LIDAR/3D HIGH DENSITY SCANNING (HDS) BRIDGE SCAN/MODEL PROJECT-TAGGART BRIDGE

Experimental Feature No. X(10)06

Prepared For:
Utah Department of Transportation Research Division

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May 2010
Prepared for:
Utah Department of Transportation

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   UT - 10.06  

2. Government Accession No.  
   LEAVE BLANK  

3. Recipient's Catalog No.  
   LEAVE BLANK  

4. Title and Subtitle  
   LIDAR/3D HIGH DENSITY SCANNING BRIDGE SCAN/MODEL PROJECT- TAGGART BRIDGE  

5. Report Date  
   MAY 2010  

6. Performing Organization Code  
   UTILIZE WHEN POSSIBLE  

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10. Work Unit No.  
    8RD1055H  

11. Contract or Grant No.  
    10-9185  

12. Sponsoring Agency Name and Address  
    Utah Department of Transportation  
    4501 South 2700 West  
    Salt Lake City, Utah 84114-8410  

13. Type of Report & Period Covered  
    FINAL REPORT  

    UT-09.003  

15. Supplementary Notes  
   Prepared in cooperation with the Utah Department of Transportation.  

16. Abstract  
   Collection of Light Detection and Ranging (LiDAR) data has existed for many years. However, the correct application of the collected data has been open for discussion and evaluation in recent years. Data collection hardware has led the way for the development of the LiDAR industry particularly with respect to engineering services. The software to process and model the data has lagged behind the hardware for data collection. Recently there has been a flood of software companies offering ways to ‘mine’ or model the data. Other issues have arisen as many service companies have provided data collection services without utilizing standard survey procedures, Quality Assurance/Quality Control (QA/QC) or licensed professional surveyors and engineers. The intent of this report is to demonstrate that LiDAR data, when captured using generally accepted survey control procedures, will result in data which can be used for design purposes.  

17. Key Words  
   LiDAR Scanning, Bridge 3D Scanning and Surveying  

18. Distribution Statement  
   UDOT Research Division  
   P.O. Box 148410  
   Salt Lake City, Utah 84114-8410  

19. Security Classification  
   (of this report)  
   Unclassified  

20. Security Classification  
   (of this page)  
   Unclassified  

21. No. of Pages  
   Reports Page Number  

22. Price  
   LEAVE BLANK  

23. Registrant's Seal  
   LEAVE BLANK
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Acknowledgements

The authors wish to acknowledge the efforts of the entire technical advisory committee who made the project possible and provided direction and encouragement to those executing the efforts. Of significant mention, UDOT’s Phil Pool and Robert Nash provided oversight and insight for the project from day 1 (data collection) to completion (final review and training). McNeil’s, Kevin Dawson, Dan Pratt and Jake Felshaw provided the yeoman’s share of the efforts to make the project a success. Congratulations and thanks are extended to all for their efforts in a successful project.

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Executive Summary

Collection of Light Detection and Ranging (LiDAR) data has existed for many years. However, the correct application of the collected data has been open for discussion and evaluation in recent years. Data collection hardware has led the way for the development of the LiDAR industry particularly with respect to engineering services. The software to process and model the data has lagged behind the hardware for data collection. Recently there has been a flood of software companies offering ways to ‘mine’ or model the data. Other issues have arisen as many service companies have provided data collection services without utilizing standard survey procedures, Quality Assurance/Quality Control (QA/QC) or licensed professional surveyors and engineers.

The intent of this report is to demonstrate that LiDAR data, when captured using generally accepted survey control procedures, will result in data which can be used for design purposes. This report is given with respect to bridge design and repair. But, it also shows, with respect to the transportation industry, that when collected and ‘mined’ properly, LiDAR data can save time, money and minimize survey safety risks and reduce lane closures.

While it is our opinion that LiDAR will eventually lead to more and more work being done as “Desk Top Survey”, it should be noted that LiDAR is one of many tools that can and should be used in the evaluation and design of transportation projects.
**Project Objective**

The main objective of this project was to evaluate static LiDAR technology available for three-dimensional bridge surveying and design deliverables and various pre-construction purposes.

Other objectives included:

1. Cost evaluation of LiDAR vs. traditional survey costs.
2. Required training for bridge designers and pre-construction engineers.
3. Evaluation of the required time for various deliverables.
4. Assessment of LIDAR data for pre-construction projects.

Finally, it was the initial desire of the TAC to utilize this project to develop a standard for future RFPs to secure High Density Scans or High Definition Surveying (HDS) for bridge design and pre-construction engineering. This effort will be done as a future effort in conjunction with McNeil Group as funding becomes available.
Background

In April 2009, McNeil Group contacted Utah Department of Transportation regarding the possibility of presenting LiDAR data capture and software evaluation to the UDOT’s technology group at the UTRAC workshops. UDOT’s Research and Development (R&D) department invited McNeil Group to present its data of a bridge they scanned in Draper, Utah (Union Pacific Bridge). The presentation included the 3D data captured – point cloud, as well as modeling and data mining software capabilities. McNeil presented features such as pedestrian tunnels, manufactured stone details, lighting and lamp details as well as dimensional accuracy. McNeil’s proposed LiDAR software evaluation project was chosen to represent the “New Technology” Group receiving funding from UDOT R&D and Federal Highway Funds for further study. McNeil Group (professional surveyors, structural and civil engineers) was to be the principal investigator evaluating various software programs for modeling, data extraction and data processing applications for transportation purposes.

After several months, UDOT contacted McNeil Group and asked them to meet with several UDOT departments (Maintenance and Asset Management, Pre-construction Engineering, Bridge Engineering and R&D) throughout August and September 2009 in an effort to redefine the objectives of the project. The new scope of work was to scan a bridge to evaluate LiDAR accuracy and its potential use in bridge design compared with traditional methods. The Taggart Bridge on Highway 84 just north of...
Morgan, Utah was selected because it would be going through a redesign to remove and replace the original 1960’s deck and had already been surveyed using traditional methods.

During October and November 2009, UDOT asked various pre-project questions to help determine long-term project objectives and sustainability. The questions ranged from safety of the laser beam to cost investments that may be needed to utilize, model and mine the data. (See appendix I) Due to changes in scope of work and potential conflict of interest, UDOT’s R&D assumed the role of principal investigator for the project.

UDOT gave McNeil Group verbal Authority to Proceed on December 3, 2009, and data collection began that day. McNeil completed data collection two days later collecting over 70 million data points (70, 345, 310). McNeil met all time schedules for processed point clouds, models, line work and animation. The project ran smoothly with no delays and was concluded with a final review and training on February 17, 2010.
Project Details

Contract Objectives

Primary Objectives of the research project were to:

1- Evaluate static LiDAR technology available for three-dimensional bridge surveying and design deliverables and various pre-construction purposes.

2- Assess the usefulness of 3D HDS to bridge design, maintenance and pre-construction engineering.

Secondary Objectives of the research project were to:

1- Compare traditional surveying with LiDAR technologies and the associated costs.

2- Determine the amount of training required for bridge designers and pre-construction engineers to use this technology.

3- Evaluate the delivery time and costs for various deliverables:
   a. Point cloud
   b. 2D line work
   c. 3D line work
   d. 3D modeling
   e. Animation (Fly-through)

4- Develop a standard for future RFPs to secure HDS for bridge design and pre-construction engineering. (Note: This task was postponed by UDOT’s R&D in order to accommodate funding constraints.)

Task Descriptions

Static Scan Taggart Bridge Experiment Feature Pricing

a. High Density Scan/Survey of Taggart Bridge
   (UDOT requested that railroad flagger costs were segregated from other LiDar survey costs.)
1- Data Capture

First, horizontal and vertical control were established and verified from the 11 control points provided by UDOT (Points 108, 111, 112, 11, 3, 44, 45, 48, 49, 4 and 54). Additional targeted points were located or shot in so the various LiDAR scans could be registered or “stitched” together.

Next, the surveyor set up the instrument (scanner) similar to a traditional survey and started the system boot on the laptop computer. The system boot up consisted of checking and coordinating scanner systems such as camera, tilt and angle of the mirror, laser functions, etc. The scanner then gathered photo images via the camera. Due to the time of year and shortened time of daylight, many of the photos collected did not provide the best colors due to shadows from the surrounding hills and structures. But it should be noted that sunlight (or the lack thereof) does not impact the data collection process. (See photo entitled “Point Cloud as seen through Gray-Scale Intensity View” on page 12.)

After acquiring the photo images, the scanner collected data in a dome scan of 270 degrees by 360 degrees. (Note that the dome and 360 degree scan is employed when that amount of data is needed and is adjusted for each individual set up area.) Points were acquired and then registered (stitched together) using the common tie points which had been located.
during the setup process. This process was repeated 17 times to capture bridges, the relevant structural members and everything in the area.

Laser Scanner Setup

2- **Survey Control**
   The 11 UDOT control points were located with a Total Station to verify accuracies to the given points for northing/easting and elevation. The statistical report is attached in Appendix II.

3- **Process Data/Point Cloud of Taggart Bridge**
   This process involved “stitching” or registering all the scans or point clouds together making them relative to each other. After combining the scans or point clouds into one point cloud, data outside of the area of interest were removed. Additionally, “noise” (items such as data collected from passing vehicles, people, etc.) was removed so the data represents only the bridge and areas of interest. The point cloud was also compared to the control points establishing a final statistical accuracy of 0.022’ for both horizontal
Point Cloud as seen through Gray-Scale Intensity View
and vertical control. (See Appendix II) It should be noted that the other
points of interest were analyzed as to statistical accuracy. Appendix II.a
provides similar analysis for a sample population of various points
gathered in the field.

4- Desk Top Survey (DTS)/Computer Aided Design (CAD)
This process, often referred to as mining the data, was performed to
identify points of interest such as striping, edge of pavement, beams,
girders, diaphragms, decking, guardrails, abutments, bents, bearing pads,
retaining walls, webs, flanges, etc. Once identified, these items were
then extracted from the point cloud data.

5- 3D Modeling and Line Work
The “mined” data from the DTS/CAD phase was then used to extract 3D
models and lines of the existing features and points of interest using
various proprietary modeling software such as AutoCAD Civil 3D,
Microstation and Cloudworx. These files were then used to prepare the
various deliverables.

The models depict the entire site and various items of interest (i.e. bridge
height relative to the railroad tracks, power line drapes and clearances,
etc.) by rotating the object to show it from various perspectives.
6- **2D Line Work**
The 3D model was then used to extract the 2D line work. This line work was compared and contrasted to the original construction documents. Several areas were evaluated, but of particular interest were the center lines of the girders which were 3-6” off from the actual bridge dimensions. LiDAR data improved and enhanced this process. Additionally, several other points of interest such as the vertical location of the abutments on the retaining wall side of the bridge were shown to be more accurate with the LiDAR data. Beam splay, girder deflection and camber and other points of interest were evaluated as well.

7- **Animation (Fly-Through)**
“Fly-Through” videos were produced using the 3D point cloud and various 3D models. These videos demonstrate the construction of the bridge by structural component as well as general views and perspectives enabling those who did not visit the site to gain a perspective as if they had visited the site. These videos also show the entire site and various points of interest (i.e. girders, diaphragms, decking, guard rails, pole location, etc.), rotating the object to show it from various perspectives in a small .avi or .mpg format. While one video was required contractually, McNeil provided several versions enabling UDOT to see the visualization potential of the data and models.
Project Results

Primary Objectives of the research project were to:

1- Evaluate static LiDAR technology available for three-dimensional bridge surveying and design deliverables and various pre-construction purposes.

Results: LiDAR proved to be invaluable in the design of bridges and structures, providing highly accurate data such as:

a- Measuring Beam Seats;

b- Measuring Beam Deflection and Camber (this may be a task to be performed as the bridge deck is removed to show the rebound in the beam for concrete quantity projections);

c- Measuring Beam Splay;

d- Identifying and Measuring bearing pad/plate dimensions;
e- Adjusting original construction documents by superimposing them on top of the LiDAR data and models;
f- Correcting Girder center lines on original construction documents (approximately 3-6 inches);
g- Identifying potential bridge subsidence or settling and other deterioration such as cracks, spalling, corrosion and bridge damage.

Identification of Bridge Deterioration

2- Assess the usefulness of 3D HDS to bridge design and maintenance and pre-construction engineering.

**Results:** The 3D HDS technology will greatly benefit bridge and structure design, furnishing data previously difficult to obtain and in quantities practically unattainable. Similar results for civil work and asset mapping are expected as precise locations and volume calculations will be easily obtained.

**Secondary objectives** of the research project were to:

1- Compare traditional surveying with LiDAR technologies and the associated costs.

**Results:** While traditional surveying and LiDAR use similar control techniques, the vast amount of data collected in less time make the comparison imperfect if not impossible. It was reported that traditional survey required several trips (over 2 weeks to collect) and provided over 3500 survey points. The 2 day LiDAR process collected over 70 million data points with statistical accuracies of 0.022’. The post processing efforts were completed in one day.
The true cost savings for any LiDAR-involved project will not be LiDAR survey vs. traditional survey, but will come from improved management and engineering decisions due to the amount and accuracy of the data. Additionally, reduced project schedules and less rework will occur due to the accuracies of data. (See appendix II for LiDAR error report.)

It is noteworthy to mention that safety is improved dramatically over traditional survey. Crews are not at risk with LiDAR because measurements are taken from outside the lanes of travel. The survey can occur while traffic proceeds because the LiDAR can be collected within a 300 ft. radius. Also, traffic delays are eliminated because lane closures are not required. In most cases, the need for a railroad flagger will be eliminated as well. Also, it should be noted, that while a railroad flagger permit was obtained for the LiDAR data collection, it was not necessary in that all data was collected outside of the railroad right-of-way and could be accessed without entering such. This would result in time and money savings for coordination efforts with the railroad.

2- Determine the amount of training required for bridge designers and pre-construction engineers to use this technology.

**Results:** During the four-hour final presentation and training session, several UDOT employees became familiar enough with TruView and Pointools software to be able to demonstrate the needed skills and perform them at a beginner level. With practice, most felt the process could be mastered, but also indicated that the modeling of the data should be left to consultants who work with this type and amount of data regularly.

3- Evaluate the delivery time and costs for various deliverables:
   a. Point cloud
      **Results:** Collection time was approximately 2 days.
   b. 2D line work
      **Results:** see 3D Modeling below
   c. 3D line work
      **Results:** see 3D Modeling below
   d. 3D modeling
      **Results:** The actual process of “mining” and modeling the data begins with the 3D Modeling and then proceeds to 3D and 2D Line work through extracting this data from the 3D Model. The 3D line work becomes very complicated and confusing due to the many lines at the various elevations. The 2D line work and 3D models are much easier to work with for drawings, comparisons and clash detection. The actual time and costs to complete the project were comparable to traditional methods.
   e. Animation (Fly-Through)
      **Results:** This 3D process does not have a traditional counterpart and is minor in the total time and cost of the project but provides a superb visualization tool for management, public relations, communities and contractors alike.

4- Develop a standard for future RFPs to secure HDS for bridge design and pre-construction engineering.
**Results:** This task was eliminated from the project scope. However, McNeil Group will collaborate with UDOT as this effort is defined in the future.
Schedule of Deliverables

Phase I: Static Scan Taggart Bridge
1- Point cloud of Taggart Bridge – provided 12/14/09 via DVD and with this report.
2- Processed Point Cloud of Taggart Bridge – provided 12/14/09 via DVD and with this report.
3- 2D Line Work (Microstation) – provided 2/17/10 and again via DVD and with this report. (See also Appendix III)
4- 3D Line Work (Microstation) – provided 2/17/10 and again via DVD and with this report.
5- 3D models (Microstation) – provided 2/17/10 and again via DVD and with this report.
6- Animations (Fly-Through) – provided 2/17/10 and again via DVD and with this report.

Phase II: Training, Documentation and Final Report
1- Provide training to UDOT designers in “TruView” and “Pointools” Software – Completed 2/17/10.
2- Write RFP standards (this will be part of future efforts).
3- Determine the cost effectiveness of various deliverables (see previous results) and the type of computer hardware and software to run the data (this will be part of future efforts).
4- Document the results (both the positives and problems/issues) and compile the McNeil final report (included in this report).
Cost Analysis

Traditional Survey (Collected XX survey points)

Total man hours (approximately 2-man crew for 12 working days)  192+ hours ($11,520.00)

Duration  16 – 17 weeks
Boom Rental  $1,000.00
Flagger Cost (generally several days)  $480.00

LiDAR Survey (Collected 70 million survey points)

Total man hours (includes control)  18 hours ($3,150.00)

Duration  2 days
Boom Rental  -0-
Flagger Cost  -0-

Savings (Traditional Survey less LiDAR)

Man hour savings  174 hours ($8,370.00)
Duration savings  14 – 15 days
Boom Rental  $1,000.00
Flagger Cost  $480.00

It should be noted that this traditional cost comparison only includes the data collection portion of the efforts and is not an “apples to apples” comparison. This is due to the vast difference in the amount of data collected. The real savings are achieved through:

1. Risk mitigation
2. Safety of personnel
3. Better project decisions due to facts, not interpolation
4. Improved project schedules
5. Management and public awareness from the data’s ability to enhance project visualization and understanding

The approximate delivery time* for the various deliverables are:

- a. Point cloud  2 days after data collection
- b. 3D modeling  10 days
- c. 2D line work  2 days
- d. 3D line work  included in 3D model
- e. Animation (Fly-Through)  3 days (note: includes six different videos)
*It should be noted that this will vary due to the complexity of each project.

After several attempts to collect this data from appropriate UDOT personnel, McNeil was instructed by the project Manager to report what was verbally communicated during the project. Unfortunately there is no documentation available to McNeil to validate the verbal report. Should this be provided, the report will be updated/corrected at that time.

However, it was estimated that actual data collection time was 192 hours reported in the line above. It is known also that several trips back to the site were made in order to collect data which was missed or to verify accuracy of suspect data. This would not only lengthen the duration but increase project cost for additional trips, mileage etc. and is common practice for traditional survey.

This is generally not the case with scanned data because of the vast amount of data collected. (Traditional survey 3500+ data points vs. 70 million plus for LiDAR data collection). Intuitively, one would believe that the vast difference in the amount of data collected would minimize the need for return visits to the site which has now been captured geometrically with HDS. This would then lead to shortened project schedules/duration which would save additional project budget which is not shown in this analysis.
**Conclusion**

LiDAR is the wave of the future. LiDAR data collection compared to traditional data collection will be analogous to electronic CAD work compared to board drafting. The LiDAR process was faster, more efficient and drastically more precise due to the greater quantities of data that can be collected and “mined”, modeled and evaluated in a shorter amount of time. Better decisions and project objectives are achievable because decisions are made on more facts and less interpolation/estimation. The only limitations to LiDAR data collection and modeling will be our own inabilities to let go of the past and embrace the future.**

**In response to inquiries regarding LiDAR data collection limitations, the following is provided:**

Specific to this project, LiDAR data collection evaluation for softscape was not part of the scope of the project. McNeil would be supportive of such a project to evaluate LiDAR data collection vs. traditional survey data collection for softscape.

However, it should also be noted that in several of the meetings, both pre and post contract award and during the UTRAC workshop, LiDAR data collection for softscape was discussed. Those within UDOT who have raised these concerns were not present at those meetings. Those present saw the results as reported here in.

It was reported that the quantities of data collected are the same for softscape and hardscape. However when “mining” or analyzing the data, 1\textsuperscript{st} and 2\textsuperscript{nd} returns of the LiDAR data must be evaluated in order to distinguish the difference between LiDAR data for foliage and plant matter and LiDAR data for ground surface. The density of the plants and foliage will impact how much ground surface LiDAR is collected. McNeil’s experience and the reported experience of other world-wide data collection service providers is that LiDAR still collects more ground surface data than traditional survey. This was demonstrated at the UTRAC workshop which showed a topographic survey for the area surrounding the Draper Bridges. Additionally, McNeil is providing a copy of a topographic survey for a recent LiDAR survey for the Wendover Airports which shows a topographic survey with contours which exceed those gathered by traditional survey. The data collected had a requirement for soft surfaces of 0.10 ft. and hard surfaces of 0.01 ft.

An additional limitation for LiDAR that was discussed during the Taggart project was the inability of some past projects to match control points and meet accuracy requirements. While the data and process was not made available to McNeil to evaluate, it was surmised by several UDOT officials that previous LiDAR data projects were performed by others who do not have the training and licensure in surveying and engineering. While LiDAR data collection is superior to traditional data collection methods, it still must follow procedures and standards which are generally accepted industry methods.
Another limitation of LiDAR is that it is line of sight. This can be compensated for in proper planning just as one would try to identify areas of interest in the planning stages of traditional survey data collection. However, again the rapid amount of data collected with LiDAR vs. traditional survey data collection far out-weights the limitation of line of sight and can be eliminated with properly planning.

Should other issues exist which need to be addressed, McNeil would be supportive of additional studies and exchange of information to improve the proper understanding of LiDAR technology.

Most importantly, it should be noted that LiDAR data collection and analysis work compared only to traditional survey costs and accuracy will not permit a greater improved project. Rather, the true understanding of its potential, allows one to “see the forest through the trees” in better project analysis and decisions due to the greater amount of information leading to the decision/evaluation process. Yes, there are times when a tape measure will do and is the best tool for the job. It is believed that common sense and UDOT’s tradition of making proper decisions will prevent an overuse of LiDAR data collection when a tape measure will suffice.
Recommendation and Implementation

Future projects for LiDAR implementation should be sought out aggressively. The TAC believes that LiDAR data collection and data mining/modeling should be used on all precast deck bridge design and should be implemented in the removal of bridge decks to monitor and evaluate beam/girder rebound. Several TAC members have commented that if the decision were solely their own, LiDAR would be used as often as possible; the only limitation is awareness within UDOT of LiDAR capabilities. These statements were based on the findings and results that culminated in better and more precise planning and decision making.

Further, it is recommended to look for ways to use and qualify a LiDAR process for structure and bridge monitoring (both in subsidence/settling and deterioration). Mobile data collection should be pursued to qualify it for asset mapping and management.

Other applications include but are not limited to:

1- As-built/record drawings for all bridges and UDOT structures
2- All remodel, replacement and rework efforts
3- Volume calculations
4- Bridge subsidence/settling and deterioration monitoring
5- Asset management
6- Public relations/community involvement
7- Monitoring surrounding structures and buildings during road construction
8- Sign location and evaluation
9- Accident clean up – quickly scan and evaluate after clean up.
10- Intersection evaluations
11- Assessing site specifics for pre-construction engineering

The committee recommends implementing LiDAR as quickly and as often as possible.
APPENDICES

Appendix I – Pre-project Questions and Answers
Appendix II – Error Report – UDOT Provided Control Points
Appendix II.a – Error Report – Various Field Points

Appendix III – Deliverables
   A – 2D Line work – Drawings
   B – Training and Training Materials
      i – TruView
      ii - Pointools
   C – Electronic Files
   D – Topographical Survey
Appendix I – Pre-Project Questions and Answers

Additional questions from UDOT and answers by McNeil and Tridex are listed. (It should be noted that at one point the scope of work included mobile scanning by a McNeil/Tridex Team.) This is not intended to be the final study/analysis of this project, but rather to assist UDOT in its preliminary evaluation for feasibility purposes.

1- Investigate and describe the new software and hardware capability for the Static Scan of the Taggart Bridge.
   a. Hardware to be used on this project is the Leica ScanStation II or Leica C10 which collects up to 50,000 survey grade data points per second.
   b. Software which will be utilized on this project are Pointools, Cyclone, AutoCAD, Microstation, TruView and Cloudworx. No software compatibility issues are foreseen at this time as the data has been successfully exported to Microstation, Oracle and other UDOT software (see further definitions below)

2- Describe if the survey data can be processed using existing UDOT software.
   a. The additional software, Pointools and TruView will provide visualization of the point cloud and provide measurements. These will provide simple, easy-to-use visualization of the survey data. All will be provided free of charge.
   It has been reported that small point cloud files may be processed in current Microstation software. However, the estimated size of the data for the bridge will exceed the reported size compatible with Microstation. Once the data has been post processed and modeled using the above listed software, existing UDOT software (Microstation) can be used seamlessly. This should be in line with the stated UDOT goals to use consultants for design and project management efforts as UDOT shifts to a management role.

3- New Software support costs.
   a. Free Pointools and TruView software will provide for visualization and measurement needs. Current pricing for the software is approximately $1,300 for Pointools, $22,000 for Cyclone and $4,000 for Cloudworx per license. Further analysis for volume purchases can be obtained during the project.

4- Investigate if the current UDOT design software can provide the same function as TruView and Pointools
   a. The current UDOT design software cannot provide all of the same functions that Pointools and TruView offer. Pointools offers additional data manipulation, visualization and functionality. TruView allows for the data (both the point cloud and photographic images to be streamed and viewed over the internet for collaboration and markup of those associated with the project. The point cloud can be brought into the UDOT design software as a point file in a Northings, Eastings and Elevation .txt format.

5- If new software is needed, cost analysis of the software and support will be included in the cost analysis of the Cost Analysis report.
   a. No additional software will be needed. This will be verified as data is exported to UDOT platforms. The additional software is free of charge and can be distributed to anyone. Both Leica and Pointools will support their own software. Previous
demonstrations to UDOT personnel, (Fred Doehring Jason Richins etc. showed the model files exported into Microstation. In addition, see numbers 1-5 above.

6- Describe the need for training in TruView and Pointools if 3D model can be imported to Microstation and Inroads
   a. While training in TruView and Pointools is not needed should UDOT only desire to have a final deliverable in Microstation format for the 3D model and line work, the raw data (point clouds, images etc.) have additional value by bringing the site to the designer’s desk. Visualizing the raw data can add the benefits of understanding the site and existing conditions which cannot be displayed by a model or line drawing.

7- Provide all costs for comparison analysis to show the detail to do LiDAR in comparison to standard Conventional Survey.
   a. While a true ‘Apples to Apples’ comparison cannot be made due to the vast difference in quantity and quality of data, it is believed that this data will prove to be a cost savings in rework, safety, schedule and other cost categories. It is anticipated that the final analysis will show that the savings/improvements in those areas will more than offset any cost disparity between traditional and high density surveying. (see also #14 below)
   b. Traditional Survey Costs are estimated below, Please note that the scope of work is estimated as well and is difficult due to traditional surveying’s inability to measure the bridge superstructure (i.e. beams, girders, flanges, webbing, rivets, nuts, bolts etc). Further discussions with the UDOT survey/bridge design group would/will provide a more accurate estimate. This estimate is provided for comparison and budgetary purposes only.
      • Establish Horizontal and vertical control and initial lineout time (meet with the State) - $1,500
      • Locate strategic points and topo structures (2)- $3,000
      • 2D drawings- $1,560
      • 3D drawings- $1,950
      • Animation- $1,500
      • Total $11,010

8- Identify cost of RR flagger.
   a. Currently, no costs are expected for this line item. Should this expense be necessary for cost analysis and the project evaluation, McNeil will secure cost estimates. Note, at the date of this revision (11/19/09), both UDOT and UP permits had expired but are in process of re-application and should be ready by Tuesday 11/23/09.

9- Help UDOT identify a valid and affordable Data Collection process.
   a. It is believed that current information provided along with the finalized project will provide UDOT with an affordable Data Collection process while improving safety, increasing quality and quantity of data, reducing rework costs and field changes and shortening project schedules making 3D data collection the method of choice.

10- Provide cost analysis for training on how to use this technology and the costs for purchase or rental of LiDAR software and hardware to be used by surveyors to create deliverables for projects.
   a. The cost to implement LiDAR Data collection will vary depending on the level of implementation UDOT seeks. Generally, static LiDAR scan data collection equipment runs from $120,000 to $150,000 per machine. Software costs are defined in number 3 above and can go higher. Training on both hardware and software will range from 9-12 months depending on individuals and circumstances.

11- Provide comparison analysis in terms of costs, accuracy and time between mobile survey feature inventory data collection for UDOT.
a. See mobile survey comments

12- Investigate the process to convert the mobile survey data/information to UDOT Operations Maintenance System (OMS). Assure UDOT will have a simple and seamless data import into the existing OMS.
   a. See mobile survey comments

13- Investigate or describe the process of converting a LiDAR “point cloud” file to .dgn-ready-to-use file
   a. LiDAR will be processed using point cloud processing software. Line work models and feature data will be extracted from the processed point cloud software and will be exported to .dgn files for final drafting. The data can also be decimated and exported as a northing, easting and elevation (xyz format) txt file for import into Microstation .dgn Inroads use

14- Describe the process of getting additional data (which is later defined as critical or important) from the same scan to import to UDOT Systems
   a. Data which is determined to be critical or important after the data collection process can merely be viewed and measured on the original point cloud or processed data. The free-viewer-easy-to-use icons can be utilized in point and click fashion to obtain distances and measurements that were not known to be of interest at the time of data collection. (Note: this is another cost savings to the traditional survey process because crews are only mobilized once). McNeil will teach UDOT how to export data out of point cloud viewing software's. On future projects, UDOT can also hire/subcontract additional services at market-rate fees to measure, mine and define the critical information.

15- Describe the process and cost of providing training to UDOT at this time and any needed future training.
   a. McNeil/Tridex will secure the free software copies and install such on the need UDOT computers. This process will be taught to and overseen by UDOT’s IT group. Training will be provided to the various UDOT departments during the half day session. Training will be conducted at UDOT headquarters in the Calvin Rampton Building.

The list of items below is from the original UTRAC Workshop Research Problem statement which was written and presented at that time. Items not addressed above have been listed to assure that the project will address all items.

1- Scan Bridges for Bridge inspection and maintenance – maintain data and compare 6-12 months later for comparative/deterioration evaluative purposes
   a. A second scan at a future time would be required in order to use the data for bridge inspection and maintenance. This could be accomplished at a later date under a separate contract. The data collection on a later scan could then be overlaid on the original scan to determine settling and deterioration.

2- Speed of processing/modeling data (verify duration of deliverable – scan to model)
   a. The estimated time from start to finish is approximately 4-5 working days. This will be part of the final report/analysis.

3- Pixels vs. Point Clouds
   a. Almost all scanning hardware incorporates cameras. Pixels are integrated with the point cloud xyz data to provide a possible view with colors that is comparable to a photo but allows for measurement of data. Other views of the data, such as intensity views, show reflectivity of the data. Pixels are not necessary, but add another dimension to the perspective.

4- Show different Methods of Point Cloud Extraction.
a. The initial R&D project was to evaluate the various methods of point cloud extraction. Over time, this scope has changed and no longer includes a comparison of data collection and extraction methods. This analysis and comparison could be part of another study.

5- Modeling abilities of data and various software.
   a. See number 4 above

6- Platform Compatibility
   a. See answers 1-6 above

7- Current Industry Standards
   a. Current industry standards are being defined as this equipment and software evolves and improves. McNeil and Tridex follow general accepted surveying QA/QC techniques and best practice and methods and have their own workflow and standards. Copies of the project workflow and standards will be provided as part of the study.

8- Safety of Scanning Survey vs. Conventional Method
   a. Laser Scanning dramatically improves safety due to the ability to obtain data from a distance, thus eliminating the need to stop traffic and lane closures. This reduces survey personnel and public risk of accident. This laser technology does not pose any threat to personal harm or injury.

9- Determine capabilities for bridge monitoring
   a. This can be done but is not part of this effort as it will require a second scan at a later date. (see number 1 above)

10- Verify quality of data
    a. Critical Points will be reconciled with 8-10 UDOT survey points on the bridge.

11- Measure deflection and warp (establish time goal and measure to the goal for the Modeling/evaluation process)
    a. With the change of scope, this effort will be part of a second study.

12- Print physical 3D composite model of bridge.
    a. This particular requirement requires special equipment. A price to provide such could be obtained from an outside source but is believed to be quiet expensive. This requirement was discussed earlier and felt to be eliminated by 3D computer models and fly-throughs.

13- Provide presentation of results for interested parties
    a. McNeil/Tridex look forward to presenting both at the UTRAC workshop and the 2010 UDOT Engineering Conference or other UDOT venues.
## Appendix II – Statistical Error Report

### UDOT Control Points

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<th>UDOT Control</th>
<th>Scanner Location</th>
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## UDOT Control Points

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<td>112</td>
<td>Mid West</td>
<td>-0.010</td>
<td>-0.022</td>
</tr>
<tr>
<td>112</td>
<td>West Bound West</td>
<td>0.029</td>
<td>-0.010</td>
</tr>
<tr>
<td>112</td>
<td>West Bound West</td>
<td>-0.019</td>
<td>-0.002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Average</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-0.001</td>
<td>-0.002</td>
<td>0.012</td>
<td>0.029</td>
<td>-0.021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.001</td>
<td>0.000</td>
<td>-0.001</td>
<td>0.031</td>
<td>-0.031</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.000</td>
<td>-0.001</td>
<td>0.018</td>
<td>0.043</td>
<td>-0.046</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.014</td>
<td>0.013</td>
<td>0.009</td>
<td>0.035</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.014</td>
<td>0.013</td>
<td>0.009</td>
<td>0.035</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.022</td>
<td>0.021</td>
<td>0.011</td>
<td>0.050</td>
<td>0.002</td>
</tr>
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</table>
## Various Field Points

<table>
<thead>
<tr>
<th>Point Description</th>
<th>Error</th>
<th>Absolute Error</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>E</td>
<td>Z</td>
</tr>
<tr>
<td>Edge of asphalt</td>
<td>-0.022</td>
<td>0.042</td>
<td>-0.009</td>
</tr>
<tr>
<td>Edge of asphalt</td>
<td>0.005</td>
<td>-0.013</td>
<td>-0.006</td>
</tr>
<tr>
<td>Edge of Concrete</td>
<td>-0.001</td>
<td>0.006</td>
<td>-0.081</td>
</tr>
<tr>
<td>Edge of Concrete</td>
<td>0.034</td>
<td>0.137</td>
<td>-0.012</td>
</tr>
<tr>
<td>Edge of Concrete</td>
<td>0.005</td>
<td>-0.027</td>
<td>-0.009</td>
</tr>
<tr>
<td>Top edge of Concrete Barrier</td>
<td>-0.046</td>
<td>0.051</td>
<td>-0.006</td>
</tr>
<tr>
<td>Beam</td>
<td>0.019</td>
<td>0.004</td>
<td>0.028</td>
</tr>
<tr>
<td>Column Bottom</td>
<td>-0.020</td>
<td>0.132</td>
<td>-0.005</td>
</tr>
<tr>
<td>Solid White Line*</td>
<td>0.003</td>
<td>0.016</td>
<td>0.111</td>
</tr>
<tr>
<td>Solid White Line*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Concrete*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Concrete*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Concrete*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Concrete*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Concrete*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid White Line</td>
<td>0.027</td>
<td>-0.047</td>
<td>0.002</td>
</tr>
<tr>
<td>Solid White Line</td>
<td>-0.007</td>
<td>0.019</td>
<td>0.002</td>
</tr>
<tr>
<td>Top Barrier</td>
<td></td>
<td>-0.006</td>
<td></td>
</tr>
</tbody>
</table>

Average: 0.050 0.028 0.054
Median: 0.028 0.009 0.043
Standard Deviation: 0.047 0.036 0.045
Max: 0.142 0.111 0.142
Min: 0.007 0.002 0.002
Note: Horizontal scan points were determined by using the nearest point to the surveyed coordinate. This is especially true in the case of lines and edges. It should also be noted that by interpreting and extrapolating, the horizontal location accuracy improves as the data is modeled.

*data collected with GPS
Appendix III - Deliverables

A – 2D Line work – Drawings

B – Training and Training Materials
   i – TruView
   ii - Pointools

C – Electronic Files

D – Topographical Survey
From: Chet.Roan@hds.leica-geosystems.com [mailto:Chet.Roan@hds.leica-geosystems.com]
Sent: Monday, April 19, 2010 6:55 PM
To: Alan DeMANN
Cc: Geoff.Jacobs@hds.leica-geosystems.com
Subject: Re: UDOT project final report

Alan,
We have no issue with you training them on the use of TruView.

Leica Geosystems provides McNeil Group and UDOT authorization to use a copy of the Leica TruView Manual Issue 1.1 January 2007 as an attachment to UDOT Taggart Bridge Project # 8RD1054H final report. All other terms of the license agreement or nondisclosure agreement remain unaltered, intact and enforceable.

Please let me know if there is any other assistance that I can offer.
Thanks,
Chet

Chet Roan
Northwest Sales Manager
Leica Geosystems HDS
Phone: (208) 371-9404
e-mail: chet.roan@leica-geosystems.com
Leica TruView

Version 1.0
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System Requirements

- Microsoft Windows XP (SP1 or higher),
- Windows 2000 (SP3 or higher with up to date security patches)
- Microsoft Internet Explorer Version 6.0 or higher
- 500 MHz Processor or faster
- 256 MB RAM or higher;
- OpenGL accelerated graphics card
- Currently you must use the Microsoft Internet Explorer Web browser 6.0 or later. Other browsers such as FireFox or Netscape might be supported in the future.
- ActiveX must be activated in the browser.
Installation

To obtain the TruView Plugin...
2. Register and download the plugin.

To install or load the TruView Plugin...
1. Double-click on TruViewSetup.exe or run it from the command line.
2. Follow the instructions on the screen.
Note: Internet Explorer 6.0 or later must be available for this plugin.
Note: Be sure to restart your computer if asked to do so at the end of the installation.
Otherwise TruView will not work properly.

To allow TruView to work if the IE security system is blocking access...
1. There is a yellow bar under the tool bars of Internet Explorer. Click it to allow ActiveX components to run. Then TruView will run.
**TruView Site Map**

Each TruView scene is a panoramic (360 degree) image of point cloud data with the viewpoint being located at the same location as the scanner that captured the point clouds. Your viewpoint in TruView is from the exact scanner location that you chose. You can pan around the scene and zoom in and out, but cannot fly around the scene as in some 3D systems. Your viewpoint is always located at a scanner location.

Often, a single project uses many scanner locations. In such cases, you can move from one scanner location to another to have various viewpoints within the project. Each viewpoint has a separate Scanworld.

![Site map - Two Scanner Locations (Viewpoints)](image)

The site map contains image icons located at the center point of each available TruView scene. (The site map above has two scanner locations.) Click on a triangle icon and TruView launches inside Internet Explorer.

*NOTE: If Internet Explorer (IE) is not your *default* browser, then you must open IE first.*
Entering a TruView Scene

1. To enter a TruView scene, either visit a web page which is a site map, or go to an HTML document on your local drive, which has a TruView site map generated by the Cyclone PUBLISHER. The filename of the site map on your local computer is SiteMap.htm.

2. Open the web page or html document.

3. The site map contains image icons located at the center point of each available TruView scene. Click on a triangle icon and TruView launches inside Internet Explorer. **NOTE: If Internet Explorer (IE) is not your default browser, then you must open IE first.**

4. You can begin panning, zooming, marking up and using all the other features of TruView.

Following is an example of a TruView window:
Basic Concepts

Leica TruView is very simple to use. After you understand the basic concepts you will find it is easy to view, markup and measure point cloud data. The main thing to understand about Leica TruView is that it has three basic working modes: Measure, Markup and View.

Measure Mode

In Measure mode, the Measure tab and Measure Control are highlighted. TruView always opens in the Measure mode. This mode lets you move your viewpoint in, out and around the scene so you can find and look at your exact area of interest. It also lets you measure between two points or get the coordinate information for a single point. However, this mode does not place those values as permanent markups. They disappear if you change modes. It only reports them to the properties table at the left of the screen. If you want to place a dimension markup, use Markup Mode.

Markup Mode

In Markup mode, the Markup tab and Markup Control are highlighted.

This mode lets you place markups like rectangles or text. When you are in markup mode the view is frozen like a screen capture or snapshot. Markups are placed as a group together on a saved (frozen) view. You can have many saved views, each with its own group of markups and its own name.

View Mode

In View mode, the View tab and View Control are highlighted.

View mode allows you to jump from view to view. When you go to each saved view you can see the markups for that view. If any of these markups have a hyperlink (a feature allowed in markup mode) then you can navigate to those links by clicking on the markup in this mode.
Switching Modes
There are several ways to switch between the various modes. Sometimes the modes automatically switch to a new correct mode as you perform other actions. For example, clicking on a markup tool automatically switches you to the Markup Mode.

TruView always starts with Measure Mode activated. The Measure tab is selected and the Measure icon is highlighted.

To Enter Measure Mode
- Open TruView
Or
- Select the Measure Tab
Or
- Select the Pan/Zoom Mode Icon
Or
- Select either of the 3D Measurement Icons
Or
- Double click in a Markup view

In Measure Mode you can pan and zoom as well as take measurements. The values of the length, and ΔX, ΔY and ΔZ components for a line between two selected points are displayed in the properties panel in the Markup tab. The X, Y and Z components for a selected point are displayed in the properties panel in the Markup tab. The color "red" highlights the current measurement.

Measurements are retained until you switch to Markup or View mode. When you switch modes, all the measurements are deleted. (Distances between points and coordinate points are retained in Markup mode.)
To Enter Markup Mode

- Select the [Markup Tab]
  Or

- Select the Markup Mode Icon
  Or

- Select any of the Markup Item Icons on the 2D Markups toolbar

A selection of markup types is available in Markup mode. Markups are placed on a 2D frozen image. This image, along with its markups, is saved as a recallable view.

To Enter View Mode

- Select the [View Tab]
  Or

- Select the View Mode Icon

View Mode allows you to pan and zoom through the view. You can also move to a previously saved Markup view by clicking on the view name in the tab.

Measure in Measure Mode versus Measure in Markup Mode

The definition of Measure in the Measure Mode for TruView is not the same as a Markup Dimension. In Measure Mode, measuring is not a drafting or markup function. It is simply measuring the distance between two points or extracting the coordinate location of a single point. The measurement values are shown in the Measure Properties Panel. However, in Markup Mode measuring is a "permanent" Markup function.
Controls and Tools

Using Zoom/Pan Controls
In Measure mode you can Pan and Zoom.

Panning
Panning is the process of moving the direction you are looking. It is similar to turning your head. You can look up, down, left or right. There is more than one way to pan in TruView.

Pan Using the Mouse
By picking any point in the TruView display widow with the left mouse button and holding it down you can pan in any direction by dragging the mouse in that direction.

A red arrow stretches from the location you picked on the screen to the current location of the mouse. The farther you drag from the point you picked, the faster the scene pans. The red arrow shows the direction and how fast (arrow length) you are panning.

Panning Arrow

Pan Using the Icon
You can use the Pan Icon on the Controls Toolbar to pan the TruView scene.

You can pick anywhere on the icon to pan in the desired direction. If you pick once, the scene pans one small step. If you pick and hold, the scene begins to pan continuously until you release. For instance, picking in the upper right corner pans your view diagonally up to the right; picking on the right side of the icon pans to the right and so forth.

Zooming
Zooming is the process of moving towards or away from the direction you are looking. It is similar to moving your head closer to or further from a picture. There is more than one way to zoom in TruView.

Zoom Using the Mouse
With a wheel mouse, pick any point in the TruView display window by depressing and holding the wheel and move the mouse down the screen to zoom in and up the screen to zoom out.

**Zoom Using the Icon**

You can use the Zoom Icon on the Controls Toolbar to zoom the TruView scene.

You can pick the icon to zoom in or out. If you pick once, the scene zooms one small step. If you pick and hold, the scene begins to zoom continuously until you release. Picking in the upper portion of the icon (+) zooms in and picking in the lower half (-) zooms out.

**Using 2D Markup Tools**

A selection of markup types are available in markup mode.

![2D Markups - Tools](image)

Markups are placed on a 2D frozen image. This image is saved as a recallable view.

**Continuous Command Looping**

After you enter and complete a markup command, it remains active so you can place several of the same types of markups in a row without having to reselect the icon. You can terminate the command by right clicking and selecting “deselect” from the menu, or by selecting a different command icon.

The various markup types are:

- **Arrow Line.**
  - Pick a point where you want the arrow head and drag the line to the length and position you want
- **Circle and Rectangle**
  - Pick a point and drag in any direction to the size and shape you want
- **Text**
  - Pick a point for the upper left point of the string and type in the text
- **Coordinate**
  - Pick a point for which you want the coordinate value then pick a point where to place the coordinate text. A rubber banding leader line is attached from the pick point to the location of the text placement
- **Distance**
You are prompted to select a first and second point. You then place the distance text label at the desired location with a rubber banding line attached.

Note: If the scanner data has image data included for areas that were not scanned, such as the sky, then there are not any points you can measure to in those areas. Therefore, the system automatically darkens the non-measurable points so you can see the points that are measurable. This could be the entire sky or even stripes of data right in the main areas you wish to dimension. This depends on the density of the scanning and the scanning methods used to collect the data.

Editing Markups

You can edit any markup by first selecting it in the view area. “Handles” appear when a markup is loaded. You can also select the markup in the list of markups on the Markup Tab.

- Arrow Lines, Rectangles and Circles can have their location and size changed. You can also adjust the properties.
- Text can be moved, the properties can be changed, and you can edit the text string by right clicking on the text item in the view area and selecting Edit Markup from the right click menu. The cursor is placed at the end of the string, and you can only delete characters, add characters, and backspace.
- Dimension labels (Coordinate and Distance) can have only the location of the text label moved. You can also change the properties.

Deleting Markups

Select the markup in the display area or in the markup tab list and press the delete key, or select the markup in the display area and right click and select delete from the pop up menu.

Adding Hyperlinks to Markups

Select any markup while in markup mode and enter any valid link value in the Link: field of the markup tab. This can be a web URL such as www.hds.leica-geosystems.com or a file location on disk such as c:\temp\temp.txt.

The link value does not appear in the scene. To activate the link, you must go to the View Mode and double click on the object with the link.

Markup Properties

When any markup is selected you can set the properties for this entity on the markup tab. Different markup types have different markup properties that apply. For instance, an Arrow Line does not have any valid Font Size property.

The available properties are:

- Unit: The unit of measure for dimension labels
- Color: Main color for line work
Fill Color: Background fill color for Circle, Rectangle, Text and Dimension Label text.
Transparency: A percentage where: zero = opaque and 100 = totally transparent (invisible)
Line Thickness: A relative factor controlling thickness of main line work of all markups except text.
Font Size: For all markups with string characters
Link: any valid hyperlink location

**Markup Metadata**
When markups are created they retain some Metadata. You can see this data displayed in the markup tab. The Metadata retains the date the item was created and the Windows login user name that created the markup.

**Setting Defaults for Markups**
At anytime you can select the “Set As Default” button in the markup tab to save the current properties settings as the default properties to use for all new markups. This setting is saved for all TruView sessions on the current computer.

To share these settings with other users see [Sharing Settings and Markups](#).

**Measurements Tools**

Two measurement types are available in markup mode.

![Measurements](image)

Measurements - Tools

**XYZ icon** - Click this icon and then click the point for which you want coordinates.

**Ruler icon** - Click this icon and then click the points between which you want the distance.

The color "red" highlights the current measure or the selected measurement.

Measurements are retained until you switch to Markup or View mode. When you switch modes, all the measurements are deleted. (Distances between points and coordinate points are retained in Markup mode.)
Tabs

View Tab
Selecting this tab puts you in View mode, which allows you to jump from view to view. When you go to each saved view you can see the markups for that view. If any of these markups have a hyperlink (a feature allowed in markup mode) then you can navigate to those links by clicking on the markup in this mode.

This section discusses the fields in the three different tabs:

- **View** - Selecting this tab puts you in View mode, which allows you to jump from view to view. When you go to each saved view you can see the markups for that view. If any of these markups have a hyperlink (a feature allowed in markup mode) then you can navigate to those links by clicking on the markup in this mode.

- **Markup** - Selecting this tab puts you in Markup mode, which lets you place markups like rectangles or text. When you are in markup mode the view is frozen like a screen capture or snapshot. Markups are placed as a group together on a saved (frozen) view. You can have many saved views, each with its own group of markups and its own name.

- **Measure** - Selecting this tab puts you in Measure mode, which lets you move your viewpoint in, out and around the scene so you can find and look at your exact area of interest. It also lets you measure between two points or get the coordinate information for a single point. However, this mode does *not* place those values as permanent markups. They disappear if you change modes. It only reports them to the properties table at the left of the screen. If you want to place a dimension markup, use Markup Mode.
View Tab

**View Display**
List of available named views (e.g., View#100)
Clicking on a view displays that view.

**View Properties**
- **Created:** - Date when this view was created.
- **User:** - Name of the person who created this view.
- **Name:** - Name of the currently selected view.
- **Delete** button - Click to delete the selected view.
- **Update** button - Click to rename the displayed view.

**Markup Data**
- **Client side marks:** or **Server side marks:** Indicates the location of the currently loaded markup files, e.g., `markup.xml`.
**Import**: Click to import markups in an XML file, sent to you by someone, into your current TruView session. See **Importing Markups** for details.

**Export**: Click to create an XML file of your current markups to send to someone. See **Exporting Markups** for details.

**Load from Server**: Click to load the markup.xml stored on a server, other central location, or the Web, which contains markups that you want to load in your current view.

1. TruView displays a dialog to confirm that you want to overwrite the existing views and markups.
2. TruView clears all existing views and markups.
3. TruView searches markup.xml in the same place where you put the Scanworld’s published data. If this file does not exist, then nothing will be loaded. Otherwise, it will load the saved views and markups from the file. (The markups from the server overwrite the current markups. You must export the current markups if you want to save them.) See **Exporting Markups** for details.

**Load Local**: Click to load (UID).xml from your local machine. This file is created automatically when you close TruView. (The last auto-saved markups overwrite the current markups. You must export the current markups if you want to save them.) See **Exporting Markups** for details.

**Clear All**: Click to clear the scene of all markups. See **Clear All Markups** for details.

*Note: Server refers to the TruView directory on the local PC or on the intranet or internet.*

*Note: Client refers to C:\Documents and Settings\(User Name)\Local Settings\Application Data\TruView\(UID).xml*

For sharing markup data, see "**Sharing Settings and Markups**".

**Utility**

**Print**: Click to print the current view.

**Markup Tab**

Selecting this tab puts you in Markup mode, which lets you place markups like rectangles or text. When you are in markup mode the view is frozen like a screen capture or snapshot. Markups are placed as a group together on a saved (frozen) view. You can have many saved views, each with its own group of markups and its own name.
Markup Display

Current named view (e.g., < View#100 >)
List of drawing objects (Line, Circle, Rectangle, Position, Distance) in the current view. Clicking on an item in the list highlights that object in the view.
**Markup Properties**

- **Created**: Date when a specific markup was created. It is only displayed when a markup is selected.
- **User**: Name of the person who created a specific markup. It is only displayed when a markup is selected.
- **Unit**: Choice of meters, centimeters, feet and inches
- **Color**: Color chosen for lines, shapes and text
- **Color palette** button: Click this button to display a palette of colors. Choose a new color from this palette for lines, shapes and text.
- **Fill Color**: Color chosen for filling shapes. The actual fill color is the transparency percentage of this color.
- **Fill Color palette** button: Click this button to display a palette of colors. Choose a new color from this palette. The actual fill color is the transparency percentage of this color.
- **Transparency (%)**: This value determines the shade of the fill color. (A percentage where: zero = opaque and 100 = totally transparent (invisible).)
- **Line Thickness**: The thickness of the line in points
- **Font Size**: The size of the type in points
- **Link**: Enter a URL to a selected markup. (You cannot jump to it from this tab. It is only activated for the View tab.)
- **Delete** button: Click to delete a selected markup (line, text, shape, coordinate, etc.)
- **Reset** button: Click to reset the properties of the markups to their original default values.
- **Set As Default** button: Saves the chosen settings for future use in this mode.

**Markup Data**

- **Client side marks**: or **Server side marks**: Indicates the location of the currently loaded markup files, e.g., `markup.xml`.
- **Import**: Click to import markups in an XML file, sent to you by someone, into your current TruView session. See Importing Markups for details.
- **Export**: Click to create an XML file of your current markups to send to someone. See Exporting Markups for details.
- **Load from Server**: Click to load the markup.xml stored on a server, other central location, or the Web, which contains markups that you want to load in your current view.
  1. TruView displays a dialog to confirm that you want to overwrite the existing views and markups.
  2. TruView clears all existing views and markups.
  3. TruView searches markup.xml in the same place where you put the Scanworld’s published data. If this file does not exist, then nothing will be loaded. Otherwise, it will load the saved views and markups from the file. (The markups from the server overwrite the current markups. You must export the current markups if you want to save them.) See Exporting Markups for details.
- **Load Local**: Click to load (UID).xml from your local machine. This file is created automatically when you close TruView. (The last auto-saved markups overwrite the...
current markups. You must export the current markups if you want to save them. See Exporting Markups for details.

**Clear All**: Click to clear the scene of all markups. See Clear All Markups for details.

*Note: Server refers to the TruView directory on the local PC or on the intranet or internet.*

*Note: Client refers to C:\Documents and Settings\(User Name)\Local Settings\Application Data\TruView\(GUID).xml*

For sharing markup data, see "Sharing Settings and Markups".

**Utility**

*Print*: Click to print the current view.

**Measure Tab**

Selecting this tab puts you in Measure mode, which lets you move your viewpoint in, out and around the scene so you can find and look at your exact area of interest. It also lets you measure between two points or get the coordinate information for a single point. However, this mode does not place those values as permanent markups. They disappear if you change modes. It only reports them in the properties table at the left of the screen. If you want to place a dimension markup, use Markup Mode.
Measure Tab with Point Coordinates (Vertex) Chosen

Measure Tab with Measure between Two Points (Distance) Chosen

**Measure Display**
List of Vertex and Distance objects in the current view. Clicking on an item in the list highlights the object and displays its values below.

**Measure Properties**
**Type:** Distance (Distance between two selected points is displayed.): or Vertex (Coordinates of a point are displayed.)
**Color:** Shows the color of the objects in the current view.
**Color Palette Button:** Click this button to display a palette of colors. Choose a new color from this palette for lines and points in the current view.
**Unit:** Select one of Centimeters, Meters, Inches, Feet
**Distance:** Zero is displayed if a coordinate point (XYZ) is chosen.
- Distance between two selected coordinate points is displayed.
- $\Delta x$: Distance in the x direction between two chosen points.
- $\Delta y$: Distance in the y direction between two chosen points.
- $\Delta z$: Distance in the z direction between two chosen points.
**x:** X coordinate of the chosen point.
**y:** Y coordinate of the chosen point.
**z:** Z coordinate of the chosen point.
**Set As Default** button: Click this button to save the currently selected values for units and color.

**Markup Data**
**Client side marks:** or **Server side marks:** Indicates the location of the currently loaded markup files, e.g., `markup.xml`.
**Import:** Click to import markups in an XML file, sent to you by someone, into your current TruView session. See Importing Markups for details.
**Export:** Click to create an XML file of your current markups to send to someone. See Exporting Markups for details.
**Load from Server:** Click to load the markup.xml stored on a server, other central location, or the Web, which contains markups that you want to load in your current view.
1. TruView displays a dialog to confirm that you want to overwrite the existing views and markups.
2. TruView clears all existing views and markups.
3. TruView searches markup.xml in the same place where you put the Scanworld’s published data. If this file does not exist, then nothing will be loaded. Otherwise, it will load the saved views and markups from the file.
(The markups from the server overwrite the current markups. You must export the current markups if you want to save them.) See Exporting Markups for details.
**Load Local:** Click to load (UID).xml from your local machine. This file is created automatically when you close TruView. (The last auto-saved markups overwrite the current markups. You must export the current markups if you want to save them.) See Exporting Markups for details.
**Clear All:** Click to clear the scene of all markups. See Clear All Markups for details.

*Note:* Server refers to the TruView directory on the local PC or on the intranet or internet.
*Note:* Client refers to C: \Documents and Settings\(User Name)\Local Settings\Application Data\TruView\(GUID)\xml
For sharing markup data, see "Sharing Settings and Markups".

**Utility**

**Print**: Click to print the current view.
Right Mouse Button Options - (Modes)

**View Mode**
Clicking on the Right mouse button, when in *View* mode gives you the following options:

- Markup - Clicking this changes the mode to Markup.
- Measure (Pan/Zoom) - Clicking this changes the mode to Measure.
- Print - Clicking this prints the current TruView display.

**Markup Mode**
Clicking on the Right mouse button, when in *Markup* mode gives you the following options:

- Rectangle - Clicking this allows you to draw a rectangle in the view.
- Circle - Clicking this allows you to draw an ellipse or circle in the view.
- Line - Clicking this allows you to draw a line in the view.
- Distance - Clicking this allows you to measure the distance between two points in the view.
- Position - Clicking this allows you to obtain the coordinates of a point that you select in the view.
- Unlock - Clicking this changes a 2D view to a 3D view. When in Markup Mode, you can return to Pan/Zoom Mode by selecting Unlock.
- View/Hyperlink - Clicking this changes the mode to View.
- Pan/Zoom - Clicking this changes the mode to Measure.
- Print - Clicking this prints the current TruView display.

**Measure Mode**
Clicking on the Right mouse button, when in *Measure* mode gives you the following options:

- Markup - Clicking this changes the mode to Markup.
- Print - Clicking this prints the current TruView display.
Metadata and Help

**Metadata Button**

Clicking on the Metadata button displays the Metadata screen. It contains information about the TruView scene that is open. Following is an example of a Metadata screen.

![Metadata Screen – Example](image)

**UID** – Unique ID for the scene. This is generated automatically and cannot be changed in TruView.
Printed Documentation

**Background Dim** – Dims the parts of the background for which a point cannot be picked, because it was not part of the Scanworld. This is always ON and cannot be turned off.

**Scan Meta** – Data about the Scanworld

**Coordinate System** – Coordinates of the scanner location for the Scanworld

**Panorama Meta** – Shows the maximum error, point count within the display, and size for the given LOD value.

**View Defaults** – Default values when the view is opened

**LOD Meta** – Default values when the screen is opened

**Owner Info** – Information about the publisher of the Scanworld

Clicking the right mouse button and choosing “Export to Microsoft Excel” allows you to save the metadata to an Excel spreadsheet.

Clicking the right mouse button and choosing “Print” allows you to print the metadata.

**Help Button**

Click on the Help button to display TruView Help and obtain information about the version of TruView that you are using.
Settings

Several settings can be used to manage the display attributes of the markups in TruView. You can control:

- Units of measure
- Color (of all entities)
- Fill color (of rectangles and circles)
- Transparency (of fill color)
- Line thickness (of circles, rectangles and arrow lines)
- Font size (of text)

You can change these values for each entity by selecting it for editing and changing the values in the markups panel. To set the current values as the default values, simply select the “Set As Default” button in the markups panel.

Sharing Default Settings With Other Users

If you have a set of default settings that you want to share with other users, then you need to find the defaults.xml file on your system and send a copy to them. After they place it in the correct location, they will inherit your default settings. This file (defaults.xml) is on your system at C:\Documents and Settings\(User Login Name)\Local Settings\Application Data\TruView.
FAQ / Troubleshooting

Q: After clicking on the Scanworld triangle, I got the message: "Leica TruView Plug-In Not Loaded", but I had installed it. What is the problem?

A: It is possible that Windows security is not allowing you to run ActiveX. If this is the cause, then there is a yellow bar under the tool bars of Internet Explorer.
   a. Click it to allow ActiveX components to run for this session of Internet Explorer. Then TruView will run.
   b. To permanently allow ActiveX to run, configure Internet Security to run by going to Start > Control Panel > Security Center > Internet Options > Security settings > ActiveX controls and plug-ins, and select Enable.
   c. You can adjust Internet Explorer to allow TruView ActiveX content to display on your computer by selecting the Tools > Internet Options… menu of Explorer, open the Advanced Tab and in the Security section add a check mark to the “Allow active content to run in files on My Computer”.

Note: This problem can occur only if you are accessing a Scanworld on your local computer drive.

Q: Why doesn't my TruView scene open when I click on a triangle icon in the scene?
A: This is probably because, either you are not using Internet Explorer, or you do not have ActiveX enabled. Internet Explorer 6.0 or later is required, and ActiveX must be enabled. Only Internet Explorer is supported at this time.

Q: A link was entered in Markup mode, and the link is displayed when the object is selected. Why is there is no jump to the link? (The link target is not displayed.)

A: Navigating to links is only active in View Mode. Otherwise there would be no way to select the item for editing in Markup Mode.

Q: What is the meaning of the UID code (e.g., A47F0C8D-F9A3-4C45-9EEE-1734DF60AF20)?

A: The UID (Unique ID) code is an internal unique number that TruView uses to keep the markups paired to the right data sets. Each TruView panoramic scene is assigned a unique ID and the markup files also inherit this ID so they can be associated with the correct data set the next time you open things up.

Q: What is LOD?

A: LOD is the Level of Detail being displayed. It is proportional to the maximum point error. Zooming in or out changes the LOD that is displayed.

Q: Why does the fill color rectangle not display the actual fill color?

A: The fill color box is not affected by the current transparency settings. It displays the starting color, and the actual fill color is the transparency percentage of that color.

Q: What is the default transparency?

A: The initial system default transparency is 87%. You can change the default value when you save your defaults.

Q: Why does part of the image darken when I try to select a coordinate value for a point?

A: If the scanner data has image data included for areas that were not scanned, such as the sky, then there will not be any points you can measure to. Therefore, the system automatically darkens the non-measurable points so you can see the points that are
measurable. This could be the entire sky or even stripes of data right in the main areas you wish to dimension. This depends on the density of the scanning and the scanning methods used to collect the data.

Q: In Markup View, I change the Unit setting from meters to feet, but the units in the view do not change. Why?

A: The units are used only from the time they are set until they are changed. New markups use the new Unit setting (feet), but the old markups use the old Unit setting (meters). The Unit setting is not applied globally.

Q: How do I change the units for an object?

A: Click on the object. Then choose your new units from the Unit drop-down menu. The units will be changed for the object that you selected and for any new objects that you create.

Q: If a markup object has a fill color, then clicking from Markup to View and back to Markup loses the fill color. It reverts to the previous fill color. Why?

A: If you leave the Markup View, then when you return, the default values, including the fill color, are displayed. To keep the new fill color, save the values as the default. Then, the new fill color is the new default and is displayed when you return to Markup View.

Q. My 3D Markup is not very accurate (repeatable), even though the precision is high. Why?

A. The 3D Markup can not be very accurate unless the view is really zoomed in. Zoom in as much as possible.

Q. How can I measure from a point in front of me to a point behind me?

A. Pick the first point in front, then pan to the back and choose the second point.
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Quick Start Guide

We understand that you may be eager to get something on screen and have a go before reading through the entire User Guide! This is a quick tutorial on loading POD files, navigating around the point cloud data and changing some settings to improve visual clarity.

Importing and Navigating POD Files

POD (Point Database) files are Pointools' native point cloud format that enable rapid background loading and compact file size through compression. Download the barn_bit.pod file from our website, or if you have a CD installation copy the file from the CD to your harddrive. Since harddrives have a much higher data access rates to CD ROM drives it is advisable to access data from a harddrive or similar device.

Note that importing and displaying a POD file does not require write-access, so it is possible to do this from read-only media, read-only locations or shared files.

Importing a POD File

Although this is a native Pointools' format we Import the file as opposed to opening it. The Open and Save options are for project files (.ptl) only. You can learn more about these in chapter 5.

1. To import the file select the File | Import option from the menu. Alternatively use the Ctrl+I keyboard shortcut.
2. Select the file in the file browser, and click Open
3. The point cloud should start to appear on screen. Note that data is streamed in the background so you don’t have to wait for the entire dataset to load before using it.

Navigating

Pointools' controls have been designed to give you full navigation using the mouse only (if you have a three button mouse).

If you have a 3 button mouse:

- The Left Mouse Button (LMB) Rotates the view around the target
- The Middle Mouse Button (MMB) *Pans* the view
- The LMB+RMB *Zooms* in or out
- The mouse scroll wheel zooms in and out.

If you have a 2 button mouse:

- The *LMB Rotates* the view around the target
- The *LMB+RMB Zooms* in or out
- To *Pan*, switch into pan mode by clicking on the Pan icon in the *View* toolbar or press 8 and use the *LMB*. You can switch back to Free Navigation mode by pressing 0.

This can be useful when using a laptop that has only Left and Right click buttons.

Rotation of the view occurs around the target point. To change the target press X whilst the mouse cursor is hovering over the point you want to make the target. Alternatively you can use the *Set Target* tool in the toolbar on the upper right of the viewport window.

To learn more about the navigation controls see chapter 3.

**Changing Shader Settings**

Now we are going to change some shader settings to enhance the clarity of the point cloud.

*Point Lighting*

Enable Point Lighting by clicking on the light bulb icon in the Points toolbar. This lights the points and can dramatically help define the form of the geometry. To use point lighting, point clouds must have normals imported or generated on import.

*Intensity Mapping*

Intensity values are mapped to an intensity colour ramp. The default ramp is a hue ramp but this can be changed. The contrast (scaling) and brightness (offset) of the mapping can also be changed.
To do this:

1. Open the Settings dialogue box by clicking on the yellow cog icon in the Settings toolbar. Alternatively use the S keyboard shortcut or select Setting from the Tools menu.
2. Select the Point Cloud tab at the top of the dialog
3. Select the Shader sub-tab.
4. Change the Contrast by dragging the Contrast slider. The view updates as you change the value.
5. Change the Brightness by dragging the Contrast slider.
User Interface

Pointools Graphical User Interface (gui) has been designed to be as simple to use as possible and offer some ability to customise the layout to suit your requirements. Whilst the UI is not a standard Windows interface you should find most of the interface components appear and work in a familiar manner.

Menubar

Most of the commands available in the application can be accessed via the Menubar.

Toolbars

The toolbars give quick access to commonly used commands. You can collapse and expand toolbars to arrange your workspace as it suits you. To do this, click on the toolbar label. Hovering over an icon for a second or so will reveal the icon’s tooltip.
The Viewport

This is where objects are displayed graphically in 3D. As well as the 3D OpenGL viewing area the viewport has an option bar that contains (from left to right):

- The View menu containing viewing direction, projection type options as well as access to camera manipulation tools
- The Mode menu containing navigation mode options
- A short toolbar with access to target setting, up-vector constraint, reset position and full screen commands.

In full-screen mode the viewport options bar remains visible giving access to viewport commands. You can toggle full-screen mode by pressing \textit{f11} or by clicking the full screen icon in the viewport’s toolbar.
Objects Browser

The objects browser displays workspace objects in a tree format with some additional information and a toolbar with object related commands. You can use the vertical and horizontal scrollbars to scroll the view or the middle mouse button to pan by clicking and dragging. For more help on this see the Objects Browser section later in this chapter.

Object Properties

Displays the currently selected object's (in the Objects Browser) properties. Some of these properties are read-only information whilst others can be edited.
Animation Bar

The Animation bar consists of:

- The Animation Toolbar containing shortcuts to animation tools and options.
- The Timeline for placing and editing keys
- The Graph Editor containing shortcuts to animation tools and options, this is hidden by default and can be revealed by dragging the animation bar upwards.

Status Bar

The status bar displays the current command status, a progress bar for some operations and help prompts for most commands. The disk icon on the far right of the bar indicates when the data is being accessed from disk. A tooltip is also displayed here when the mouse pointer hovers over an icon in any of the toolbars.

Interface Colours

You can change the user interface colour scheme by opening the Settings toolbox (press S or use the Tools | Settings menu option) and changing the colour scheme setting under the General | Interface tab.
Object Types

Pointools View can import the following types of objects:

**Point Clouds**

A point cloud is a large number of points in space (hence cloud) that describe an object. Typically point clouds are captured with laser scanning technology where the scanner observes and records a large number of points on the surface of an object. Point clouds can provide an accurate and often relatively efficient representation of complex forms. Point clouds can also be generated by computational methods from solid or surface geometry or extracted from photography using photogrammetry methods.

In addition to a x,y,z coordinate in space, each point may have additional properties such as reflective intensity, colour or surface normal.

Pointools is highly optimised for the display of point clouds and can handle 100's of millions of points with modest hardware requirements.

Point cloud data can be imported from various files types (See Chapter 4) but is always saved in Pointools pod format to enable rapid background loading and compact file sizes. View Pro also has a number of export options including a generic ascii exporter, please see Chapter 4 for more details.

An example of a point cloud. Data courtesy of APR services, UK.
**3D Models**

The import and display of fully textured 3D Models complete with material properties and transparency is supported from a number of model common formats. Models are correctly displayed and depth clipped with cloud data or any supported other objects types.

Currently there are a number of import and display limitations:

- NURB or Sub-patch/division surfaces are not supported.
- Only UV, Planar and Box texture mapping modes are supported.

Pointools View does not support model export.

![Example of a textured model](image)

**Drawings**

View supports the import and display of layered CAD drawing files from a DXF, DWG and SHP file formats. Most drawing primitives are supported, including lines, arcs, circles, text and dimensions. 3D solids in drawing files are not fully supported and are represented by their outlines when displayed.

Drawing export is not supported
Notes

Notes can be attached to objects within the workspace providing a convenient way to annotate a scene. A note can also include a hyperlink making it possible to link web pages, files or configuration settings into a project.

Currently there are no import format for notes.

Notes can be exported as a text (csv) or HTML file with an embedded image.
Objects Browser

Objects in the workspace are managed via the objects browser. The interface is shown below. The entire panel can be collapsed and expanded using the collapse icon on the top right of the panel and the vertical bar to expand. It can also be resized by dragging it in or out from its right edge. This can be useful to give a larger viewport area.

The image on the left shows the objects browser loaded with different types of objects.

Note that the colours used in the interface may vary depending on the current colour scheme, so your interface may look slightly different.
To select an object click on the object in the tree. To select multiple objects hold down Shift whilst clicking. The icons along the top perform actions on the currently selected objects. Not all the commands work on all object types. For example 3D models can not be exported. The diamond in the left column controls visibility of the object and all objects in its branch. The tree view can be scrolled by using the vertical and horizontal scrollbars or by panning with the middle mouse button held down, or by using the mouse wheel.

*Import Objects*

See Chapter 4 Importing Objects

*Export Selected*

Export the selected objects to a file. This command will only work on objects types that can be exported.

*Remove Selected*

Removes the selected items from the project. This can also be achieved by selecting the objects you want to remove and pressing the delete key.

*Zoom to Selected*

Zooms the view to the selected object/s. This can be useful for locating objects.

*Zoom to Origin*

Zooms the view from the origin of the selected object's coordinate system. This can be useful to view a scan cloud from its origin if this information is available.
Navigation

The navigation controls are accessed through the View toolbar shown below.

The default navigation mode in Pointools is the combined navigation mode. Whist using some tools the navigation of the viewport is locked. This is to prevent unintended movement of the view and in most cases can be overridden by use of the Alt key. Note that selecting a navigation mode does not drop the current tool.

Zoom

The zoom mode moves the viewer towards or away from the view target. This is a hybrid zoom that uses the field-of-view to zoom in closer when you become close to the target. Whilst in this mode hold the Left Mouse Button down and drag down to zoom in and up to zoom out.

Pan

Hold the Left Button down and drag in the direction you want to pan the viewer. In perspective projection, panning occurs at the target distance, so a target further away will cause a larger pan.

Rotate

The mode menu of the viewport controls the what is rotated. In Explore mode the camera is rotated instead of the scene around the target. The gives the feeling of 'walking' or exploring the scene as a viewer in the scene.

In Light Direction mode the light source is rotated around the centre. Note this is a parallel beam light source conceptually at infinity so that only the direction is rotated. The light source direction is shown by an arrow in the viewport.

In Examine mode (default) the viewer is rotated around the target. The effect of
this is as if you are rotating the scene in your hand to look at it from different angles. This is constrained to rotation around the current up axis. The current up axis is indicated by the high-lighted pole of the axes icon in the viewport. For example the axes below show the z axis as the up axis.

You can release this constraint by un-selecting the constrain to axis icon on the top right of the viewport shown below.

Releasing the up-axis constraint gives an arcball rotation mode. This mode may be more suitable for viewing complex un-oriented models. Clicking the icon again sets the up-axis to the currently most upright axis.

To rotate hold down the Left Mouse Button and drag.

*Combined*

The combined mode gives full navigation via a 3 button mouse:

*View Target*

The target of the view can be set by clicking the target icon on the top right of the viewport shown below.

The mouse cursor changes to a crosshair. Left click on any point of any object in the viewport to centre the view on that point. Alternatively you can use the X key whilst the cursor is hovering over the point you want to set as the target. This affects the target of Rotation and Panning.

*Using a 3D Connexion Mouse*

Pointools View and View Pro support the full range of 3D Connexion Mice. To use one of these simply plug the mouse in (if it isn’t already) and Pointools will pick up the connection within a few seconds. You can then use the mouse as useful. Note that changing the rotation mode between Explore and Examine will affect the motion.
Changing Settings

You can open the Settings box by:

- Selecting the Tools | Settings menu item
- Using the S keyboard shortcut or
- Clicking on the Settings icon in the Settings toolbar shown below

This opens the settings dialog (shown below). If you have installed additional plug-ins you may have extra options available than those shown.
**10 Taking Measurements**

There are two measure tools in Pointools View, point information and point to point measure. You can access these tools from the toolbar, the menu or by using the keyboard shortcuts.

Pointools currently allows measurement operations to use points of point clouds and endpoints of drawing entities.

**Point Measurements**

To take a point measurement ie the position of a point:

1. Select the Point Measure tool, this opens the Measure dialog.
2. Move the mouse cursor over the points, a thick cross hair indicates a valid point under the cursor. You can use the Alt key to navigate whilst using this tool.
3. Click on the point, the point's position is shown in the viewport as a tag.
Distance Measurements

To take a distance measurement:

1. Select the Distance Measure tool, this opens the Measure dialog.
2. Move the mouse cursor over the start point, a thick cross hair indicates a valid point under the cursor. You can use the Alt key to navigate whilst using this tool.
3. Click to set the start point.
4. Use the same method to select the finish point.
5. The measurement is shown in the viewport as in the image below.
Measurements are part of a Pointools project file (ptl file) and are one of the ways you can add value to a deliverable data project.
Measurement Options

The following options are available in the Measure dialog

Show

Controls which measurements appear in the viewport. Note that this only refers to measurements that have been logged. The following options are available:

All

Shows all the measurements

Selected Only

Shows only those measurements that are selected in the list

Current Only

Shows only the current measurement

Display Colour

Sets the colour of the measurement display in the viewport. This can be used to improve clarity in some instances.

Only in measure mode

Only shows measurements whilst the measure mode/tool is active

Coord Units

Changes the units in which coordinates are displayed. Note that this does not affect the distance units.

Distance Units

Changes the units in which distances are displayed.

Precision

Changes the precision to which both distances and coordinates are displayed.

Tag

This is a 'tag' or code that is applied to the following measurement.
**Clear tag after measurement**

Clears the measurement tag field after the measurement is made returning focus to the text-box so you can type in a new tag without clicking on it to place the cursor.

**Save Options**

The logged measurements can be saved as a Tab or Comma-Delimited text file. This can be easily imported into a database or spreadsheet for further analysis or output.

**Tag**

A tag can be applied to each measurement making it easier to identify. Enter the tag in the text box before making the measurement. To clear the text after the measurement in preparation for the next measurement check the *Clear tag after Measurement* option. This also returns focus to the text box after a measurement so you don't have to click in the text box to enter the new tag.

**Filter**

Filters coordinate values from the second point of a point to point measurement. This can be used to get delta X, Y or Z measurements.

**Log measurements**

Enters the subsequent measurements in the measure log.

**Send to Kubit**

Sends the measurement’s position to AutoCAD via Kubit’s Point Cloud / FaroCloud or TachyCAD plug-in. To make use of this coordinate you should first start the required command within AutoCAD. When AutoCAD expects a point entry you can then use a Point Measurement in Pointools View to enter this point. This can be used for generating line or model geometry within AutoCAD, creating dimensions or any other operation that is based on coordinate entry.

You need a full commercial license (not evaluation) of either Kubit PointCloud / FaroCloud or TachyCAD 4.x running in AutoCAD 2004/05/06 or 2007.
Using the Measurement Log

To log measurements being made check the Log Measurements option. This will log any subsequent measurements in the measure log. You can redisplay any logged measurements by selecting them in the log. Hold down the Shift key to make multiple selections.

Measurements are saved in Pointools project files (.ptl).

The following Measurement Log options are available:

Clear
Clears the log.

Save
Saves the measurements to an delimited ascii file. This is a common format that can be read by most spreadsheets and databases. The Measure File Output dialog box has the following options:

Format
Choose between comma-delimited or tab-delimited ascii files. Both types are commonly understood by software importing delimited field data.

tag
Includes the tag field in the output.

distance
Includes the distance field in the output.

pnt 1
Includes position of point 1 fields in the output.

pnt 2
Includes position of point 2 fields in the output.

dx
Includes delta-x field in the output.
06 Viewing Point Cloud Objects

Shading Options

Point cloud shading options are accessed under the Point Cloud | Shader tab of the Settings box.

The following options are available:

Show RGB

Sets the global RGB filter. Switching this option off prevents any RGB data being shown.

Show Intensity

Sets the global Intensity filter. Switching this option off prevents any Intensity data being shown.

Blending

This effects the display of point clouds where both Intensity and RGB data for points are available. Showing both values blends the two shading models. This may be used to enhance the visual quality of the data.

Intensity Ramp

Sets the colour ramp that is used to display intensity values.

Brightness

Sets the offset for the intensity values. This is analogous to brightness in a greyscale image.

Contrast

Sets the range over which the intensity values are distributed or scaled. This is analogous to contrast in a greyscale image.

Point Cloud Lighting

If checked applies lighting to point clouds. This can greatly enhance the clarity of the data showing detail that is otherwise hidden.

Lighting is only enabled for point clouds with Normal data. This data is either
imported from the source file or generated on import. See Importing Point Clouds for more information on generating normals.

The Point Cloud Lighting option requires support for the ARB Vertex Shader extension in your graphics hardware. This is a commonly available extension in most graphics hardware less than 5 years old but may require a driver update to be accessible.

Material Quality

This option only affects points when lighting is in use and determines the specular and diffuse quality of the material used to represent the points of a point cloud.
Plane Shading

This feature is named 'Height Shading' in version 1.5-1.52.

Point cloud plane shading options are accessed under the Point Cloud | PlaneShader tab of the Settings box.

Plane shading shades points according to their distance from a plane. By default the Z plane is used. This is very useful for visualising aerial LIDAR data, especially when intensity or RGB values are not available. New in version 1.55 is the ability to use X or Y planes or define a custom plane.

The following options are available:

Distance

This is the distance over which the entire colour ramp is stretched

Offset

The height at which shading starts.
The shade value (0->1.0) is calculated as (z-offset) % distance

Fit to Data

Fits the Distance and Offset parameters to the point cloud data extents

Axis

The normal of the shading plane ie the direction in which the shader operates. This can be set to X, Y or Z or an arbitrary vector. To set the plane on a 'face' of points:

1. Align the view using the 2 point or 3 point align tools.
2. Use the Align View option to set the vector of the plane to that of the camera view.

This can be useful to bring out detail in surfaces with gentle relief.

Edge

Determines the behaviour of the shader beyond the shading range that is offset > z > offset + distance or 0 > shade value > 1.0
Repeat

The ramp is repeated

Clamp

The ramp is clamped to the edge value so all values > 1 are clamped to 1 and all values < 0 are clamped to 0.

Black

A black value is assigned to points outside the range.

Ramp

Sets the shading colour ramp. Note that this lists all the available ramps although some are not very useful for plane shading.

Plane shader, lighting and fog used to show detail in a façade. Note that no intensity or RGB is shown.
Other Settings

General Tab

Memory Usage

This determines the amount of available memory that Pointools should use. This setting is best left unchanged for optimum performance. If you want Pointools to use less memory change this value by small amounts until you have freed the required amount of memory.

Delayed Channel Loading

Point clouds consist of a number of channels: Geometry, Intensity, RGB Colour and Normals. Often a subset of these channels are required for rendering the points depending on the settings in use. This option delays loading of unused channels until they are required. As a consequence general loading is quicker but changing display options may require loading of additional channels and so is slower.

The option is off by default.

Display Tab

Dynamic View Options

Minimum Output %

Sets the minimum percent of the entire point cloud data set to be drawn during dynamic navigation. This overrides the frame rate reduction. Setting high values will significantly improve the quality of the view whilst navigating but at the expense of the frame rate.

Front Bias

Sets a bias to point closer to the viewer when reducing the view during navigation. This is most suitable for views of objects viewed from the exterior where the points closest to the viewer are most often those of interest. Conversely this option will not work well when viewing objects from inside.
This option is off by default.

*Adaptive Point Size*

During navigation Pointools adaptively reducing the point density in different areas of the point cloud to suit the current view. The Adaptive Point Size option compensates for density reduction by increasing the point size. This results in a much fuller view whilst navigating.

This option is off by default.

*Static View Options*

*Static View Reduction Optimizer*

Pointools optimizes the display of static views by calculating an optimum amount of data to display for different parts of the point cloud data. This percentage value influences the aggressiveness of the optimizer. Higher values result in faster display but may start to drop out some detail.

If you find that detail is being dropped out of the static view, reduce the optimizer value.

If you are viewing large amounts of data, increase this value until the reduction becomes apparent. This can dramatically improve performance and reduce memory usage.

Note that this is not a simple linear reduction of the amount of data on screen but an adjustment of localised density estimation to adapt this estimation to different scenarios.

*Point Size*

Sets the point display size. This can also be set from the toolbar or by using the keyboard shortcuts 1-5.

*Scanner Display*

If scanner locations of the point cloud data are known these can be displayed in the viewport in one of the following ways:
None

Does not display scanners.

Axis

Scanners are displayed as an 1m oriented axis.

Point

Scanners are displayed as a 10 pixel point.
Isolating Areas Using the Clip Box

When viewing large or complex point cloud scenes it can be helpful to isolate the area (or volume) of interest. Pointools enables this via the editable clip box tools. Points that fall outside the clipbox are hidden.

The clip toolbar contains all icons for the clip box commands.

Editing the Clipbox

To edit the clipping box position and size:

1. Start the clipbox tool select the Edit clip box command from the toolbar, or use the C keyboard shortcut.
2. This displays the clipping box as a transparent box. If this is the first time the tool has been activated in the current session, the box will expand to fit the area of point cloud.
3. Use the round handles to drag the sides of the box to isolate the area of interest. Click once on the handle to pick it up and again to drop it. Note that clipping is not yet in effect.
4. You can rotate the clip box in the Z axis by using the outer orbit handle.
5. To turn on clipping use the Clip icon in the Clipping toolbar or the Toggle clipping button. Point data outside the box is now clipped out.
6. You can adjust the box further, point data will be clipped out in real-time.
7. Alternatively use the input boxes on the clip box dialog to enter the Range or Size of the box.
8. Right click or click OK to drop the Edit Clip Box tool once the clip box is set.

Use the Extents button to reset the clip box to the extents of the data.

The Align 2 Points button enables rotational alignment of the clipbox to a line defined by 2 points. Simply select the start and end points of the line you want to align to and the clipbox will be rotated accordingly. These points can be cloud points or endpoints of drawing objects. Note that the alignment is unaffected by the Z position of the points since the rotation itself is in the Z axis. A typical use for this is to align the clipbox to section lines imported as a drawing.
from dwg or dxf.

**Disappearing Data**

When importing different data sets be sure to check if clipping is active as it is possible to leave clipping active from a previous data set. If you import a new data set you may not see any data in the viewport because the data is clipped out entirely.

**Section Viewer**

The section view tool provides a convenient way to move a thin clip box to view a sections through the data. The section viewer will use the box axis with the shortest dimension to move through.

To activate the section viewer select Section viewer from the clip box dialog or the clipping toolbar. This opens the section viewer options with the following controls:

*The slider*

The slider sets the position of the box along its shortest axis.

*Mark*

Sets the extent of the slider range. The left Mark option indicates the lower end of the range.

*Nudge >>*

Nudges the section box in the positive direction.

*Nudge <<*

Nudges the section box in the negative direction.

*Hide Box*

Hides the box, this does not effect the clipping which is set independently.

*Show Box*

Shows the box, this does not effect the clipping which is set independently.