Brainstorming as a Route to Improving Software Processes

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Abstract-**This contribution shows how a "guided brainstorming" process facilitates the applicability of an assessment and process improvement model (such as for example SPiCE or CMMi) to Companies that develop Critical Software applications. For a Manufacturer that deals with time-to-market and customer satisfaction, as well as with regulations and laws, both efficiency and efficacy are mandatory for regulatory and commercial purposes, and become strictly related. A Process Improvement is often necessary for a company that develops and distributes critical software in order to establish a Quality System, which is a set of established procedures with measurable and auditable output. To be effective these procedures must be or become a natural part of the daily activities. To provide an efficient way to approach and implement the improvement plan, we suggest guided brainstorm sessions, which are a good interactive opportunity for team and formalization building. Although the concept of brainstorming is not novel in organizations, it is generally a first approach to discussions that are later formalized. The use of this technique for definition of critical requirements or regulated activities is not common. For the definition of Quality Systems, a top-down approach (definition, training, roll-out, audit) is generally used whereas brainstorming can be considered bottom-up approach, from experience to formalization.**

Keywords-improvement; participation; experience; motivation.

I. INTRODUCTION

This contribution shows how a "guided brainstorming" process facilitates the applicability of an assessment and process improvement model (such as SPiCE or CMMi) to Companies that develop Critical Software applications. It comes after a study for the definition of a simplified Spice model for Small Companies and a study about the application of Spice to Medical Devices.

Critical Software manufacturing companies are generally of limited dimension, or small / medium departments inside large Companies. We define as critical, the software that controls apparatus or activities that may imply direct benefits or risks for life, security, and the environment. In applications such as Medical Devices (our specific sector), the software has generally to provide and handle the overall protection to guarantee safety and liability of the system.

The Manufacturer deals with time-to-market and customer satisfaction, as well as with regulations and laws. The risks derived from the product characteristics and from the processes applied to design control have to be considered, in addition to typical project and commercial risks.

In this context, both efficiency and efficacy are mandatory for regulatory and commercial purposes, and become strictly related.

A Process Improvement plan, tailored and tuned to the needs of the Company, is the main route to reach the trade-off of the efficacy and efficiency required.

What is an efficient and effective way to approach and implement the improvement plan for a Small Company? We suggest that guided brainstorm sessions are a good interactive opportunity for team and formalization building.

The paper has the following structure. Section II presents maturity levels of processes following standard models, and develops brainstorming methods. Section III exposes potential evolution of topics under survey.

II. PROCESSES FOLLOWING STANDARDS MODELS AND USE OF BRAINSTORMING METHODS

From SPICE Level 2 to Level 3, from an informal process to an established process, the advantages of using a standard reference model for Process Improvement are multiple:

First of all, the model is ready and has been proved in a number of other companies. This may not be feasible as it is, as the Improvement Plan may need to be implemented with limited resources, often in parallel with the daily tasks assigned. This implies that small companies need a specific approach to make ROI of Process Improvement interesting for the business.

Process Improvement requests for a company that develops and distributes critical software [2][3][4] have a main outcome, namely, the definition and control of a Quality System [5][6], which is a set of established procedures with measurable and auditable output. Translated in SPICE concepts [1], it means that Process Improvement has capability level 3 as a target.

SPICE capability level 2 "certifies" that a controlled common process is followed within a Company, with activities that are carried out in a common way by all team and project members, with similar outcomes. When a Company reaches SPICE capability level 3, those processes that are managed and controlled have been formalized and established within the Company.

To move from level two to the following levels, the steps to an effective and efficient improvement for a Small Company can be summarised as:

- Select the set of basic processes that are needed for Design Control and ancillary mandatory activities
- Define the processes
- Define the support for processes (instructions, templates, checklists, etc.)

A. Define your Quality System

The set of processes to be established is the minimum set that covers the Project Life Cycle phases, including control of design, validation, configuration, risk management, and all others specific to the sector, required to comply with customer requirements and with regulations.

In a Company that is active in a critical sector, most of those processes are implicitly defined. If a common approach is applied through the projects the Company is generally at a capability level 2. It has to move one step higher by establishing the processes mentioned above.

1) Guided Brainstorming

To acquire process formalization and description for roll-out, training and control, we suggest using guided brainstorming sessions.

Guided brainstorming goes beyond the purpose of allowing "everyone to say his own opinion freely about a subject". Applied as a working tool, it is more structured:

It is a guided meeting attended by people involved with the subject, often experts themselves.

Each attendee replies with 3 to 5 answers or suggestions to each of the questions specified in the agenda of the meeting. Such as for example: "list which are, in your opinion, the 3 main characteristics of xxx".

Attendees get 10 to 15 minutes to prepare and write the answer separately.

The answers are then presented and explained.

They are rated and ranked for popularity (i.e. given a higher rating if more attendees gave same or similar answers then ranked by the resulting score).

The first arguments in the list, the highest rated, are then refined and considered in detail. The result of the discussion is recorded.

For example, if the question was "Which are the 3 main activities of process X?", the three most rated proposed actions are detailed in terms of responsibility, flow, inputs, outputs, etc.

A guided brainstorm is called with the purpose of describing and building a process or sub-process or supporting material for the required phases, with the contribution of all the attendees. The moderator of the meeting has prepared a minimum set of items that the list of answers HAS to contain, and will guide the participants to include them. The approach is based on the belief that the process is implemented and implicitly defined in the majority of the parts, and the people involved are the best candidates to describe, analyze and formalize it. The moderator will help to fill in the gaps.

A step forward in a small company, equally relevant after the identification and definition of processes, is to define templates and practical instructions which will easily and cost-effectively carry out the tasks. Templates and instructions can also be the result of brainstorm sessions, generally with a smaller number of participants.

2) Advantages

What are the advantages of the technique?

In the belief that in the Company processes are implemented, in order to reach a higher capability level and compliance with regulation, they must be formalized in procedures, and so, becoming repeatable and controllable.

Brainstorm meetings are used to gather the practices, share and formalize with the advantage that:

- All are protagonists and motivated
- The base is a company culture already in place
- Sharing is not imposing
- Changes and up-grading of the practices, if needed, are easily accepted
- Roll-out of the process will not find resistance as it is accepted "by definition" by people that contributed to build it
- It is also an economical saving, as you don't have to call in experts to define processes and train on them

3) Drawbacks

This technique is not a panacea; it presents some drawbacks. Warnings to be considered are:

- As it is based on the use of existing knowledge and experience, it can be effective only if the activities to formalize are already part of the culture and daily experience.
- Instead, if one wants to apply the technique to introduce new concepts, some extra technique and expertise is required. The outcomes of the brainstorm have to be reviewed and revisited after a pilot experience, often happening for processes such as risk management and metric collection. In these cases brainstorming becomes a good training technique.
- The strength of this approach is its usage and sharing of experience. It is also a weakness as the quality system generated is recognized by the authors but does not have the "authority" of a recognized standard for their colleagues (no man is a prophet in his own land!). Mapping to the standard used as a reference to guide the brainstorm will be useful.
- There is a time cost involved in the preparation of the meetings and formalization of the results, which is partially avoided by the use external experts. On the other side the ROI is high in terms of training and roll-out.
- The outcome is not accepted without time limit and has to be periodically updated even if it may still be valid because:
- People change and so does the approach
- People need to be protagonists and new people need to be part of a revision to accept their own

procedures as did the team defining the original system.

Based on the analysis of the advantages and draw backs, and on the experience within our Company and companies with which we have worked using the method, we believe that the approach is appropriate and of high ROI in companies with real internal practical know how on the activities to be organized and formalized in processes. Most of the draw-backs have simple mitigations and the others are in fact the correct stimulus for continuous improvement and action plans.

Once the Company reaches the level of compliance with regulation, continuous process improvement will focus on improving efficiency. Regulatory compliance is required to stay in the business.

The above brings us to the conclusion that through the initial scope of the technique, small companies, and with expansion larger ones, gain the advantages of being people and company-culture centred.

If the company is entering a new sector or business and the participants in brainstorming sessions do not have specific previous experience to share and formalize, the technique can still give good results. Advantages such as motivation, participation and buy-in are still relevant. In this case it will be necessary to acquire the help of a moderator who is expert in the sector of the application, able to guide and focus the questions and answers for the purpose of getting compliance with the requirements.

B. Examples

1) Example 1 – Brainstorming to define SW Design Process

   a) Rules:

- Each participant receives two questions then is requested to give 1 to 5 replies to each question
- There will be 15 min. for individual answering
- The answers will be collected in a round table session. Rating of an answer is equal to the number of people giving the same one
- The 5 most rated answers will be discussed to generate a draft procedure
- *The total time of the meeting will be two hours*
- *The moderator will distribute minutes*

   b) Questions:

- list 5 major steps in a controlled Software Development
- Process list 5 major activities to support and keep a project under control

TABLE I. ANSWER QUESTION 1

What	Rating
Requirements	IIIII
Design	IIII
Project Planning	III

Risk Analysis	III
Integration and Test	III
Test Planning	*II*
Test Protocol definition	*I*
Release control	*I*

TABLE II. ANSWER QUESTION 2

What	*Rating*
Risk Management	IIII
Release Planning	III
Defect Management	III
Change Management	III
Configuration Control	II

A draft SW Design Procedure was defined based on the first table, defining tasks for each major step, responsibility and templates, based on current practices and suggestions for improvement. The second table defines the supporting activities and required metrics. Later on, parts of the SW design flow were detailed in dedicated procedures (for example requirement management, testing etc.)

2) Example 2 – Brainstorming to define SW Testing Process

   a) Rules : same rules

   b) Questions:

- list 5 major SW Testing Tasks
- list 5 mandatory sections of a SW Test Plan
- list 5 mandatory sections of a SW Test Case

TABLE III. ANSWER QUESTION 1

What	*Rating*
Test Run	IIIII
Design Tests	II
Planning Test	II
Test Report	II
~~Defect Management~~	~~II~~
~~Coverage Metrics~~	~~--~~

TABLE IV. ANSWER QUESTION 2

What	*Rating*
Features to be tested	III
Responsibility	II
Strategy	II
Test Environment	*II*
~~Version description~~	~~--~~
~~Pass / Fail criteria~~	~~--~~
~~Defect Metrics~~	~~--~~

As the participants DO NOT have experience in organized formal testing, the third questions were even harder to reply to. The moderator enters the meeting with a pre-prepared list of answers expected and leads the group to understand which of the answers are ~~out of scope~~, and which *are missing*. The tables of answers are completed and

corrected and on this basis the brainstorm continues as shown in the previous example.

C. Lessons learnt

The method has been applied initially in our Company, when the Software department contained less than 20 people, and the testing team was starting with a group of 5, including myself.

The Company had defined a Quality System based on international standards that applied to another division, working for Space missions. The Quality System was not tailored to the new department, and too complicated for a small team. On the other side, the people in the new department had good experience of Software engineering. Use of the brainstorming technique allowed us to define in a few months the nucleus of the Quality System that later became the base for the current one. The Quality System developed on this nucleus applies to a Company currently able to sell in international markets and to comply with different regulations and standards.

The resistance in following procedures common to many Software Engineers has been overcome by the fact that everyone was in some way the author of the procedure, and because they were aware of the requirements beneath each process.

The method was then applied in other companies which either wanted to gain more efficiency or comply with regulation. The two most successful examples involved the definition of the basic software design processes in a Company developing economically critical software, and the creation of the team and processes for Software verification and validation in a Company developing Medical Devices. In both Companies the Software team was unstructured and parts of the projects were assigned to consultants.

Of major relevance for the first company was the formalization of the flow, in order to describe it to the external partners and monitor the progress and quality.

For the second it was mandatory to define the process of testing to be able to check internal and external parts and to demonstrate to Regulatory Bodies and customers the quality of the system and the compliance with regulations.

Both companies were aware that an efficient process had to be simple. They matched their goal defining a Quality System based on their experience, with the help and review of an expert.

III. EVOLUTION OF THE METHOD FOR EVOLUTION OF THE QUALITY SYSTEM

In our Company the roll-out of the first Quality System defined was relatively simple with low resistance, as described above but in five years difficulties appeared.

The processes defined initially had been progressively updated to adapt them to the new standards, practices, projects. At that point the main problem was not the adequacy of the process, it was that the resistance to apply it had increased.

The people who had defined the initial nucleus are no longer employed in the company, or have been assigned to other roles.

Two years ago we decided to revisit all the defined processes and add new ones. We used approximately the same technique in a slightly different format, adapted to the current dimension of the company and to the variety of services. Brainstorming was used in larger groups to gather needs and experience and details then discussed in small working groups.

We defined a set of procedures and activities similar to the original ones, produced by the new owners of the processes.

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