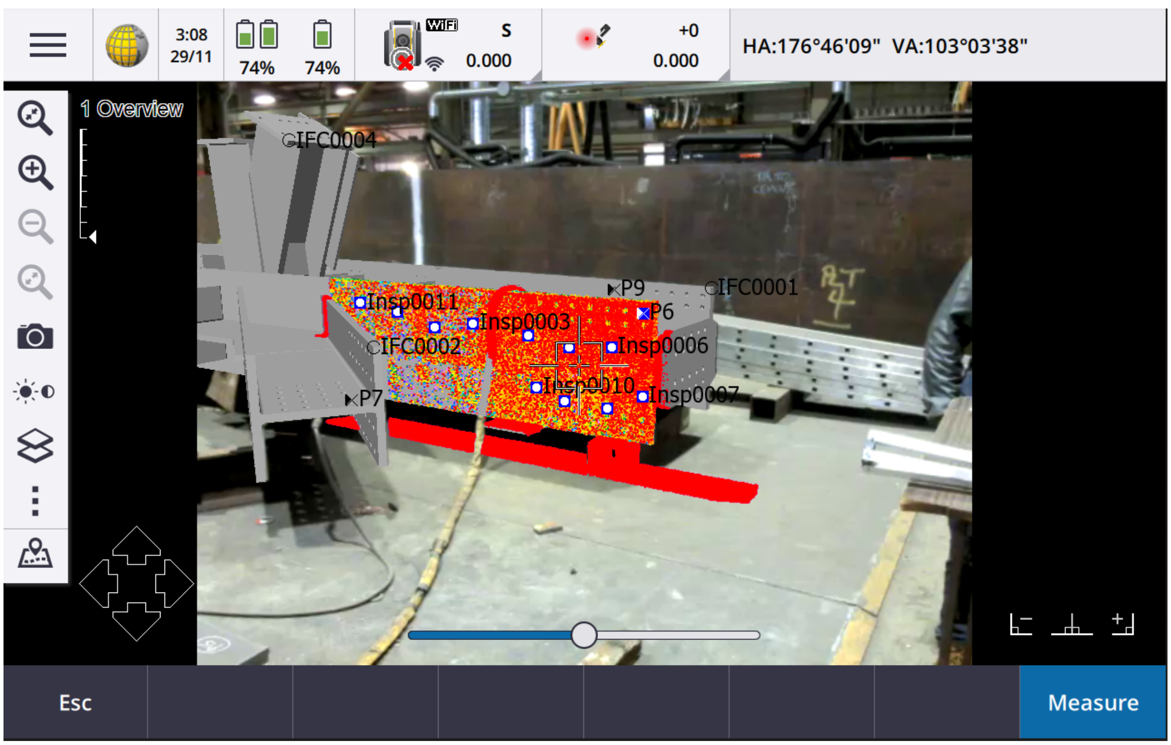


When the calculation is complete, an instant deviation value between the as-built object and the design data can be presented by simply selecting the specific point of interest. By pressing “Store” a snapshot of the screen is taken and the selected deviation points are stored. The inspection data is stored in a separate tab under the layer manager, which makes it easy to select and check individual deviations.



The “Inspection to surface” can also be done with prism measurements through the function “Measure Surface”. In this case, when taking a measurement to the prism, the system will calculate the perpendicular deviation value between the measurement and the underlying 3D model surface.

The inspection map and additional captured data (points) can also be displayed in the camera as an AR capability. That allows the user to immediately see the deviations on the real object. With the SX12 laser pointer capability, users can also point to the point of interest.



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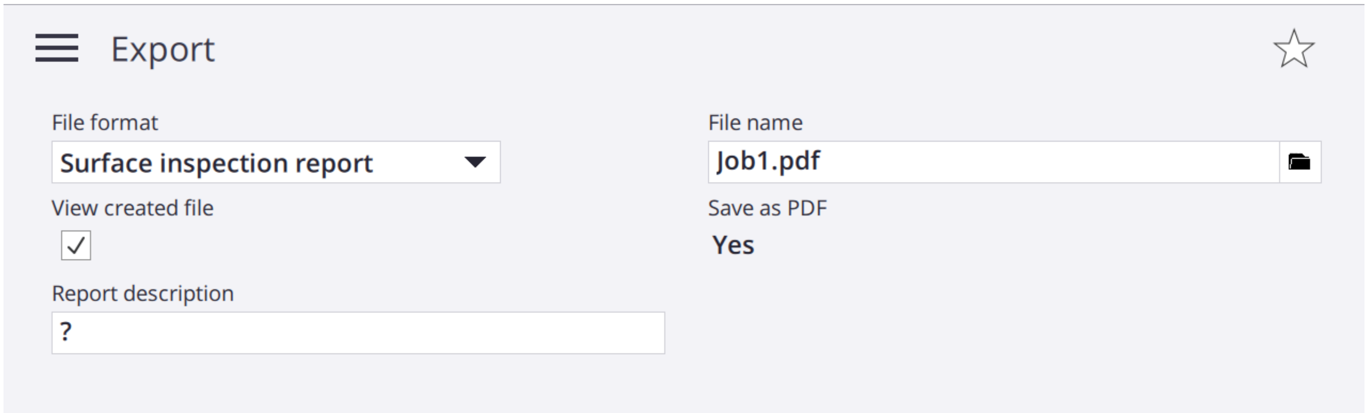
Reporting

All data that is measured or calculated can be exported or reported on from within the Trimble Access database. There is an instant field report available for the scan inspection tool. This export function is called "Surface Inspection Report" and can be found under the normal export option.

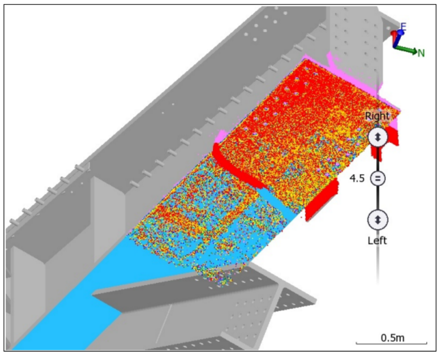


The report provides a PDF file containing a header (Logo can be changed depending on the customer needs), details of the inspection, a screenshot of the inspected area and the selected deviation points. Example of such a report is included below.

Trimble™

Surface Inspection Report - Job1

Operator:	
Date:	NaN NaN
Instrument:	Trimble SX10, Serial number: 30410003



Inspection: Wall5

Method	Scan to surface
Reference surface	combined.trb
Selected scans	Wall3
Minimum delta	-0.194
Maximum delta	0.181
Color scale	Rainbow

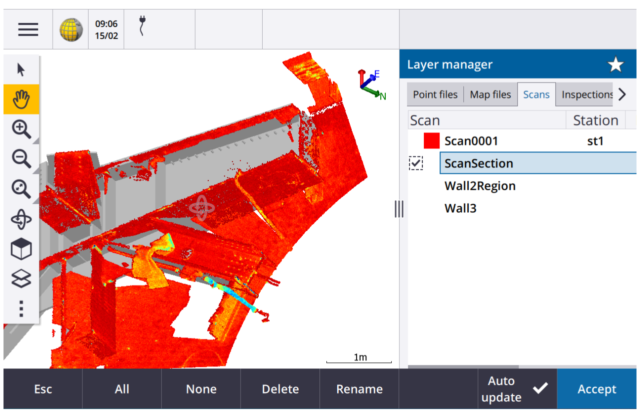
Inspection point deviations for: Wall5

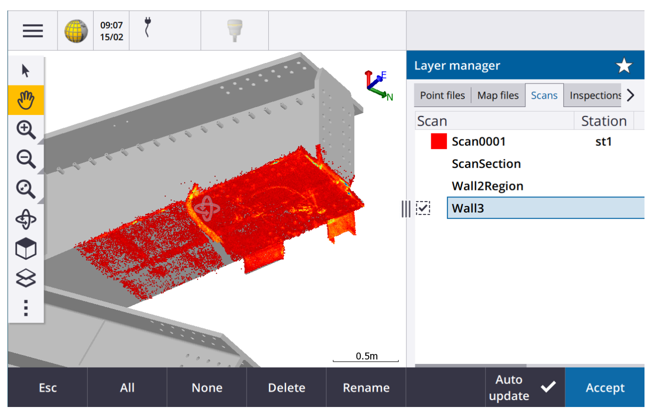
Point name	North	East	Elevation	Deviation	
Insp0012	303.067	85.323	67.942		0.013
Insp0013	303.256	85.230	67.933		0.022
Insp0014	303.468	85.153	67.953		0.002
Insp0015	302.640	84.462	67.859		0.096
Insp0016	303.370	84.474	67.946		0.009
Insp0017	303.020	84.924	67.945		0.010
Insp0018	302.337	83.532	67.946		0.009
Insp0019	302.973	83.346	67.961		-0.006
Insp0020	302.575	83.809	67.940		0.015

For those who want a customisable report, Trimble Access supports XML stylesheet generation so any data that sits in the database can be used to make customisable reports.

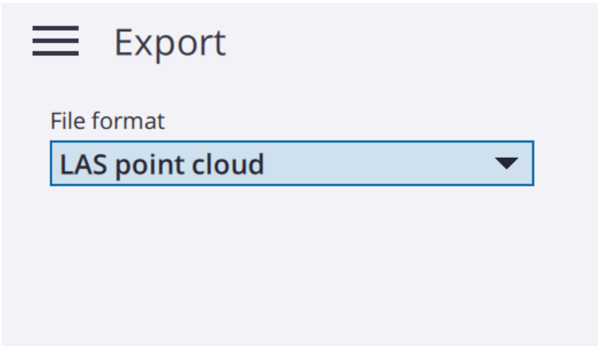
In many cases a user may want to get the data back to an office environment such as Tekla Structures for doing further QC work. Data can of course be exported the traditional way, though a USB memory stick, but more effectively, it can be exported and synchronized directly with Trimble Connect via Trimble Access. If the project contains point observations, these can be exported as standard text files or set up through style sheet formatting.

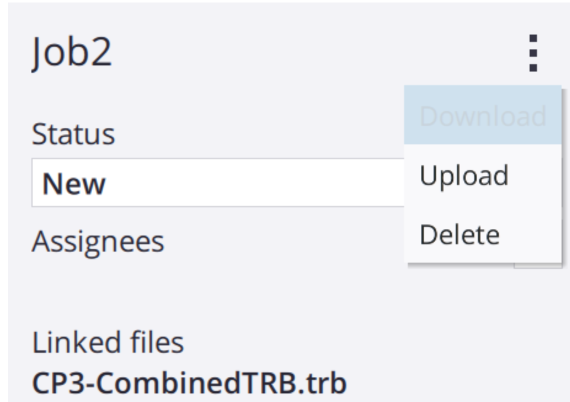
In terms of the scan data, data can be either exported as LAS files, or segmented sections can be exported individually. A user can control what to export through the “Scan” tab in the layer manager.



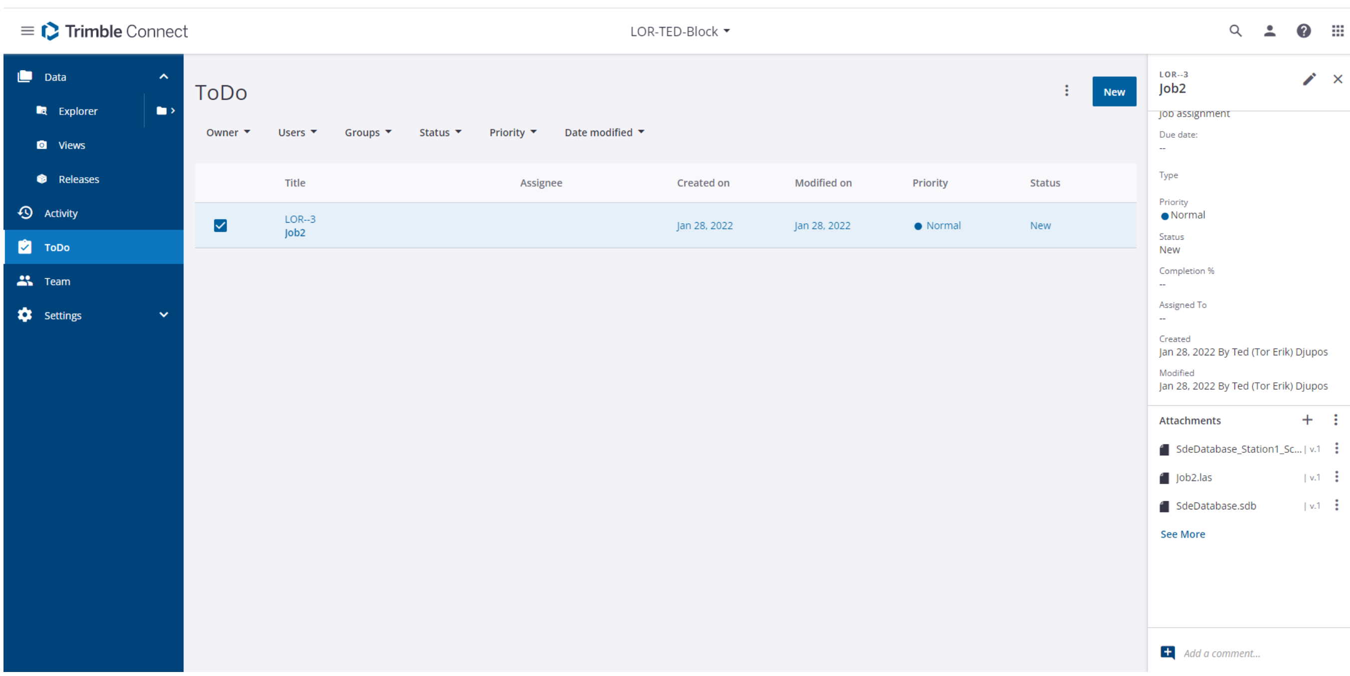


When ready to send the data back, the user can choose the preferred export option, in this case a LAS file, and then the “Upload” command in the job menu.

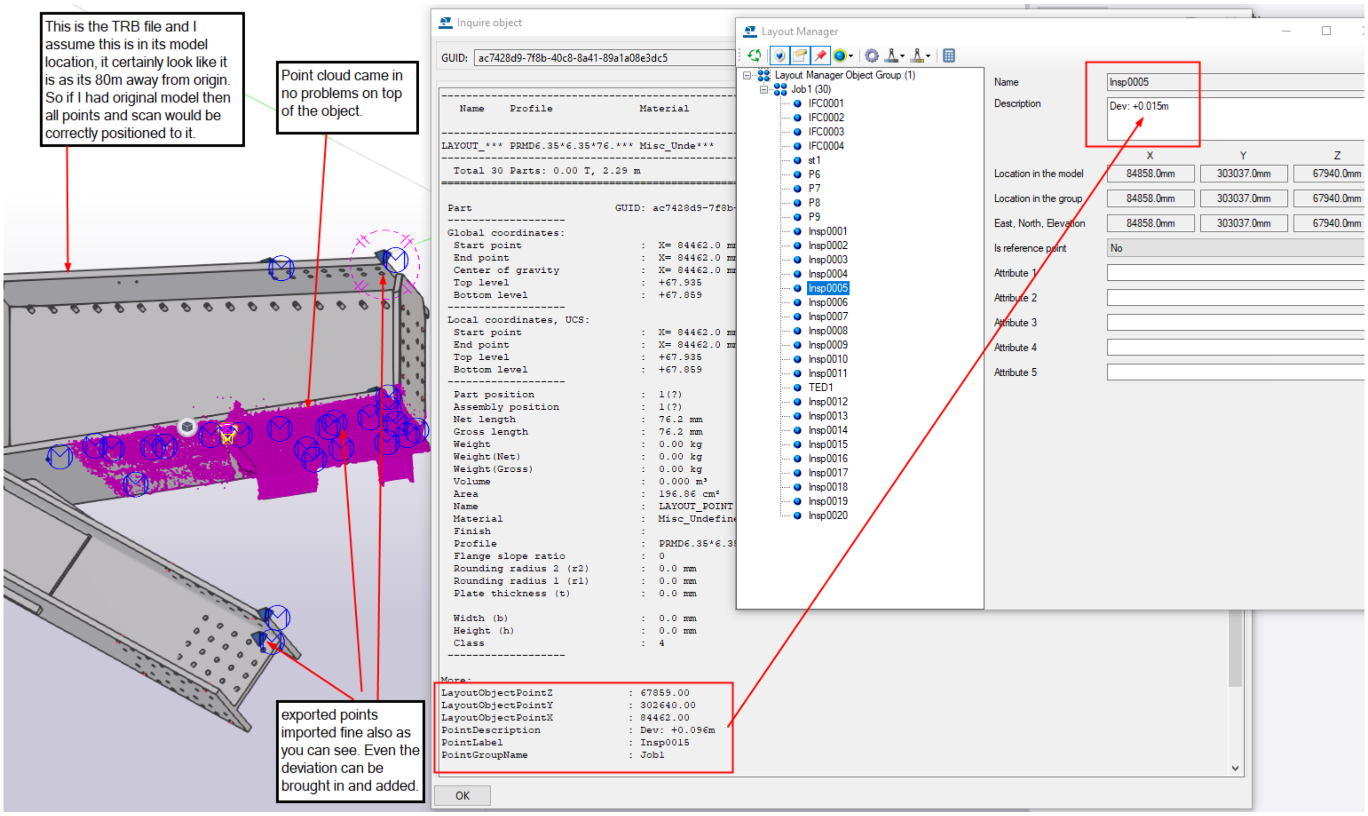




Back in Trimble Connect, this will come back as a ToDo, which contains all the field data, as it can be seen in the image below. This can then be imported directly to Tekla Structure from Trimble Connect.



Then data can be imported to Tekla Structures and further processed for QA purposes. Scans can be used for clash detection, points can be displayed with their deviation values and modifications can be made if required. Example of this data in Tekla Structures is depicted in the figure below.


This is the TRB file and I assume this is in its model location, it certainly look like it is as its 80m away from origin. So if I had original model then all points and scan would be correctly positioned to it.
Point cloud came in no problems on top of the object.
exported points imported fine also as you can see. Even the deviation can be brought in and added.
Inquire object
GUID: ac7428d9-7f8b-40c8-8a41-89a1a08e3dc5
LayoutObjectPointZ : 67859.00
LayoutObjectPointY : 302640.00
LayoutObjectPointX : 84462.00
PointDescription : Dev: +0.096m
PointLabel : Insp0015
PointGroupName : Job1
OK
Layout Manager
Layout Manager Object Group (1)
Job1 (30)
Name
Insp0005
Description
Dev: +0.015m
Location in the model
84858.0mm
303037.0mm
67940.0mm
Is reference point
No