INTERNATIONAL STANDARD

ISO 14253-3

First edition
2011-04-15

Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

Part 3: Guidelines for achieving agreements on measurement uncertainty statements

Spécification géométrique des produits (GPS) — Vérification par la mesure des pièces et des équipements de mesure —

Partie 3: Lignes directrices pour l'obtention d'accords sur la déclaration des incertitudes de mesure

Reference number
ISO 14253-3:2011(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14253-3 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This first edition of ISO 14253-3 cancels and replaces ISO/TS 14253-3:2002, which has been technically revised.

ISO 14253 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment*:

— *Part 1: Decision rules for proving conformance or non-conformance with specifications*

— *Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

— *Part 3: Guidelines for achieving agreements on measurement uncertainty statements*

— *Part 4: Background on functional limits and specification limits in decision rules* [Technical Specification]

Introduction

This part of ISO 14253 is a geometrical product specification (GPS) International Standard and is to be regarded as a global GPS Standard (see ISO/TR 14638). It influences links 4, 5 and 6 of all chains of standards in the general GPS matrix.

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this part of ISO 14253 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 14253 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 14253, unless otherwise indicated.

For more detailed information on the relation of this International Standard to other standards and the GPS matrix model, see Annex A.

ISO 14253-1 provides decision rules for proving conformance or non-conformance with specifications of workpieces and measuring equipment when taking into account the uncertainty of measurement. ISO 14253-2 provides instructions for preparing uncertainty budgets for determining measurement uncertainty as defined in the *Guide to the Expression of Uncertainty in Measurement* (*GUM*). However, the possibility still exists that disagreement between customer and supplier can occur on the estimated measurement uncertainty.

It is becoming increasingly common for suppliers to have in place a quality system providing satisfactory assurance to the customer that the latter is receiving a product which conforms to specifications. This avoids the need for costly duplicate inspections.

For this reason, the most common case of disagreement over a measurement uncertainty statement or an uncertainty budget involves the customer questioning the supplier's uncertainty budget. The customer may also question the measured value of a characteristic of a workpiece or of measuring equipment, thus indirectly questioning the total uncertainty budget (see ISO 14253-1).

In a rarer case of disagreement, the supplier may question the customer's uncertainty budget when the customer rejects a workpiece or measuring equipment (see ISO 14253-1:1998, 6.2).

In addition to those mentioned, there are other cases of disagreement, as well as other motivations that may lead to discussion of stated uncertainties.

Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

Part 3: Guidelines for achieving agreements on measurement uncertainty statements

1 Scope

This part of ISO 14253 provides guidelines and defines procedures for assisting the customer and supplier to reach amicable agreements on disputed measurement uncertainty statements regulated in accordance with ISO 14253-1, and so avoid costly and time-consuming disputes.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14253-1:1998, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for proving conformance or non-conformance with specifications*

ISO 14253-2:2011, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

ISO 14978:2006, *Geometrical product specifications (GPS) — General concepts and requirements for GPS measuring equipment*

ISO 17450-1:—[1)], *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

ISO 17450-2:—[2)], *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

1) To be published. (Revision of ISO/TS 17450-1:2005)

2) To be published. (Revision of ISO/TS 17450-2:2002)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14253-1, ISO 14253-2, ISO 14978, ISO 17450-1, ISO 17450-2, ISO/IEC Guide 98-3 and ISO/IEC Guide 99 apply.

4 Reaching an agreement on a stated expanded uncertainty

4.1 Early agreement on the stated measurement uncertainty

In a case where either the customer's or supplier's measurement uncertainty statement is in question, an uncertainty budget supporting and documenting the measurement uncertainty statement may be necessary. It is the responsibility of the party preparing the uncertainty budget to justify the individual components and the resulting estimated expanded uncertainty of the uncertainty budget.

In an ideal situation, customer and supplier will address the issue of measurement uncertainty at the same time as they address the product specifications of the workpiece, at the pre-contract stage. Agreement on the magnitude of the measurement uncertainty or uncertainties and the rules for its application at this early stage of the business relationship will avoid later disputes over acceptance or rejection of product and the consequent need to apply the default rules given in ISO 14253-1.

NOTE In most cases, there are several GPS characteristics specified for a workpiece and for each of these characteristics a measuring task with corresponding measurement uncertainty statement is required.

Two different persons can produce two different uncertainty statements due to differing knowledge, experience and assumptions. Resolving these differences at the pre-contract stage is likely to be less contentious and less costly than waiting until an argument develops over the acceptance or rejection of the product during the manufacture and delivery stage.

4.2 Possibilities for solving disagreements over a stated measurement uncertainty

The most basic way of reaching an agreement is to agree to choose one of the two statements of measurement uncertainty from either party to the agreement. If this type of settlement is not appropriate, another solution is to use the more refined procedure given in Clause 5, or to use a third party consultation or a review or both.

Clause 6 of ISO 14253-1:1998 gives specific rules on dealing with uncertainty of measurement when proving conformance or non-conformance with a specification:

— supplier proving conformance with specifications (ISO 14253-1:1998, 6.2);

— customer proving non-conformance with specifications (ISO 14253-1:1998, 6.3).

The magnitude of the measurement uncertainty is of importance, because it decreases the conformance zone (supplier proving conformance) and the non-conformance zone (customer proving non-conformance).

NOTE 1 Decreasing the non-conformance zone increases the interval where non-conformance cannot be proven. According to ISO 14253-1, the measurement uncertainty is stated by the party providing the proof of conformance or non-conformance with a specification, i.e. the party making the measurements. In the following clauses of this part of ISO 14253, the party stating the measurement uncertainty is designated “party 1”. The other of the two parties is designated “party 2”. “Party 2” is the party likely to question or disagree with the stated measurement uncertainty.

NOTE 2 When the supplier is proving conformance with specification, the supplier is “party 1” and it is the customer, “party 2”, who provides the specification. When the customer is proving non-conformance, the customer is “party 1” and is also considered to have provided the specification, hence it is the supplier who is “party 2”.

A number of scenarios can be demonstrated for cases where a stated measurement uncertainty from "party 1" may be questioned by "party 2". Figure 1 illustrates the most common scenarios, as follows.

a) A measurement uncertainty is stated by "party 1" (**box a**).

b) "Party 2" has two options (**box b**).

   1) If "party 2" agrees to the measurement uncertainty statement (**box b — "Yes"**), both parties have come to the same conclusion. The issue is resolved (**box z**).

      NOTE A measurement uncertainty statement can be a simple claimed value without any documentation or an uncertainty budget with a resulting expanded uncertainty according to ISO 14253-2.

   2) If "party 2" disagrees with the measurement uncertainty statement (**box b — "No"**), this part of ISO 14253 applies.

c) The two parties may use a third party to resolve their disagreement.

   1) If yes (**box c — "Yes"**), the third party will evaluate the uncertainty budget (**box v**). The issue is resolved (**box z**).

   2) If no (**box c — "No"**), the two parties continue with the procedure (**box d**).

d) "Party 1" may or may not have generated an uncertainty budget according to ISO 14253-2 (**box d**).

   1) If an uncertainty budget does not exist (**box d — "No"**), there are two options.

      i) The two parties agree, by decision, and without further documentation, on a "new" measurement uncertainty statement (**box e — "Yes"**). In this case, "party 1" shall change the uncertainty statement according to the agreement (**box f**), and the issue is resolved (**box z**).

      ii) "Party 2" requires an uncertainty budget from "party 1" (**box e — "No"**). "Party 1" then has two options.

         I) Use a third party (**box g — "Yes"**). The third party shall evaluate the uncertainty budget (**box v**). The issue is resolved (**box z**).

         II) Do not use third party (**box g — "No"**). "Party 1" shall generate an uncertainty budget (**box h**) according to the guidelines given in ISO 14253-2 (**box j**). When the uncertainty budget is prepared, the procedure recommences from the starting point (**box a**).

   2) If the uncertainty budget exists (**box d — "Yes"**), proceed to the next option.

e) The uncertainty budget prepared by "party 1" may or may not be known to "party 2" at this moment (**box k**).

   1) If the uncertainty budget exists, but only the measurement uncertainty has been reported to "party 2" (**box k — "No"**), "party 1" shall make the uncertainty budget and the inherent documentation known to "party 2" (**box m**). The procedure then recommences from the starting point (**box a**).

   2) If the uncertainty budget is known to "party 2", the following situations arise (**box k — "Yes")**.

f) The two parties either will or will not come to an immediate agreement based on the presented uncertainty budget and without making further detailed investigations (**box n**).

   1) The two parties can, by decision, and without further documentation, agree on the stated or a "new" measurement uncertainty statement (**box n — "Yes"**). In the case of a "new" uncertainty statement, "party 1" shall change the uncertainty budget and the uncertainty statement according to the agreement (**box o**), thus resolving the issue (**box z**).

   2) If the two parties cannot agree immediately on the presented uncertainty budget (**box n — "No"**), the approach will depend on the level of the uncertainty budget at which they disagree.

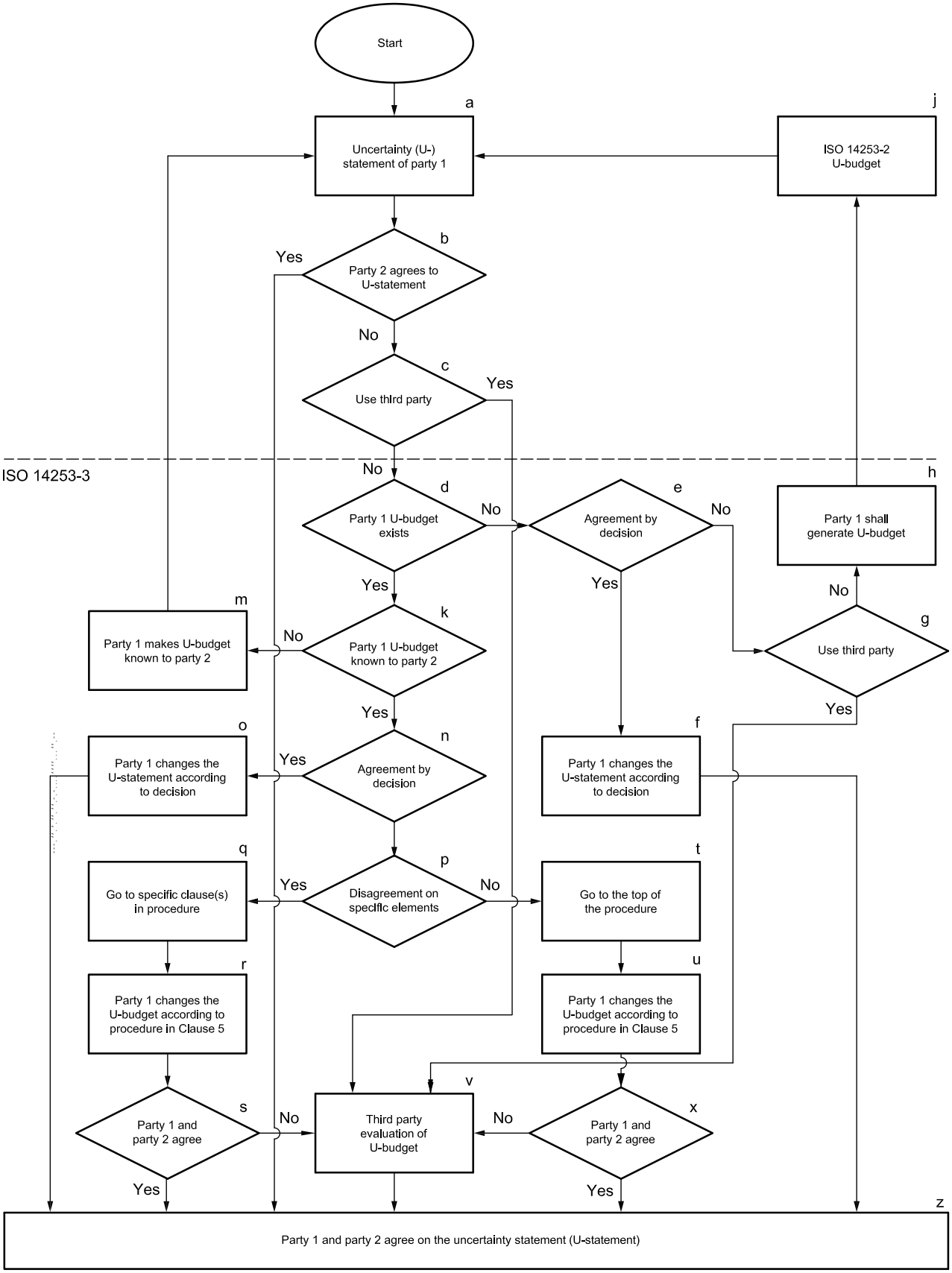

Figure 1 — How to agree on an uncertainty statement

g) Disagreement on the presented uncertainty budget or measurement uncertainty or both could be limited to specific components in the uncertainty budget, or it could be a general disagreement (**box p**).

   1) If the disagreement concerns only specific and identifiable components of the uncertainty budget and its preconditions, it is possible (**box q**) to re-evaluate, and work directly on, the elements in the procedure described in Clause 5. “Party 1” shall modify the uncertainty budget or preconditions or both, as well as the resulting uncertainty statement (**box r**), according to common agreement.

      i) The result may not be acceptable to one of the parties (**box s — “No”**). The possibility of an amicable solution remains, by means of third party evaluation (**box v**), and the issue is resolved (**box z**).

      ii) If the result of the modification in the uncertainty budget is acceptable to both parties (**box s — “Yes”**), the issue is resolved (**box z**).

   2) If the disagreement on the uncertainty budget and its preconditions is of a general character, the solution is to proceed to the starting point of the procedure given in Clause 5 (**box t**). “Party 1” shall modify the uncertainty budget or preconditions or both, as well as the resulting uncertainty statement (**box u**).

      i) The result may not be acceptable to one of the parties (**box x — “No”**). Use third party evaluation of the uncertainty budget (**box v**). The issue is resolved (**box z**).

      ii) If the result of the modification in the uncertainty budget is acceptable to both parties (**box x — “Yes”**), the issue is resolved (**box z**).

5 Sequential procedure for evaluating and reaching agreement on an uncertainty statement

5.1 General

The basis and documentation of an uncertainty statement are the uncertainty budget together with its defined preconditions (see ISO 14253-2:2011, 9.2). The basis for an agreement on an uncertainty statement is the agreement on the uncertainty budget together with the preconditions of that budget.

In simple cases, and if experience exists, the uncertainty statement may be accepted and agreed to by both parties without the documentation of a specific uncertainty budget.

To reach common agreement on the uncertainty statement in more complex cases, the sequence of activities/stages (see Figure 2, 1 to 11) in an uncertainty budgeting process (given in 5.2 to 5.12) shall be executed in the mentioned order. Agreement shall be reached clause by clause in order to establish, from the outset, the argumentation and proof for the uncertainty as the agreed prerequisites.

If any major modification is made at any stage in the sequence, it is essential that the modification be sequentially applied right through to the final statement of expanded uncertainty, U, in order to see the effect on the function of the product and its impact on any possible agreement.

Details of the uncertainty estimation and its necessary budgeting referred to in the following subclauses are given in ISO 14253-2. References to the relevant clauses in ISO 14253-2 are given as follows.

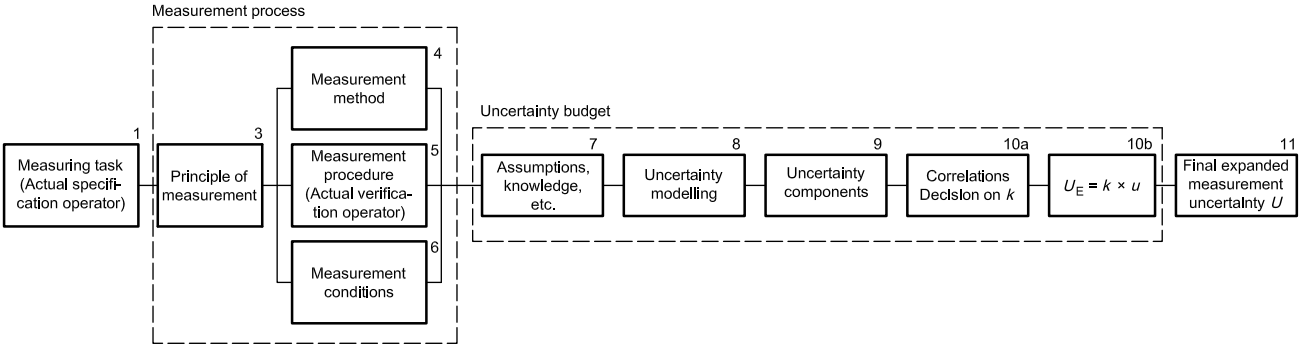

Figure 2 — Stages from measuring task (actual specification operator) to stated uncertainty

5.2 Agreement on measuring task — Measurand (specification operator)

One of the prerequisites of an uncertainty budget is the specification operator. Without definition and agreement on the actual specification operator, discussion or evaluation of the uncertainty budget and statement of uncertainty is meaningless (see **box 1** in Figure 2). The necessary elements that the two parties shall agree upon at this stage are the following:

— the definition or definitions of the actual specification operator, based on the specification given in the product documentation;

— the overall measuring task or tasks and, if necessary, the intermediate measuring task or tasks allowed by the actual specification operator definition;

— the ISO GPS standards defining the drawing indication (actual specification operator) and the resulting chain or chains of standards (see ISO/TR 14638) and their content;

— possible imperfections in the measurement object (workpiece or measuring equipment) that might influence the specification uncertainty and measurement uncertainty.

The findings about the actual specification operator shall be documented to form the basis of the subsequent stages in the sequence of an agreed measurement uncertainty evaluation (see Figure 2).

5.3 Agreement on acceptability of actual verification operator (ISO 14253-2:2011, 9.2 and 9.3)

A second prerequisite for an uncertainty budget is the choice of the actual verification operator in accordance with the actual specification operator. Without definition of and agreement (in terms of common understanding) on the verification operator, discussion or evaluation of the uncertainty budget and statement of uncertainty is meaningless (see **boxes 3 to 6** in Figure 2). Based on the agreed specification operator, agreement shall be reached on the detailed definition of the verification operator.

The necessary elements that the two parties shall agree upon at this stage are the

— overall and intermediate measuring processes to be performed (see **boxes 3 to 6** in Figure 2, and ISO 14253-2:2011, 9.2 and 9.3),

— measurement principle (see **box 3** in Figure 2, and ISO 14253-2:2011, 9.2 and 9.3),

— measurement method (see **box 4** in Figure 2, and ISO 14253-2:2011, 9.2 and 9.3),

— measurement procedure, including the choice of measuring equipment (see **box 5** in Figure 2, and ISO 14253-2:2011, 9.2 and 9.3),

— necessary details in the documented instruction/procedure,

— partition, extraction, filtration, association, collection, construction and evaluation (see ISO 17450-1:—, Clause 8 and Annex C),

— the identification of a piece measuring equipment (or measuring equipment group), and

— measuring conditions, documented (see **box 6** in Figure 2).

The findings on the actual verification operator shall be documented, in order to form the basis for the subsequent stages in the sequence of steps for reaching an agreed measurement uncertainty evaluation.

The two parts forming the basis for the uncertainty budget, requirement and measurement, have now been established. The next stages in the sequence enable calculation or estimation of the consequence of the foundation on the uncertainty only.

5.4 **Agreement on assumptions** (box 7 of Figure 2)

It is seldom necessary to document all activities and conditions. A number of assumptions have to be made. Agreement at this stage shall include the following:

— a list of supplementary assumptions. If there is disagreement, a combined list from “party 1” and “party 2” may help towards a resolution;

— consideration of whether or not the documentation for the assumptions is sufficient;

— consideration of whether the use of simplified verification operators is acceptable — documentation on the manner in which the difference from the perfect verification operator is solved, either by adjustment or by task-related calibration of the simplified verification operator or by both.

5.5 **Agreement on uncertainty modelling** (box 8 of Figure 2)

The choice of the uncertainty model is important, because it must reflect the actual verification operator and the level of information present about the conditions. The agreement shall include the following:

— a choice of black box or transparent box or partially black/transparent box model (see ISO 14253-2:2011, 8.4, 8.5 and 8.6);

— use of the PUMA principle of upper bound estimates where doubt exists (see ISO 14253-2:2011, Clause 5);

— a decision on a possible mathematical model (see ISO 14253-2:2011, 9.3.4);

— a statement of the time period and duration for which the uncertainty statement is valid;

— a check for possible outliers or the possible risk posed by outliers (see ISO 14253-2:2011, Clause 7); and

— documentation.

5.6 **Agreement on list of uncertainty contributors/components** (box 9 of Figure 2)

The list of contributors shall, as a minimum, include the dominant uncertainty contributors. If not, the resulting uncertainty will definitely be too small.

As the tools to obtain a full list and a systematic approach, use

— the three elements of ISO 14253-2:2011, Figure 6: “reference point”, “travel” and “measuring point” (see ISO 14253-2:2011, 9.1),

— the check lists of ISO 14253-2:2011, Clause 7, and Figures 3 and 4, and

— if relevant, the specification uncertainty contributors as inclusions in the list.

If in disagreement, use or investigate the combined list of the two parties and include from this list the missing contributors of importance (larger ones relative to the already largest contributors).

5.7 Agreement on possible corrections

In cases where corrections are taken into account in the uncertainty budget, the two parties shall agree on the following:

— that the performed corrections be made with correct values according to the present documentation and conditions;

— that the correction procedure used in the uncertainty budget be in accordance with the measurement procedure;

— that the uncertainty of the correction itself (i.e. the remaining uncertainty component) be included in the uncertainty budget.

5.8 Agreement on magnitude of uncertainty contributors (box 9 of Figure 2)

With the total agreed-upon list of uncertainty contributors/contributions, an essential task is to evaluate the magnitude of each of them. Starting the investigation with the dominant (large) contributors, check the effect of each on the resulting expanded uncertainty.

For each uncertainty component (see ISO 14253-2:2011, Clause 8), investigate and agree on the following:

a) the needed/performed corrections or detailed assumptions, or both, concerning the individual component;

b) the evaluation method, i.e. Type A or Type B (see ISO 14253-2:2011, Clause 8);

c) documentation and argumentation for the magnitude of the uncertainty component (data validity and data correctness for a Type A evaluation; limit value and assumptions about distribution type for a Type B evaluation) — see ISO 14253-2:2011, 8.3, Annexes A, B and C. Special attention shall be given to

   — calibration certificates (traceable calibration values for MPEs) for uncertainty statements,

   — calibration records,

   — calibration intervals,

   — influence quantities, and the physical equations and constants used, and

   — formulae and calculations.

5.9 Agreement on correlation between contributors (box 10a of Figure 2)

An unrecognized possible correlation between uncertainty contributors could lead to a significant underestimation or overestimation of the resulting expanded uncertainty.

Agreement on possible correlation and the nature of the correlation can therefore be of great importance for total agreement.

Investigate and agree a possible correlation between uncertainty contributors (see ISO 14253-2:2011, 8.6, 8.7 and 9.3.7).

In case of doubt, use the rules in ISO 14253-2:2011: upper bound (PUMA) strategy, based on correlation coefficients 0 and 1 and -1 only (see ISO 14253-2:2011, 8.6 and 8.7).

5.10 Agreement on summation rules (ISO 14253-2:2011, 8.6, 8.7 and 9.3.8)

Check that the summation rule (mathematical formula) is in accordance with the chosen agreed uncertainty model (see 5.6) and the agreed correlation between contributors (see 5.9).

5.11 Agreement on k value — Resulting distribution — Level of confidence (ISO 14253-2:2011, 8.7 and 8.8)

In general, the amount of information in the data presented for the uncertainty budget does not allow a detailed discussion and choice of k on the basis of a decided level of confidence. According to ISO 14253-1:1998, k shall be equal to 2 if no other argument can be presented in terms of knowledge on the distribution type.

In some cases, where the type of distribution of a dominant uncertainty contributor is known, it is possible to argue for a change of the k value from 2.

If the distribution type of the dominant uncertainty contributor is

— rectangular, a k-value of 1,7 to 1,8 will result in a 100 % level of confidence, but if it is

— U-shaped, a k-value of 1,4 to 1,5 will result in a 100 % level of confidence.

Distributions exist where k needs to be larger than 2 to reach a 95 % or higher level of confidence (i.e. triangular distribution).

If agreement on the change of k cannot be reached on the basis of the presented documentation, $k = 2$ shall be used.

5.12 Agreement on expanded uncertainty, U

Agreement on all stages in the sequence of activities from 5.3 to 5.11 shall automatically lead to an agreement of the estimated value of the expanded uncertainty, U.

Annex A
(informative)

Relation to the GPS matrix model

A.1 General

For full details about the GPS matrix model, see ISO/TR 14638.

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this part of ISO 14253 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 14253 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 14253, unless otherwise indicated.

A.2 Information about this part of ISO 14253 and its use

This part of ISO 14253 provides guidelines and defines procedures for assisting the customer and supplier to reach an amicable agreement on disputed measurement uncertainty statements regulated in accordance with ISO 14253-1.

A.3 Position in the GPS matrix model

This part of ISO 14253 is a global GPS standard, which influences chain links 4, 5 and 6 of all the chains of standards in the general GPS matrix, as graphically illustrated in Figure A.1.

Fundamental GPS standards	Global GPS standards						
	General GPS standards						
	Chain link number	1	2	3	4	5	6
	Size						
	Distance						
	Radius						
	Angle						
	Form of line independent of datum						
	Form of line dependent on datum						
	Form of surface independent of datum						
	Form of surface dependent on datum						
	Orientation						
	Location						
	Circular run-out						
	Total run-out						
	Datums						
	Roughness profile						
	Waviness profile						
	Primary profile						
	Surface imperfections						
	Edges						

Figure A.1 — Position in the GPS matrix model

A.4 Related International Standards

The related International Standards and Technical Specifications are those of the chains of standards indicated in Figure A.1 and, in particular, ISO 14253-1, ISO 14253-2 and ISO/IEC Guide 98-3.

Bibliography

[1] ISO 8015, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

[2] ISO 12179:2000, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Calibration of contact (stylus) instruments*

[3] ISO/TR 14638:1995, *Geometrical product specification (GPS) — Masterplan*

ICS 17.040.01

Price based on 12 pages