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SOFTWARE PROCESS IMPROVEMENT BY *SPICE* METHODOLOGY

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In this paper the results of SPICE methodology implementation are described – the concepts and the organisations of SPICE, SPICE process model architecture, and the matter of the practical use of a SPICE methodology in process assessment and improvement. A generic model for process management and its components are presented as well as SPICE process categories, capability levels, assessment scope and an improvement strategy. Processes are evaluated against capability levels, using common features such as the evaluation basis to option a capability profile of the organisation.

A SPICE profile of one Croatian software producer and its own experience in process assessment and improvement are shown. Also, personal opinions regarding the relationship between SPICE, CMM and the ISO 9000 approach are discussed.

Keywords: software process improvement, quality, SPICE, Bootstrap, ISO 9000.

1. INTRODUCTION

The crisis in the matter of software production as a basic component of information systems culminated in the second half of the 1980s. For this reason, initiatives such as the CMM approach, ISO 9000 quality systems (ISO 9000-3), Bootstrap, Trillium and others started to appear in the world, aiming to improve this situation. As time passed, it became evident that the focus of the problem was the software processes that were nowhere close to complying with the demands of professional engineering, and that the problem could be solved only by improving these processes.

In June 1991, the fourth plenary meeting of ISO/IEC JTC1/SC7 approved a study period (resolution 144) to investigate the needs and requirements for a standard for software process assessment. In January 1993 ISO/IEC approved a project under the working title SPICE (Software Process Improvement and Capability dEtermination) which included the participation of leading world experts in the field of software engineering. The project goal was to develop a standard for determining the maturity of software production processes and its continual improvement. Since 1996 the SPICE project has been officially known as the ISO/IEC 15504 (Information Technology-Software Process Assessment). It was in the validation phase until the end

of 1997, and today it is a rounded off, finished product with which a certain goal can be reached.

SPICE or standard ISO/IEC 15504 provides a framework for the assessment of software processes. This framework can be used by organisations involved in planning, managing, monitoring, controlling and improving the acquisition, supply, development, operation, evaluation and support of software.

The high level view of the relationships between a process, process assessment, process improvement and process capability determination is shown in Figure 1 [1].

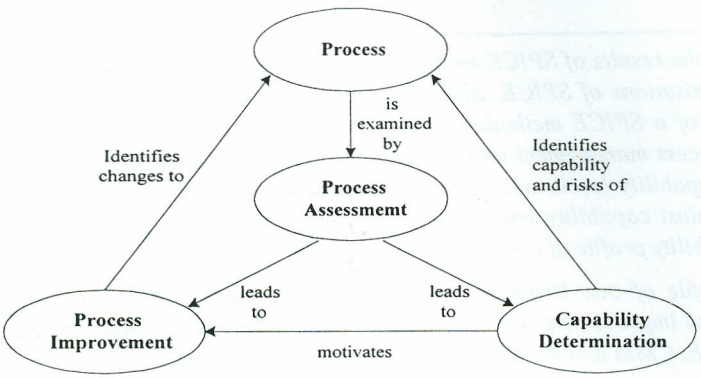

Figure 1. Software process assessment

In order to manage this process, it is necessary to understand the SPICE process model architecture, its capability levels, the assessment scope and its improvement strategy.

2. CONCEPTS AND ORGANISATION OF SPICE METHODOLOGY

2.1. SPICE process model architecture

A SPICE assessment determines the extent to which current practices in a company are effective in achieving process goals. Analysis of the results in the light of the organisation's business needs can help to identify strengths, weaknesses and risks inherent in the processes. Additional guidance is also available under the SPICE framework in order to determine the most appropriate process improvement strategy. SPICE process model architecture is shown in Figure 2 [1], [4].

The process model is a two dimensional structure: the process dimension and the capability dimension. The process dimension contains process categories, which comprise the essential processes and base practices that address the same general area of activity. The capability dimension contains the capability levels, which are characterised by common features and generic practices.

Processes are evaluated against the capability levels, using common features such as the evaluation basis to obtain a capability profile of the organisation. This capability profile is made up of a route map for improving the software processes in a logical fashion, i.e., increasing capability from level 0 to level 5.

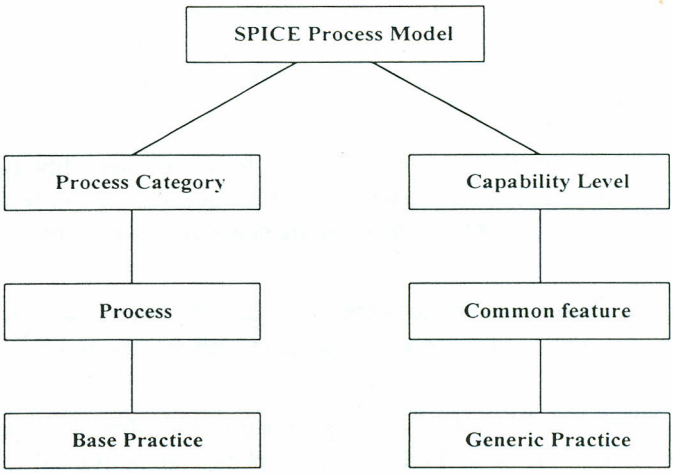

Figure 2. SPICE process model architecture

2.2. Process categories

The SPICE model distinguishes between the 5 categories of processes. The model defines the fundamental activities that are essential for good software engineering. It describes which activities are required. This model for processes and process management is applicable to all software organisations and does not presume a particular organisational structure, management philosophy, software life cycle model, software technology, or development methodology [1], [5].

These process categories are: customer supplier, engineering, project, support and organisation.

Customer-Suppliers (CUS) are groups of processes that directly affect the customer, support development and transition of the software to the customer, and provide for its correct operation and use. There are 8 CUS processes.

Engineering (ENG) are groups of processes that specify directly, implement, or maintain a system and software product and its user documentation. There are 7 ENG processes.

Project (PRO) is groups of processes that help establish the project and co-ordinate and manage its resources to produce a product or provide a service, which satisfies the customer's needs. There are 8 PRO processes.

Supports (SUP) are groups of processes that enable and support the performance of the other processes in a project. There are 5 SUP processes.

Organisations (ORG) are groups of processes that establish the business goals of the organisation and develop process, product, and resource assets, which will help the organisation achieve its business goals. There are 7 ORG processes.

Each process in the model is described in terms of its basic practices, which are its unique software engineering or management activities. Process categories, processes, and base practice provide a grouping by type of activity. These processes and activities characterise the performance of a process. The performance of the base practice may be ad hoc, unpredictable, inconsistent, poorly planned, significant or complete.

2.3. Capability levels in SPICE

Evolving process capability is expressed in terms of capability levels, common features, and generic practice. A capability level is a set of common features that work together to provide a major enhancement in the capability to perform a process. There are 6 capability levels.

Level 0: *Not-Performed*: Here there is a general failure to perform the base practices in the process. There are no easily identifiable work products or outputs of the process.

Level 1: *Performed-Informally*: This process is informally performed, not rigorously planned or tracked. Performance depends on individual knowledge and effort. There are identifiable work products for the process. Common features are that it allocates resources, assigns responsibility, documents the process, provides tools, ensures training and plans the process.

Level 2: *Planned-and-Tracked*: The performance of the process is planned and tracked. Performance according to specified procedures is verified. Work products conform to specified standards and requirements. Common features are the use plans, standards and procedures, and it allows configuration management, it verifies process compliance, it has audit work products, and it can track with measurements and take corrective action.

Level 3: *Well-Defined*: This process is performed according to a well-defined process using approved and tailored versions of standard, documented processes. Its primary distinction from the Planned-and-Tracked Level is that the process of the Well-Defined level is planned and managed using an organisation-wide standards process. Common features include the ability to standardise a process, tailor the standard process, use a well-defined process, perform peer reviews and use well-defined data.

Level 4: *Quantitatively-Controlled*: Detailed measures of performance are collected and analysed. This leads to a quantitative understanding of process capability and an improved ability to predict performance. Performance is objectively managed. The quality of work products is quantitatively known. Common features include the ability to establish quality goals, determine process capability and use this process capability.

Level 5: *Continuously-Improving*: Quantitative process effectiveness and efficiency goals (targets) from performance are established and these are based on the business goals of the organisation. Continuous process improvement against these goals is enabled by quantitative feedback. Common features include the ability to: establish process effectiveness goals, it can continuously improve the standard process, perform consolary analysis, eliminate causes of defect and continuously improve the defined process.

3. USING THE SPICE METHODOLOGY IN PROCESS ASSESSMENT AND IMPROVEMENT

3.1. Assessment scope for SPICE

The SPICE methodology is supported by BootCheck tool. A beta version of BootCheck is available from the European Software Institute (http://www.esi.es).

BootCheck's assessment scope under a SPICE framework covers only the highest level of the process structure, i.e. the process categories and the capability levels. Capability levels are considered for the assessment range from level 0 to level 4. Much more detailed information would be necessary to obtain a full capability profile, normally based on a scale from level 0 to level 5.

Each process category is represented by a bar. If no bar exists for a particular category, this means that such a category has not been assessed. Maybe that category was not relevant or there was no input for that category.

Processes are grouped together under each of the five categories. A capability profile is obtained by adding up all the ratings of the processes for each category. Since the information needed to evaluate practices and processes for level 5 is very indepth, the SPICE profile provided by BootCheck only covers levels 0 to 4 for the capability profile determination. The SPICE profile of one Croatian software producer is shown in Figure 3. It is possible to see that at the beginning the first (performed informally) and the second (planned-and-tracked) levels are dominant in all five process categories. Well-defined and quantitatively controlled levels don't feature at all here.

In the graph, the percentages shown in each bar indicate the extent to which the process category satisfies each capability level. The absence of a percentage for a specific level, when higher levels are present means that this capability level was fully achieved.

For each process category, the highest percentage really represents the capability level achieved by this process category. Low percentages below the predominant level reveal weaknesses and risks for that process category. On the other hand, low percentages above that level indicate strengths within that process category.

On the basis of these initial results, an improvement strategy is generated.

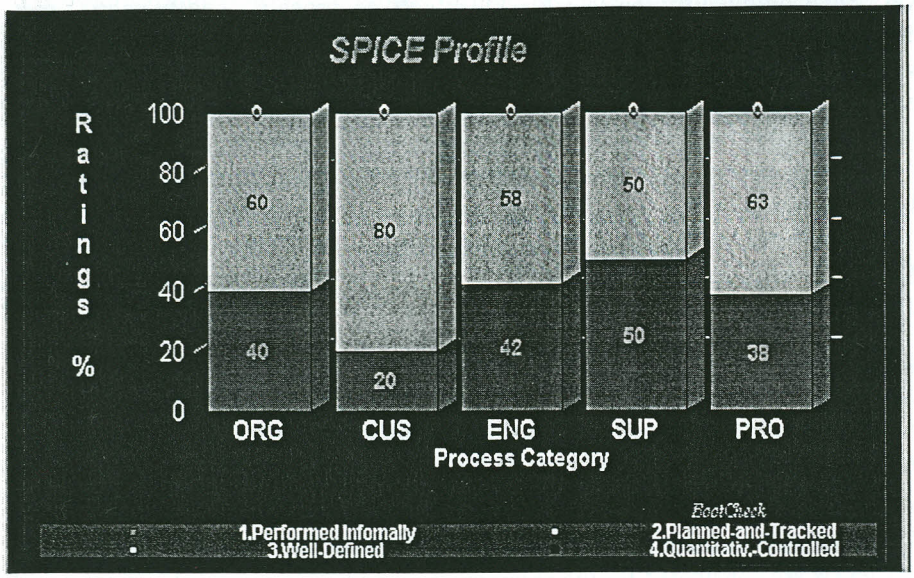

Figure 3. The SPICE profile of one Croatian software producer

3.2. An improvement strategy and its results

Capability levels where weaknesses and risks were detected suggest that improvement actions should be undertaken. These improvement actions should be applied to the activities developed within those capability levels. Priority should be given to those improvement actions that will help to fully achieve the desired capability level, starting with the lowest incomplete level.

In order to be certain that the benefits from the improvement actions are achieved, quantitative measurements should be used to monitor current performance against improvement goals. Furthermore, in order to sustain the benefits from this process improvement a conscious effort is needed from management to demonstrate their continued commitment to this process.

SPICE guidance includes an eight-step model for improving software processes. These eight steps form a continuous cycle of improvement.

The SPICE Process Improvement Steps are:

Step 1 Examine the organisation's needs.
- Input:the organisation's needs, the software process improvement request
- Output: identified scope and priorities

Step 2 Initiate process improvement.
- Input: identified scope and priorities, improvement in action
- Output: a preliminary improvement plan

Step 3 Prepare and conduct the process assessment.

- Input: a preliminary improvement plan, a re-assessment request, and a current profile
- Output: an assessment request, the results

Step 4 Analyse results and conduct an action plan.
- Input: the results, the needs, the industrial benchmarks, the target capability profile
- Output: the analysed re-assessment results, an approved improvement plan

Step 5 Implement improvements.
- Input: an approved improvement plan
- Output: the implemented improvements

Step 6 Confirm improvements.
- Input: an analysed re-assessment, the implemented improvements
- Output: the validated improvements, a re-assessment request

Step 7 Sustain improvement gains.
- Input: the validated improvements
- Output: the institutionalised improvements

Step 8 Monitor performance.
- Input: the institutionalised improvements
- Output: the improvement in action

Because of this improvement strategy the levels of process categories rise during the year. This can be seen in Figure 4. It is obvious that level 3 is now dominant and that level 4 is also partly present.

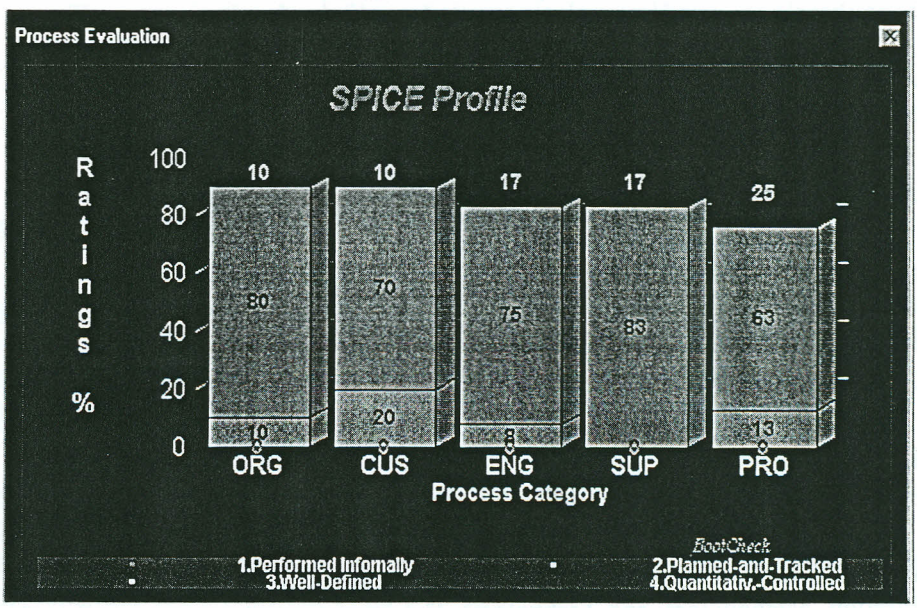

Figure 4. SPICE profile of one Croatian software producer, one year later

4. CONNECTING SPICE WITH BOOTSTRAP AND ISO 9000

4.1. Connections with Bootstrap

The Bootstrap methodology is designed to help organisations improve the maturing process for their software development processes. It also supports software process improvement through the definition of a process improvement action plan. This methodology is based upon some of the best packages in the world and these include the Software Engineering Institute's Capability Maturity Model (CMM), ISO 9000 quality standards, European Space Agency life-cycle model and the SPICE process.

Bootstrap process architecture is structured like a tree that identifies its objects, the main categories of process areas, the process areas, the processes and base practices which are analysed from the perspective of the Software Producing Unit (SPU) and the software project. This structure of processes forms a reference map for Bootstrap assessment and improvement methodology [6], [8].

The following graph in Figure 5 shows the hierarchical relationship between the various components of the process architecture.

The objects at the highest level of the process architecture are the Software Producing Unit and the software projects. The SPU perspective focuses on the general processes that address a set of procedures for the software production to be followed by the whole organisation. The software project level itself is the fulfilment of the procedures in practice for each software development project.

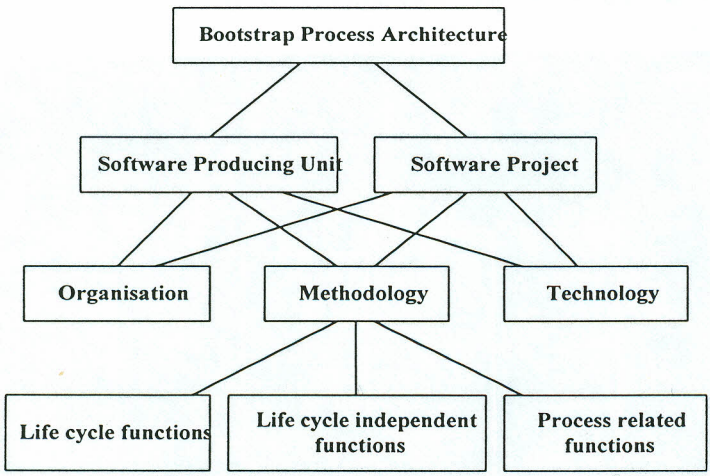

Figure 5.The hierarchical relationship between various components of process architecture in the Bootstrap methodology

At the next level of the process architecture there are three main process categories: Organisation, Methodology and Technology. The improvement process assumes that

good organisational practice is the basis for sound methodology implementation, which again ensures successful technical support.

The Methodology process category is further broken down into three process areas: the life-cycle functions, the life-cycle independent functions and the process related functions.

Although some information about the projects is collected, BootCheck's assessment scope is restricted to the SPU view for process definitions. Much more detailed information on projects would be necessary in order to carry out an assessment on a project level. The organisation and the methodology process categories at the third level of the hierarchy form the main focus of the self-assessment exercise.

Bootstrap uses the original maturity levels defined in SEI's CMM model as a measurement scale. Overall capability is expressed as the last satisfied maturity level. An important enhancement of the Bootstrap methodology is that capability may also be measured between maturity levels using quartile precision for each maturity level.

The graphical analysis under the Bootstrap framework presents the conclusions in two dimensions: the process attributes, representing the main functions to be evaluated for each process area, and the capability levels, which rate the different process attributes according to the maturity scale.

The result of the self-assessment session under this framework produces a maturity analysis for the following profiles:

- The SPU profile, which looks into the set of policies for the software production to be followed by the whole organisation.
- The organisational profile, where particular emphasis is placed on those practices related to the quality system and resource management.
- The methodology profile, which is broken down into three categories: the process related functions, the life-cycle independent functions and the life-cycle functions.

The transformation of the SPICE result into the Bootstrap result can be seen in Figure 6.

The overall maturity profile displayed above suggests that a strong emphasis is placed on the process related functions although the focus area might be somewhat narrow, since the maturity levels for the SPU and the Organisation processes are considerably lower. In the sample graph, a rating of 2.75 means that the maturity for that particular process area is in the third quartile for the "repeatable" level.

The improvement strategy proposed by the Bootstrap methodology is goal-oriented, and should be designed along with the overall business needs. Bootstrap provides the opportunity to divide the main process improvement goal into intermediate goals according to the assessment results. This approach is clearly advantageous in those cases where heavy investments cannot be afforded or where effective improvement activities are expected to be implemented in the near future.

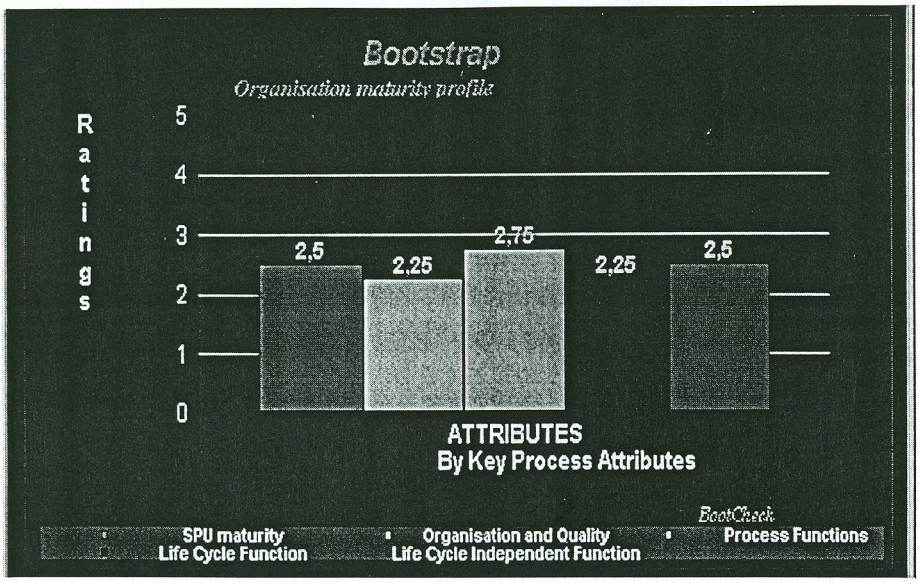

Figure 6. A Bootstrap maturity profile derived from a SPICE result

Any improvement program implemented under this framework should pass through all the maturity levels in ascending order. Each maturity level increase requires the establishment of a set of well-identified processes and practices defined within the process architecture. Since these processes are individually mapped onto the maturity level structure, it is possible to define a clear process improvement strategy. By considering improvement risks one may also influence the definition of the improvement priorities and will help to complement the improvement strategy with the actions to mitigate potential failure factors.

Typically, the activities involved in a software process improvement include:

1. *Assessment result verification*
   The improvement plan is generated and based on the assessment findings.
2. *Target profile definition*
   This sets the maturity level and the target capability profile for the SPU that are to be achieved in the forthcoming steps.
3. *Priority identification*
   Suggested improvement actions are prioritised over a longer period taking into account the weakest areas and processes in the SPU, the overall business goals, the ongoing activities and requirements and also the risks and possible impact of the improvement action on the SPU.
4. *The improvement action definition*
   Based on the previous activities, some well-identified improvement goals are set in order to define concrete improvement actions.

5. *Scheduling*
The time scale is defined for the selected improvement actions.

These improvement actions should be performed iteratively until the target capability profile set for the SPU is reached. Achievement of this capability profile becomes the driving force for the process improvement strategy since people in the organisation find themselves committed to a very clearly defined objective.

4.2. Connecting with ISO 9000

The ISO 9000 series of standards is a set of documents specifying the quality system requirements to be used when a contract between two parties requires the demonstration of a supplier's capability to design and supply a product.

The ISO 9001 standard covers the design/development, production, installation, and servicing phases. The ISO 9000-3 standard is a guideline for applying ISO 9001 to the development, supply, and maintenance of software [2], [3].

BootCheck's assessment scope for the ISO 9000 framework covers all the requirements that need to be met for the development, supply and maintenance of the software. However, a maximum profile for ISO 9000 in a BootCheck assessment, (i.e. a 100% rating for all clauses), does not necessarily imply full ISO 9000 compliance. This result should be interpreted as an indication that the organisation is adequately applying the quality standards included in the ISO 9000 framework.

Bootcheck's ISO 9000 graphical analysis is made up of the following elements:

- Concentric circles, which represent a scale that shows the level of compliance with ISO 9000 requirements, and this level of compliance is low near the centre, and gets higher as it moves towards the outer circles.
- Twenty radii, which represent each of the ISO 9000 clauses.
- A graphic line, which is a closed polygon that shows the current position of the company against the ISO 9000 framework.
- A gap between the outer circle and the current graphic line, which reflects the distance needed to achieve full compliance with the ISO 9000 requirements.

The transformation of the SPICE result into the ISO 9000 result can be seen in Figure 7.

The graphic line can adopt several shapes, which could lead to different interpretations. If the graph line has many sharp corners, it could reflect some deficiencies in a process; perhaps the process is highly dependent on its responsible functions rather than on a good definition of that process. A smoother shape, resembling any of the concentric circles in the graph, could suggest that the organisation has managed to achieve a good balance for the different processes related to the development, supply, and maintenance of the software.

This graph shows the weaknesses of an organisation as those clauses whose position is closer to the centre. The objective here should be to try and cover as big a surface as possible with the closed polygon line, in order to minimise any weaknesses

reflected by the sharp corners. The first steps in an improvement program should be directed towards fulfilling the deficiencies shown by the graphical analysis.

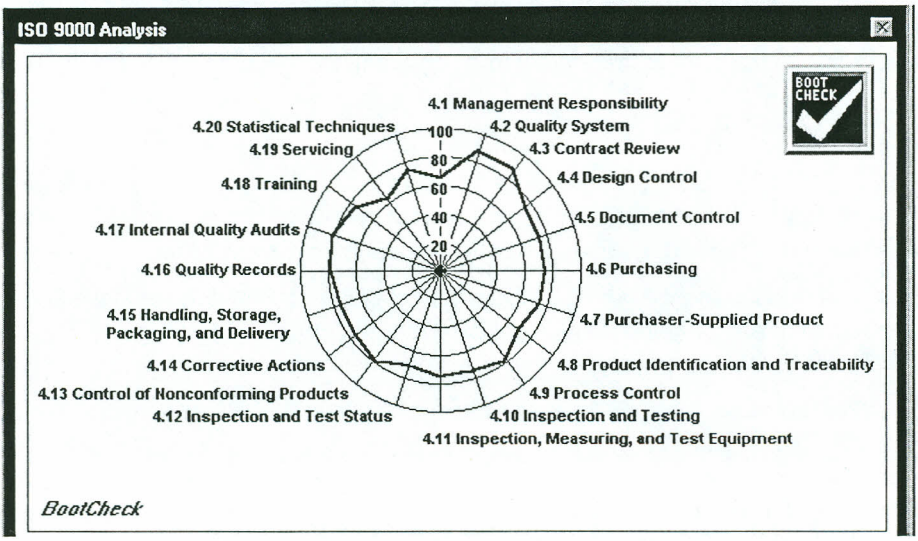

Figure 7. Bootcheck's ISO 9000 graphical analysis derived from a SPICE result

5. CONCLUDING REMARKS

The SPICE project or the ISO/IEC standard 15504 has been developed to the level of a rounded off and usable product that partly integrates the methods of managing maturity development (CMM, Bootstrap) with the ISO 9000 approach [5], [7]. As such, it is suitable for: software producers, because it objectively assesses their capability, suppliers, since it can also be used for process examination, and management, since it can be used to meet business needs that comply with the existing working processes. However, at the moment there are also uncertainties. Using the ISO/IEC 15504 assessment would it be possible to create an ISO 9001 or ISO 9000-3 certification, or would ISO/IEC 15504 completely remove the need for this ISO 9000 certification? What will the future relationship between the CMM and Bootstrap methodology and the ISO/IEC 15504 norm be? For now these questions have no answers. However, regardless of these dilemmas it is certain that ISO/IEC 15504 will have a huge influence on the future development of software engineering. Therefore, it is important that Croatian informatics gradually introduce this model as it would prove very advantageous.

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UNAPREĐENJE PROCESA PROIZVODNJE PROGRAMSKE OPREME SPICE METODOLOGIJOM

Sažetak

U radu se opisuju rezultati uporabe SPICE metodologije u poboljšanju procesa proizvodnje programske opreme. Prikazan je koncept i organizacija ovog modela, njegova arhitektura, kao i način procjene i poboljšanja procesa. Postoji sedam kategorija procesa i ukupno 35 konkretnih procesa čijm se upravljanjem postiže jedna od šest razina zrelosti. Također, prikazana je i strategija poboljšanja procesa u vidu obvezatnih koraka.

Određen je SPICE profil jednog konkretnog proizvođača programske opreme, te opisana vlastita iskustva u poboljšanju procesa. Navedeni su i odnosi između SPICE metodologije i CMM i ISO 9000 pristupa.

Ključne riječi: poboljšanje procesa, kvaliteta, SPICE Bootstrap, ISO 9000.