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# Localisation and Acquisition of Knowledge in Software Developing Organisations in the Light of Empirical Research

**Abstract:**

The purpose of the paper is to present the organisation and results of the empirical research facilitating the localisation and acquisition of knowledge in software developing organisations which have designed, documented, implemented and maintain quality management systems.The author's interest is focused on presenting a project of empirical research aimed at the localisation and acquisition of knowledge in software developing organisations.The paper contains an assessment of the usability of the previously proposed model of transition from quality management systems to knowledge management systems in software developing organisations for the purpose of establishing KMS elements (solely for knowledge localisation and acquisition processes). The assessment of usability is made in relation to quality management systems conformable with the ISO 9001:2000 supplemented by ISO/IEC 90003:2004.

**Keywords:** knowledge management**,** knowledge localisation, knowledge acquisition, quality management systems, software developing organisation, organisation of empirical studies.

## 1. A short recapitulation of transition model elements

The starting point of this paper is the author's model of transition (hereinafter called transition model) from a QMS (Quality Management System) to a KMS (Knowledge Management System) for SDOs (Software Developing Organizations).

The model is the author's own concept. It has been described in detail in the previous paper (A Model of Transition from Quality Management Systems to Knowledge Management Systems in Organisations in Software Developing Organizations).

It consists of five elements – results (E1, E2, E3, E4, E5) and four processes (P1, P2, P3, P4). The processes are sets of activities allowing to obtain results in the form of indicated elements. Below, designations and names of the processes are indicated as well as the results (elements) obtained in the course of the processes. The first element is the starting point for the whole transition model. It is related to quality management systems (ISO 9001:2000 and ISO/IEC 90003:2004). Below are the other transition model elements:

Process P1 – working out a methodology of knowledge localisation. Result E2 –

presents a methodology composed of five stages (stage 1: classification of QMS processes, stage 2: working out assumptions for a semantic model of presentation of requirements of ISO 9001:2000 and recommendations of ISO/IEC 90003:2004, stage 3: presenting individual QMS processes by means of a semantic model, stage 4: preparing maps of individual processes while taking into consideration model assumptions, stage 5: working out potential decisions as a means of localising and then acquiring knowledge). Process P2 – defining knowledge elements. Result E3 – adopting six elements of knowledge description level hierarchy (levels A to F). Process P3 – working knowledge acquisition tools. Result E4 – allows to adopt four tools of knowledge acquisition (developing and maintaining the knowledge basis, reconstructing the process, reconstructing the project manager's profile, developing knowledge maps). Process P4 – empirical studies. It defines the organisation of conducting of empirical studies enabling verification of the assumptions made. Result E5 – presents results of empirical studies.

Process P4 and Result E5 make up the subject of this paper.

## 2. Configuring selected elements of KMSs for SDOs and conducting empirical studies

Generally, the empirical studies are focused on the SDO. This is particularly true when features of the studies can be defined on the basis of the following criteria (Figure 1):

a) key processes,

b) generations of knowledge management systems,

c) models of organisations of the future.

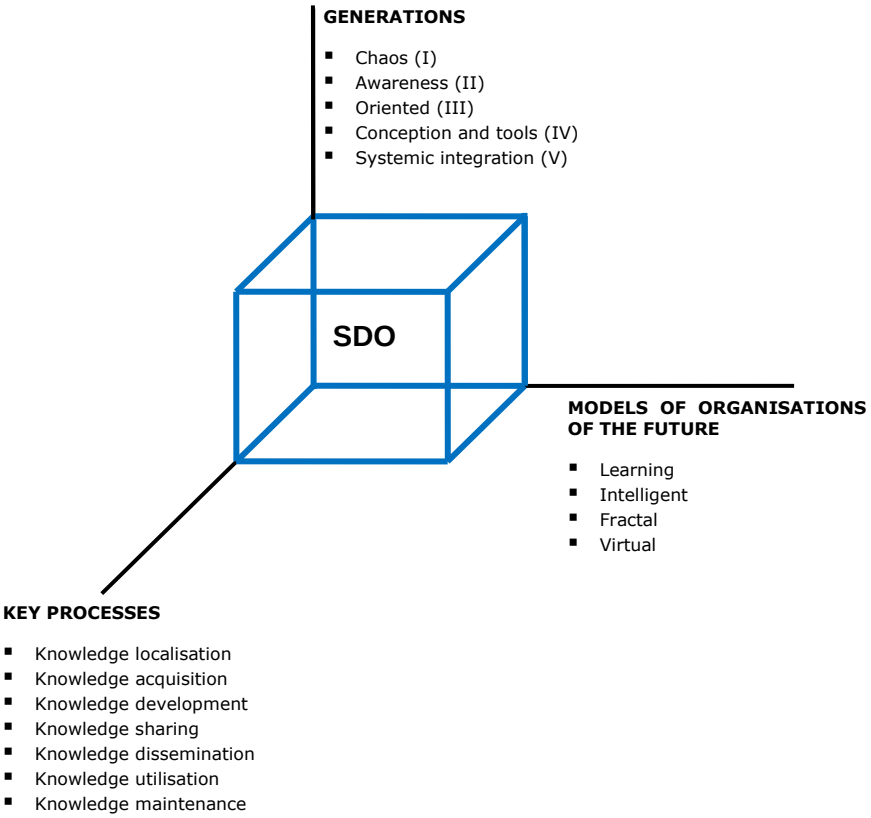


Figure 1. Three-dimensional model of configuring selected KMS elements for SDOs

Source:

Fourth generation SDOs have been selected for further empirical studies in respect of knowledge localisation and acquisition processes for a model of the organisation of the future as defined as a learning organisation.

The author's interest in generations of KMSs results from the fact that generations represent the "maturity" of organisations in respect of knowledge management. According to KPMG's proposal [Grudzewski, Hejduk 2004, pp. 110-111], the term "fourth generation" pertains to an organisation in cases in which knowledge management is based on a concept, procedures and tools. The structure of knowledge management is undoubtedly an advantage of a fourth generation organisation.

## 3. Assumptions for the empirical study

Attempts of empirical studies on knowledge management are more and more frequently made and presented in the literature on the subject. The ones described by P.H. Grey and D.B. Meister [Grey, Meister 2006] are among the most interesting. They concerned the substitutivity of various methods of acquisition of source knowledge and included assumptions, attempted calculations and conclusions. The author of this paper has also made an attempt at conducting empirical studies on knowledge management. The empirical study assumptions include the following elements:

a) concept of the empirical study,
b) plan of the study,
c) restrictions related to conducting the study,
d) advantages and disadvantages of the study.

The above empirical study elements will be described in order.

## 3.1. Concept of the empirical study

In this section, the author's concept of the empirical study is presented. The study is aimed at assessing the usability of the presented concept of construction of KMS elements in the SDO where a QMS is applied. The scope of the empirical study was restricted as indicated in Table 1.

Table 1. The scope of the presented empirical study in an SDO of the fourth generation in respect of knowledge management

| **Elements of the fourth generation** | **Scope** | **Specification in the paper** |
|---|---|---|
| Concept | The model of transition from a QMS to a KMS Effects have been designated as E2 | Knowledge description level hierarchy:<br>A - Basic process<br>B - Design and development – 7.3<br>C - 7.3.1, 7.3.2 **(X),** 7.3.3 **(X)**, 7.3.4, 7.3.5, 7.3.6, 7.3.7<br>D - Not applicable<br>E - 7.3.2-1 to 7.3.2-9 **(X)**, 7.3.3-10 to 7.3.3-22 **(X)** |
| Procedures | Model of learning | Different understanding of the notion of decision. Knowledge is contributed in the process of decision taking. To take a decision means to create a new fragment of knowledge not existing before. |
| Tools | E4 – tools used for knowledge acquisition | A - developing and maintaining a knowledge base<br>B - reconstructing the process (X)<br>C - reconstructing the project manager's profile<br>D - developing knowledge maps |

Legend: Sign "X" used to designate the scope of the empirical study.

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## 3.2. Plan of the empirical study

The empirical study was selected according to the following plan composed of three steps:

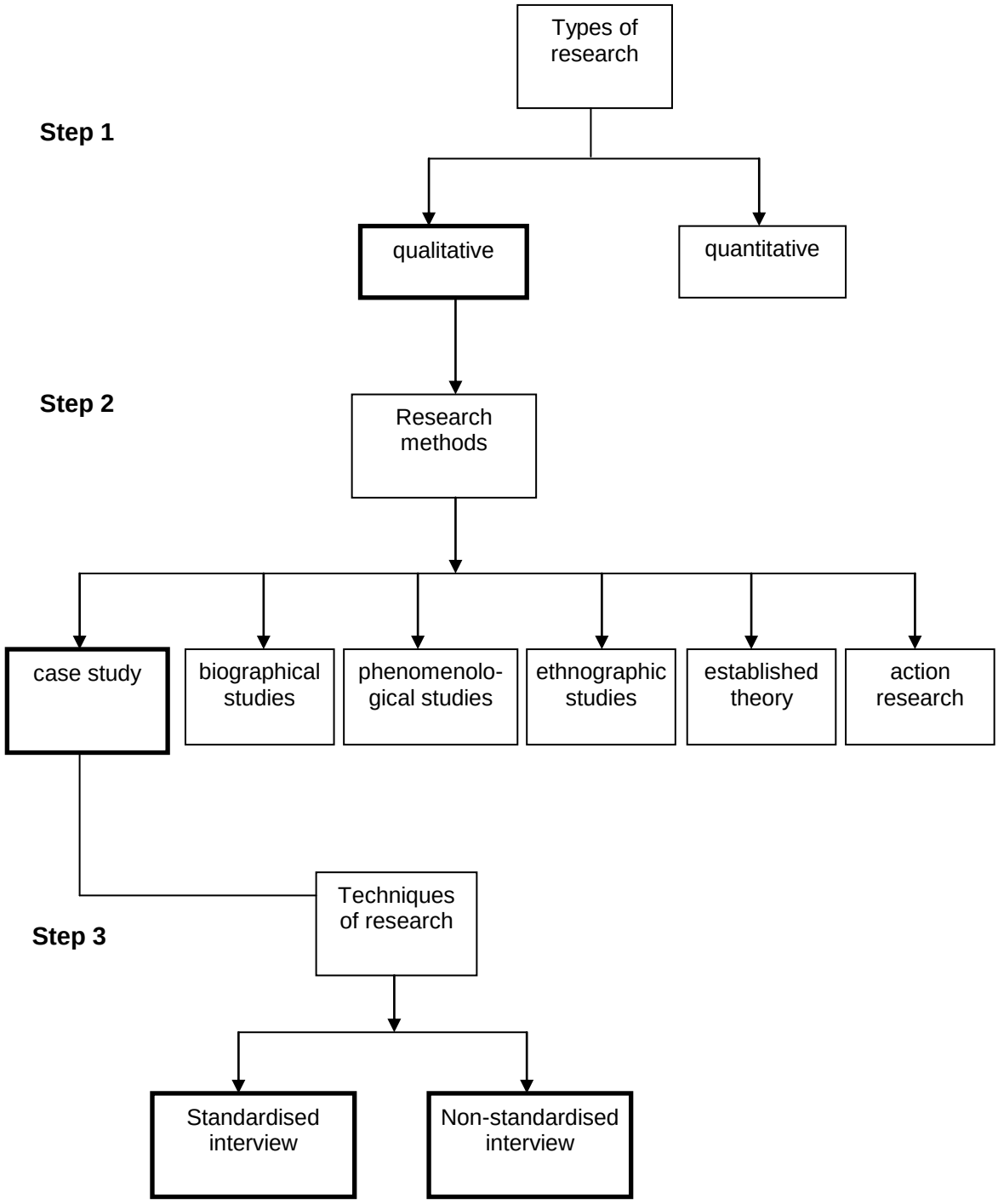


Figure 2. Plan of selection of the empirical study

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**Step 1: Selection of the type of studies (qualitative, quantitative)**

Qualitative research was selected owing to the conviction that they might provide a "deeper" understanding of the phenomena (i.e. the concept of construction of a KMS in

a SDO where a QMS is applied) than purely quantitative research [Silverman D., 2001]. This, however, does not exclude the possibility of using, to a limited extent, quantitative research.

**Step 2: Selection of the research method**

The research method was selected from among numerous types of research described in the literature on the subject, such as: biographical, phenomenological, ethnographic, established theory, action research, case study, etc. The case study method was selected.

**Step 3: Selection of the research technique**

The interview was selected as the research technique. In this case, the following arguments tipped the balance:

1) The interview allows to obtain source information through a direct conversation between the interviewer and the respondent. This is important, the more so that respondents know the subject matter of managing projects at the stage of design and development significantly better than the requirements related to ISO 9001:2000 and the recommendations given in ISO/IEC 90003:2004. Hence, any explanations given to the interviewer (in this case – the author of the study) necessitated respective activities. Additionally, the reference to the requirements of ISO 9001:2000 and its recommendations in the form of ISO/IEC 90003:2004 required explanations. The recommendations are not so generally known and available as the ISO 9001:2000 standard. The translation made of the recommendations included in ISO/IEC 90003:2004 required additional explanations.
2) The division of functions between the interviewer (here: the author) and the respondent (a software project manager). The interviewer asks questions and provides explanations and the respondent gives answers. The questions asked – in the written form – are available to the respondent. Interviews can be divided into standardised (i.e. based on questionnaires) and non-standardised (open). For this study, a standardised interview was applied. According to Table 1, this paper presents only level E of the knowledge description hierarchy, while taking into consideration level B (design and development (7.3)) and the subordinated level C of the knowledge description hierarchy (design and development inputs (7.3.2) and design and development outputs (7.3.3)).

## 3.3. Restrictions related to conducting case study research

Below are the restrictions related to conducting case study research. They were formulated by R.K. Yin [Yin 2003, pp. 50-51]. The tages and substages of conducting research are presented in Figure 3.

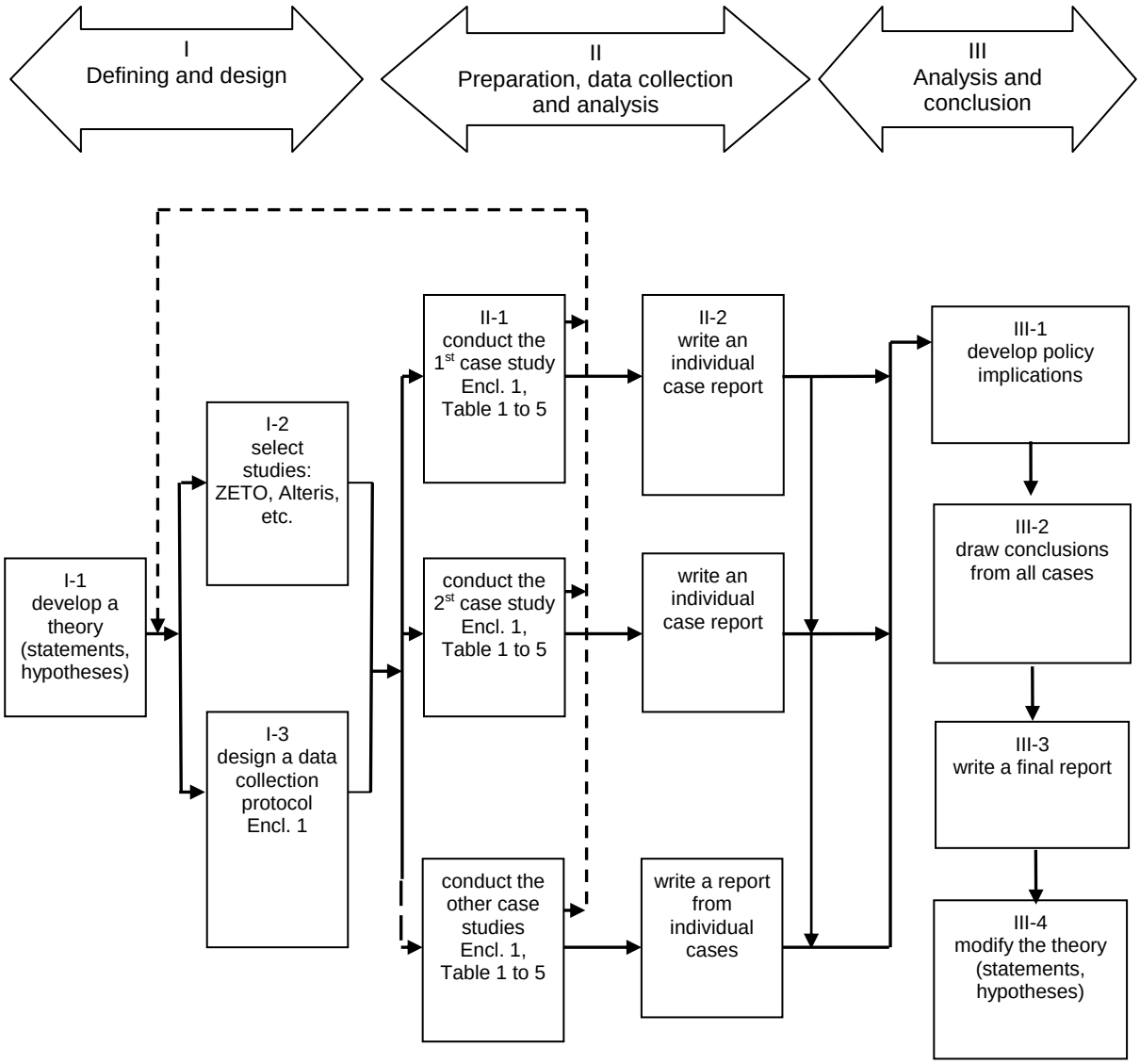


Figure 3. Stages of conducting research by means of the case study according to R.K. Yin

Source: [Yin 2003, pp. 50-51].

The respective stages and substages of conducting the research can be divided as follows:

I. Define and design:

I-1 develop a theory (statements, hypotheses),

I-2 select cases,

I-3 design a data collection protocol.

II. Prepare, collect and analyse:

II-1 conduct 1st case study,

II-2 write an individual case report.

III. Analysis and conclusions:

III-2 draw cross-case conclusions,

III-4 modify the theory (statements, hypotheses),

III-1 develop policy implications,

III-3 write a cross-case report.

The indicated stages and substages of conducting the research will be described in detail below.

## 3.4. Case studies

Research on the broadly conceived knowledge management and knowledge management systems is undertaken by both individual researchers and research teams. Some of the studies (not older than those of 2009) are described in brief below. They are related to information technology:

a) A.M. Subramianian [2009] identified factors affecting the use of knowledge management systems,

b) P. Arora, D. Owens, D. Khazanchi are engaged in developing a (software) tool facilitating knowledge management in organisations participating in the implementation of virtual projects,

c) R. Krishnaveni and S. Raja [2009] indicated seven processes of the knowledge management life cycle. All the processes were defined by means of 51 descriptors.

d) J. Batra [2010] developed research forms based on different sources (articles, periodicals, the Internet, etc.) which allow to define interactions between knowledge management and the individual growth of knowledge of the organisation's employees,

e) L.Z. Cantu [2009] with a team constructed and validated a model of generating and transferring knowledge in an organisation. The model allows to investigate the relations between three dimensions which include: knowledge generation, knowledge transfer, and secret knowledge extension (occurrence areas).

f) E. Revilla selected for the research 80 developed products. There was examined the impact of individual categories of the information technology description (differentiation, assimilation, exploitation, exploration) on the knowledge base of the products developed.

g) N. Mundra, with collaborators, undertook research concerning the participation of knowledge management in the realisation of a more effective organisation management strategy.

**Stage I-1: Defining and design; substage: develop a theory (statements, hypotheses)**

The process of defining statements and hypotheses was conducted in compliance with M. Bratnicki's [2007] recommendations that the theory in a case study should provide a

higher order structure according to which the whole line of reasoning is to be arranged and the theory generation process should be clearly described. A construction of a fourth generation KMS (concept, procedures and tools) is an equivalent of the theory. It has been referred to an SDO which applies a QMS. The description is included in E2, E3 and E4, whereas statements (marked with "T", not investigated) and hypotheses (marked with "H", investigated) have been formulated as follows:

T.1 – an SDO, as a software provider, should have both a QMS and a KMS,

T.2 – usually, SDOs have designed, documented, implemented and maintained QMS,

T.3 – usually, SDOs do not have documented KMS,

H.1 – a QMS can be a frame (a body) for the KMS,

H.2 – it seems that the most suitable for SDOs would be KMSs which can be classified – according to the KPMG classification – as four generation systems, which means in practice presenting concept, procedures and tools for knowledge management,

H.3 – a conception of transition from a QMS to a KMS can be proposed,

H.4 – there can be developed such a model of interpretation of requirements included in series 9000 ISO standards and other recommendations (e.g. ISO/IEC 90003:2004) relating to SDOs which enables a transition from a QMS to a KMS. Then QMSs will become frames for KMSs,

T.4 – the adopted knowledge description level hierarchy (levels A, B, C, D, E, F) can be filled with relevant elements of the model developed for the interpretation of the requirements included in series 9000 ISO standards and the recommendations (e.g. ISO/IEC 90003:2004) referring to SDOs,

H.5 – decisions taken as an element of the model of interpretation of requirements included in series 9000 ISO standards and other recommendations can constitute a fragment of knowledge from the knowledge description level hierarchy model,

T.5 – identification of decisions taken allows to specify knowledge atoms form the knowledge description level hierarchy model,

H.6 – knowledge in the SDO can be localised through the decisions taken,

T.6 – specific tools have been proposed for acquiring the knowledge previously localised. They include: developing and maintaining knowledge bases, reconstructing the process, reconstructing the project manager's profile, preparing knowledge maps,

H.7 – the proposed knowledge localisation concept. as well as the tools for knowledge acquisition in SDOs, should be helpful in analysing knowledge in the SDO treated as a learning organisation.

Research conducted with the case study method will allow to verify the above hypotheses. This can be done as follows:

- formally, while taking into consideration requirements and recommendations of the ISO standards indicated, which leads to a construction of a semantic model of standard interpretation [Chrabański, Gwioździk, Kostka-Bochenek 2007],
- formally, through an attempt of transition from the semantic model of ISO

standard interpretation to the knowledge description level hierarchy,

- practically, through assessing – by persons managing information technology projects from various SDOs – the knowledge levels actually found in the information technology projects implemented, in research purposefully confined to design and development processes, and, more specifically, to processes 7.3.2 and 7.3.3,
- practically, through acquiring the contents of the lowest level of the knowledge description hierarchy (here: knowledge atoms) from a number of respondents managing various information technology projects from different SDOs (applying QMSs).

**Stage I-2: Defining and design; substage: select cases**

For the study, cases were selected which comply with the following criteria:

**First criterion** – the participating entities are software developing organisations (SDO), which in practice means that they realise at least one of the stages of the software life cycle. M. Bratnicki [2007] emphasises that the examined organisation(s), i.e. the case(s) must be consciously selected so that to enable a detailed insight into interesting categories and phenomena aspects. In the cases described, these were SDOs having QMSs and audited by the author (certifying, control, or re-certifying audited). They are localised in different Polish cities (Warsaw, Cracow, Katowice, Tychy, Gliwice, Kielce). M. Bratnicki suggests that the selection of the sample from a theortical point of view is more oriented at contributing to the theory development within a particular set than justified by the sample uniqueness. An analogous situation is in cases of the theory verification.

**Second criterion** – The SDOs have designed, documented, implemented and maintain QMSs conformable with the series 9000 ISO standard. In the course of undertakings (projects) conducted, they comply with the recommendations given in ISO/IEC 90003:2004.

**Third criterion** – The SDOs apply QMSs for the purpose of design and development. W. Czakon [2006] says that the number of cases should range from 4 to 10. This is justified by methodological and pragmatic considerations. Let us quote K.M. Eisenhardt [1991] once again, he suggests that randomness in case studies is neither needed nor even desirable. The issue here is not verification of the hypothesis investigated, but a formulation of a theoretical proposal which reflects the reality as faithfully as possible.

**Fourth criterion** – the respondents were recruited from among the persons managing software design and development projects. The projects were completed comparatively recently. The respondents still remembered the projects but were able to maintain – after a lapse of time – a certain detachment from them. As members of the so called target group, they were asked to fill in a questionnaire (they were interviewed). The author obtained the consent of the respective organisations for conducting the interviews. The respondents knew very well the requirements of the ISO 9001:2000 standard and were familiar with the recommendations given in ISO/IEC 90003:2004. The author had an opportunity to verify their knowledge since he repeatedly audited the subject areas managed by the respondents.

**Fifth criterion** – The SDOs are seated in different parts of Poland and implement various software design and management projects.

**Sixth criterion** – access to the entities and respondents was facilitated by the author's long-standing collaboration with the organisations and with individual respondents. During the audits, the author noted that the entities' activities complied with the recommendations stated in ISO/IEC 90003:2004.

The empirical study included seven projects consisted in design and development of computer systems in different SDOs in Poland. The projects have been designated as follows (in parentheses – names of the cities/towns): ZETO (Kielce), NETSCH (Kraków), COMFORTEL (Tychy), ALTKOM AKADEMIA (Warsaw), BULL (Warsaw), AIUT (Gliwice), ALTERIS (Katowice).

**Stage I-3: Defining and design, substage: design a data collection protocol**

The data collection protocol was organised in the manner described below (while taking into consideration the restrictions stated in Table 1):

1. For knowledge elements from the knowledge description level hierarchy, elements of the semantic model were referred to. As has already been mentioned, the elements of the said model occur on three levels, i.e. standards, meanings of contents (postulates, questions), elaborations of contents (the proposed manner of implementation, specification of the scope, etc.).
2. Each group of postulates and questions was assigned with decisions identified by means of the model of interpreting the requirements included in series 9000 ISO standards and other recommendations (e.g. ISO/IEC 90003:2004) related to SDOs so as to enable the transition from QMSs to KMSs.
3. The respondents (chief designers) declared independently from each other whether or not they had taken the specified decisions as part of the projects managed by them by choosing one of the following statuses: definitely yes, probably yes, neither yes nor no, probably no, definitely no. The information obtained was summarised in Table 2 (appendix). It should be noticed here that a numerical scale was applied as specified in detail in stage II-1.
4. Four tools for the acquisition of knowledge in SDOs were indicated. One of them called "process reconstruction" (marked as B) will be discussed in detail further on.

Prior to the presentation of stage II of the case study (prepare, collect and analyse) with its substages, attention should be paid to relations between knowledge and decisions or KMSs with decision-taking systems. Among the opinions formulated in the Polish literature on the subject by such authors as: J. Kisielnicki, W. Wolny, P. Zadora, A.M. Kwiatkowska, the following deserve special attention:

1) Apart from the classical interpretation of the decision taking process, there is also another one consisting in understanding the process as based on knowledge. In that interpretation, taking decisions means creating a new fragment of knowledge which did not exist before.
2) Taking decisions in the management process (here: knowledge management) is a foundation of any management activity (planning, organising, motivating, controlling). What is more, the term "decision" means a result of a specific selection or the selection procedure.
3) Knowledge is contributed in the decision taking process in the course of the

operation of an expert system (here: project manager system).

The knowledge description level hierarchy was applied to all of the knowledge elements in the SDOs. Since the knowledge description level hierarchy has been extended as far as to knowledge atoms, we can presume that it is no longer knowledge localisation only, but also the possibility of knowledge acquisition, which in turn enables different knowledge analyses.

To summarise this part of the paper, it should be noticed that the model presented is a convenient starting point for research related to possible knowledge analyses.

**Stage II-1: Preparation, data collection and analysis (conduct another case study)**

The case study was conducted in the period of February to July 2009. The research was preceded by an extensive publication on the problems of QMS in SDOs [Chrabański, Gwioździk, Kostka-Bochenek 2007]. A report on an individual case was included in Table 2 (see Appendix). The tables identify potential decisions locating knowledge in SDOs for the main QMS process, i.e. design and development (standard section 7.3), together with respondents' answers. Their scope corresponds to the respective parts of the standard contents for section 7.3.

A single case – as has already been mentioned – is realised through making an entry in the column marked with the respondent's name.

Successive respondents filled in the tables corresponding to knowledge elements by choosing one of the five statuses for individual decisions (knowledge fragments). The said statuses are: definitely yes, probably yes, neither yes nor no, probably no, definitely no. Thereby a verbal scale was applied (words describe the intensity degree of the attitude measured) as described, among other researchers, by N. Hill and J. Alexander [Hill, Aleksander 1996]. The author participated in each such session and provided, if necessary, some explanations which undoubtedly allowed to specify more precisely the context of the decisions regarding specific projects managed by respondents. Individual decisions listed in Table 2 (Appendix) are accompanied with the statuses given by the respondents to relevant knowledge fragments. It should be mentioned that in the table, the verbal status has been changed to a corresponding number in the numeric scale. Respectively: status "definitely yes" corresponds to number 5, "probably yes" to 4, "neither yes nor no" to 3, "probably not" to 2 and "definitely not" to 1. The transition from the verbal scale to the numerical one was only a formal measure facilitating various analyses made with the use of radar charts. Additionally, available information technology tools helpful at making radar charts were applied. The numeric scale adopted – known as Likert's scale – is generally applied in such studies [Han 2007, p. 424; Revilla 2009, p. 354].

**Stage II-2: Preparation, data collection and analysis (write an individual case report)**

An individual case report applies to potential decisions regarding potential decision areas related to the sections of ISO 9001:2000 and ISO/IEC 90003:2004 marked as 7.3.2 and 7.3.3. for the process reconstruction tool (B). The potential decision taken by team managers are presented in Table 2 (Appendix).

Individual respondents gave answers based on the specific project (information technology undertakings) implemented, while providing each decision with a status. In such cases, there is an opportunity to acquire knowledge by means of tool B (process

reconstruction).

Respondents' answers given in Table 2 (Appendix) will be used for reconstructing the process (7.3.2 and 7.3.3) for seven successive respondents and presenting it in the form of radar charts( see figures-4-10

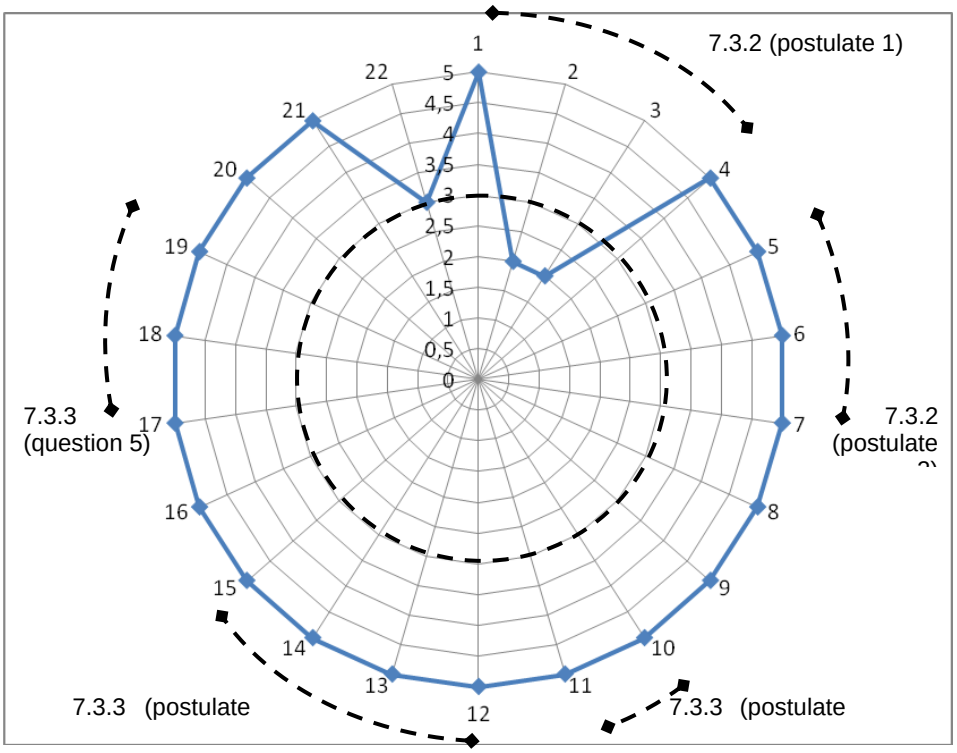


Figure 4. Reconstruction of the part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Bull

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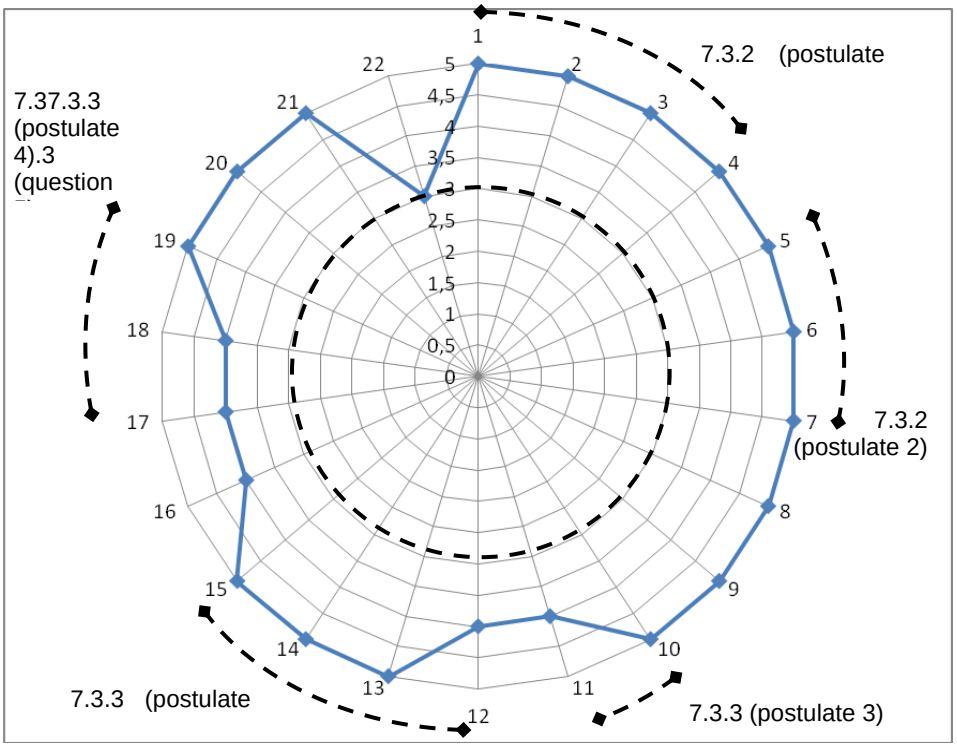


Figure 5. Reconstruction of a part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Aiu

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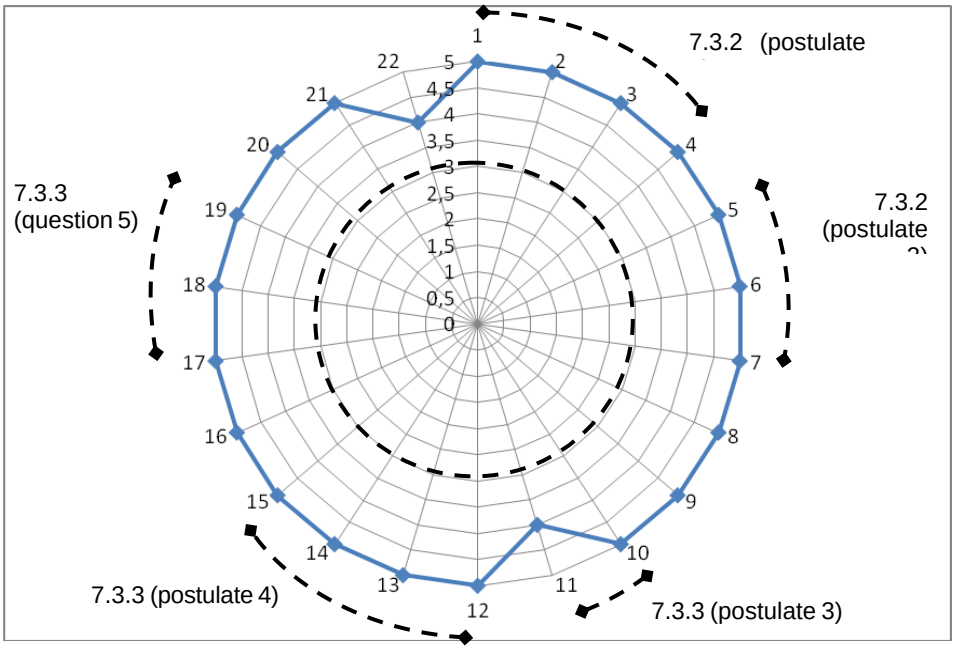


Figure 6. Reconstruction of a part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Altkom Akademia

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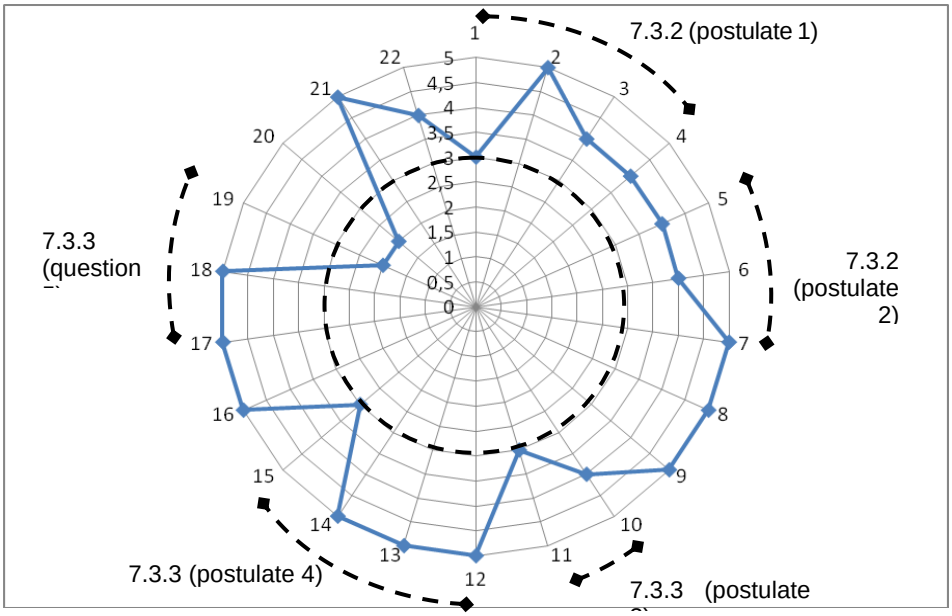


Figure 7. Reconstruction of a part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Comfortel

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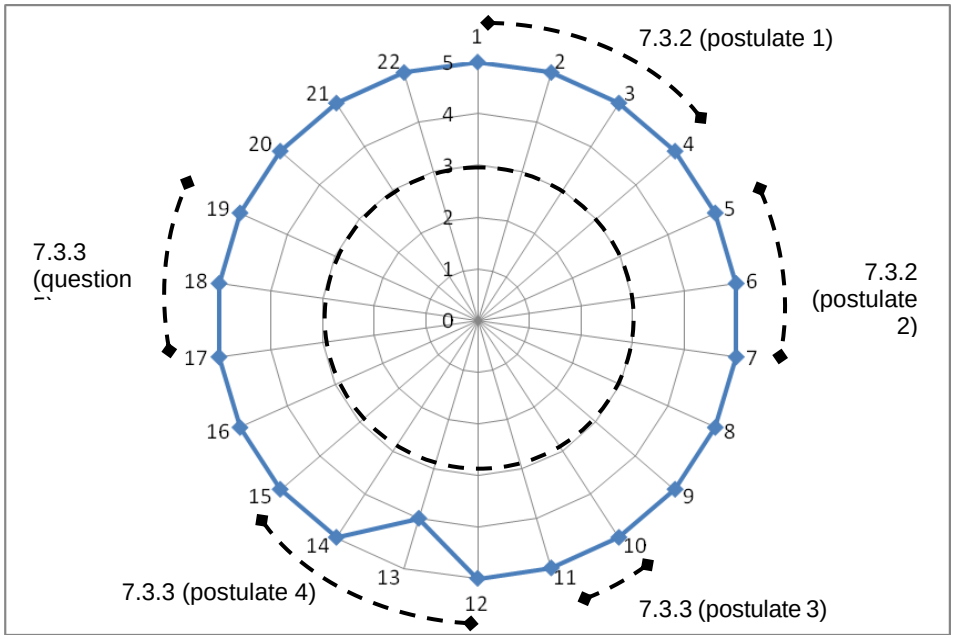


Figure 8. Reconstruction of a part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Zeto

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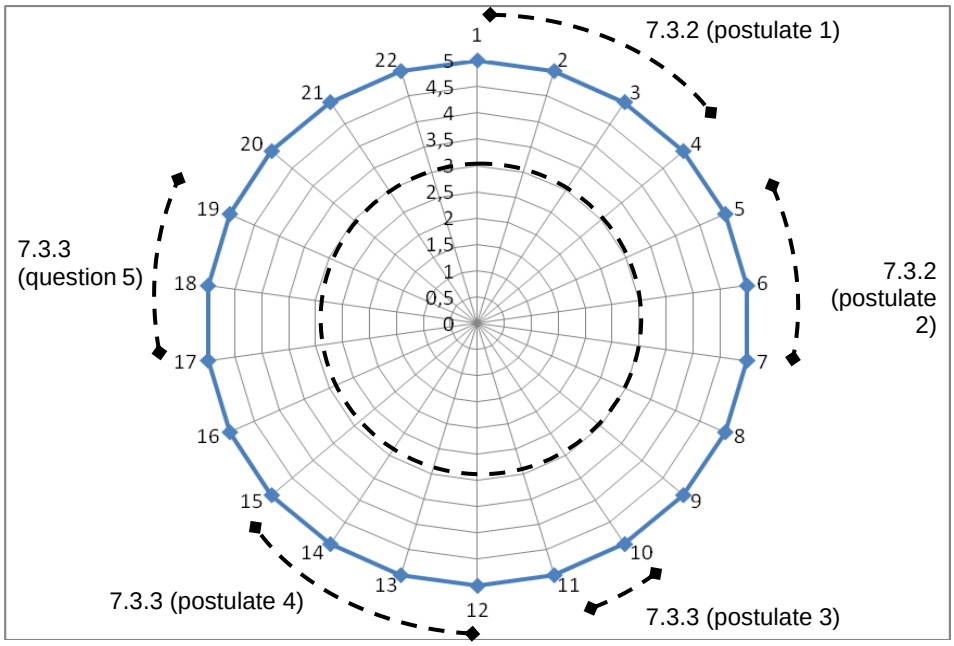


Figure 9. Reconstruction of a part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Netzsch

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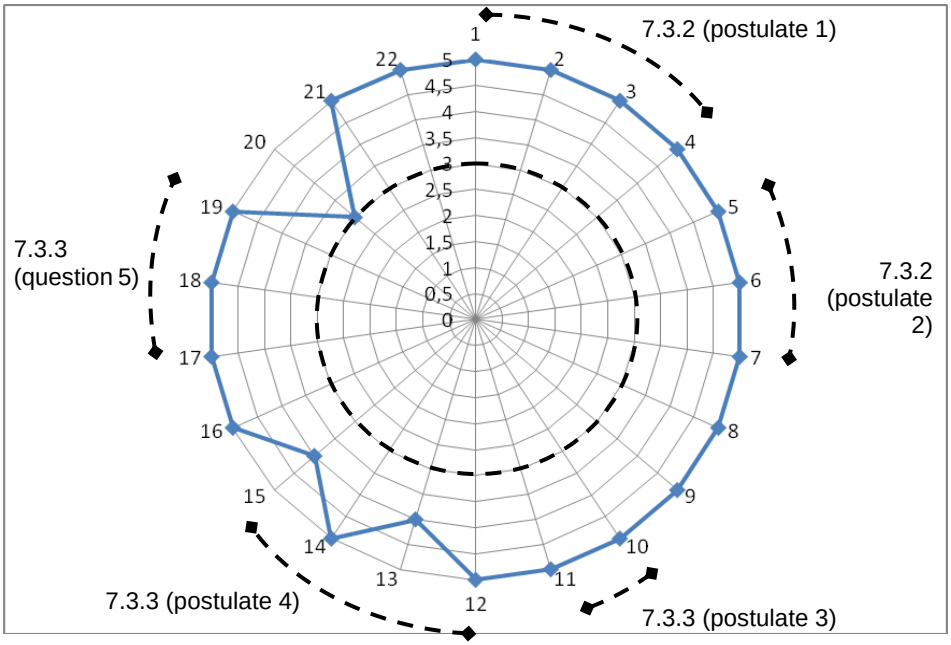


Figure 10. Reconstruction of a part of the QMS main process, i.e. inputs for the design and development process and design outputs (7.3.2 and 7.3.3) – Alteris

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**Stage III-1: Analysis and conclusions (develop policy implications)**

The four previously defined knowledge acquisition tools are useful for developing policy implications. Below are policy implications presented in relation to individual tools (criteria). It should be stressed that the limitations introduced consist in:

a) analysis of selected elements of the knowledge description level hierarchy (e.g. 7.3.2 and 7.3.3),

b) presentation (radar charts) of the process reconstruction by the persons participating in the study.

In the first place, they result from the intention to prove that the theoretical part of the work can be verified through undertaking relevant empirical studies and to present exemplary conclusions from the analyses made as confirming the correctness of the activities undertaken (the SDO heads towards a learning organisation). The restriction on the volume of the paper also matters here.

**Stage III-2: Analysis and conclusions (draw cross-case conclusions)**

The reconstructed processes, due to the tool B application, can be a subject of analyses and conclusion formulation. The potential decisions taken as part of postulates and questions are presented in Table 2 (Appendix). The reconstructed processes have been divided into groups:

**First group:** postulates and questions with the highest mark statuses (with 5's and 4's prevailing)

The following postulates and questions can be included here (standard sections in parentheses):

a) postulates: 2 (7.3.2 – decision 5,6,7), 4 (7.3.3 – decision 14),

b) questions: 1 (7.3.2 – decision 8), 2 (7.3.2 – decision 9), 8 (7.3.3 – decision 21).

**Second group:** postulates and questions with the lowest mark statuses (with 3's, 2's and 1's prevailing)

A part of question 9 (7.3.3) for decision 22 can be rated here.

**Third group:** islands of dissimilarity

They may include: Postulate 1 (7.3.2 – decision 2 and 3. Question 6 (7.3.3 – decision 19), Question 7 (7.3.3 – decision 20).

**Stage III-3: Analysis and conclusions (write a cross-case report)**

The analysis and conclusions shall be referred to the previously formulated hypotheses (see: section I-1). Designations of respective hypotheses are given in parentheses.

A QMS may be a frame (a body) of a KMS (H1). It seems that in the present conditions, an attainable degree of maturity of the SDO corresponds to the fourth generation of knowledge management according to KPMG's classification. It is possible to present a concept, procedures and tools for knowledge management (H2). The concept consists in indicating the method of transition from a QMS to a KMS (H3). One of components of the said concept is such a model of interpretation of requirements included in series 9000 ISO standards and other recommendations (e.g. ISO/IEC 90003:2004) relating to SDOs which enables a transition from a QMS to a KMS. Then QMSs will become frames for KMSs (H4). According to the developed knowledge description level hierarchy related to the requirement interpretation model included in series 9000 ISO

standards and other recommendations, the decisions taken are elements of the knowledge description level hierarchy (H5). Knowledge in the SDO can be localised through the decisions taken (H6). The proposed knowledge localisation concept, as well as the tools for knowledge acquisition in SDOs, is helpful in analysing knowledge in the SDO treated as a learning organisation (H7).

The material for knowledge analyses was obtained from the respondents (managing information technology projects) who had classified in the five-degree scale the decisions based on requirements of ISO 9001:2000 and recommendation of ISO/IEC 90003:2004. Acquiring knowledge is a function the KMS. The knowledge acquisition process and the knowledge acquired can be subjected to analysis. Conclusions from the knowledge analysis have been compiled below.

1) The tool proposed as one of four, i.e. the process reconstruction, allows to obtain the results expected.
2) The usability of respective tools for acquiring the previously localised knowledge can be assessed in a different way. However, each time the assessment criterion was related to the possibility of the SDO's "heading" towards models of the organisation of the future (here: a learning organisation).
3) The application of tool B (process reconstruction) allowed to specify – in relation to each respondent – what decisions were actually taken from among the potential ones. In each case, the process reconstruction pertained to a project already completed, relatively not long ago. Therefore the marks assigned by individual respondents have been ordered according to the scale: definitely yes, probably yes, neither yes nor no, probably no, definitely no. The marks proved very useful in the analysis conducted.
4) One can notice that in the process reconstruction, "high" marks, i.e. "definitely yes" and "probably yes" prevail.
5) The application of radar charts allows to document the fact of taking specific decisions in the information technology design and development process. Hence the previously personalised and non-manifest knowledge of the project manager becomes an overt knowledge which can be applied by other project managers.

**Stage III-4: Modify the theory (statements, hypotheses)**

The research conducted with the case study method allowed to verify the above statements and hypotheses as well as to introduced modifications, if any. The research confirmed that:

1. The QMS in an SDO can be a frame for the KMS, whereas the KMS should comply with the requirements of the fourth generation according to KPMG's classification. This means that the organisation has a concept, procedures and tools for implementing the KMS.
2. The developed concept of transition from the QMS applied in an SDO to a KMS has been verified in the course of the empirical study conducted. Also the usability of the procedure and tools was verified. The advantages of their application outweigh the disadvantages.
3. Significant elements of the said concept confirmed their usability in the course of the empirical study related to SDOs. These elements include:

a) model of interpretation of requirements and recommendations,

b) knowledge description level hierarchy,

c) filling of the knowledge description level hierarchy with relevant elements of the developed model interpretation of requirements and recommendations,

d) localisation of knowledge brought to the smallest indivisible unit, i.e. an atom,

e) acquiring knowledge on the basis of the four tools proposed,

f) feasibility of analysing the knowledge acquired.

4. The developed model of interpretation of requirements and recommendations may include the requirements contained in series 9000 ISO standards and the recommendations given in ISO/IEC 90003:2004 and relating to the SDO.
5. The adopted knowledge description level hierarchy (levels A, B, C, D, E, F) can be filled with relevant elements of the model developed for the interpretation of requirements included in series 9000 ISO standards and recommendations (e.g. ISO/IEC 90003:2000) referring to SDOs.
6. Knowledge in the SDO can be localised through specifying potentially adopted decisions (level E).
7. Previously localised knowledge can be acquired through applying specifically indicated tools (in the paper, tool B, i.e. process reconstruction has been highlighted).
8. The proposed tools for knowledge acquisition have been selected from the point of view of assessment of the knowledge for models of the organisation of the future (here: a learning organisation).
9. It is possible to document the previously localised and acquired knowledge in an SDO applying a QMS. The tools applied allow to depart gradually from non-manifest and personalised knowledge to an overt one which is suitable for disseminating in the organisation, and also for knowledge analyses carried out from the point of view of transferring the experience acquired to subsequent projects (undertakings). The documented knowledge has the form of:

    a) knowledge base, i.e. knowledge atoms which have the contents formulated by the decision-maker,

    b) radar chart reconstructing the process (here: information technology system design and development) for each of project managers (as presented in the paper),

    c) radar chart reconstructing the project manager's profile,

    d) knowledge maps for a specific process with a definite semantic structure, definite knowledge atoms and a formulated conclusion content.

10. There are elements which probably should be modified. They can include:

    a) the necessity of additional training of respondents prior to the stage of formulating the level of the knowledge description hierarchy marked as F

(knowledge atoms). The training should present examples of giving proper (full, complete) answers. In that case, maybe restrictions will not occur in the form of limited possibilities of the comparative analysis of answers given by various respondents as regards knowledge atoms as a level of the knowledge description hierarchy,

b) treating knowledge maps as a static, graphical picture of the process with applied elements of semantic interpretation of the requirements included in the standard ISO 9001:2000 and the recommendation given in the standard ISO/IEC 90003:2004. One should not expect that their analysis will bring about a significant progress in improving the KMS in the SDO applying a QMS,

c) the necessity to extend the tools for knowledge acquisition.

11. The so called “islands of dissimilarity have been identified”. The fact that some respondents attributed diametrically different marks to respective decisions than the remaining ones suggests that any generalisations should be formulated very cautiously. The differences may result from such factors as: the respondents' background (technical, university, economic, etc.), their experience from participation in design and development of a limited group of information technology systems, the type of information technology system which was the subject of the design and development project – this should be investigated. It seems that the answers to the above questions might be obtained in the course of separate (supplementary) studies.

12. The "islands of dissimilarity" identified with tool B (process reconstruction) are surprising since the lowest marks were given to the decisions related to team training in respect of requirement analysis, design and development, integration and assistance assurance as regards acceptance of design process products. This means in practice that project managers (respondents) refrain from usually low-cost activities, thus raising the effectiveness of the works conducted. Another possibility – which should be investigated – consists in the lack of formalisation of these decisions.

# 4. Summary

The presented organisation of empirical research allowed to assess the usability of fourth generation knowledge management systems in SDOs applying the QMS. This generation requires developing a concept, procedures and tools. The paper focused on the assessment of the usability of the concept and the selected tool. In the course of the empirical research, the usability of the concept and the selected tool for the purpose of knowledge localisation and acquisition in SDOs have been confirmed.

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**Lokalizacja i pozyskiwanie wiedzy w orgnizacjach wytwarzajacych oprogramowanie w świetle empirycznych badań**

**Streszczenie**

Celem artykułu jest prezentacja organizacji i rezultatów empirycznych badań ułatwiajacych lokalizację i pozyskanie wiedzy w organizacjach wytwarzajacych oprogramowanie, mających zaprojektowany, udokumentowany, wdrożony i utrzymywany system zarządzania jakością. Zainteresowania autora skupiają się na przedstawieniu propozycji empirycznych badań mających na celu lokalizowanie i pozyskiwanie wiedzy w organizacjach wytwarzających oprogramowanie. Artykuł zawiera ocenę użyteczności zaproponowanego w innym artukule modelu przejścia z systemu zarządzania jakością do systemu zarządzania wiedzą w organizacjach wytwarzających oprogramowanie z przeznaczeniem ustalenia elemenów system zarządzania wiedzą (jedynie dla procesu lokalizacji i pozyskania). Ocena użyteczności jest wykonana z uwzględnieniem wymagań system zarządzania jakością ISO 9001: 2000 uzupełnionych o zalecenia podane w ISO/IEC 90003:2004.

**Słowa kluczowe:** zarządzanie wiedzą, lokalizacja wiedzy, pozyskanie wiedzy ,system zarządzania jakością, organizacje wytwarzające oprogramowanie, studia przypadków.

Appendix

Table 2. Level E of the knowledge description hierarchy together with respondents' answers for level B (design and development – 7.3) and level C, i.e. design and development inputs (7.3.2) and design and development outputs (7.3.3).

| No. | MODEL ELEMENT | POTENTIAL DECISIONS LOCALISING KNOWLEDGE IN SDOs | Designation in the Enclosure | Bull | Aiut | Altkom Akademia | Comfortel | Zeto | Netzsch | Alteris |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Postulate 1 (7.3.2) | . Inputs relating to product requirements shall be determined and quality records maintained – in respect of functional and performance requirements | 1 | 5 | 5 | 5 | 3 | 5 | 5 | 5 |
| | | 2. Inputs relating to product requirements shall be determined and quality records maintained – in respect of applicable statutory and regulatory requirements | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 |
| | | 3. Inputs relating to product requirements shall be determined and quality records maintained – information derived from previous similar designs | 3 | 2 | 5 | 5 | 4 | 5 | 5 | 5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 4. Inputs relating to product requirements shall be determined and quality records maintained – other requirements essential for design and development | 4 | 5 | 5 | 5 | 4 | 5 | 5 | 5 |
| 2. | Postulate 2 (7.3.2) | 5. Design and development inputs shall be complete | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 |
| | | 6. Design and development inputs shall be unambiguous | 6 | 5 | 5 | 5 | 4 | 5 | 5 | 5 |
| | | 7. Design and development inputs shall not be in conflict with each other | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 3. | Question 1 (7.3.2) | 8. Determination of the system requirements allocated to software and specification of the interfaces between the system components for the purpose of software requirement analysis | 8 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4. | Question 2 (7.3.2) | 9. Determination of design and development input (e.g. on the basis of functional, performance, quality, relevant safety and security requirements, system design constraints, derived through prototyping techniques, design change requests originating from previous phases in iterative development model, problems to be fixed, or requirements arising from acceptance criteria, etc.) | 9 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 5. | Postulate 3 (7.3.3) | 10. The outputs of design and development shall be provided in a form that enables verification against design and development input | 10 | 5 | 5 | 5 | 4 | 5 | 5 | 5 |
| | | 11. The outputs of design and development shall be approved prior to release | 11 | 5 | 4 | 4 | 3 | 5 | 5 | 5 |
| 6. | Postulate 4 (7.3.3) | 12. Design and development outputs shall meet the input requirements for design and development | 12 | 5 | 4 | 5 | 5 | 5 | 5 | 5 |
| | | 13. Design and development outputs shall provide appropriate information for purchasing production and for service provision | 13 | 5 | 5 | 5 | 5 | 4 | 5 | 4 |
| | | 14. Design and development outputs shall contain or reference product acceptance criteria | 14 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | | 15. Design and development outputs shall specify the characteristics of the product that are essential for its safe and proper use | 15 | 5 | 5 | 5 | 3 | 5 | 5 | 4 |
| 7. | Question 4 (7.3.3) | 16. Determination whether the output from the design and development process are defined and documented in accordance with the prescribed and chosen method | 16 | 5 | 4 | 5 | 5 | 5 | 5 | 5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8. | Question 5 (7.3.3) | 17. Determination whether the output from design and development are complete | 17 | 5 | 4 | 5 | 5 | 5 | 5 | 5 |
| | | 18. Determination whether the output from design and development are accurate and consistent with the requirements | 18 | 5 | 4 | 5 | 5 | 5 | 5 | 5 |
| 9. | Question 6 (7.3.3) | 19. Determination of the form of expressing design and development outputs, e.g. a text, a diagram, a symbolic modelling notation (e.g. data models, pseudo code or source code, etc.) | 19 | 5 | 5 | 5 | 2 | 5 | 5 | 5 |
| 10. | Question 7 (7.3.3) | 20. Determination whether design and development documentation has been worked out for the prototyping applied | 20 | 5 | 5 | 5 | 2 | 5 | 5 | 3 |
| 11. | Question 8 (7.3.3) | 21. Defining of acceptance criteria for design and development in order to demonstrate that the inputs to each design and development stage is correctly reflected in the outputs | 21 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 12. | Question 9 (7.3.3) | 22. their intended use | 22 | 3 | 3 | 4 | 4 | 5 | 5 | 5 |

Source: own elaboration.