Publications 1985 – 1990

Bollmann, Peter; Zuse, Horst:
An Axiomatic Approach to Software Complexity Measures.
Proceedings of the Third Symposium on Empirical Foundations of Information and Software Science III,

Roskilde, Denmark, October 21-24, 1985.
Reprinted in:
Empirical Foundations of Information and Software Science III,
Edited by Jens Rasmussen and Pranas Zunde,
Plenum Press, New York and London, 1987, pp.13-20.

This paper contains the basic concepts of measurement theory with an application to software measures. The scale types, the meaningfulness and the conditions for the use of a measure as an ordinal, interval and ratio scale were given. Additionally, the viewpoint of a user was introduced. The idea that the use of software measures depends on the view of the humans is also supported by Fenton /FENT91a/, p.253 (called: user-view). In 1984 Basili et al. /BASI84/ also proposed the GQM (Goal-Question-Metric) paradigm which is used for defining measurement goals.

Zuse, Horst; Bollmann, Peter:
Software Metrics: Using Measurement Theory to Describe the Properties and Scales of Static Software Complexity Metrics,
IBM RC 13504, 1988.

Zuse, Horst; Bollmann-Sdorra, Peter:
Software Metrics: Using Measurement Theory to Describe the Properties and Scales of Static Software Complexity Metrics,
SIGPLAN NOTICES, August 1989.

This paper is an extension and a more precise description of the 1985 and 1988 papers.

Zuse, Horst:
A New Set of Static Software Metrics to Measure the Control Flow Complexity of Programs,
IBM RC13692, 1988.

In this paper a set of software measures is discussed.

Zuse, Horst:
METRICS.
IBM, Hawthorne, April 5, 1988.

In this paper the System METRICS is described.

Zuse, Horst:
Software Complexity Measures
Properties of Software Complexity Measures.
Proceedings of the Workshop: Rechnergestützte Softwarebewertung,
Technische Universität Magdeburg, Sektion Mathematik,
October 18/19, 1990.

In this paper an overview of properties of software measures were presented.

Publications in 1991

Zuse, Horst:
[Software Complexity - Measures and Methods](#).
Book of: De Gruyter Publisher,
Berlin, New York, 605 pages, 498 figures, 1991.

Zuse, Horst:
Gegenkritik an dem WBS-Bericht 6/90:
Erhard Konrad
Über Softwarekomplexität, Meßtheorie und Standpunkte - Kritik des Bollmannschen Ansatzes,
Jan. 1991, 88 pages, TU-Berlin, FR 5-3, Franklinstra§e 28/29, D-1 Berlin 10.

Zuse, Horst:
Properties of Software Metrics (Short version).
Proc. of the 1st International Conference on Software Quality, (1ICSQ), pp. 12-18,
Dayton Convention Center, Dayton/Ohio, October 6-9, 1991.

In this paper the foundations for the investigation of verbally formulated properties are given. The full version of these paper is [published in Software Quality Journal 1992](#).

Zuse, Horst:
METKIT Module AM2.2: Measurement Theory and Software Metrics,
Educational module for academics,
ESPRIT Project METKIT 2384 (Metrics-Education-Toolkit), pages: 160, 1991.

This paper contains the educational material for teaching measurement theory with an application to software measures for students.

Zuse, Horst:
METKIT Module AM3.2.4: Measurement of Internal Attributes,
Educational module for academics and engineers,
ESPRIT Project METKIT 2384 (Metrics-Education-Toolkit), pages: 170, 1991.

This paper contains the educational material for teaching how to measure internal attributes of programs. Internal attributes are those which can be directly measured, for example nesting and size of programs. Internal and external attributes are described by Fenton /FENT91/.

Zuse, Horst:
METKIT Module AM3.2.5: Measurement of External Attributes,
Educational module for academics and engineers,
ESPRIT Project METKIT 2384 (Metrics-Education-Toolkit), pages: 30, 1991.

This paper contains the educational material in order to teach the measurement of external attributes. Following Fenton /FENT91/ external Attributes of a product, process, or resource are those which can only be measured with respect to how the product, process, or resource relates to its envirement.

Publications in 1992

Zuse, Horst:
Properties of Software Design Metrics.
Proceedings of the Oregon Workshop on Software Metrics,
Silver State Park, Oregon, March 23-25, 1992.
This paper contains a discussion of properties of software design measures.

Zuse, Horst:
Measuring Factors Contributing to Software Maintenance Complexity.
In: Proceeding of the 2ICSQ (Second International Conference on Software Quality),
Triangle Research Park, North Carolina, USA, October 4-7, 1992, pp. 178-190.

This paper contains the following: In 1991 an investigation by Lima /LIMA91/, who made an inquiry by companies in Portugal about the factors contributing to software maintenance complexity, was presented. The factors contributing to software maintenance complexity in percentages are: excessive interaction between modules (30%), excessive use of IF-Statements (10%), deeply nested DO-Loops (10%), self-modifying code (10%), redundant modules (10%), excessive use of global variables (5%), excessive use of GOTO statements (5%), old and inexistent documentation (5%), difficult dialog with users (5%), code which is not structured (5%), standardization of the changes suffered by the same application used by different users (10%). In this paper a set of software complexity measures is discussed which analyzes the discussed factors of software maintenance complexity above.

Zuse, Horst:
Support of Experimentation by Measurement Theory.
Position Paper for the International Workshop on Experimentation,
Dagstuhl, Sept. 14-18, 1992.

This is a position paper which describes how to make experiments in the area of software measurement.

Zuse, Horst:
Program Comprehension.
Position Paper for the Program Comprehension Workshop,
Nov. 9, 1992, Orlando Florida.

This is a position paper which gives ideas how the term "program comprehension" can be formalized.

Zuse, Horst:
Properties of Software Metrics (Full version).
Software Quality Journal. Vol 1, 1992, pp. 225-260.

In this paper measurement theory is introduced which gives conditions for the properties of measures. The properties of software measures and conditions of the use of software measures as an ordinal and ratio scale are given and applied, as an example, to the Measures of McCabe. Because composition and decomposition operations are major strategies in software development, theorems, which describe the properties of software measures related to this type of operations, are presented. Properties of software measures, as required in literature by

many authors, are discussed and explained with statements of measurement theory. The results show that it is possible to explain most of the required properties of software measures in literature with conditions of measurement theory. This makes the properties of software measures during the software life-cycle and the application in practice more visible.

Zuse, Horst; Bollmann-Sdorra, Peter:
Measurement Theory and Software Measures.
In: Workshops in Computing: T.Denvir, R.Herman and R.Whitty (Eds.):
Proceedings of the BCS-FACS Workshop on Formal Aspects of Measurement,
South Bank University, London, May 5, 1991.
Series Edited by Professor C.J. Rijsbergen. ISBN 3-540-19788-5.
Springer Verlag London Ltd,
Springer House, 8 Alexandra Road, Wimbledon, London SW19 7JZ, UK, 1992,
pp. 219-259.

This paper contains the following: measurement theory gives qualitative conditions for the use of measures. The properties of software measures related to the ordinal and ratio scale are given and applied to the Measure of McCabe. Furthermore the application of measurement theory to flowgraphs and programs is discussed. Additionally necessary and sufficient conditions for the behaviour of software measures with respect to concatenation operations are investigated.

Bollmann-Sdorra, Peter; Zuse, Horst:
Supplement to:
Zuse, Horst: Software Complexity - Measures and Methods
Proof of Theorems (Part I).
Technical Report,
Technische Universitèt Berlin, Franklinstra§e 28-29, FR 5-3, 1 Berlin 10, Germany, 1992.

This paper contains the proofs of some theorems in the book of Horst Zuse entitled: "Software Complexity - Measures and Methods". In the book of Zuse "ideas of proofs" are given, but not the complete proof. The proofs are given for the Measures of McCabe, Lines of Code LOC, Oviedo (Number of edges), Range Measures (Concept of Harrison and Magel), Measure SCOPE of Harrison and Magel, Measure PEN, and Measure NL.

Publications in 1993

Zuse, Horst:
Criteria for Program Comprehension Derived from Software Complexity Metrics.
Proceedings of the Second International Workshop on Software Comprehension,
July 8-9, 1993, Capri/Italy.

This paper contains: Program comprehension is close related to program complexity. In order to analyze program complexity much effort has been spent to measure the complexity of programs. For this reason hundreds of software complexity measures were proposed. In this paper criteria/conditions for program comprehension from software complexity measures are derived. It is also shown that using measurement theoretic numerical conditions from software complexity measures can be translated back to empirical conditions. That means the term comprehension can be described by empirical axioms. This approach makes it easier to talk about the term program comprehension.

Bollmann-Sdorra, Peter; Zuse, Horst:
Prediction Models and Complexity Measures from a Measurement Theoretic View.
Proceedings of the 3ISQC (3rd Int. Software Quality Conference),
Lake Tahoe, October 4-7, 1993.

In a prediction model software complexity measures are used to predict effort, number of errors, costs, etc.. An example is the COCOMO model which predicts effort based on the software complexity Measure LOC. In this paper the interdependence between the predicted variable and the software complexity measure is investigated from a measurement theoretic point of view. It is shown that wholeness (the whole is larger than the sum of the parts) does not carry over to the predicted variable, whereas independence holds for complexity if and only if it holds for the predicted variable. Additionally, it is shown that under given assumptions the COCOMO-like models are the only possible prediction models. The measurement theoretic view gives alternatives for the validation of models besides the use of correlations.

Publications in 1994

Zuse, Horst:
Software Complexity Metrics/Analysis.
In: Marciniak, John, J. (Editor-in-Chief):
Encyclopedia of Software Engineering,
Volume I, John Wiley & Sons, Inc. 1994, pp. 131-166.

This paper gives an overview of software complexity measurement in theory and practice.

Zuse, Horst:
Foundations of Validation, Prediction, and Software Measures.
Proceedings of the AOSW94 (Annual Oregon Software Metric Workshop,
Portland, April 20-22, 1994.

In this paper foundations of software measurement, validation and prediction are given. Among others, it is shown what it means to validate software metrics. Examples are given with the metric of McCabe. The interdependence between the predicted variable and the software complexity measure is investigated from a measurement theoretic point of view. It is shown that wholeness (the whole is larger than the sum of the parts) does not carry over to the predicted variable, whereas independence holds for complexity if and only if it holds for the predicted variable. Additionally, it is shown that under given assumptions the COCOMO-like models are the only possible prediction models. The measurement theoretic view gives alternatives for the validation of models besides the use of correlations.

Dumke, Reiner; Zuse, Horst:
Software-Metriken in der Objektorientierten Software-Entwicklung.
In: Wartung von wissensbasierten Systemen.
Editor: Professor Lehnert.
Verlag Hänsel-Hohenhausen, Egelsbach, Frankfurt, Washington, 1994.

In this paper the state-of-the-art of software metrics in the area of Object-oriented programming is presented.

Zuse, Horst:
Quality Measurement - Validation of Software Measures.
Invited paper to the Seventh International Software Quality Week Conference,
May 17-20, 1994, San Franzisko/California.

In this paper the COCOMO-model is discussed. Zuse, Horst: Foundations of the Validation of Object-Oriented Software Measures. Deutscher Universtètsverlag, 1994.

Zuse, Horst:
Foundations of the Validation of Object-Oriented Software Measures.
In: Dumke, R.; Zuse, H. (Editors):
Theorie und Praxis der Softwaremessung,
Deutscher Universitätsverlag DUV, Gabler - Vieweg - Westdeutscher Verlag,
1994, pp. 136-214.

Dumke, R.; Zuse, H. (Editors):
Theorie und Praxis der Softwaremessung,
Deutscher Universitätsverlag DUV, Gabler - Vieweg - Westdeutscher Verlag,
1994. (Theory and Practice of Software Measurement)

Publications in 1995

Zuse, Horst; Fetcke, Thomas:
Properties of Object-oriented Software Measures.
Proceedings of the 1995 Annual Oregon Workshop on Software Metrics,
June 3-5, 1995, Silver State Park / Oregon, USA.

In this paper foundations of the properties of object-oriented software measures are presented. The criteria for the properties of object-oriented software measures are characterized with several concatenation operations between objects, classes, methods, etc. Concatenation operations can be used as a tool to give numbers an interpretation above the ordinal scale level. The result of this investigation is that software measures for object-oriented techniques have completely other properties than measures for imperative languages. It is shown that many of the measures in the object-oriented programming area follow the Dempster-Shafer Function of Belief and the DeFinetti axioms. These axioms give criteria above the ordinal scale level. The consequences of these properties of object-oriented measures related to prediction models and validation are also discussed.

Zuse, Horst:
Software Measures in the Software Design Phase.
Deutsche Gesellschaft für Luft- und Raumfahrt - Lilienthal-Oberth e.V.,
DGLR-Bericht 95-04, 1995.

This article illustrtates the methods how to measure complexity, understandability of software designs in the software life-cycle.

Zuse, Horst; Dumke, Reiner (Editors):
Proceedings of the 5.Workshop of the GI-Arbeitsgruppe Softwaremetriken.
Technische Universität Berlin, 21.-22. September 1995.

Der 5. Workshop der GI-Arbeitsgruppe Softwaremetriken wurde vom 21.-22. September 1995 in den Räumen der Technischen Universität Berlin abgehalten. Die Workshops der Arbeitsgruppe Softwaremetriken werden in ca. einjährigen Abständen an wechselnden Orten der Bundesrepublik Deutschland durchgeführt. Ziel der Arbeitsgruppe und der Workshops ist, Forschungsergebnisse theoretischer und praktischer Art auf dem Gebiet der Softwaremetriken unter Interessenten aus Universitäten und der Industrie auszutauschen

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Publications in 1996

Zuse, Horst:
Foundations of Object-oriented Software Measures.
Accepted by IEEE Third International Symposium on Software Metrics,
March 1996, Berlin.
In this paper foundations of the foundations of object-oriented software measures are presented. It is shown that many of the measures in the object-oriented programming area follow the Dempster-Shafer Function of Belief and the DeFinetti axioms. These axioms give criteria above the ordinal scale level. The consequences of these properties of object-oriented measures related to prediction models and validation are also discussed.

Zuse, Horst:
Meßtheorie und Software Messung.
In: Ebert, Christof; Dumke, Reiner (Eds):
Software-Metriken in der Praxis
Einführung und Anwendung von Software-Metriken in der industriellen Praxis.
Springer Verlag, 1996.

Zuse, Horst:
ZD-MIS: A Software Measure Information System.
Proceedings of the 6.Workshop of the GI-Arbeitsgruppe Softwaremetriken,
Regensburg, September 19-20, 1996.

Zuse, Horst; Drabe, Karin:
ZD-MIS - A Software Measure Information System.
Third Australien Conference on Software Metrics,
Melbourne, 21 November 1996.

In order to give people of industry and academics guidelines to quantify software quality attributes, in 1994 the development of the System ZD-MIS has been started. ZD-MIS stands for Zuse / Drabe Measure-Information-System. The major goal of ZD-MIS is to provide people with a comprehensive framework of software measurement. Among others, ZD-MIS presents the models of complexity, readability, cost estimation, etc. behind measures. It also contains a database of more than 1200 software measures which are characterized by many software quality attributes and measurement theoretic assumption. A database for literature with more than 1500 entries shall help to give students, scientists and practitioners an overview of the literature in the software measurement area. The major goal of ZD-MIS is to provide scientists, students and practitioners with the necessary knowledge for software measurement.