2012 Annual Workshop and Conference • October 8-9
Hotel Mision Queretaro Juriquilla, Santiago de Queretaro, Mexico

Agenda: Monday October 8, 2012

08:45 – 09:25 **Workshop Registration**

9:25 – 9:30 **Presentation of Event Panel**

9:30 – 9:45 **Words from our Director**
Dr. H. Nava; NACMA Rep

9:45 – 11 :15 **Profile Tolerancing:**
Proof of Compliance - vs.- Process Feedback
Dr. Greg Hetland, President
International Institute of Geometric Dimensioning and Tolerancing (IIGDT), USA

Profile tolerancing is used more aggressively today throughout all discrete part manufacturing companies than ever before as it more precisely represents the mechanical designer's true functional intent for surface geometries. The perceived challenges seem to be in providing value-add measurement within the metrology / inspection group for "proof of compliance" as well as to the manufacturing group for "process feedback." In addition, providing low uncertainty measurement data back to the original designers for optimization of respective tolerances in their design through tolerancing optimization and stack up analysis. In most cases the analysis (analytical algorithms used) and the graphical representation provided would be completely different as the users are looking for different things. This presentation will make visible the different methods of analysis and provide insights as to why they would be different and how to utilize the tools to help manufacturing optimize their processes quicker to improve lead times and reduce costs and also increase confidence within the design and measurement environments at significantly reduced cost.

Implications to Technical & Business Disciplines:

- **Designers**: The desigers are more agressively using profile tolerancing today than ever as it better represents the surface geometries they are actually trying to control. Fundamentally what the designers are looking for is all of the features on the part to simultaneously lie within their respective tolerance zones. The tolerances can be larger in some areas and smaller in others but they all must simultaneously lie within their respective tolerance zones. If this is true then the only way Agenda:

- to accomplish this, for surface geometries, would be to utilize profile tolerancing. It is essential that designers clearly define their explicite design intent through geometric callouts that can be defended mathematically. This presentation will make visible shortcoming of linear tolerancing and the robust and defendable strength of profile tolerancing.

- **Manufacturing**: Historically manufacturing has not trusted measurement results coming from the metrology group as it has not matched what they speculated it should look like. In addition the measurement data provided to manufacturing has been difficult to interpret and of limited benefit to manufacturing to know how to correct for the problem they are trying to fix. In fact we make many attempts to fix what we believe is the problem only to then be told there are other implications that were not made visible in the previous analysis. This presenation will make visible how measurement data can be analyzed to more efffectively prove the product being produced better conforms to the product specification then the metrologists believe. In addition this presentation will show how to more optimally analyze profile results so the information is of more value to manufacturing to expedite optimizing their manufacturing processes.

- **Metrology**: Historically analytical softwares provided with CMM's (contact & non-contact) have utilized algorithms most commonly referred to as "Best Fit," however the best fit algorithms were for the most part based on least-squares fitting which fundamentally averaged all the results. This means that if the metrologists only objective was to figure out a way for their results to be more repeatable and reproducible (GR&R) then what better way to accomplish this then to average all the results. Least-Squares fitting also does not take into consideration the tolerance which means by itself would not have the ability to optimzie the fit(s). For profile tolerancing the optimal algorithm to use would be a fitting algorithm which would optimze the fit within the respective tolerance zone(s) and proportionately optimize all related profile tolerance results simultaneously as a ratio of their respective tolerances. This presentation will make visible the shortcomings of least-squares / best fit algorihims and will also make visible the strength of proportionatly optimizing algorithms for proof of compliance.

- **Business**: To optimize our return on investment is essentail that we ensure all our technical disciplies have the critical skill-sets to preform their jobs at an optimal level. In addition is the critical we provide the necessary tools and equipment essential for all employees to achieve the goals and challenges we put in front of

them. As we look ahead at some of the technology constrants in manufacturing enterprises the one common thing easy to agree on is that tolerances on critical features will continue to get tighter and in may cases the compontents and features within these components will get smaller. This brings natural challenges to the business model. This presentation will make visible some of the historical technical challenges that have resulted in negatively impacting timelines and budgets and will highlight key areas of opportunity for future cost and timeline reductions that have a positive impact on the business model.

11:15 – 12:00 **Coffee Break / Exhibitions**

12:00 – 13:00 **GD&T versus Manufacturing and SPC**

Mr. Kostadin Doytchinov, President
KOTEM Technologies, Inc., Hungary

This presentation will discuss the advantages of using GD&T and at the same time discuss the misconception that “The GD&T drawing is all you need” to ensure both function and be a guidance for the manufacturing process. The presentation will show that there is a need for a completely different approach to data evaluation. While the GD&T requirements target the combined effects of all factors: size, location, orientation, the needs of the manufacturing analysis are very different and require the separation of factors. The fundamental differences between “evaluation of measurements to ensure function” and “evaluation of measurements to provide direct feedback to manufacturing” will be presented. These differences involve the datums used, the role of coordinate systems as opposed to DRFs, the philosophy of the presentation of the results – to mention a few. Specific advices on what and how to do it will be discussed.

13:00 – 14:00 **Lunch / Exhibitions**

14:00 – 14:45 **New Concepts for Inspection Analysis directly using Specialized Software and Laser Scanning**

Bertrand Gili
President & CEO, METROLOGIC Group Services, Inc, USA

Point cloud data analysis - a new approach to inspection processes. Technology gains and new data gathering technologies using laser or optical probing systems allow the acquisition of large amounts of point data which open the possibility to change the way measurement is performed. Traditional inspection software

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packages are not adapted to neither handle the larger number of points nor perform automatic FTA Based analysis automatically and seamlessly. They are not prepared to process the data in an optimized way but function based upon individual points or geometry. This presentation will display a new way to efficiently perform inspection based upon a cloud of points with geometry extraction and individual point comparison to the Native V5 CAD Data along with the enhanced possibilities of complete part inspection analysis using the cloud of points and embedded tolerances from the native CAD file to automatically create a complete Geometric analysis and evaluation of the tolerances following strictly the standards in place removing any room for operator/user interpretation that could get the GD&T Intent falsely interpreted.

14:45 – 15:15 **Practical considerations in the evaluation of Large CMM's under ASME B89.4.10360.2-2008 and ISO 10360-2: 2009**

Leonardo Espinosa, Soporte CMM;
Edgar Arizmendi, CENAM, Mexico

Traditionally in North America, the CMM´s have been evaluated under two well known standards: ISO 10360 and ASME B89.4.12. This evaluation is meant to determine mainly the volumetric accuracy of a CMM. Since 2008, when the two standards were virtually unified, a whole set of new calibrated artefacts and suggested techniques for the evaluation of the performance of CMMs was included, but with them, further specifications and instructions to carry the tests such as number of volumetric lines to be measured and minimum size of the artefacts to be used.

However, the implementation of the proposed tests is not easy. Accredited laboratories for the evaluation of CMMs have been confronted to these practical problems and confusion in the interpretation of these standards, especially for large CMMs. Some of these problems will be presented.

In addition, many CMMs were manufactured before the existence of these standards and therefore their performance specified under different testing conditions. This also represents a problem when submitting it to a test of the standard to see if it complies with its original specifications. Some examples and practical cases are presented.

Last but not least, the transport and careful handling of delicate and many times large artefacts to be used as standards represents a lot of trouble.

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15:15 – 15:45 **Coffee Break / Exhibitions**

15:45 – 16:30 **Active Stereoscopy Three-dimensional Measurement Accuracy Test of a Low-Cost Experimental Setup**

Octavio Icasio, Dr. Miguel Viliesid
Centro Nacional de Metrología, CENAM

Stereoscopy is nowadays being used in commercial measurement systems for three dimensional non-contact measurements. While passive stereoscopy systems do not need a source of light but require more than one camera, active systems only need one camera but require the illumination by some kind of light. This paper presents the tests performed on a three-dimensional measurements setup consisting of a common webcam and a common laser pointer used to make active stereoscopy. The measurements obtained with this setup are compared to those performed with a CMM used as metrological reference. The purpose of the experiment is to determine the accuracy of such a low-cost active stereoscopy device to verify, in one hand, the possibilities of such an inexpensive device, and in the other hand, the performance of the measurement principle.

Digital cameras and computers are common assets in today's world, their costs rapidly drop and their performance increases. This has leaded to what is called Computer Vision Systems and, within these the Stereoscopic Vision ones.

However, images are two-dimensional and real scenes are three dimensional. In Passive Stereoscopy the third dimension lost in a single image is recovered using two images. If we calibrate the cameras, we know the distance between them and we perform certain transformations of the two images in the computer, it is possible to obtain whole geometry with its distances. An alternate method is Active Stereoscopy where only one image is used, but the second camera is replaced by a laser emitting a line-beam generating a plane in space. The camera must be previously calibrated for its intrinsic parameters such as pixel size, focal length, and lens distortion with a known 2-D standard which also allows determining the orientation of the camera, as an extrinsic calibration parameter, when the standard is placed at the reference plane. By knowing the spatial equation of the plane generated by the laser beam and the distance and orientation of the laser and the camera with respect to the reference plane, it is also possible to determine the height of a point out of the reference plane and lying on a an object under measurement. If we now move the beam through the object the whole geometry with its dimensions is generated. This is the method tested in the present work.

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16:30 – 17:00

Inspection of Complex Geometries - The Human Element

Brian Guadauskas
National Applications Engineering Manager, Hexagon Metrology

A better quality of life is a noble goal, and metrology, as we all know, is an unknown in many people's lives. All products have a lifecycle that starts with an idea, and ends with a transformation into another product or idea. While certain metrology innovations are obvious, such as targeted radiology, and composite aircraft, others are not. Deep within our science, we find operators, programmers, designers, engineers, managers and others - all users and consumers of the information metrology provides. The need for innovation within is measurable.

Until recent years, inspection, interpretation, and disposition of complex geometries such as gears, blades, blisks, and biologically contoured shapes has long been an art, inaccessible to most, and not understood by many. Add to this the advent of new scanning and sensor technology, point cloud engines capable of processing billions of points, datasets larger than ever before, and the information available to us can be overwhelming. Today our challenge is how to present this information, how to distill it, how to use it to create safer, lighter, stronger, more reliable parts faster, and more safely.

This presentation will demonstrate the distillation of data into human-readable form for users and consumers of metrology, and it will highlight concepts that we can use to increase understanding of large datasets. It will show the benefits gained by greater understanding of these complex geometries and application of tools that handle large quantities of information gracefully.

Our goal as metrologists to provide the best actionable information is critical to innovation in measurement and providing a better quality of life for all.

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Agenda: Tuesday October 9, 2012

8:30 – 9:30

Laser Trackers and Laser Scanners for large scale coordinate metrology

Dr. Steven Phillips
National Institute of Standards and Technology, NIST, USA

Recent advances in optoelectronics have created a new class of metrology instruments that are rapidly displacing conventional CMMs, particularly for large scale coordinate metrology. However, many challenges exist in selecting, testing and implementing these new technologies for industrial applications. This talk will examine the strengths and weakness of these metrology systems and provide users with some guidance on appropriately implementing these instruments.

9:30 – 10:15

Verification of Large CMMs by means of artifacts

Dr. Eugen Trapet
TRAPET Metrology, Spain

Large coordinate measuring machines (CMMs) suffer from changes with time and environment much more than “small” laboratory type CMMs and they are as well more difficult to adjust and to error map (to compensate) than smaller ones.

Changes of several mm in the geometry can often be observed within the typical service interval of 1 year.

This is why it is of importance to:

1. Thoroughly verify any changes introduced by service personnel into the machine geometry via adjustments and error compensation.

2. Monitor the changes of geometric accuracy periodically by the user himself.

This presentation deals with the main means for machine acceptance testing and the related ISO standard. A detailed view of large artifacts, their use, and the effort related to that use, their calibration, and their

accuracy is given. Specific recommendations for dealing with large CMM testing are given (e.g. deformations of foundations, duplex coupling errors, column tilt errors, vibrations, propagation of geometry errors into probe head qualification,…). An introduction to the ISO 10360-2 (2009) and -5 under the aspect of large CMM verification is given with examples of measurement data.

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10:15 – 10:45 **Coffee Break / Exhibitions**

10:45 – 11:15 **Innovative and Adaptive Image Processing Techniques for CT-Metrology**

Raghuram Bhogaraju
App. Comp. Tomography, C. ZEISS Industrial Metrology, USA

Computed Tomography (CT) was introduced in 1972 by Hounsfield and Cormack as an innovative departure from traditional X-ray technology used in medical applications and efforts in that field were awarded a Noble Prize in medicine [1]. Over the past 10 years CT started migrating from medical applications to industrial metrology applications. Industrial X-ray computed tomography (CT) provides a fast and powerful method to extract the geometrical features of complex parts. It can be used for non-destructive testing, reverse engineering and dimensional metrology. However, the reconstructed part sometimes shows CT-specific artifacts that are caused by the broad energy spectrum of X-rays generated by the source (“beam hardening”) and the complex interaction of the radiation with the part and the detector (“scatter”). These artifacts are especially critical for measuring purposes. Adaptive image processing techniques can be used to suppress the artifacts, improving the accuracy of the extracted surface geometry.

11:15 – 11:45 **Measurement System Capability Analysis**

Ramón Zeleny
MITUTOYO Mexicana S.A. de C.V., Mexico

The document ISO/TS 16949:2009 is ISO 9001 specifically applied to the automotive industry. In its item 7.6.1 it indicates that the manufacturer must use the manual of Measurement System Analysis of its customer. Previously, it referred to the unique manual, called precisely Measurement System Analysis (MSA, now in its fourth edition) and was widely applied in the American auto industry. However now the German auto industry has come up with a new manual

Capability of Measurement Process (VDA5, already in its second edition) that somehow integrates the methods already used in MSA, but treats them as uncertainty components along with other factors not considered in MSA.

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We discuss the differences between MSA and VDA5, and present the new approach of the latter to determine whether a system and a measurement process can adequately measure a manufactured part by use of the measurement uncertainty concept. As many European car manufacturers that follow VDA5 are establishing in Mexico, it

is recommend that their local providers get acquainted with VDA5 methodology to be able to satisfy these customers.

Until present, the methodology to determine the measurement uncertainty in industry has been applied mainly by testing and calibration laboratories either internal or external to it that follow ISO 17025. VDA5 has generalized the application of the concept of measurement uncertainty to make conformity assessments in industry.

VDA5 along with Capability and Performance – Part 7: Capability of Measurement Processes (ISO 22514-7), which will be published in the near future, may be leading the trend in how to determine the capacity of systems and processes of measurement in industry.

11:45 – 12:30 **Evaluation of CMM Measurement System According to VDA 5**

Alfonso Cotera
VOLKSWAGEN de México, México

Nowadays the demands of internal and external clients require the manufacturers to improve their products and their quality assurance. As a first activity, it the quality assurance of the measurement results is needed. To achieve it, it is not enough to have the measurement means (CMM) calibrated under a established program, it is also required to consider, from the planning stage, the relationship between the measurement uncertainty and the manufacturing tolerances. The new standard VDA 5 (Verband der Automobilindsutrie) proposes a method to grade the adequacy of a measurement process on a CMM with respect to the manufacturing tolerances. When this activity is systematized, the confidence and comparability of measurement results will increase. The present work presets the methodology proposed and illustrates it through some examples.

12:30 – 12:50 **Discussion Panel**

12:50 – 13:00 **Summary of the Conference and Closure**