Leica Geosystems Laser Tracker
Metrology Assisted Assembly & Automated Inspection
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Introduction

The Metrology division of Leica Geosystems is part of Hexagon Metrology. The core measurement sensors has been keepen with the same level of quality that is expected from the Leica Geosystems name, but have been able to leverage the many strengths of the new Hexagon Metrology organization. One of these strengths is the addition of the EMS PC-DMIS measurement software. This software package gives Leica Geosystems far more power and functionality for advanced automation. Not only are we now capable to satisfy many of the automation tasks from a technical side, we are also far more prepared from the commercial side. Hexagon Metrology now has the required competences to be able to handle many of these major integration projects. The Hexagon Commercial Organisations (or COs) have literally hundreds of software integrators around the world, and an installed base of more than 30,000 seats of PC-DMIS. The COs are also responsible for the full Hexagon Metrology product portfolio including: articulated arms, CMMs, vision machines, and a full line of precision tools, any of which Hexagon would be glad to support during an integration project. However, the primary focus of this document will be based on the Leica Absolute Tracker and our associated 6DoF products. We will detail two different concepts that will allow both the front-end (Human Machine Interface) and the backend (Analysis and Database Management) of the metrology software to be completely independent of our final hardware solution. This will allow each individual process to use the most appropriate measurement software available. This could be PC-DMIS, Spatial Analyser, Metrologic, Build It, PolyWorks, or something completely custom made. We don't intend to force the customer or the integrator to use a software solution that is outside of their scope, so these concepts aim to simplify the integration of our hardware solutions.

Now with support of our extended Hexagon Metrology brands, we can offer the strength and knowledge of a world-class automation infrastructure like PC-DMIS with hundreds of EMS PC-DMIS software integrators around the world, and a full portfolio of additional metrology hardware, like articulated arms and CMMs. In addition to this we have recently created an Automation and Integration group within Leica Geosystems natively. This group of dedicated application engineers and software programmers have the ideal combination of software and programming expertise, mixed with years of portable measurement experience to be able to assist with, or even create full turn key customized software solutions. With our unique proven technologies, extensive metrology background, and creative software solutions, we are constantly pushing the envelope of what can be done in the field of Metrology Assisted Assembly and Automated Inspection.
Automated Integration Experiences

Existing Automation Integration Success
Leica Geosystems was one of the first companies to help the Aerospace industry with Metrology Assisted Assembly. We have dozens of integrations all around the world with laser tracker installations going back more than a decade. The following integration projects were successful due to our close cooperation with the local system integrator who was leading the project.

Airbus France
Meaulte Erebus A318-19-20-21 assembly & part inspection automated system: 6 LTD500 Axyz/PAM
Meaulte Erebus A330-340 assembly & part inspection automated system: 1 LTD500, 1 LTD640 Axyz/PAM
Meaulte Erebus A380 assembly & part inspection automated system: 1 LTD640 Axyz/PAM
Meaulte Box landing system Sec.11 assembly & part inspection automated system: 1 LTD600 Axyz/PAM
Nantes RCT A340-330/500-600 assembly & part inspection automated system: 2 LTD500 Axyz/Visual Basic
Nantes TR21 A340/A330 part inspection partly automated system: 1 LTD500 Axyz/Visual Basic
Toulouse Pylones all Airbus plane part inspection automated system: 2 LTD500 Axyz/Visual Basic
Toulouse FAL A320 assembly automated system: 1 LTD600 emScon 1.5.3
Toulouse FAL A320 assembly automated system: 1 TDA5005 Specific IHM
Toulouse FAL A380 assembly automated system: 4 LTD500 , 1 LTD640 emScon 1.5.3
St-Nazaire Station 390 A340/330 assembly automated system: 1 LTD500 emScon 1.5.2

Dassault Aviation
Istres Anechoide Chamber robotique automated system: 1 LTD800 emScon 1.5.3
Biarritz Falcon 7X part inspection automated system: 1 LTD840 emScon 2.3

CEMAR
La Bruz Solange robotique automated system: 2 LTD500 emScon 1.5.3

SNECMA
Bordeaux M51 (Rockets submarine) part inspection automated system: 2 LTD500 Axyz/Visual Basic

DCN
Toulon Military frigate Monitoring antennas automated system: TDA5005 D-Master

AIA
Cuers Maintenance Aircraft Triangulation partly automated system: TDA5005 Axyz/Visual Basic

PSA
Velizy Romer TrackLink Manufacturing robotique partly automated system: 2 LTD640 emScon 2.3

CEA
Fontenay aux Roses ITER robotique 6D automated system: 1 LTD840/Leica T-Probe emScon 2.3
Bruyère Le Chatel LMJ part inspection automated system: 1 LTD500 Axyz/Visual Basic

Airbus Deutschland GmbH
Bremen A 400M, AS 100-400 assembly automated system: 1 LTD800 emScon 2.3
Bremen A 400M, Sec.600 assembly automated system:
1 LTD640 emScon 2.3
Bremen A 400M, Sec.700 assembly automated system;
2 LTD640 emScon 2.3
Bremen A 400M, Sec. 850 assembly automated system:
2 LTD640 emScon 2.3
Hamburg Hatrack A 380 assembly partly automated system:
1 LTD600 Axyz/PAM
Hamburg Hatrack LR (A330/340) assembly partly automated system:
1 LTD600 Axyz/PAM
Hamburg RMK assembly automated system:
1 LTD600, 1LTD800 emScon 1.5.3
Hamburg Sec. 13 assembly automated system:
2 LTD600 emScon 1.5.3
Hamburg Sec. 18.1 assembly automated system:
2 LTD500 emScon 1.5.2
Hamburg Sec. 18.3 assembly automated system:
1 LTD500 emScon 1.5.3
Hamburg Megaschale assembly automated system:
2 LTD500 emScon 1.5.2
Hamburg MCA (Ass. 18.1, 18.3,19) assembly automated system:
2 LTD800 Axyz/PAM
Stade VS A380 assembly & part inspection automated system: 1 LTD640 emScon 2.0
Stade VS A400M assembly & part inspection automated system: 1 LTD640 emScon 2.3

**EADS**

Getafe Eurofighter assembly fuselage and Integration automated system: 2 LTD600 emScon 1.5.3
Sevilla FAL A400M 2 x assembly wing to body automated system: 2 x 2LTD640 emScon 2.0
Sevilla FAL A400M sub- assembly automated system: 2 LTD640 emScon 2.0
Sevilla FAL A400M Final assembly and part inspection automated system: 2 LTD640 emScon 2.3

**Airbus Spain**

Getafe A380 Sec. 19 manufacturing & assembly automated system: 1 LTD640 emScon 2.3
Getafe A320 manufacturing & assembly automated system: 1 LTD640 emScon 1.5.3
P.Real A380 HTTP assembly automated system:
1 LTD640 emScon 2.3

**CERN LHC**

Inspection and alignement of magnets automated system: 19 LTD500 Axyz Ole /DGM

**ABB Robotics**

Manufacturing robots calibration robots to get absolute accuracy automated system: 1 LTD500 Axyz/ Script
Manufacturing robots calibration robots to get absolute accuracy partly automated system: 1 TDA5005 Axyz/ Script

**BAE**

Warton Eurofighter assembly fuselage and Integration automated system: 2 LTD500 emScon 1.5.3

**Rolls Royce**

3 BSM auto inspection partly automated system: LTD840/Leica T-Probe emScon 2.3

**Westland Helicopters**

R101 Airframe structural test automated system: 2 LTD640 emScon 2.0

**Boeing Renton WA**

B737 Wing to Body Join automated movement of wing to body: 5 LTD500 Axyz/Visual Basic

**Boeing St Louis MO**

FA-18 Fuseage Join automated movement of fuseages 1 LTD500 Axyz/Visual Basic

**Gulfstream**

Wing assembly automated movement of wing section: 1 LTD500 Axyz/Visual Basic

**Berkley Lab**

Particle Accelerator Survey of Magnets Survey and align magnets: 1 LTD800 Axyz/PAM

**Boeing/Tulsa OK**

B777 Inspection floor rails by Part no: 1 LTD Axyz/PAM

**ADC Engineering**

Helicopter Inspection/Modification Integrated measurement/document: 1 LTD emScon/Visual Basic
A “Front End” Software Independent Solution

**Software with an Advanced Internal Scripting language**

There are two main concepts on how to integrate a metrology based software solution into an automated assembly cell. The first and most common, is to use the metrology software as the Measurement Process Manager. In this scenario the metrology software is responsible to interface with all of the needed products i.e. measurement sensors, databases, positioning systems, etc…

This process has been used on a number of automation installations due to its ease of integration. In this setup the Assembly Process Manager provides the correction parameters from measurement software to the jig and tool controllers (actuators). In this case, the measurement software package needs to be very advanced, and must include native interfaces to any of the control devices, and have a highly customizable internal macro language. An example of this type of solution would be either Spatial Analyzer, or Metrologic. We will not go into too much detail on this type of integration since it is well accepted in most industries. Currently we have interfaces to an extensive list of these advanced metrology packages, all of which maintain state of the art interfaces to our hardware through our embedded system control (emScon) SDK.

**Software with an SDK based External Scripting language**

The second concept is to use an independent Measurement Process Manager that wraps around the actual measurement software. In this configuration the measurement software package doesn’t need to be able to interface to every required device. The measurement software can talk to the measurement sensor(s), while the Measurement Process Manager is responsible for the communication between the measurement software, external positioning systems, databases, etc…

The advantages of this type of solution have been clearly identified on some of our most recent integration projects. The Measurement Process Manager, or MPM, controls all of the functions related to the actual metrology measurements, and can then be controlled by any independent Application Process Manager, or integrated Human Machine Interface. This could be demonstrated in a recent project where multiple Laser Trackers were bundled together, oriented to a single station location, and then controlled by a very simple Visual basic application. This not only allows you to separate the software front end, but also (as shown in this example) allows you to then send the measured results to any addition software package for further analysis.
Let’s look at how this concept could be used in a standard measurement process as it would relate to a 3D point based wing to body assembly. In the first three steps listed below, the Laser Tracker needs to be initialized, the nominal points need to be read in from the global database, and the reference points need to be measured. In the last three steps the multiple stations are bundled together using the reference points and are then aligned directly to the fuselage. Once the stations are aligned to each other and to the fuselage, the points on the wings can be measured sequentially. The MPM takes control of this complete process by allowing all of the measurements to be stored, bundled, and best-fit with only a handful of commands required by the controlling application. This removes the need for the integration company to have an in-depth knowledge of metrology to be able to achieve the desired results very quickly through a simple SDK.

Step 1: Initialize Measurement Process
Step 2: Read in Nominal from Database
Step 3: Measure Reference Points
Step 4: Bundle Stations
Step 5: Align Stations Setup to Fuselage
Step 6: Measure Actual Wing Position

Now let’s take this process a step further. Traditionally the Laser Tracker measures a series of fixed points on the wing and body respectively; the measurement software (e.g. Spatial Analyzer) then calculates the movement deltas and writes the results to a central database. The Assembly Process Manager can read those values and move the actuators incrementally in an iterative process between measuring, moving, stopping, etc… until the wing is in its final assembly location. The iterations require the object to be stationary while being measured and this can be a tedious and time consuming process. To speed this process up we could use the Leica Geosystems 6DoF MAP System that allows the wing to be tracked in real-time with an automated feedback loop directly to the Assembly Process Manager from the MPM.

The MPM would not only control all of the measurements and their mathematics, but would also communicate directly with the Assembly Process Manager for the control loop between the 6DoF measurements and the actuators. This would allow for a system integrator to use the core measurement technology in the most beneficial way, without the need to constantly worry about whether the Human Machine Interface or the analysis package can control all of the requested functions in the measurement hardware.
Automated Assembly using 3D point networks and the Leica Geosystems 6DoF MAP System

As we have already started to describe some ideas regarding wing to body stations let's continue on this topic. We will not spend too much time on the 3D point network process for these automated assembly processes due to the fact that they are fairly well known and accepted, as well as the fact that we have already detailed the two "front end" control software possibilities. Instead, we will describe a hybrid combination of 3D point based assembly with the addition of 6DoF real-time tracking that creates the Leica Geosystems Metrology Assisted Positioning, or MAP system. The proposed Leica Geosystems 6DoF MAP system could cut the standard MAA joining times by as much as a third, or at least a quarter. In a standard application a Laser Tracker would have to measure a network of between 6 – 8 points on the wing, plus a series of points on the body. This process would typically take between 30 to 40 seconds to complete. However, it is not the measurement time that slows this process down. The limiting factor is the time that it takes to move the Jigs and re-measure the parts in an iterative process. If we concentrate on a single wing (above) then the time required to move this wing into position could take up to 45 minutes for just the measurements. This is assuming roughly 5 seconds per point for positioning and measurement of the Laser Tracker, and between 10 – 15 iterations to bring the wing into the final alignment position. In comparison, using the same wing, but this time rather than calculating the positioning deltas from a network of points, we'll use the Leica Geosystems 6DoF MAP System to track the wing in real-time. The 6DoF MAP system consists of a Leica T-Mac in combination with a Leica Absolute Laser Tracker and T-Cam. The Leica T-Mac is attached to the part that needs to be aligned (in this case the wing), and the 6DoF deltas are fed back in real-time directly to the wing positioners. The Leica T-Mac has the same 3D positional uncertainty of a standard Laser Tracker measurement, but also generates pitch, roll, and yaw angles. The 2 Sigma angular uncertainty is 0.01° so long as the Leica T-Mac is mounted no more than 6 meters from any edge of the mating surface, the achievable accuracy along this surface is equal to about 1.0mm (where \( \Delta b = \sin^* \text{Radius} \)). This allows for a very flexible setup process where the Leica T-Mac could even be placed meters above the wing for extremely easy line of sight requirements.

The communication from the Leica T-Mac position to the wing positioners is a direct feedback loop to keep the data latency as low as possible. This helps to position the wing with the maximum amount of time savings. In order to guarantee that the wing never touches the body during the MAP process, a positive gap of 5mm should be maintained. This is roughly equal to a doubling of the 6H uncertainty of the Leica T-Mac rotation angles at these distances (e.g. 6 meters).

Once the Leica Geosystems 6DoF MAP system finishes, and the wing is within 5mm of its final location, then the standard process of measuring the fixed reflectors and calculating the best-fit positioning for the final location should start. This process should run as it does with the other Aerospace FAL processes that are already proven out. Whether the process is controlled from an external Application Process Manager or from an integrated metrology package is inconsequential to our overall solution. The main differences would be that if it is implemented in an integrated metrology package (e.g. Spatial Analyzer, or Metrologic), all parts of the communication would need to be integrated by this metrology software. If however it is implemented as a measurement process in the Measurement Process Manager it could use the functionality that is integrated in the MPM (e.g. transformations, bundle, etc…) and communicate directly with the Assembly Process Manager that is controlling the wing positioners.

Page 9 of 15 Application Specific Measurement Processes
The time savings from the Leica Geosystems 6DoF Map system as described above is detailed in the following diagram. In addition, the cost of the complete system can be scaled by the number of Leica T-Mac sensors shared between all of the assembly structures. The trade off is obviously the speed at which the complete process would run. An integration with three Laser Trackers and three Leica T-Mac’s could do both of the wings, and the stabilizer simultaneously in a period of approximately 15 minutes, while a system with only one Leica T-Mac would take almost three times as long due to the need to run the processes sequentially. These times only look at the estimates for the measuring and do not take into account the times required for the positioners to actually move the parts. For instance this process in an existing installation takes approximately 2.5 hours not just 45 minutes. However, the time savings noted above are directly proportional. It should also be noted that time savings is not the only major advantage here.

Transitioning to an on-line movement could also reduce the cost of the tools and jigs. This can also translate into using less overall reflectors, as well as less accurate positioners since the true location would always be known from the MAP system.

<table>
<thead>
<tr>
<th>Program Function</th>
<th>Number of points</th>
<th>detail</th>
<th>measurement position</th>
<th>time conventional</th>
<th>time T-Mac solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initialization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fix point measurement</td>
<td>8</td>
<td>wing left 5 points + 1 T-Mac</td>
<td>8</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wing right 5 points + 1 T-Mac</td>
<td>6</td>
<td>10</td>
<td>10</td>
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<tr>
<td>Part point measurement</td>
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<td>outer wing box left 4 points</td>
<td>8</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>outer wing box right 4 points</td>
<td>8</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fixture joint points 6 points</td>
<td>6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Transformation and establishing systems</td>
<td></td>
<td>total of 40 points + 1 T-Mac</td>
<td>14</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Coordinate systems</td>
<td></td>
<td>calculation time 10 seconds</td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>On-line measurement process</td>
<td>10 iterations</td>
<td>wing joint left 13 points + 1 T-Mac</td>
<td>14</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wing joint right 13 points + 1 T-Mac</td>
<td>14</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HTTP VIP joint 13 points + 1 T-Mac</td>
<td>14</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T-Mac calibration joint actuator movement time</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Back to process</td>
<td>3 iterations</td>
<td>conventional + 2 x 11 points</td>
<td>50</td>
<td>410</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T-Mac solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time saving</td>
<td></td>
<td></td>
<td></td>
<td>2000 seconds</td>
<td></td>
</tr>
</tbody>
</table>

An internal and external Measurement Process Manager in one piece of software

In section 3 we detailed the differences between a measurement software that uses an internal scripting language, and an external Measurement Process Manager that wraps around the individual hardware’s measurement commands. However it should be noted that it is possible for one piece of software to be able to do both.

It is well understood that PC-DMIS has the ability to run advanced part programs that contain conditional looping, and on the fly operator input to be able adapt accordingly. But it is less well known that PC-DMIS also has an advanced external scripting language that allows 3rd party integrators to use the basic SW package as an MPM as previously described.
In this case it would be possible to replace the user interface completely as seen in the visualbasic example in section 3.2. PC-DMIS becomes the “brains” of the measurement process controlling the import & export of data, all measurement commands, bundle & alignment mathematics, and complete database control. The Human Machine Interface can then be completely customized based on the needs of the automation project with a simple program that no longer needs to worry about the actual metrology processes.

We can use the Leica Geosystems 6DoF MAP system as an example of how PC-DMIS could be used as a Measurement Process Manager independent of the Human Machine Interface, or the final reporting database. The workflow assembly process could look as follows, where PC-DMIS would be responsible for steps 1 – 9 below. Here the 3rd party integrators Human Machine Interface only needs call step 1, and then PC-DMIS could take over the automation through step 9 until the Assembly Process Manager becomes involved to reactivate the measurement process after the jig has moved. This loop would continue until step 11 when PC-DMIS would then send the completed measurement results to a global database storing the wings final location. At this point the Human Machine Interface would then become integral in detailing the next steps, or stating the process over again.

Step 1: Initialize Measurement Process
Step 2: Read in Nominal from Database
Step 3: Measure Reference Points
Step 4: Bundle Stations
Step 5: Align Stations Setup to Fuselage
Step 6: Measure Actual Wing Position
Step 7: Measure T-Mac Position
Step 8: Determine T-Mac Transformation
Step 9: Measure T-Mac Position
   \( \text{Calc deviation of actual Datum Point position} \)
   \( \text{Above specified Safety Gap} \)
   \( \text{Send Deviations to Assembly Process} \)
Step 10: Measure automated all Datum Points on Wing
   \( \text{Re-measure Points} \)
   \( \text{Re-measure} \)
Step 11: Measure final position of Datum Transfer Points on Wing
   \( \text{White results to Database} \)
PC-DMIS could also take the MPM concept a step further where it could also be extended to use CAD models as the mathematical nominal data, and to be able to do advanced analysis on the data such as automatic feature creation, and GD&T calculations.

This analysis data could then be output in a neutral format to a global database for storage and further calculations, or could automatically generate a Page 12 of 15 standardized report for documentation purposes. In either respect, PC-DMIS becomes an integral tool that allows all of our 3rd party integrators to create advanced automation projects based around our 3D and 6DoF hardware without the need to create customized measurement applications.

**Automated non-contact inspection utilizing 6DoF technology**

The second advancement that has come from the integrated implementation of our 6DoF technology is the ability to do automated non-contact inspection applications. This obviously requires the addition of a robot, or gantry system to position the Leica T-Mac or Leica T-Scan sensor, but then allows for a highly accurate measurement system with a volume of up to 30 meters.

The Leica T-Scan is not a new product, but being able to use a robot or gantry system to control its positioning is a fairly new concept. This expands on the concept where we use a dedicated Measurement Process Manager to control the full measurement process, but now we also add a third component being the Robot Process Manager.

The Application Process Manager communicates separately to the individual subprocess managers. By utilizing our dedicated Measurement Process Manager, we are able to treat the measurements just as we would if they were scanned by hand, but once we integrate the scanner with a robotic arm, we need to be able to control the arm as well. Here our Application Process Manager deals with the specific communication between the Measurement Process Manager, the Robot Process Manager, and the Analysis Process Manager (e.g. Polyworks). This concept allows the measurement hardware to not only be independent of the front end of the software (including the GUI), but also the ability to be independent of the back end (including the analysis, and post processing). This allows the integrator to implement the measurement technologies, without constant software modifications for new Human Machine Interfaces, and new analysis processing requirements for each individual integration project.
Unlike the Leica Geosystems 6DoF MAP system described previously, where we use the 6DoF information to correct a positioning device; we now need to pre-program the robot to know how and where to scan. This needs to be programmed into the Robot Process Manager before hand, but then once the robot program is started, the robots accuracy becomes arbitrary since the absolute position is measured using our 6DoF technology. This allows for a very accurate point cloud to be collected over an extremely large measurement volume. The appropriate software package should be selected depending on the type of analysis that is required by the job. For instance, if the process requires detailed feature extraction from the cloud of points, then a package like PC-Dmis or Metrolog may be beneficial, however if complex free form surface analysis, and flush and gap measurements need to be analyzed, then a package like Polyworks may be more applicable. No matter which way is used, at the end the customer/ integrator has complete control over exactly how the data is processed and how the results are finally reported. This process could be implemented for "hand-held" usage as well by simply removing the Robot Process Manager, and replacing it with a trained operator. As mentioned earlier, the robotic positioning system has no relation to the achievable accuracy of the measurements. The robot (or operator) only needs to be accurate enough to make sure that the measurements are in the correct location. This same concept need not only be applied to the Leica T-Scan, but can be applied to a line scanner on the Leica T-Probe, or a Leica T-Mac as well. It is possible to mount a Leica T-Mac like the Leica T-Scan on any robot or gantry positioning system. It can even be mounted as a sensor on a machine tool to allow for in process inspection.

Take for instance a structural assembly stations, where additional measurement functionality could be extended from a standard Laser Tracker integration. A Leica T-Mac could be added to the machine tool to allow both positioning control, and adaptive control of the end-effector (i.e. a drilling machine). In addition to this, a laser probe could be added to this configuration to allow for non-contact surface measurements aiding with as-built surface inspection, and or automated shimming. With one core piece of hardware (e.g. a 6DoF Laser Tracker) the entire structural assembly system could be controlled and automated, and again it could be done either with an integrated software package like Spatial Analyzer, or Metrologic, or with an independent Application Process Manager, and Measurement Process Manager like PC-DMIS.

In the above example we are using a Leica T-Mac and a non-contact laser probe attached to a robot to measure like a standard shop floor CMM. This configuration could also be extended to a touch trigger probe that would effectively turn the system into an ultra large volume CMM with better than 0.1mm absolute accuracy over the entire volume. A robotic arm could be mounted on a translation slide that would allow it to reach Page 14 of 15 across, and slide down the full length of the structure. This would allow such a device to measure something as large as a meter wing fixture.

Many of these Leica T-Mac/Leica T-Probe/PC-DMIS automation concepts are currently in the prototype phase within Leica Geosystems. However, due to the complex nature of these systems, we are looking for further specifications for final products from our lead customers, that would allow the opportunity to create cutting edge solutions based on technologically mature core components. The specific extensions to the 6DoF hardware are detailed in the following chapters. Please be aware that these solutions are only in the prototype stage, and are not yet completed final products.
Extension of Leica T-Mac by non-contact sensor
Non-contact probes are already used together with conventional CMMs. These devices use specific triangulation sensors and deliver a trigger pulse if the laser beam is at focus position to the surface point. This trigger pulse would be used for both 6DoF data collection, and to stop the robot movement in process.

Extensions of Leica T-Mac by a touch trigger sensor
TESA (part of the Hexagon Metrology group) currently manufactures a series of touch trigger probes directly related to this application. Overall the technical enhancement would be the equivalent to the non-contact sensor, with the only difference being that the trigger pulse is generated by surface contact and not optically.

Multi-sided Machine Control Probe
Instead of just one working surface with reflectors and marker LED’s the goal would be that a combination of different frames (up to 4 frames with 7 LED’s per face) could be interchanged. This would create a scaleable solution with options extending from 1 to 4 sides.

Leica T-Probe / Leica T-Mac integrated line Scanner
Connecting a line scanning device to create a low price solution would be useful for many standard applications, especially in the direction of automated surface scanning. This type of sensor could be connected to a Leica T-Mac, or Leica T-Probe like it exists already, or it could be used with a multi sided Machine Control Probe as described above. The integration shown below allows the scanning head to be rotated +/- 60° around the center position for better laser line control.
Whether building the fastest car, the biggest plane, or the most precise tooling, you need exact measurements to improve quality and productivity. So when it has to be right, professionals trust Leica Geosystems Metrology to help collect, analyze, and present 3-dimensional (3D) data for industrial measurement.

Leica Geosystems Metrology is best known for its broad array of control and industrial measurement products including laser trackers, Local Positioning Technology (LPT) based systems, hand-held scanners, 3D software and high-precision total stations. Those who use Leica Metrology products every day trust them for their dependability, the value they deliver, and the world-class service & support that’s second to none.

Precision, reliability and service from Leica Geosystems Metrology.

When it has to be right.

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