Zdravko Krakar
Faculty of Organization and Informatics, Varaždin

Stanislav Vučica
Pulsar, d.o.o., Split

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Croatian Experiences in the Software Producers Maturity Profile Determination and Improvement

Importance of managing maturity development in software production process and usage of Bootstrap method in these processes' maturity level measurements are explained in this paper. Maturity assessment results in thirteen concrete cases are presented. On the basis of that expected Croatian software industry profile is determinate.

Key words: process maturity level, Bootstrap, maturity profile.

1. Introduction

Software is clearly recognized as the weakest point of information systems, as well as of informatization process itself. Software costs in the world are constantly growing. In 1985 they were 140 billion USD; in 1990 more than 250, and in 1994 more than 390 billion USD. It is estimated that this amount will be more than 800 billion USD (1) by the year 2000. On the other side there is a permanent lack of software in the world, especially of the so called end-user software.

Demands for improvement of production and usage of software are also increasing. What is software production - is it a craft, professional engineering or something else? This seems to be the question that both users and software producers have been asking for a long time (2). This question was originally initiated at the well known and frequently quoted NATO Science Committee conference in 1968. It is obvious that since then the software production has been improved, but demands on its usage have also been multiplied. Hence, the problem is only greater now. Low

productivity, high maintenance costs and small possibility of developing a product that will satisfy the user are the main characteristics of software industry.

Software users - especially more sophisticated ones like defense departments and space industry, but also governments, banks, insurance companies, environment or safety critical industries - have many reasons for initiating changes, as well as the software producers trying to improve the way they work, and make optimal balance between profit, costs and quality. Many methods for software producers maturity assessment as well as the improvement methods appeared as the result of these pressures.

This paper presents thirteen software producers maturity assessments results performed in Croatia this year using ESPRIT-Bootstrap compatible method. The experiences in their maturity improvement are also shown.

2. Importance of software process maturity control

The thorny process of growing in maturity is the way an organization passes from the state of craft to the professional engineering. First concepts were introduced by Watts Humphrey, whose model presented five evolutionary levels of maturity. Managing improvement process is very complex and sensitive problem having its own goals, methods and duration. To achieve a higher maturity level it is necessary to satisfy demands for each key process area. Key problems have organizational and methodological character and cannot be resolved with any particular technology (tools). This refers specially to the lower levels of maturity. Investments in the development tools turn out to be complete disasters if there is no organizational and methodological presumptions.

The goal of software process maturity development is to influence the probability distribution regarding time, costs and quality. On the lower levels this distribution is wider, and on the higher levels it is narrower. So, to increase productivity and quality in software development, it is necessary to reduce uncertainty by process improvement towards higher levels of maturity, as shown in the figure 1.

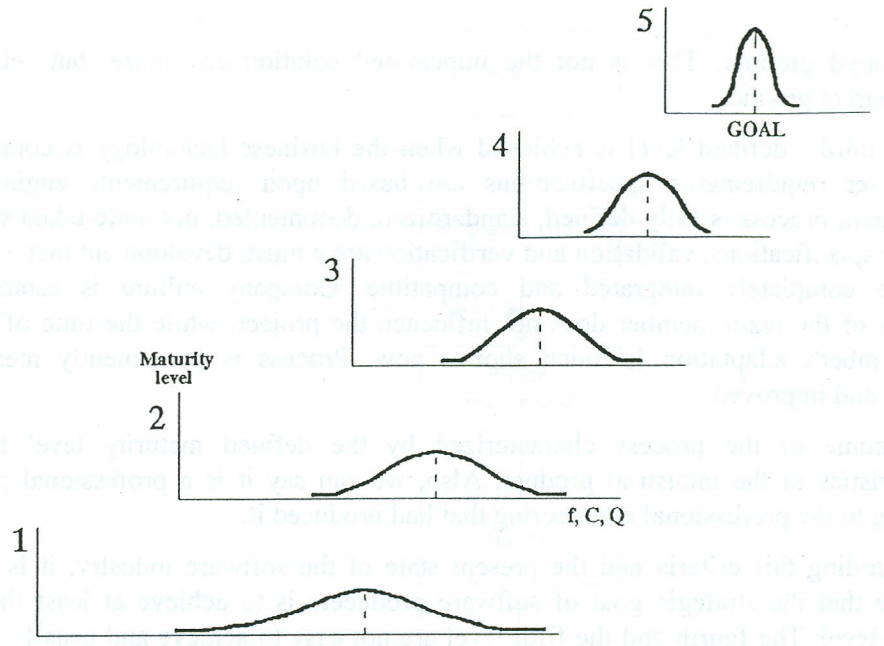

Figure 1. Software maturity production evolution in perspective of time (f), costs (C) and quality (Q)

Features of the initial maturity level are undefined and unstable business technology, unclear and unpredictable user requirements, uncompleted and undisciplined development process, suboptimal usage of tools; knowledge of software development methods is missing, project success depends primarily on the management heroism, individual creativity is dominating factor, and the primary goal is to finish the project on time regardless of other objectives (such as quality, cost and risks) which are only taken into account individually and instinctively by project managers.

The result of such work is some kind of software semiproduct, which is unique or prototype, and requires permanent and intensive maintenance. That is the reason for its low functionality, high production cost and very expensive maintenance.

The second, repeatable maturity level is achieved when the business technology is stable, user requirements more clear and better defined, phases of the software process are recognized and validation and verification are introduced, development is

manufactured product. This is not the improvised solution any more, but relatively correct market product.

The third - defined level is achieved when the business technology is completely stable, user requirements specifications are based upon requirements engineering, development process is fully defined, standardized, documented, not undertaken without complete specifications, validation and verification are a must, development methods and tools are completely integrated and compatible. Company culture is established, departure of the team member does not influence the project, while the time of a new team member's adaptation is much shorter now. Process is permanently measured, analyzed and improved.

Outcome of the process characterized by the defined maturity level has all characteristics of the industrial product. Also, we can say it is a professional product according to the professional engineering that had produced it.

Regarding this criteria and the present state of the software industry, it is understandable that the strategic goal of software producers is to achieve at least the third maturity level. The fourth and the fifth level are not easy to achieve and usually **belong to the long-term goals.**

What is the situation in the Republic of Croatia and what is the capability of Croatian software industry today? In the attempt to answer this question as reliably as possible we have performed a series of thirteen Croatian software companies maturity assessments. Here we also present some experiences of the one particular company in increasing the maturity level.

3. Maturity level maturity level assesment

3.1. Methods for measuring maturity level

The Bootstrap method used in these assessments was developed under European development program ESPRIT. Republic of Croatia has accreditation for its use through the Croatian Information Technology Agency. European Community recommended this method in April 1995 as a standard software producers assessment method. The assessment procedure is presented in the figure 2.

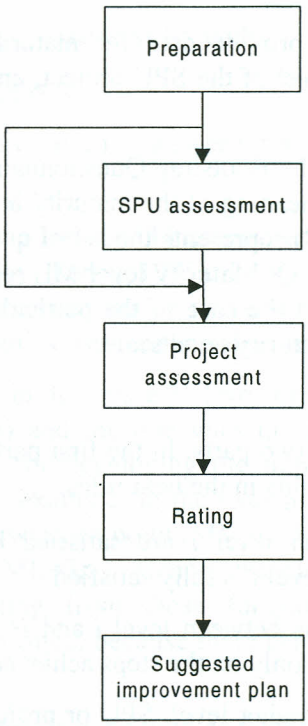

Figure 2. ESPRIT Bootstrap assessment procedure

Assessment preparation consists of opening briefings with management, explanations of the method and its usage, expected results and post-assessment improvement actions.

Method provides measurement of the maturity level of a whole organization (SPU in Bootstrap terminology) and/or a particular project. SPU assessment includes measurement of about 130 state indicators through the work reviews, documentation reviews and conversation with senior management as well as with project managers.

Project measurement is conducted in a similar way by measurement of about 110 indicators through the project documentation reviews and conversation with team members.

These measurements provide data for maturity level calculation. Algorithm calculates total maturity level of the SPU/project, and also maturity levels of 18 key areas.

Results of answering the Bootstrap Questionnaire Q represent a subset of N×L× S, where L=(2,3,4,5) has meaning of the maturity level set , S=(0,1,2,3,4) represents set of possible scores and N represents the set of question numbers. Every answered question belongs to the set Q. Maturity level ML represents mapping from subset Q (or V as the subset of Q in the case of the particular attribute) to the values in the range from 1 to 5 on the maturity level scale.

$ML : V \rightarrow [1,5]$

Algorithm consists of two parts. In the first part the number of steps is counted, taking into account constraints in the next rules:

1) If all questions on level *i* are satisfied by a Percentage [i] ≥ Defined Threshold we define that level *i* is fully satisfied.

2) If SPU or project is between level *i* and *i+1* after calculating the steps, the calculation has to be based only on the steps achieved on levels *2* to *i+2*.

3) To reach the next higher level, SPU or project must satisfy all key attributes on the current level with a certain minimum.

4) To calculate the maturity level of an SPU or project we need the restrictions of both 2. and 3. To calculate the maturity level of an individual process quality attribute we need the restriction in point 3, only if a defined key attribute is a subset of the process quality attribute.

Then the steps are put on the dynamic scale, and the steps-value is transformed into a maturity level value:

$ML(V) = G(F(V))$

$F: V \rightarrow [O, D]$

$D=d[2]+d[3]+d[4]+d[5]$

$G: [O, D] \rightarrow [1, 5]$

F is a function of all scores given for questions which are elements of V and it calculates the number of the achieved steps:

F(V) = F(score[x1], score[x2], ..., score[xn]) , with

$|V| = n$, and x1, x2, x3, ... xn $\in$ V

score[xj] ... element of S, given score for answer j, for j = 1...n

3.2. Measurement results

Using the Bootstrap compatible method, 13 assessments were conducted in Croatia during one year period (Spring 1994 - Spring 1995). Two of these were SPU assessments and the rest of them were project assessments. In two cases SPUs were part of the larger business system while other companies were independent software producers.

A part of the results is shown in the figure 3. Two companies are presented, the one with the highest (upper diagram) and the one with the lowest maturity level (lower diagram). These results are used for developing the improvement plan and software process maturity management. For example, in the case shown in the figure 3a, we can see that project management is the weakest point (ML=1,75), while process measurement is the best function performed (ML=3,5). Hence, we can use this graph to set the priorities for improvement, starting from those functions in the SPU which are recognized as the most poorly performed, because there is no sense in improving the best areas.

The results of these 13 assessments were used as the baseline for shaping the current Croatian software market profile.

On the basis of these measurements, it is estimated that the expected maturity levels of the Croatian software companies are between 1.25 and 2.75, with the average value of 1.75. Project development organization is rated between the 1.50 and 3.00 (expected 2.00), and methodology between 1.50 and 2.75 (expected 2.00).

In the organizational domain, the weakest points are development organization, verification and validation, and project development support (ML=1.50). On the other side opposite, coordination during life cycle is one of the best performed functions in the software companies (ML=2.25).

Figure 3. The highest and the lowest measured maturity profile

Some of the results are shown in the Table 1.

	Maturity Level			
	Max	Min	$\bar{x}$	σ
Total Maturity Level	2.75	1.25	1.85	0.46
Organization	3.00	1.50	2.00	0.44
Coordination	3.00	1.50	2.38	0.41
Development	2.25	1.50	1.71	0.29
Validation & Verification	2.00	1.50	1.71	0.25
Project Support	2.00	1.25	1.56	0.29
Life Cycle Independent Functions	2.50	1.25	1.83	0.39
Configuration Management	2.75	1.25	2.33	0.19
Risk Management	2.50	1.00	1.48	0.51
Project Management	2.75	1.25	1.60	.044
Quality Control	2.50	1.00	1.79	0.43
Subcontractor Management	3.00	2.25	2.17	0.72
Process Related Functions	3.00	2.00	2.31	0.36
Process Description	3.00	1.50	1.94	0.49
Process Measurement	3.50	2.50	2.94	0.38
Process Control	3.00	1.00	2.23	0.58
Life Cycle Functions	2.75	1.75	2.19	0.33
Development Model	3.00	1.00	2.37	0.49
Requirements Specification	2.50	1.50	2.06	0.42
Architectural Design	3.00	1.00	1.77	0.65
Detailed Design	3.50	1.75	2.52	0.73
Testing	2.50	1.75	2.00	0.20
Methodology	2.75	1.50	2.06	0.33

Table 1.

In the methodology domain, process dependent and life cycle functions (2.25) are better side of the process regarding the life cycle independent functions (1.75).

Observing life cycle independent functions, we can see that configuration management (2.25) and subcontractor management (2.25) are better performed than risk management (1.50), project management (1.50) and quality control (1.75).

Observing life cycle functions, we see that requirements specification, development model, architectural design and testing (1.75-2.25) are weaker than detailed design (2.50).

Regarding process functions, one can see that process measurement is better defined and practiced than process description (2.00) and process control (2.25).

Technology measurement (development tools) has shown that state-of-the-art technologies are not being used throughout process (they cover only 30%). Tools are not used at all in requirements specification (0%), or architectural design (10%) contrasted to detailed design an implementation (70%). Also, project management tools usage is very low (5-10%), just as risk management (0%), testing and integration (10%), etc.

3.3 Results interpretation

Expected maturity level of the average Croatian software company is 1.75. This result tells us that Croatian software industry is stepping into the phase of the so called repeatable production. There are characteristics of both the industrial and the craft production. Production process is not defined, methods are poorly used and individual talent dominates in the production (mainly project managers and key members of the development team). Tool usage skill still has advantage compared to usage of mature methodologies. Products are more unique, and still lack quality of industrial product. However, it is noticeable that there is common view that this situation should change. Some actions have been taken in this direction, but they are still isolated and instinctive.

Difference between the lowest (1.25) and highest maturity level (2.75) indicates large diversities on the market (from reliable to highly risky producers). Differences in observed sample depending on the company size and ownership have also been noticed. Market driven companies are more interested in acquiring new knowledge and technology transfer, but they are mostly understaffed. Most of the companies have development teams of only 2 to 4 team members, and unexpected departure of one of them may cause serious problems in project development - what makes these companies more unstable.

In the organizational domain, coordination is stronger than development organization, validation and development support. That is because SPU project managers, usually very experienced and educated staff, correctly plan and manage resources and their responsibilities. But validation and verification, as well as the configuration control functions are not taken into account seriously enough.

In the methodology domain it is interesting that its maturity is equal to organization. Focus of attention was directed towards process related functions - process measurement and control.

Expected Croatian software producers maturity level and its characteristics are shown in table 2.

4. Maturity management experiences

One of the first assessments in Croatia was in the company developing business information systems. This company, we shall call it X-Informatika, had to be assessed for the contracting purposes.

Quality management in X-Informatika was already recognized as key business need according to their consultation with experts from Croatian Association for Quality Assurance in Information Technologies (HrQA Info), as well as with foreign software companies and through their own research. Arising problems of schedule and cost overruns, uncontrolled introduction of new technologies in the development process as attempt to resolve problems, almost destroyed the company.

After all, top management tried to resolve the problem through organizational changes, but finally it was clear that all these efforts should be systematic and that without detailed assessment and good improvement plan this situation cannot be resolved.

They used SEI-compatible method, similar to Bootstrap, in self-assessment process, and preliminary results indicated critical functions: configuration management, project management, process control and description, and completely missing quality system. Total maturity level of software production was on the repeatable level.

Total Maturity Level	1.75
Organization	2.00
Coordination	2.25
Development	1.75
Validation&Verification	1.75
Project Support	1.50
Life Cycle Independent Functions	**1.75**
Configuration Management	2.25
Risk Management	1.50
Project Management	1.50
Quality Control	1.75
Supplier Management	2.25

Process Related Functions	2.25
Process Description	2.00
Process Measurement	3.00
Process Control	2.25
Life Cycle Functions	**2.25**
Development Model	2.25
Requirement Specification	2.00
Architectural Design	1.75
Detailed Design	2.50
Testing	2.00
Methodology	**2.00**

Table 2. Expected Croatian software producers maturity level and its characteristics

On the basis of these findings new mechanisms were established to introduce new methods and to change organization. All improvement actions were followed by adequate documentation, manuals and procedures.

New software life cycle model with detail description of all process tasks was tailored after examination of present methodologies for system analysis and design (e.g. SSADM, MERISE, Information Engineering, etc.) and life cycle models (e.g. MIL-STD-2167A and Boehm spiral model). This model included risk management mechanisms and controlled evolutionary prototyping. Configuration management function was supported through development tools and discipline in regular documentation management. Project management function was established and recognized as the most important component of the process. Quality system was introduced through the establishment of SQA function.

After one year, new assessment was performed. Significant improvement in previously detected weak functions of about half of maturity level was achieved, (as can be expected for small and middle sized companies for one-year period). Process related functions, like V&V and process measurement that were not directly tracked through the improvement process, have also been improved.

The results of this one-year improvement cycle cannot be expressed by the cost analysis before and after improvement (because of the lack of previous project documentation), but baseline for future analysis is now established.

Final evaluation is always the one from the user. User's satisfaction with software product is the final valuable feedback information about process improvement. Applications were delivered after thorough acceptance testing against 13 quality attributes (RADC model). It should be emphasized that quality introduction in company resulted finally with new projects for obviously satisfied customer. Next planned steps are introduction of complex software metrics and statistical development control. Certification for ISO 9001 is also included in middle-term plans.

5. Conclusion

Software production is the weakest segment of the information technologies in Croatia, as it is also with the rest of the world.

Croatian software industry market consists of about 350 to 400 market driven software companies and about 350 computer centers that belong to larger business systems, producing software mainly for internal usage. Average software company has

only 5 to 8 developers, and in the computer centers this number is near eleven. That is the reason why the need for process improvement is not quite well recognized. But things have been changing recently.

Thirteen assessments have showed that software production in Croatia is reaching so-called repeatable level. Production organization is at the same level as methodology. Particular maturity levels in methodology domain indicate that our software companies are primarily programming-oriented.

Software production improvement is a great challenge and a must for our software industry. It can be done by improving all single quality aspects shown in this paper. Introduction of quality management systems and rough selection of reliable and non-reliable software producers is the next step. Maturity improvement experiences are very encouraging, showing that there is the way to quality - thorny, but possible.

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Sažetak

U radu se objašnjavaju razlozi upravljanja razvojem zrelosti i przentiraju rezultati dobiveni mjerenjem 13 proizvođača softvera u Hrvatskoj. Na taj način određen je i vjerojatni profil naše softverske industrije. Iznose se i spoznaje u podizanju ove razine.