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## GPS&VToolbox – project that facilitates professional training in ISO GPS system

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### Abstract

The need to develop innovative vocational training platform *Geometrical Product Specification and Verification as toolbox to meet up-to-date technical requirements* is justified. The latest changes in the standards that form fundamentals of the ISO GPS system are shortly described in this paper. Then the concept of the new training platform is presented and the content illustrated.

Keywords: Geometrical Product Specification, ISO GPS system, geometrical tolerancing, e-learning, vocational training

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### 1. Introduction

For recent several years, an intensive development of standards in Geometrical Product Specification (GPS) field has been observed [1, 2]. The ISO Technical Committee ISO/TC 213 *Business plan* [3] shows all important areas and aims for standardization regarding the geometrical tolerancing to achieve unique specification of the workpieces geometry. The GPS is a system of rules and symbols developed to define the geometrical requirements of workpieces in engineering specifications, and the requirements for their verification in the conditions of the up-to-date machine industry.

### 2. Erasmus+ project for professional training in the ISO GPS

A contemporary engineer should know the general concept of the GPS standards system and in detail those standards that are relevant to his current activities. Due to the fact that there have been many significant changes in the ISO GPS standards recently, it is necessary to create and then update the training system for industry employees. Therefore, the international consortium (University of Bielsko-Biala, Warsaw University of Technology, Università Degli Studi di Padova, Friedrich-Alexander-Universität Erlangen Nuernberg, Interstaatliche Hochschule Fur Technik Buchs NTB, University of Huddersfield, Universitatea Tehnica din Cluj-Napoca, Ecole Normale Supérieure de Cachan, Volkswagen AG Wolfsburg) has decided to develop vocational training platform *Geometrical Product Specification and Verification as toolbox to meet up-to-date technical requirements* [4] in the frame of European programme Erasmus+ KA-2 Strategic Partnerships, project no. 2015-1-PL01-KA202-016875. The aim of the consortium is to share and combine partners educational experience with industrial needs. Thanks to synergy effect we have develop innovative teaching materials regarding GPS applications in design and verification with special emphasis on metrological aspects. The results are addressed to vocational training for employees (design, production and metrology technicians or engineers) and will be available for online access via e-learning platform as well as offline in the interactive PDF format. Another target group that can benefit from the project are students of mechanical engineering faculties.

Currently the project is carried out and its first internet version host by University of Bielsko-Biala has been put into operation and is examined by invited test users. According to the project scope two main parts of the proposed vocational training may be distinguished:

- presentation and explanation of the ISO GPS symbol language for geometrical specification of workpieces and rules for its application and interpretation;
- presentation and explanation of methods that may be applied to verify whether produced workpieces are within the limits defined by specifications.

It is worth to mention that developed interactive tutorial contains also tests that enable self-evaluation of a user, whether he/she understands well presented symbols, rules and concepts of the ISO GPS system and is able to apply it effectively during day-to-day work.

After some trials the project partners decided to use eXeLearning as the authoring tool to transfer to the web developed educational interactive contents. Thanks to the capabilities of the computer environment the multimedia approach applied by the project partners includes combination of text, graphics (sketches and photos) enriched by interactive animations controlled by a user. The links within developed teaching materials gave opportunity for a user to browse through the course according to individual needs as well as work experience and knowledge already gained in the GPS field. In the developed multimedia course a user has some control of what is presented. The duration as well as the speed of the study may be adjusted alone by each user.

### 3. The ISO GPS system

The study of the GPS standards system shall start with ISO 14638:2015 standard, which provides an overview of the structure of the ISO GPS system. The model presented in the standard divides the GPS standards into three types: *fundamental*, *general* and *complementary*. In the past the group of the *global standards* was additionally distinguished. Those standards are currently categorized as fundamental or general. The fundamental standards (e.g. ISO 17450, ISO 8015, ISO 1) are the standards which define rules and principles which apply to all categories, geometrical property categories as well as other categories, and all chain links in the *ISO GPS*

matrix. The general standards (e.g. ISO 1101, ISO 1938, ISO 2692, ISO 10360) are standards which apply to one or more geometrical property categories, and to one or more chain links, but are not fundamental standards. Finally, the complementary standards are the standards which refer to specific manufacturing processes or to specific machine elements.

Currently nine geometrical properties are identified in the ISO GPS system: *size, distance, form, orientation, location, run-out, profile surface texture, areal surface texture and surface imperfections*. In the past *radius, angle and edges* were categorized as geometrical properties but currently *angles* are covered within the properties of *size and distance*, while *radii* are covered within the property of *distance and form*. Moreover, there was another detailed breakdown before 2015, e.g. beside the current category *form* there were *form of a line independent of datum* and *form of a surface independent of datum*. It has been decided that *form of a line dependent of datum* and *form of a surface dependent of datum* are included in *orientation* and *location* tolerances, respectively. *Roughness profile, waviness profile and primary profile* are grouped in *profile surface texture*. *Datums and edges* were removed because they are not considered to be geometrical property. Each geometrical property category corresponds to a row in the ISO GPS matrix.

In the ISO GPS standards matrix model seven *chain links* consists of all general GPS standards which relate to a particular function in the specification or verification of a geometrical property. Each chain link corresponds to a column in the matrix, which is indicated with consecutive letters: A – *Symbols and indications*, B – *Feature requirements*, C – *Feature properties*, D – *Conformance and non-conformance*, E – *Measurement*, F – *Measurement equipment*, G – *Calibration*.

The standard ISO 8015:2011 is of key importance. Many years ago the concept of independency principle was introduced in this standard. Currently it sets out thirteen general principles binding in GPS and gives legal basis for resolving anticipated conflicts between suppliers and customers.

#### 4. Key GPS standards concerning product macro-geometry

The most important GPS standards concerning products macro-geometry are definitely ISO 1101, ISO 5459, ISO 5458 and ISO 2692. The standards ISO 1101:2017 and ISO 5459:2011 have been recently expanded significantly. The ISO 1101 includes many new tools for precise, unambiguous specification of requirements such as *auxiliary feature indicators by direction feature, collection plane, intersection plane, orientation plane*. The ISO 5459 introduces new modifiers: *orientation constraint only, moveable datum target, contacting feature, variable distance (for common datum) and situation feature*.

The new ISO 5458 standard is substantially amended and expanded. It was approved in the January 2018 by national standards bodies and it is under publication. The ISO 5458 gives rules to be applied to pattern specifications. The modifiers CZ – *combined zone*, SZ – *separate zones* and SIM – *Simultaneous requirements* give new possibilities for unique specification for limits of geometrical variations for patterns of features.

#### 5. Multimedia instructional tools in GPS&VToolbox

The GPS&VToolbox project intends to improve the instructions in the GPS issues by creating web base learning environment. Below example screenshots (Fig. 1, 2) from one of a few animations that have been especially adopted for the project are shown. The project co-authors are developing the application *Geometrical Tolerancing* for a few years [5]. A number training performed in industry has shown that the

use of the application is appreciated by participants and helps them to understand the GPS complex concepts and rules.

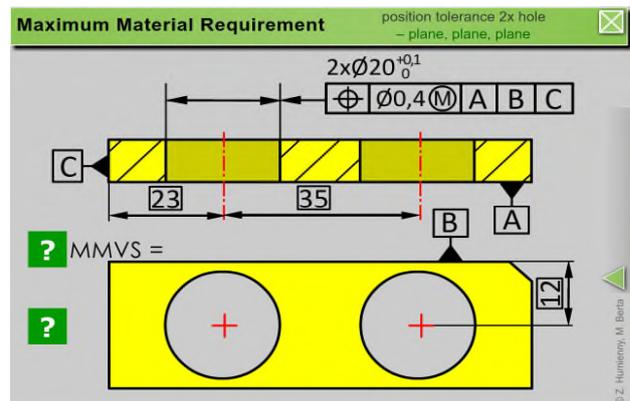


Figure 1. Maximum material requirement for pattern of two holes based on the size and location (position) requirements with respect to three plane datum system. The diameter of the gauge pin MMVS is not directly given – a user may get it thanks to the Question mark button.

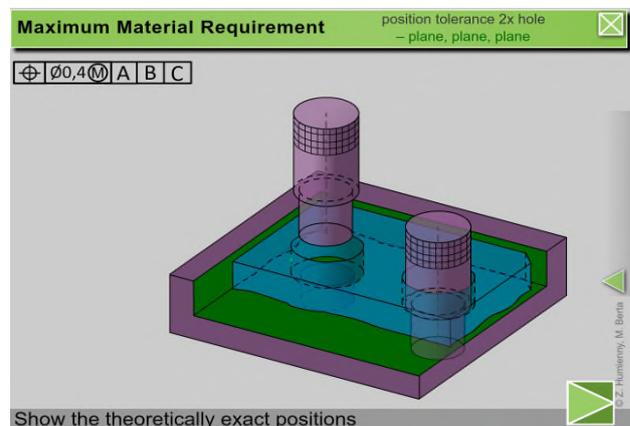


Figure 2. The last but one scene developed to explain position tolerance with MMR for pattern of two holes. The plate is fixed in the datum system. The position of the first hole is verified as OK. The second pin is used to verify whether the second hole is in the correct position.

#### 5. Conclusions

Implementation of the e-learning training platform *Geometrical Product Specification and Verification as toolbox to meet up-to-date technical requirements* gives new opportunities to deliver advanced vocational training. The platform enables systematic and interactive presentation of all ISO GPS concepts that shall be known and respected by each engineer working in industry that produces parts to be assembled and work properly according to designer intends. It is especially important for mass production such as in the automobile industry or due to the safety reasons as in the aviation industry.

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#### References

- [1] Cao Y L, Mathieu L, Jiang J. 2015, Key research on computer aided tolerancing. *Zhejiang Univ-Sci A (Appl Phys & Eng)* 16(5):335-340.
- [2] Humienny Z. 2009, State of Art in Standardization in GPS Area. *CIRP Journal of Manufacturing Science and Technology*, v.2, p. 1–7.
- [3] <https://www.iso.org/committee/54924.html>
- [4] <http://gpsvtoolbox.ath.eu/>, access 02.2018.
- [5] Humienny Z, Berta M. 2018, Interactive multimedia learning environment for geometrical specification indication & verification rules, accepted for 15th CIRP CAT 2018, [www.sciencedirect.com](http://www.sciencedirect.com)