TECHNICAL REPORT

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Selected illustrations of full factorial experiments with four factors

Illustrations choisies de plans d'expérience factoriels complets à quatre facteurs

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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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 29901 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*.

Introduction

The Six Sigma and international statistical standards communities share a philosophy of continuous improvement and many analytical tools. The Six Sigma community tends to adopt a pragmatic approach driven by time and resource constraints. The statistical standards community arrives at rigorous documents through long-term international consensus. The disparities in time pressures, mathematical rigor and statistical software usage have inhibited exchanges, synergy and mutual appreciation between the two groups.

The present document takes one specific statistical tool (full factorial designs with four factors, 2^4 designs) and develops the topic somewhat generically (in the spirit of International Standards) but then illustrates it through the use of five detailed and distinct applications. The generic description focuses on the commonalities across 2^4 designs. These commonalities hold more generally for arbitrary numbers of factors, but a value of four was chosen for this Technical Report. The annexes containing the five illustrations follow the basic framework but also identify the nuances and peculiarities in the specific applications. Each example offers at least one "wrinkle" to the problem, which is generally the case for real Six Sigma applications. It is thus hoped that practitioners can identify with at least one of the five examples, if only to remind them of the basic material on factorial designs that was encountered during their Six Sigma training. Each of the five examples is developed and analysed using statistical software of current vintage. The explanations throughout are devoid of mathematical detail — such material can be readily obtained from the many design and analysis of experiments textbooks available (such as those given in the Bibliography).

Selected illustrations of full factorial experiments with four factors

1 Scope

This Technical Report describes the steps necessary to specify, to use and to analyse 2^4 full factorial designs through illustration, with five distinct applications of this methodology.

Depending on the application, a number of factors other than four may be considered in the experiment.

NOTE 1 Each of these five illustrations is similar in that sufficient resources were available to implement the design. Other commonalities among the five examples are noted (e.g. study objective, two levels for factors, response variable(s), factors effecting the response). The individual illustrations have some salient features that are distinct such as presence/absence of repetitions, centre points, interactions, or different types of response variables. Each illustration takes place in a different environment such as marketing, software, manufacturing, telecommunications and chemical processing.

NOTE 2 For the purposes of this Technical Report, the selection of four factors with two levels (aside from centre points) was made in advance. Furthermore, the detailed use of response surface designs as a follow-up or augmentation of the existing designs was excluded from this Technical Report, although their use is noted in some of the illustrations. Likewise, Taguchi designs and blocking designs were not included.

NOTE 3 Full factorial experiments are often employed by individuals (so-called “black belts” or “green belts”) associated with Six Sigma methods. Six Sigma methods are concerned with problem solving and continuous improvement. A full factorial experiment with four factors is one of many tools available to Six Sigma practitioners, but hitherto has not been addressed in detail in ISO International Standards.

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 3534-1:2006, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 3534-2, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

ISO 3534-3:1999, *Statistics —Vocabulary and symbols — Part 3: Design of experiments*