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SERVICE ORIENTED PROCESS MODEL FOR TEST ORGANIZATION PORTFOLIO MANAGEMENT

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ABSTRACT

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In the end of a product development cycle there is a need to execute integration and verification testing to ensure the quality goals of the product under development. The model of the test organization in the target enterprise has been moved towards an independent test organization which is virtually collaborating with other research and development teams. Those separated teams are dispersed over the globe, and therefore test management has faced new challenges.

The research is concentrated on finding answers to how to lead and manage virtual high quality teams in complex integration and verification projects, and how to improve the overall quality of test organization.

The study is based on existing literature, researches, journals and articles of virtual leadership and total quality management. The exploratory research method was used together with a questionnaire and interviews of a target group. The literature theories were combined with the results of interviews and observations from of the target enterprise existing methods and processes.

As a result of the study, six fundamental issues have been found to affect virtual collaboration. It has been showed that work process is the key enabler for high performance virtual teams. Total quality management models have been researched to find a model which is supporting virtual management. And based on these findings, a service oriented process model has been created, for integration and verification test organization portfolio management.

The service oriented process model can be used to improve the overall quality of test organization in the complex virtual research and development business. Further studies could focus on new agile test methods and improve the model created in this thesis.

Keywords: Collaboration, Integration, Testing, Total quality management, Verification, Virtual, Continuous improvement

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ACRONYMS

CM^3	Corrective Maintenance Maturity Model
CMMI	Capability Maturity Model Integration
CMS	Configuration Management System
CSI	Continual Service Improvement
DMAIC	Define, Measure, Analyze, Improve, Control
DMADV	Define, Measure, Analyze, Design, Verify
PDCA	Plan, Do, Check, Act
ISTBQ	International Software Testing Qualifications Board
ITILv3	IT Infrastructure Library version 3
I&V	Integration and Verification
KPI	Key Performance Indicator
TQM	Total Quality Management

1 INTRODUCTION

The work in the complex and changing product development business environment must adopt a flexible stance and ultimately achieve a competitive advantage to survive in the fast paced global marketplace. This has shaped global organizations to find optimum models for product research and development. The form of global enterprise organization seems to settle down a geographically dispersed multisite model which is spread across the globe. These spread research and development teams are collaborating virtually together and are considered of group of teams or individuals who are collaborating on projects together through information communication technology.

One important part of product development is testing. The test organization has a goal to test and verify developed industrial products. Test teams are mostly project-based organizations where high priority has been put on managing increasing product complexity, cross-functional expertise, customer focused quality, and control uncertainty of new technological development. It applies particularly to high value, complex industrial products and systems which need to have a high quality and performance with a low defect and error rate of the product.

The total quality management (TQM) is a multilevel process which needs very wide knowledge and experience in many areas. That is why quality management should be developed step by step to achieve the level of quality awards winner. TQM has many different methodologies for controlling systems, services and products quality. The relationship of the methodologies to the concept of certain techniques defines the quality management complexity to reduce the number of total defects and ensure those defects are not found in products or services. The increasing demand and sophistication of customers have virtually modified the rules of competition and forced organizations to focus on the overall quality. Today, what underlies competitive advantage is the ability to provide quality products and services that meet or exceed the needs of customers. This

implies that to survive in the race, organizations must apply new high quality management systems based on the tenets of total quality, and not only by focusing quality of products but management should also develop the quality of organization service level. The execution and implementation difficulties arise from the fact that the quality management is a soft science and as such invites philosophical discussion and sophisticated methods to practice it successfully in the virtual world. The elements of total quality management are rather straightforward but the execution and implementation are quite difficult. Without the awareness of the framework model and analysis of critical implementation issues, it is difficult or even impossible to make the best quality on the market.

In this thesis, the aim was to study out the challenges of the test project managers to manage and implement high quality product testing practicing and develop framework solutions and methods to help test project managers manage their challenging job in the area of global virtual organization. The research starting was based on the author's own earlier experiences and beliefs on the subject and the study of target organization challenges were based on those assumptions. This thesis was started on interviewing a target group of the project and line managers and collecting data by a questionnaire of virtual way of working and quality management methods. The literature was used to seek out from what are the newest methods and sophisticated practical tools. Then, finally, a framework model was developed, together with recommended management tools for test managers to lead and manage the virtual teams with high quality. Preferably, the described findings and process should be implemented at the enterprise level, but this thesis focus was to give advice and recommendation for management of the frame work model in the future. The main limitation of the research relates to the scope of the work. The duration of the work was limited to a one-year period along with other work. The study took place only in one site location (current country) and a limited amount of the focus group. Also, there were limited resources to focus deeply on different cultural behavior.

2 RESEARCH METHOD

This research has been carried out following the action research principles. The plan was to use exploratory research method as relies on secondary research such as reviewing available literature and research articles, and qualitative approaches such as informal discussions with employees, management and more formal approaches through in-depth interviews of focus groups of test project management. The results of exploratory research are not usually useful for decision-making by themselves, but they can provide significant insight into a given situation. Although the results of qualitative research can give some indication as to the "why", "how" and "when" something occurs. The used research method was chosen because there was need for flexibility in approaching the problem. In addition there were limitations for interviewing personnel and limited work time to use for this thesis. Qualitative research methods such as field research were used together with quantitative research to support data collection.

Theoretical framework for this research was analyzing the concept to implement of total quality management (TQM) for integration and verification (I&V) test organization. Implementation of TQM in this study adopts instrument and best practices used in the earlier research and publications. Theoretical framework describes the research paradigm of thinking the relationship between independent variables and intervening variables of virtual organizational and their dependent variables of high quality performance. Interview method will be used to gather information from focus group to gather data to support analysis of the created hypothesis of the practical implementation of TQM for I&V organization.

This thesis aims to give answers for the followings research questions:

- How to lead and manage effectively the test team’s work in a virtual matrix organization?
- How to improve virtual communication between different stakeholders?
- How self organizing teams can be set up, led and managed?

- How virtual self-organizing teams work together and how can that be managed efficiently?
- How can communication and change requests be implement in self-organizing teams?
- How can virtual teams be committed together for the common project goals?
- What are the practical concepts and tools that allow efficient implementation of total quality management in the organization?
- What kind of other methods and tools can be used effectively to improve the quality of the organization than product defect reporting?
- How to improve the test organization's overall quality management?

The main limitation of the research relates to the scope of work that can be covered within the one year period along other work of the author of the thesis. Because of time limitation during office hours of the author of the thesis and interviewing people, the research work went more on exploratory direction and interviews was lesser than estimated in the beginning. The study took place only in one location (current country) and limited amount of the focus group. Also, in this thesis the thesis writer had limited resources to focus deeply on different cultural behaviors of people. The importance of the research – even if limited in scope and location – lies in its practical approach involving existing real actors and its potential to produce applicable concepts and tools that have been developed and agreed by a wider enterprise level forum.

In the beginning of the work it was estimated the potential outcomes that may consist of recommendations of formulated methods or process proposals. Expectations of the outcome were to find a practical method and a well-defined and documented management model that meets the requirements of the I&V test project managers to improve the total quality of the virtual matrix organization. Preferably, the described findings and process could be implement in enterprise, but this thesis is limited to give only advice for management.

2.1 Questionnaire

The questionnaire was targeted to the project and line managers and the purpose of this was to get a personal view of their in the subject of virtual working and quality management maturity of level in the company. There were 72 questions for virtual leading dynamics and 24 questions of internal factors and conditions which are significantly affect the readiness level of an organization in moving toward total quality management. The questions were selected based on theories of virtual working and total quality management and those were overlapping in the same part because the issues were similar. The answers were given in scale from one to five which was meaning that respondent were not satisfied at all for current situation if given answer was one and if number five was given respondent feel satisfied. The asked questions and average results with variance can be found in the appendices, where virtual leading questions and quality management questions are respectively. The questionnaire was sent for seven persons but only three returned the answers on time. The number of the returns was not very successful but the questionnaire gave some indications, regardless of low return rate, which direction research should focus and what kind of extra questions should be asked, when meeting personally the target group peoples. The results showed that there was not any particular area in the virtual leading and quality management which could be out of order, but some areas virtual collaboration and communication methods need to have deeper focus when studying theories more deeply.

2.2 Interviews

The interviews were made for seven persons. Those persons were selected from I&V test organization who are working as project managers, line managers, and senior manager and also in specialist roles. Interviews took place in private conversation of each other in Finnish. The interview was informal discussion which I had prepared set of guiding questions from the subject of virtual leading, collaboration challenges and how quality management can be seen as in virtual organization. The answers were translated to English by the author of

the thesis and the results are shown without names and ranks to keep confidentiality.

The highlights from the interviews have been transcribed, and sorted out according to subject areas to help readers to follow the storyline on interviews. The text in quotations express person's views on the matter and the text without quotations is mine and added here to explain the flow of interviews and explain more detailed the context where those words has been said.

Quality management

"Quality management and especially continuous improvement model is not fully transparent at the moment. The process has not been defined clearly, which is an essential element of quality development in organizations". The management use action point list of recognized problems but it seems to be that those are not known and not handled in root level. Solution could be that "managers start to follow continuous improvement model in teams and begin to systematically collect information about the problems and eliminate the problems" also after solutions are found "problems and solutions are documented and shared inside of team and also another teams as well". One solution arise during the interview that "each organization and teams should have person(s) who should have responsibility of quality in their areas of subject. They should gather problems and issues found from their teams and systematically point those out on the team meetings and set out task forces to found root cause and eliminate the problems. Line managers and project managers help and get resources for solutions if needed". Quality management culture "has been focusing on strict targets to decrease the amounts the faults from the products by executing virtual zero defect tolerance". This is quality method developed by Philip Crosby (Crosby 1979, 127–139). "The culture could be changed in the long term in the direction that culture favor positive ways to found the defects not only trying to avoid those, because of humans are not flawless in the nature, but before change can be happen the organization maturity on quality management model should be better than it is at the moment". And when talking about "virtual envi-

ronments, there is need to create system to ensure quality plans and control and monitor for the agreed procedure. It has been noted, that “virtual zero tolerance in the quality thinking directing the way that defect reports are avoided and quality criteria is a game of the managers. Quality policy changing all the time, and the objectives of this relationship is difficult to keep up and lead. Middle manager is unable to influence very much the larger pattern, so values, strategies, policies, and priority should be directed more precisely.”

Organization should make better “use of history data of problems and defects found and test process key performance indicators should be revised definitely”. It has been noted that KPI indicators “are quite one-dimensional at the moment and those should be revised towards known theories and developed clear KPI indicators so management would be more efficient and understandable”. Continuous improvement would be easier when “information of issues which need development would come through teams more fluently”. “Control and indicators should be the set up in the beginning of the project and monitored to ensure the quality of the during the development cycle. Also reviewing process should be started right the beginning of the project.” The feeling is that, “the bigger overall picture of how the quality is done between R&D organizations is missing. Rules of the game can be different between stakeholders even in the meetings. It should be creating a comprehensive policy for organizations for quality, and policy should be followed through organizations.” Projects should be planned in accordance with the policy and the plans should be reviewed. If defects are found then implement corrective actions. Every project should have feedback session done at the end and follow up action should be created and implement of corrective actions. When there are well defined planning processes “it will be systematic and based on test analysis data then defect founding could be more efficient than before”. It is also important that “project feedback will be analyzed and plans are developed based on the feedback”. Processes “should be harmonized so that common IT tools can be used”. All project reporting and test “reporting should have formal templates and those should be used by all. Report templates should be able to be customized if necessary”. At the moment

“senior management and business management has not defined what kind of reports they want and this has been causing huge amount of questions coming from different stakeholders.” Project management training “and systematic process like project planning work should be trained for project managers”, so that everyone in the project understand goal and schedule.

“The test organization should be seen as service organization for the internal and external customer”. (External refers to the end customer and the internal customer mean business management). “Service organization paradigm should be understood as determination of control points, which are monitored and controlled, as well as addressing the discrepancy of external and internal testing requirements prior to customers”. “At the moment requirement definitions may not be sufficient, but needs to get the customer's view of the test requirements.” “Benchmarking of requirements, restrictions and limitations of constraints to log on the basis of which are prioritized against testing analysis.” “Product management should focus on the customer specification requirements, which should lead to external test case process development and testing to test the functionality of the customer use cases”. And “test analysis exercises should be done a large scale, which are based on the facts and I&V should make prioritized plans according to analysis”.

Virtual way of working

“The organizational structure of the virtual teams is quite blurry even when the product development teams are local. Networks are huge and difficult to understand the interfaces between teams and stakeholders. It is very hard to understand the link to your work sometimes.” “Communication is the most important and challenging virtual interaction tool. Contact and personal interaction is missing, and thus makes it much harder to interact, and also cultural differences and different way of understanding the difficulties, are causing special confusion among organization.” “Virtual management needs clear responsibilities, which has not been successfully defined so far. Without clear roles and definitions testing activities are micromanaged by senior managers or business managers

and this will lead confusion". "A description of the virtual project team roles and definitions and an organizational chart with clear roles and responsibilities" should be done for every project. When IT tools are discussed, "every project should have its own virtual workspace, where you can find documents and to share data, because email distribution lists at the moment just fill inbox and many of those messages are not relevant part for your job. Also big part of the project and work status reporting is done by e-mail where as more efficient media could be used for secondary information sharing."

"Virtual team project plans in I&V is not describing the precise details of the plan. Plans are usually PowerPoint types of descriptions of the targets and timetables. Master test plan describing the main activities, but not the detail of the project in terms of the operating model, schedule and so on. This has not never been questioned, is that the best model to work." "Virtual teams collection of feedback has been weak. The model is missing or is not put in place. In a Number of teams a small-scale feedback is given, but not collected systematically." "Tools are important for making virtual team relevant. At the moment they are a legacy tools to just try to survive. The use of Microsoft SharePoint, and other project management tools, release management tools, and testing tools, should be considered. A key issue for the management of quality management is to share information and analyze it using the right tools."

Leading and managing in virtual organizations

The management process "is missing definition of, orientation, decision making process, escalation, and some of working and operation model in virtual organizations. It should need documented way of working models for virtual projects." "Satellite R&D sites have become weaker for directing and managing the development of a virtual environment, because of missing instructions from the top managers of the virtual programs."

When discussing conflicts, "escalation process needs to be improved for management. The management model appears to be currently escalation model, where cooperation is not the first way to solve problems together. The man-

agement system should follow conflict resolution model in seeking out a solution for the problem before escalation in virtual ecosystems. Problems are exported to top managers only when the higher decision making responsibilities are exceeded." Meaning of budget or hiring people. "At the moment things are not progressing without escalation." It can be cultural characteristic that could be removed from proper instructions, because "such an approach was not observed in other company, but there were quite a lot of Finnish managers in charge during that time."

"Change management should be moved from Excel management model out of the transition, where change management tools are for use with a dedicated change management program. Transparent and changes linked with contexts / projects / products / software releases but not only the products, but also testing environments, and issues in overall business" "Changes in the management system and the configuration management system is largely based on human reliability - It should be possible to develop a system so that the effects of the changes are reflected in the total view of business".

The problem management process "has not been used very well in general". Methods like "brainstorming and others need to systematic training and problem solving teams could be more cross-disciplinary". This means that when some team found any issue which is causing problems in work problem should be shared through some media and ideas changed to find solution for the problem.

When discussing of communication in virtual organization, it came up that "managers need to understand, that the message what you are going to share, have enough information but not too much. It may be due to the fact that the communication plan is missing. This is because of quality management model does not take into account the improvement of communication." "Effective communication and communication between teams is not efficient at all." The threshold to start communication could be too high in some situations because of email culture and lack of training.

3 INTEGRATION AND VERIFICATION TESTING

Software and hardware development, called embedded systems, has relayed traditionally on research and development engineers design and implementation work, where testing of the developed product have been done by development engineer or his/her peer-colleague and sometimes test specialist. Product development work especially complex embedded system has been moved to more iterative development model direction but follow in some part the traditional work models as well. The importance of testing and relation to product development life cycle has been changing since the speed of the product development business life cycle in the software industry and has been dramatically increased and lead times shortened in the last decades. A new software development model developed for these business targets, called agile development or extreme programming, has also made a big impact on software testing. In the complex systems and demanding business models, the testing has been moved from development teams to specific test teams which could be inside of product development organization or, as it bee in large enterprises, independent test organizations. This kind of testing calls for approaches that are well suited for iterative and incremental software testing. These test organization targets are to find defects from the requirements, developed products and systems by using many testing techniques like functional testing, regression testing, performance testing, stress testing, black box testing and so on. These found defects are then fixed by the development team and then the testing team retests them. Once they are fixed, the embedded system is retested again. This testing cycle continues during product development life cycle and testing is to be performed according to plan.

3.1 Concept of Integration and Verification testing

“Testing is the process of executing a program or system with the intent of finding errors” (Myers 1979, 6). Testing differs from debugging whereas testing is the process of evaluation a software item to find errors or differences between

given input and expected output. Testing assesses the quality of the product. It is an activity aimed at evaluating an attribute of a program of system (Hezel 1988, 242). Testing is a quality process control tool of product development and that should be done during the development process.

> Also test activities include planning, control, choosing test conditions, designing, and executing test cases, checking results, evaluating exit criteria, reporting on the testing process and system under test and finalizing closure activities after test phase has been completed (ISTQB 2011a, 13).

The purpose of testing is to find defects, ensure level of quality, provide information for decision making and prevent defects by early activities of designing tests in the beginning of product development life cycle like reviews of documents and requirements. During the different lifecycle, there are different objectives to be taken into account. Types of integration and verification (I&V) testing includes, integration testing, system testing, performance, verification and validation testing activities.

Integration and verification testing is a dynamic analysis of response from the system to variables that are not constant and change with time. Also, the interaction between software and hardware is tested in I&V testing if software and hardware components have any relation. The software under test is actually be compiled and ran, input values are given and outputs results are checked are those as expected by executing specific test cases, which can be done manually or with the use of an automated process. (Software testing 2013.)

Verification testing is the process to make sure the products, systems or services meets the conditions imposed at the start of the design phase. The object of verification testing is to ensure that the product is being built according to the requirements and design specifications. Also verification testing is to make sure the product, system or service requirements are valid in post-development phase when changes or new features are requested by customers. Verification test work activities are mostly reviews, walkthroughs and inspections. Validation testing process is for evaluating software during or at the end of the development process to determine whether it satisfies specified business require-

ments. The object of validation testing is to ensure that the product actually meets the user's needs, and that the specifications were correct in the first place. Validation testing includes system testing, performance and stability testing, and regression testing work activities. (Software fundamentals, Verification vs. Validation.)

An I&V test organization has many responsibilities and many stakeholders which are giving their own goals for supporting business related activities. The main responsibility of I&V organization is integrating, verifying and supporting software releases and feature builds by testing, including quality assurance of those. Also I&V organization develops and supports test tool framework, test automation and other common test tools for software development. Business operations and product development programs management are giving inputs for I&V organization operation. The main inputs are related to products (customer) requirements, specifications and performance targets. Every product development project has their own schedule and budget targets, and mostly there are several product development projects on-going at the same time. Program management prioritizes the projects which are given for I&V organization. There are also support request for I&V organization from development teams and customer care teams for problem analysis. Business management also gives inputs for the execution of key targets and resources grants. The quality management defines the plans and targets of the products and systems under test. The output expectation of I&V organization is of course relating to test planning, design and execution. I&V organization should give output of the test results, create problem reports when defects are found, fulfill support request from the development teams or customer care teams and produce reports of defect analysis. Of course, all the actions should be done on the given timeframe and budget defined by the business management.

3.2 Test management

The leading and management of the test organization at the enterprise level needs much more than focusing only on actual test project issues, which are

explained on later chapters, it requires overall management skills. “People management is the critical part of test manager’s role” (ISTQB 2011c, 18). The key competence skill is ability to build, develop and lead their organization’s individuals, multiple teams, virtual teams, offshore resources, and managing the managers. Also test manager should have skills for supplier and customer management. Test manager should understand of how leadership communication should be done and how managing across the organization works. The test manager must be aware of and participate in the overall project management tasks as well, so the test manager should have essential skills in the art of project management and risk management. (ISTQB 2011c, 45.)

Test management includes the execution, control and reporting of activities through the test stages of service transition but it also requires manager different kind of other skills defined by ISTQB:

- Skills of building and developing test teams
- Relationship management skills
- Overall managing skills
- Promoting and selling test organization
- Protect and support test organization
- Managing teams, test management and overall organization ethic
- Advocating quality issues over organizations
- Project management skills
- Monitoring, evaluating and reporting skills
- Problem solving and risk management skills
- Leadership skills
- Change management skills
- Test process improvement

Team building is based on good hiring decision skills of a test manager. It is important to recruit right kind of people for the team. Lou Adler has stated in his publication that there are four different kinds of jobs in the world: “Thinkers: these are the strategists, creators of new products, those that come up with big

ideas and new ways of doing things. Builders: these are the people who take these ideas and convert them into something tangible. Improvers: these people improve whatever has been created and built, and make it better. Producers: these are the people who deliver high quality products and services to the customer" (Adler 2013).

For example a testing specialist is going to ensure that test cases are going to run smoothly 24 hours at seven days, which is a producer role. Improvers are thinking how to new product features under testing can be implemented to the test lines so that product or systems could be tested. Test managers working on new road maps and coming future products and systems need to develop long time plans, so those are thinkers. Or if there are need to find people to solve complex problems then thinker type is the right one. People, who are good at implementing the new test line and configure those is the builder work type. If there are big projects or changes that need to be implemented then Builder type is the selection, and what aspects of the job require high-quality repeatable activities, then there should be considerate Producer type. Hiring managers need to recognize that every person is comprised of a mix of each work type, with one or two dominant strengths of the different work types, as Lou Adler have stated in his publication:

> The models works extremely well when hiring manager is define the job first and then break it into the four work types. It's less meaningful when you use it to broadly classify a person. In this case, it only implies interests and preferences, not competencies. For example, just because someone is an Improver, doesn't mean they're good at it, and even if they are good at it, it's only in their niche. (Adler 2013.)

It is also good to notice that many cases the best performing teams are diverse teams. Dr. R. Meredith Belbin has stated that "a team is not a bunch of people with job titles, but a congregation of individuals, each of whom has a role which is understood by other members. Members of a team seek out certain roles and they perform most effectively in the ones that are most natural to them" (Belbin team roles 2013). When people understand the defined individuals, group, project and personal roles, then other team members can understand each other's

skills and contribution for team to work effectively as a unit. Especially when the company is large and there are many project stakeholders, everyone needs to understand the role of the test organization.

The competence of the project team and development of the competence is very important to gain succeed in the projects. Focusing on sociological perspective is not enough, but project manager should notice and put effort to leadership and communication, if project is complex and large. Also project manager should have different kind of tools to guide teamwork in many ways when needed. Competence development including following aspects of areas:

1. Meaning Competency: The person assessed must be able to identify with the purpose of the organization or community and act from the preferred future in accordance with the values of the organization or community.
2. Relation Competency: The ability to create and nurture connections to the stakeholders of the primary tasks must be shown.
3. Learning Competency: The person assessed must be able to create and look for situations that make it possible to experiment with the set of solutions that make it possible to complete the primary tasks and reflect on the experience.
4. Change Competency: The person assessed must be able to act in new ways when it will promote the purpose of the organization or community and make the preferred future come to life.

(Competence (human resources) 2013.)

Sociological perspective refers to identifying patterns in human interactions. For the test management this aspect refers more like to team competence level to carry out the given actions. Leading, communication, roles and teamwork should be taken notice of when executing projects because these areas inflected of human interactions in organizational work.

“As organizations consist of various kinds of individuals, there is a real need for accurate diplomacy with willingness to listen and to be careful with choice of words used” (Pääkkönen – Sajaniemi 2009, 2). Thus, because of the nature of the testing, the test manager must be open, respectful and honest with the team and should encourage a safe environment where test team members are not punished for sharing bad news. In addition, test managers need to foster the ethic of the test team to report the results of testing, internal communication such as defect reports, emails, status reports and other written and verbal communication always be objective, fair and contain the proper background information so that the context of communication is understandable, professional and diplomatic so that test teams may not lose credibility when unprofessionally written defect report or root analysis are sent for the stakeholders. (ISTQB 2011c, 26.)

“The test team primary focus should be on quality” (ISTQB 2011c, 38). Leadership communication and interactions between people are often complex and without the necessary skills can result in misunderstandings. The test manager should advocate the test team and must be able to effectively communicate with stakeholders where information is critical to the success. “Information usually comes from the development team, analyst team, business stakeholders, project managers and many other project stakeholders” (ISTQB 2011c, 38). The quality level of the product or system under test should be reported for the management chain so that there is detailed knowledge of the maturity level of product or system under development. A test reports also gives information of risk factors for project stakeholders. When the test manager can be able to accurately present the benefits and costs of testing in terms that the stakeholders can understand and appreciate, it creates mutual understanding of the fact that testing raises overall quality of the product development and customer satisfaction. In addition to good communication the test organization needs strong structured test process which help test manager to communicate for projects stakeholders how the test organization works and gain confidence in the team

and helps understand what to expect during the project life cycle. (ISTQB 2011c, 35-38).

It is important to understand that testing and quality activities should not be limited only to testing of the product or systems, because testing does not create the quality. It should be understood also in larger concept of quality management. Testing and quality should be aware of every group that takes part of definition, creation, and support of product development. Also, quality concept needs to be covered by test organization services for business and development organizations as well as end customers. The test management process in the context of the total quality management has been explained more detailed in chapter 5.2.2.4.

3.3 Risk management in testing

The risk management is part of quality management. A risk is not synonym for uncertainty. It should be understood also as an expansion of the concern from the one-sided view of distribution of events to working on both-sides, risks and possibilities. The uncertainty can provide risk and/or opportunity, so test project manager and team should adapt and evolve new or changing circumstances before uncertainty has decreased. The team must take into account also the problems, and evaluate are those risks or possibilities to improve something. Management of uncertainty requires flexibility of the designed system, but at the same time strong scope management to avoid excess costs, but there are no exact rules for flexibility and it needs overall understanding of the concept and situation from the test manager. And the project scope is mostly strictly limited for certain specification and speed of the market development and nature of innovations causing uncertainty for projects. So there should be therefore developed analysis techniques for forecast of the areas where the most software bugs could be found, because rarely there are unlimited resources to execute exhaustive testing for the product or system. An efficient test process and procedures for translating these uncertainties into measures of value that can be compared with planned engineered system need to adapt flexibly to new oppor-

tunities or new circumstances. This is more like iterative planning through entire project lifecycle and some of the uncertainties should be taken as optional features. In parallel test project manager should keep mind of the scope from one that meets specifications and to one that provides the best performance over a range of test scenarios. Communication is the primary way to reduce the uncertainty. (Neufville 2004.)

Management of uncertainty requires according to Richard de Neufville the following:

- Emphasizing situational awareness to understand better context, circumstances and consequence.
- Identify the risk or problem, quantify its impact, investigate causes, and manage and monitor its effects for the system and project.
- The requirements of the specifications by the customers or markets and reality checking before implementation.
- Specifying deliverables with customers and sponsors (conceptual phase before design and implementation phases).
- Assumptions testing, knowing what could happen and converting assumptions into knowledge (measurable values for testing).
- Managing the milestones by testing assumptions and verifying those.

Managing uncertainty is part of quality management work and organization should have developed some kind of framework model to investigate product or organization quality problems, resolve of those and test new assumptions or ideas in early stages before to major scope changes or capital investment is done. One solution of framework model for quality management is explained on chapter five in this thesis.

3.4 Software development lifecycles

The test manager should understand of organization software development lifecycle models. Awareness of differences will help in determining the appropriate moment of involvement and develop and implement the best testing ap-

proach and the training for the test team because different lifecycle models can strongly influence approach to given test project. The test manager should understand how software development lifecycle model determines the moment of involvement, the level of involvement, the amount of documentation available and produced, and the testing goals. Table 1 is from ISTQB test management book and it is provides a comparison of the lifecycle models and the testing implications (ISTQB 2011c, 61).

TABLE 1. *Lifecycle models and testing implications by ISTQB*

Lifecycle model	Moment of involment	Documentation Supplied	Documentation Created	Level of Involvement	Testing Goals
Waterfall	After code is complete	Complete specifications	Complete test documentation	None until code complete	System testing, some acceptance testing
V-model	Reviews during requirements phases, planning during code development, testing when code is complete	Complete specification	Complete test documentation	Planning early, reviews of requirements documents, testing when code complete	Integration, system and acceptance testing
Iterative/Incremental	Involved for first testable iteration of code	Iterative specific documentation	Iteration test plans, iteration relative test cases, some automation	Just in time planning and testing for the iteration, emphasis on regression testing	Integration, system and acceptance testing
Agile	Project initiation	Light, if any	Test automation, test checklists	Embedded in project team from initiation	All levels of testing

Integration and verification projects may differ from the moment of involvement when the I&V test organization is independent on the organization outside of the development teams or the software project is an externally developed project.

Moment of involvement is then often later than a project where integration testing is part of the development team. The software code is developed and unit tested but those separate components are not integrated and tested together. Also I&V test team may not have been involved in requirements and design reviews. This is leading to planning, analysis and design time for I&V test project being significantly reduced and a lot of uncertainty. Another point to understand lifecycle models difference of the moment when I&V testing can start is in projects which have combinations of hardware and software testing (embedded systems). Embedded project tends to be more complex, because of prototype equipment, early firmware and tools in the environments may cause unexpected downtime. Also troubleshooting issues can be difficult and time consuming and retesting time can be extensive. So this embedded systems complexity should be allotted in the test project schedule and the moment of involvement for set up and testing of the test environments and its configurations need to be considered carefully. In lifecycle management the test manager plays an important role to coordinate the schedules of the software components so that efficient testing can start and be done in time. This usually requires multiple schedule meetings, frequent status updates, and re-ordering of feature delivery to enable testing while also supporting a logical development schedule. (ISTQB 2011c, 64-65.)

3.5 Tool support for testing

One part of test management is to select tools for testing. Those include test execution tools, test data generation and test analyzing tools. Also test management tools are need for process control and monitoring and other information tools which are supporting test work and overall business in virtual organization. This thesis is focusing more on methods and fundamentals of quality management of virtual organization so actual specific IT tools are not listed or described in detail. (ISTQB 2011a, 58.)

3.6 Summary

When thinking about testing work, it should be quality-driven process framework that promotes quality of work as well as checkpoints in the process model. Knowledge, competence and experience of people bring innovation and a mature quality-driven process framework brings quality of test work. Without standard process framework, it is difficult to execute large and complex test projects, especially in those circumstances when people are working at geographically remote locations as virtual teams, and are not able to communicate effectively face-to-face. In those cases the test organization process model should have solid processes to support test work throughout the test life cycle. Chapter 5 aims to give solution for management process, on how to continuously improve all these tasks in I&V organization.

4 VIRTUAL TEAM AND LEADING TOWARDS HIGH QUALITY

In this thesis virtual working has a meaning of work across space, time and organizational boundaries. Virtual organization is geographically dispersed teams and also it is set of teams or individuals who are tied up together with communication technologies. A virtual team may be temporary or permanent and interaction mostly through electronic means but face-to-face communication may be involved sometimes. Virtual teams have committed common purpose mostly program, project or smaller development task, of which performance and progress is monitored by management. Virtual teams have shared an approach to work for which they are accountable.

There are possible several different reasons why virtual organizations have been created on the history of enterprises but probably many of geographically dispersed teams have been created because of corporation fusions, or need to hire certain set of special skills of people near of universities location, or some cases enterprises have to be near on business market area, or some areas of the world has concentrated certain areas of knowledge: like silicon valley has software development business in California, The United States of America. Also, virtual working in different time zones, enable twenty - four - hour coverage on a service, problem, or product development when team members or organizations working across time zones.

4.1 Challenges in virtual way of working

“Innovation will come from bringing people together from different companies, disciplines, products, markets, processes, and industries” (Malhotran – Majchrzak – Carman – Lott 2001, 230). Such virtual organization is hard to manage because the team members do not have a common language, cultural background, and they are experts in very different disciplines, competences, company culture, and way of working. Also, virtual teams could not have common history or previous experience working together even inside the same enterprise.

Companies which have provided their workers with the technological capabilities to collaborate virtually may not be aware of the training and support needed in areas such as decision making, communication skills, cultural awareness, and virtual meeting facilitation (Nemiro – Beyerlein – Bradley – Beyerlein 2008, 3). Traditional collocated teams work in the same place, time and often within their functional areas so they do not usually meet so much communication problems or misunderstanding as in virtual teams facing. Virtual collaboration and communication inquires intelligence in business, organization and technical issues and also effective communication among team members. Communication and innovation is a critical factor in success of business, product development and problem solving on virtual teams. (Braga – Jones – Bowyer 2008, 392-393.)

4.2 Knowledge, information and communication in virtual organization

Knowledge based industry and especially virtual organization, whereas employees are their own area of experts or specialist, success in product and business development is depended on information available, how information is shared and when. Information and knowledge is in all levels of organization and the key in leadership communication should basis on that leaders are enablers of information flow between employees, teams and stakeholders of the business. Intelligent leadership communication builds the trust between people and it is the process through we human beings interact with each others in the organization at all levels. Intelligent communication creates positive mind set and attitude which start to feed itself and leads eventually for high performance organization. “When the management has recognized the possibility to generate mental energy within the company and when appropriate people skills and educational backgrounds as well as other business critical resources have been confirmed, the conditions for innovation and super productivity have been established” (Hämäläinen – Saarinen 2007, 98). Managers need to focus, commit and crystallize constantly the core of the message, but keep in mind that the organization is rich complex human system and others’ interest should be taken into account. Also it should be taken notice that the organization’s structure, culture and climate encourage (or discourage) communication. The organization way of

working have to be created in such way that individual opinions, knowledge and ideas are heard, valued, and individuals have the power to influence the organization and business.

The leaders' role in information sharing is important. They can influence to parties how to share information and communicate interactively via different media. The target of communication should be that the parties' involvement can create a common interpretation of the information. Managers should, in an intelligent way affect the organization's culture and communication climate so that everyone is involved in information sharing. Intelligent leaders proactively react to weak signals from internal or external stakeholders and notice changes in the business environment starting from the employee level to the global level and react accordingly. Leader's communication skills are essential in virtual knowledge based organizations so their own personal leadership competences and characters influence how well they can take into consideration their employees' attitudes, emotions and motives towards high performance productivity and improved quality. (Rissanen 2011, 82-88.)

One part of the communication is to notice conflict and make rules for escalating conflicts. "A lack of trust, respect, effective listening skills, and perceptual differences can lead to serious communication problems" (Verma 1998, 2). Also overlapping areas of management responsibilities, complex problems, lack of communication media and skills and cultural background could cause needs to escalate conflicts towards upper management even the arisen conflict could be resolve on the team or middle management level. Verma has summarized in his study that virtual organization must learn how to create atmosphere that encourages open communication in order to resolve conflict and gain team member's commitment to goals. Managers should work at source of conflict and encourage team members to resolve project conflicts permanently and not only symptoms of it. Negotiation skills and understanding of cultural differences among team members giving tools to reduce amount of conflicts to be reported towards upper management layer on those matter of issues which could have been resolved by middle management layer or even in team level.

> The key to resolving conflict with a positive outcome includes looking for a win-win situation, cutting losses when necessary, formulating proactive conflict management strategies, using effective negotiation and communication, and appreciating cultural differences among project stakeholders (Verma 1998, 12).

This means that managers should learn and study how social system works in the company. One part of social system is feedback among the people. It is crucial in communication and it should be properly set up between people to avoid miscommunication and conflicts. When keeping feedback loop as short as possible there are smaller odds of misunderstanding and probability to doing wrong actions by assumptions according to information gotten in the communication attempt. “Internal conflict is natural aspect of complex systems and a prerequisite for creativity and innovation” (Appelo 2011, 24). When teams and managers are dealing with complex systems (products and organizations) there are many levels of creativity and ideas how things should be done, which are sometimes causing wrong assumptions, misunderstanding of others work output and wrong expectations towards teams and those members competences and ability to do their tasks. That’s why it is important for managers to establish rules for escalation of conflicts. Management via escalation is a symptom of unclear management system and criteria for decision making but it could also be reflection of lack of managerial maturity to resolve issues at their team level. Escalation culture can rise from the unsuccessful feedback system, commitment and misunderstanding of the root cause for unwillingness to collaboration together in the complex issues, where middle managers could resolve issues together with their teams. “But when middle level managers do not get along or are unwilling to collaborate on issues that they can resolve, and then the right leadership move is to push the accountability back down for resolution”. (Kates – Erickson 2008, 637).

4.3 Problem solving with virtual teams

When people are in diverse locations the key for resolving problems is ability to collect information from virtual specialist of their own areas. The method and tools for effective information collection and method to help structure infor-

mation for analyzing the problem virtually is important for success. “When there are difficult or complex problems to solve, there are often barriers to overcome, many of them psychological in nature” (Braga co. 2008, 392). Individuals need to be aware and understand the existence of the system and its structure, the impact of the problem for the system and ability to think out of larger concept of systems. Those virtual workers should view the world and systems in it as part of a series of connections and interrelations to network of people. “The person who is willing to act systems intelligently is attempting to improve the system, not just for their own benefit, but for the benefit of all parts of the system and for the good of the system itself” (Hämäläinen – Saarinen 2007, 244).

In the virtual way of working information sharing in the problem definition phase targeting to get shared understanding of the specific context and commitment to resolve defined problem. Problem definition should specify complex problem where it is impacting and open the greater meaning for overall system. It can also open barriers between people. When it is agreed and explained of level of collaboration during problem solving work for virtual team members, it can give opportunity for individuals or local teams for working alone. Also those individual persons or team can network by themselves and use different media for information sharing when level of collaboration is agreed and problem solving team members are known. Effective virtual problem solving needs process with agreed roles of people. Process should be followed and mixed with method needed to be used for engaged people in the process. Successful virtual problem solving requires awareness, advanced intelligent thinking, social skills, strict planning and process guidance. Problem solving aim is to find root cause of the problem fix it so it would not happen again, but it does not mean that something is not going wrong in the future. When there are known setups of methods, process and tools for virtual problem solving, it will speed up creation of task force teams to resolve complex problems efficiently in the virtual world.

4.4 Successful collaboration in virtual team

Kimball and Digenti have been noted in their book that communication and using various different media on leading virtual teams is crucial for success (Kimball – Digenti 2001, 17). Also there should be used collaborative approaches which increase and intensify team interactions early in the life of the virtual team building and maintaining the team spirit. The virtual teams should spend some times together and adapt the new team roles and get familiar with mutual expectations for leaders, managers, and members because the culture and way of working and dynamics of interactions are unfamiliar. Without good understanding of each other, it's easy to fall into misunderstandings and become frustrated with each other.

Face-to-face meetings with large amount of people could be expensive to arrange because of long distances and dispersed locations, and because of economical aspect. In these cases the solution could be the rotation of small number of team members onto other teams. If this solution is seen also costly then another concrete option could be make an introduction video of virtual team and their working environment. But the better approach is rotate people to other teams for short period time in order for them to learn how virtual colleagues have organized their tasks and get information of their culture. Also this rotation gives something what video introduction cannot give, it is knowledge of the problems what other teams are facing in their daily work and what kind of input information they expect or want other virtual teams giving to them. This kind of rotation model improves also quality of communication and enables efficient networking within internal or external organizations. Face-to-face meeting affect also one of the important part of virtual working which is trust.

Successful collaboration especially problem solving requires systems thinking ability in virtual teams. Systems thinking tools, analysis and diagrams (links, loops and signal diagrams, or stock and flow charts) and other visual methods can help virtual teams to focus on analysis process and strengthen the group

ownership and commitment to find solution to the problem. (Kimball – Digenti 2001, 23-24.)

For the successful collaboration on virtual problem solving the key is to have problem statement which has meaning of common understanding of the problem and its effect for the system. Analytical thinking requires virtual way to present information. People who are taking part of the virtual problem solving should have skills for systems thinking and methods to gather information from different sources and large number of networked people. Virtual problem solving requires methods to systematically obtain as many as possible ideas and generate understating among team members to find best solutions to the problem. When the virtual problem model is working efficiently then it serves managers to make decisions effectively. A one suitable problem solving method has been explained more detailed in chapter 5.2.4.4.

4.5 Path towards high performance virtual team

From the work of Nemiro and co. authors in the handbook of high-performance virtual teams, they have pointed out six major challenges of virtual teams: distance, time, technology, culture, trust, and leadership. These six challenges have been descript in figure 1. Distance, time and technology are defining characteristic of virtual teams whereas distance and time are boundaries for collaboration and technology is a solution for collaborative team work. Culture, trust and leadership are created and sustained by virtual team. Every virtual team has cultural differences which occur at many levels such as national and corporate dispersed units of a particular organization. Trust and leadership are fundamental part of virtual organization, which foundation collaboration is based on. An awareness of cultural differences and potential connections among members, as well as virtual team member trust and managers leadership capability leads toward high performance virtual teams, but it requires also solid and commonly agreed work process before it happen. (Nemiro – Beyerlein – Bradley – Beyerlein 2008, 4-5.)

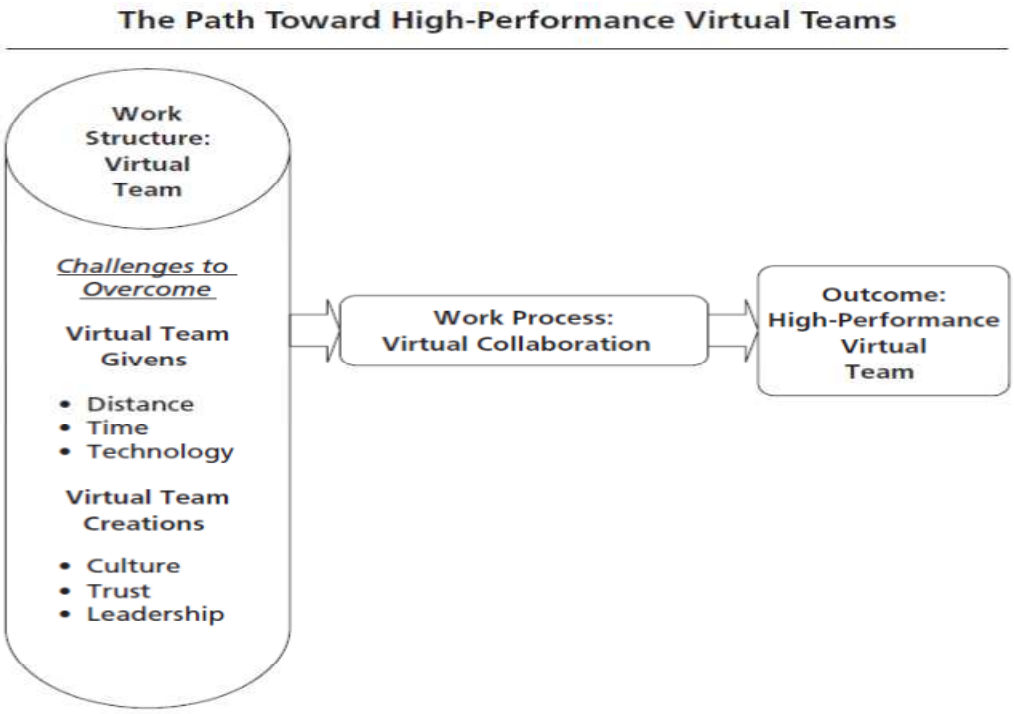

FIGURE 1. *The Path Toward High-Performance Virtual Teams (Nemiro and co. 2008, 5)*

4.5.1 Culture

Culture of organization and national culture is often affecting way of working in team. Thus challenges in a team's collaboration can come in two different ways. There can also be regional differences, generational differences, departmental or functional differences and inter-organizational virtual organizational differences in the culture. Also management styles across cultures and nations affect members of the same virtual team in different ways. Virtual work increase cultural differences because more boundaries are crossed and team members' are mixed and being embedded in different cultures to same virtual group. This leads to that a virtual team creates its own additional culture. There can be developed ways by management to decrease the cultural problem. (Nemiro and co. 2008, 8-9.)

Cultural differences are the hidden scripts that people use to guide their behaviors in many level like described earlier. Differences can be categorized in the values that distinguished countries from each other. Hofstede conducted one of the studies of how values in the workplace are influenced by culture. In his study values are grouped statistically into clusters and these groups' then shows dimensions of national culture. (Hofstede, 2013)

For example, cultural differences between Finland and Japan are the following (see figure 2), according to Hofstede's study, where national societies are compared to other societies and dimensions have been given relative scores. Without making a comparison a country score is meaningless. This evaluation in figure 2 is only for national culture and not taken count any organizational culture in the group inside of Finland and Japan.

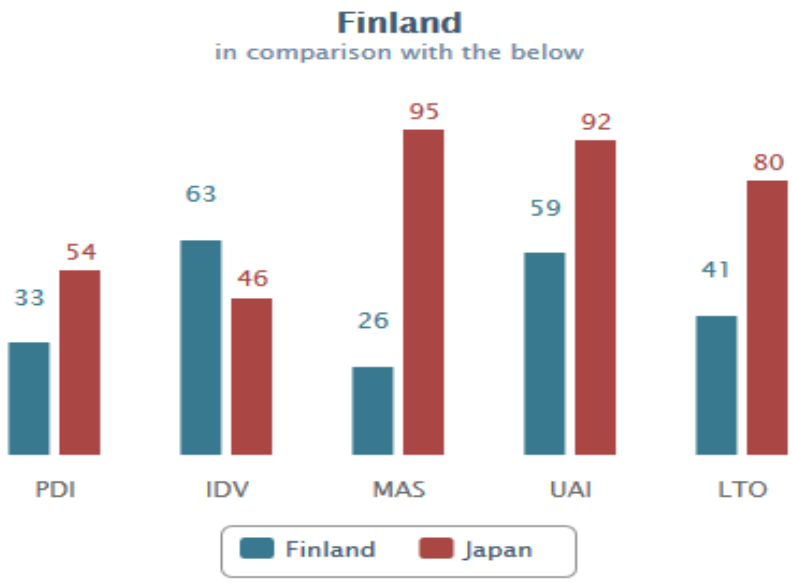

FIGURE 2. *Finland versus Japan National culture dimensions by Hofstede*

The nation culture has been studied through the lens of the 5-D Model developed by Hofstede. Through his study there is possibility to get quickly overview of the deep drivers of nation culture relative to other world cultures what is under interest of viewer. For example in this thesis Finland and Japan differences

are shortly referred based on Hofstede model and analysis (the full original analysis of Finland and Japan can be read on the web page tool: http://geert-hofstede.com/countries.html).

Power Distance (PDI) expresses the degree to which the less powerful members of society accept and expect that power is distributed unequally, which mean fundamentally how a society handles inequalities among people (Hofstede, Dimensions). Hofstede result shows that differences are not so big between Finland and Japan. In Finland individuals are independent with equal rights as in Japan but in Finland the hierarchy is only for just convenience, while Japan is more hierarchical than Finland. Japanese always act consciously by knowing their hierarchical position in social situation and act accordingly. In the Japanese business decision-making process model all decision must be confirmed by each hierarchical layer and finally by top management. Unlike it, in Finland leading style is more like coaching and empowering. The team members' experience is trusted and they are expected to act like consultant of the management so control is disliked and communication is direct and people strive to equalize the distribution of power and demand justification for inequalities of power.

Individualism versus Collectivism (IDV) mean that how society's position is reflected in whether people's self-image is defined in terms of I or we (Hofstede, Dimensions). Finland is individual society where as Japan shows the individualism by own will to choose the groups where they want to belong and put harmony of group ahead of individual opinions. Finnish are expected to take care of themselves and relationship in life is a contract based on mutual advantage. Japanese are more in-group situational than Finnish but not as collective as other Asian cultures are.

Masculinity versus Femininity (MAS) represents a preference in society for achievement, heroism, assertiveness and material reward for success or its opposite force for cooperation, modesty, caring for the weak and quality of life (Hofstede, Dimensions). Hofstede results show that Finland is feminine society

while Japan is masculine. In Finland work is considered as a means to stay alive as for Japanese workaholic is common masculine norm of hard and long working hours. In Finland conflicts are resolved by compromise and managers are trying to negotiate for consensus and solidarity. Overall focus is on well-being which means that such as free time and flexibility are favored. Japan is one of the most masculine societies in the world according to Hofstede. In Japan individuals do not behave in assertive and competitive manners but it is between groups because of their mild collectivism. Masculinity shows up also for excellence and perfection in their material production, services and presentation.

Uncertainty Avoidance (UAI) dimension expresses the fundamental issue how a society deals with the fact that the future can never be known (Hofstede, Dimensions). Japan is one of the most uncertainty avoiding countries in the world according to Hofstede study. As Finland has lower rate for avoiding uncertainty but security is important element in individual motivation and people have an inner urge to be busy and work hard. Japanese uncertainty avoidance reflects in everything that they are doing by maximizing their risk mitigation plans and making sure that they know all the fact before make any decision. Hofstede has stated is his study that “this high need for uncertainty avoidance is one of the reasons why changes are so difficult to realize in Japan”.

Long-term versus short term orientation (LTO) can be interpreted as societies with a short-term orientation generally are normative in their thinking and they exhibit great respect for traditions. Also short-term societies have a relatively small propensity to save for the future and a focus on achieving quick results. In societies with a long-term orientation, people believe that truth depends very much on situation, context and time, also long term societies has ability to adapt traditions to changed conditions, a strong propensity to save and invest, thriftiness, and perseverance in achieving results. (Hofstede, Dimensions.)

Finland is a short term orientation culture. The Finnish culture has a relatively small propensity to save and there is quite strong social pressure and impa-

tience for achieving quick results. It is quite typical for western societies at the short-term thinking. When compared to Japan, which is one of the long oriented societies in the world, they see their life as very short moment in a long history of mankind and corporate do high rate investments in R&D even in economical difficult times - idea behind to serve the stakeholders and society at large for many generations to come.

When working in a virtual global environment and in a large enterprise, team members should understand at least a little bit of each other's cultures. Also there should be understanding of how other teams in other side of the world act according to their cultural norm. "Each organization has its own culture, which defines the organizational values, beliefs, rules, norms, history and basic assumptions. The organization's culture may differ from national or regional cultures; it is created from business perspectives and can be changed according to new requirements, which can arise from business, national or global environment, employees, stakeholders, customers and laws". (Rissanen 2011, 74.)

A culture "which values its staff may have an environment in which all staff are motivated to be involved in helping to change the environment" (Brown 1997, 184). The change in the quality driven culture may cause resistance in the staff because of current culture, lack of coherent leadership communication and cooperation of teams. Efficient teamwork is the way to solve complex problems and improve processes because it allows individuals and organizations to grow and create a culture in which everyone are committed and focused towards continual improvements in the delivery of the customers' requirements. Improvements in communication, energy, and involvement level together effect change in the culture of the organization and build upon solid ground for organization to improve quality culture.

4.5.2 Trust

Trust is the crucial thing in the team work. The human interactions are social systems which are naturally easier developed when people are collocated, because of spontaneous interactions and information sharing face-to-face. "The

fact is that in most human systems and organizations the true system often includes hidden subsystems such as processes of fear or trust generation, so persons should be able to understand how these are influences in the organizations way of working" (Hämäläinen – Saarinen 2007, 72). The trust is based on interaction or time spent together, because knowledge of those with whom one works and communicates is necessary for understanding and interpreting interaction styles. Team members trust better each other when they are knowing and being known by one another. (Trust social sciences 2013.)

Compared to collocated teams, trust may be developed more slowly among virtual teams, because of limitations of communication which is the key element of trust. A key to gain trust in virtual team work is to communicate right and keep promised commitments to each other and therefore making only commitments what team can and will keep (Nemiro and co. 2008, 9-10). All people have individual values and when virtual team members know what other people values are and how to create trust by speaking directly to their values, communication style and trust building for different people from different culture and different individual values are easier to do. When understanding different collaboration style models, it is easier to change communication style and change own behavior towards more collaborative direction. Also when manager and team members behavior is predictable it is helping to vain the trust among people. If the trust level among team members is low for any reason, communication should be improved and commitment for any activities in the team should be negotiated and respected by assisting individual team members in doing what they promised to do so other team members can trust them. If it turns out that team members or teams cannot keep their commitment, it is manager action to help them to communicate this early and honestly.

Appelo has recognized four types of trust and respect for all need to be placed 1) trust to others 2) gaining trust from team members, 3) getting team members to trust each other, and 4) trusting yourself (Appelo 2011, 138). Trust and respect are crucial virtues to make empowerment for virtual teams. Otherwise it is leading to loss of motivation, loss of creativity and decreased productivity.

When people trust to each other and work as a team to common goal they are happy and positive to outcome. Positive mind set and happiness is side-effect of the goal that is to increase productivity, creativity and innovations. One other important step for management is to understand the jobs and challenges of teams and members so the manager can give valuable feedback and create atmosphere of trust and respect. Berkun has stated that one must believe in yourself and stay true to your own reason and common sense, even when others disagree with you. Person should only change his mind when new insights have convinced him/her, not when other people have pressured to reconsider because doing something that person do not believe in is an act against the trust in yourself (Berkun 2008, 256). Trust in virtual teams shall be developed from positive and ongoing experiences among members of the team. Virtual team members should believe in the individual expertise and competence and trust every one's accountability and commitment on what they are agree to do. Managers are key enablers to create and sustain this atmosphere. (Appelo 2011, 138-144.)

It is very important especially for the testing organization that management practices fostering loyalty and trust within the test team, because of its nature of bringing and sharing bad news of other team work failures. The environment where test team members are working should encourage and treat team with respect even when test team member making failures in reporting defect wrongly about a system or product under test. Test management process and practices should be creating and fostering positive team dynamics and open communication between team members to achieve cohesive teams. Motivation and challenging the test team by keeping them informed on important project and business related issues and giving them honest and helpful feedback on their work give people the opportunity to improve their actions on job. Also job rotation and new task allow people to improve their skills and job satisfaction in long term. Especially in virtually distributed teams which are located in different geographically locations and time zones with cultural differences and with different skill levels and expectations, create critical challenge to plan and implement

test management and communication system that cover all these needs to lead test teams. (ISTQB 2011c, 28.)

4.5.3 Leadership

Leading and managing traditional collocated teams versus virtual team has different conditions. Quality performance of dispersed team members need to be ensured as well as it is ensured for traditional teams. Virtual team leading has raised set of new competencies for managers to lead teams.

> These include technological proficiency to use appropriate media for communication, cultural management skills, ability to coach distant team members, ability to build trust among virtual team members, networking with others outside the team such as customers of other stakeholders, and remote project management skills (Nemiro and co. 2008, 10-11).

Virtual team leading needs multiple capabilities from the managers to perform efficient virtual way of working, but virtual team leaders should not control people but the system. Managing should be more coaching than micromanagement and control should focus on the system. The manager job is to make sure that virtual teams work collaboratively together to find its own way to the edge of chaos (Appelo 2011, 175). Virtual teams should be developed by managers in such way that those are self-organized and teams have created their own rules by certain restrictions that are defined in accordance with the management. Appelo has stated that people may draw their organizations as hierarchies but that does not change the fact that they are actually networks and social relationships which managers should see as living systems (Appelo 2011, 25).

So managers should define directions and constrains for virtual team collaboration and goals in business which are then controlled and directed by the system. Jack Welch, CEO of General Electric acknowledged this in a MIT seminar by noting that one of the paradoxes of leadership is “managing short and thinking long” (MIT Sloan School Of Management 2005). Leaders should have intuition and act intelligently even when they do not exactly know what is happening but they should have vision without knowing the complete solution. Also it is important to develop such kind of system that there is control to monitoring pro-

gress and ability to delegate tasks efficiently to subordinates but letting them to develop their own solutions for the given tasks in a self-organized way.

By self-organizing teams here, it is meant that no method or process is imposed on team to get work done. “They are trusted to get the work done in ways that they think are best, assuming that they know how to do that, with accountability for their results” (Appelo, 2011, page 22). So this means that actual work processes or methods are not defined by management. Their only job is to manage the system but self-organizing teams are able to create their own method and process to get work done within the limits defined by management. Those limits can come from the many directions like customer requirements, industrial specifications, delivered products by the supplier and other stakeholders of the project. When the right constrains is set in place by management, self-organization can solve many quality problems.

But it should be reconsidered wisely what kind of constraints for the given goals are set, because self-organizing teams will do exactly what asked. For example if timeline is set for constrain and pushed by management to get tasks done exactly on time, then team will do that, but the quality of the performed tasks can be low. Also management need to understand that constraints cannot cover everything, but if constraints are not clearly set then quality of the product is also unclear and many cases it is not reaching such level as customer is expecting it to be. Virtual teams must have well defined and measurable shared goal that is communicated well so that is guides team in their work. (Appelo 2011, 185-188.)

Hämäläinen and Saarinen have listed the key ideas to understand human intelligence in systems setting in their book of “Systems Intelligence in Leadership and Everyday Life”. These ideas can apply for virtual leading concept as follows. The overall virtual project leading point of view the whole is more important than parts. This means that if overall virtual way of working does not progress as wanted then there is no senses to fine tune one part of it, but it should be noted that “part” and “whole” is relative and depend on the perspec-

tive of viewer. Virtual team members should have the ability to see world through the eyes of another person, because in global virtual collaboration there are many different cultures, different way of thinking and different way of acting people. This will give opportunity for further virtual problem solving. It helps the human conceptual system to look beyond linear cause-effect chains for thinking and seeing interconnections and interrelations of matters. Also, it will help innovate in much richer ways on the global market area. From the virtual management point of view the real danger is that people get caught in poorly managed system that serves nobody's interest. Normally co-operation between people are natural but fundamentally based on the assumptions and meta-assumptions that people make of others. In virtual collaboration face-to-face communication is limited which affects individual's beliefs or guess of other people's behavior models but that can be completely erroneous. With a well designed and implemented virtual management system people can act in such way that they improve the system own behavior within it and influence upon the others by generating positive flow to the organization. (Hämäläinen – Saarinen 2007, 52-53.)

4.6 Summary

As the reader can see in figure 1, the path for the high performance virtual way of working is the work process managed by the management. Virtual team "manager job is to manage the system and not the people in it" (Appelo 2011, 164). A well functioning virtual work process should operate as self-organized and the success of a leader is measured to the extent the system can cope without direct personal daily supervision. Information sharing and knowledge management in virtual collaboration enable path towards high quality decision making.

The management system should support managers to make the critical decisions with metrics supported by the system. The work process system should be designed and implemented such a way that it supports continuous improvement in adaptable, explorative and proactive way. Continuous improvement in virtual working needs co-operation of trusted people as subordinates, which are

capable to handle the system themselves when there are boundaries around it. Creating understandable and easily followed work process is the key element of virtual collaboration of which desired outcomes will be met consistently. The recommended work process solution for the virtual collaboration in integration and verification test organization is the service oriented quality management model, which is explained in chapter 5.

5 SERVICE ORIENTED QUALITY MANAGEMENT MODEL

> Brilliant process management is our strategy. We get brilliant results from average people managing brilliant processes. We observe that our competitors often get average (or worse) results from brilliant people managing broken processes. Source: a senior Toyota executive

For greater business efficiency and high quality results methods and systems should be developed to manage organization culture, process and work actions dedicated to test organization business. Management style and knowledge of organization maturity level helps management to identify what priority areas are, and when and what actions must be done to develop organization efficiency and improve quality. Figure 3 shows steps of the business process management improvement model and what management actions organization is going to need when it is travelling towards continuous process improvement model and innovative technologies.

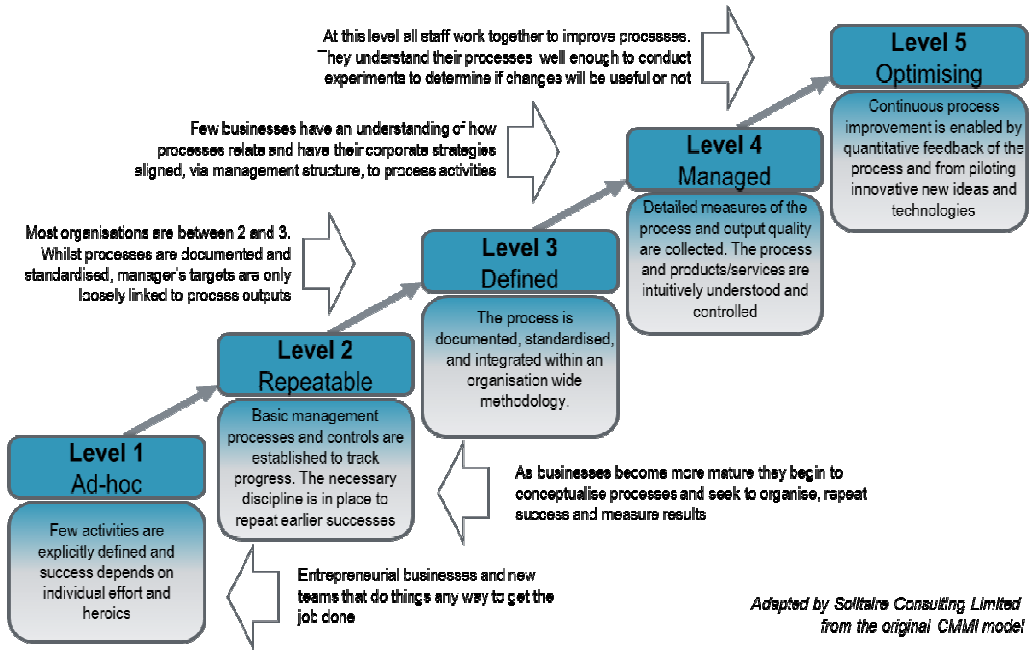

FIGURE 3: *CMMI model with business process management by Solitaire Consulting*

The Capability Maturity Model Integration (CMMI) is development model providing leadership in advancing the state of the practice of software engineering in order to improve continuously the quality of systems that depend on software. It is developed by the Software Engineering Institute as a part of Carnegie Mellon University. It focuses on the concept of "engineering systems thinking" with discipline processes. The CMMI provides a framework be used to guide process improvement across business activities, and organize an entire organization. (Kasse 2008, Chapter 1)

Developing integrated management systems is one part of the organization's value chain that strives to provide end-to-end quality to its internal and or external customers. The total quality management should focus to improve business processes of the organization, be they related to services or products, so that customer requirements are met in the schedule and reasonable cost. Knowledge of the customer needs and expectations are understood from the beginning and reflected accurately in specification for service, product and processes what organization is capable to produce. Organization, which has well defined and documented processes and those are integrated and operating at measurable and standardized maturity level, may develop in the long run level five organizations. It needs integrated framework of management system, focus on operational effectiveness and continuous improvement program in place to get results in reduced cycle time, improved throughput, reduced crisis situations, and improves overall efficiency and productivity. (Software Engineering Institute 2008.)

5.1 Continual service Improvement and quality breakthrough

> Continuous improvement is not about the things you do well – that's work. Continuous improvement is about removing the things that get in the way of your work. The headaches, the things that slow you down, that are what continuous improvement is all about. Source: Bruce Hamilton, President GBMP

The target is to create and maintain value for customers throughout better design, transition and operation of organization by developing problem-prevention

mind set for organization. In the other hand problems cannot be prevented fully so it is important to create culture where all members of an organization need to work together on company-wide quality improvement. The cooperation of everyone at every interface is required to achieve perfection. (Oakland 1993, 8.)

Quality excellence can be achieved by integrating technology, processes and people management to the services being provided. Continual quality management practices are for improving performance of communication, organizational culture and commitment that will integrate the systems and tools with the people and process components to achieve service and business objectives.

The concept of total quality management is basically very simple. Each part of an organization has customers, whether within or without and the need to identify what the customer requirements are, and then set about meeting them, forms the core a total quality approach. This requires the three hard management necessities: a good quality management system, tools such as statistical process control and teamwork (Oakland 1993, 433).

The overall quality improvement of the organization needs commitment of the top management and tight team work to achieve successful results. The control and monitoring of product, process and services are essential activities of everyone in the organization. The problems which cause quality issues should be found and eliminated as early as possible together within organization and make sure that the requirements of the customer are continually met.

There are some of different total quality management models developed by Crosby, Deming, Juran and Oakland but the “fundamentally those are handling the same issues with different dialect” (Hätilä – Norlund - Yli-Hukkala, 2). One of the available Total Quality Management (TQM) model is selected in this thesis which is supporting service model I&V portfolio management and virtual team leading. Model in figure 4 is developed by Oakland and it work as a framework for TQM. Figure 4 shows the core of the model, which is for the customer, both external and internal, interfaces and related business processes. The surrounding triangle point out the management necessities of teams, tools and systems

and the outer shell shows how those are collaborating with organization culture, communication and commitment. (Hätilä – Norlund - Yli-Hukkala, 6.)

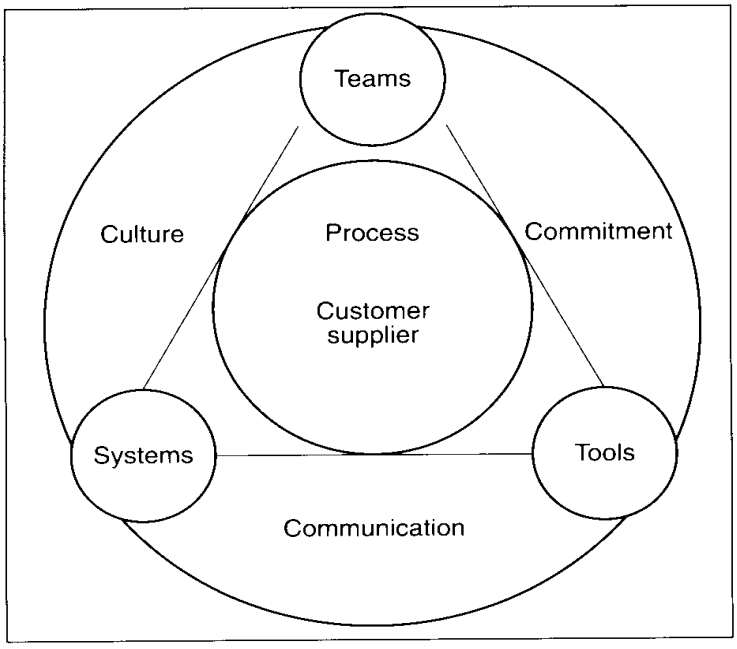

FIGURE 4: *Total quality management model by Oakland in 1993*

Quality does not only happen; “it needs commitment and understanding by senior management and effective team leadership and teamwork” (Hätälä and co., 3). The management must communicate positive way, motivate and make sure that the whole organization understands the importance of the quality improvements in particular areas during the time. Senior leaders need to ensure that the whole command chain is doing the improvement actions and control and guiding the direction if necessary. Team supervisors should motivate and create routines for teams in such way that they are committed to improve their work. Hoffherr and co. listing four key factors to increase peoples willingness and motivation towards quality change: perception of benefits, energy, involvement level, and communication. The perception of benefits is initiation of the personnel for continuous improvement and it should be sold by management as long-term benefits of transformation where whole organization is going. The mind set of personnel should be motivated towards high energy state where their commit-

ment level to the transformation grows out of their belief that the transformation serves both their personal best interests as well as the best interests of the organization. It is necessary to obtain a high level of involvement and a commitment to the continual improvement process and this is done by management action and interactive communication. (Hoffherr – Moran – Nadler 1994.)

5.1.1 Information and knowledge management

Effective information and knowledge management has a big role for meaningful communication and decision making in knowledge-based organizations. Leader's communication of the matter of vision, goals and strategy must be clear and on such detail levels that the specialist in the knowledge base organization can adapt actions on tactic level and daily work in the way that organization quality breakthrough is possible and people are committed to work towards new common innovative technologies and services. The need of high quality level information for communication or decision making is vital factor in knowledge based organization and it is surely competitive advantage, when organization personnel communicates with customers, suppliers, subcontractors or other stakeholders inside the organization. Also, the continual improvement of an organization needs continuous learning in all organization levels because of changing business environment. Learning is based on information available and communication of the leaders who are reflecting their vision of company future needs of knowledge capital. Leaders and managers should encourage, ensure and support everyone in the organization to be involved in sharing tacit and explicit knowledge by interactive communication dialect with each other. The leader's communication style should be a role model for employees to act wisely. Tacit and intangible tacit knowledge should be made visible starting from the individual level by converting it into explicit and shared around the organization to support organization learning and continual improvement of individual's skills and their expertise. These improvements in communication can lead organization to an ability to create new knowledge and improve overall organization's quality of service portfolio and also improve new products and services to increase profit in the future. (Rissanen 2011.)

5.1.2 Quality problem solving models

As Albert Einstein has said, "The formulation of a problem is often more essential than its solution...To raise new questions, new problems, to regard old problems from a new angle, require creative imagination and makes real advances..." In the team level, the first step is identifying the cause of quality problem by developing a purpose statement which is formulating of a problem. This purpose statement then becomes the problem statement, and the mission, for the team where they are committing. The purpose statement should be the largest level as possible of the quality improvement subject. This gives advantage of attacking the problem at the largest level possible. And the solutions generated will be the most comprehensive and creative possible. The narrow range statement will not give possibilities for teams to create new ideas to solve quality problems. (More information how purpose statement can be done found in book of Glen D. Hoffherr: Breakthrough Thinking in Total Quality Management in chapter one.)

It is important that all teams and team members are involved in improving quality. Organization leaders should empower their employees by lowering decision making by establishing quality circles which are self-directed and self-managed teams. Members of the quality circle team should be cross-trained persons with wide perspective of their areas of responsibility and they get involved in planning, design and problem solving tasks. Personnel should learn to think like effective problem-solvers. Also personnel should be trained to think organization as whole and developing and improving customers (internal and external) expectations of the solutions and services future-focused bigger purpose perspective, like executives thinking of (Hoffherr and co. 1994, Chapter 3.)

Approaching quality problems by the purpose of the larger environment within a framework of scope, time available and meaning of the solution to the problem together with driving force of customer’s requirements, shape the group’s thinking and their vision of ideal system towards long-term continuous improvement. Each quality circle team needs skills of situation awareness, entrepreneurial

spirit and also encouragement of management to bring in people from the outside of the team with new ideas. “In the high competitive area of the business, customer satisfaction is the most important measure of quality for all organizational product, services and activities” (Hoffherr and co.1994, Chapter 3).

It is important to remember that the internal customers of the organization (like business or program management is customer for research and development organization) requirements should be tied to external customers’ requirements and measured satisfaction as whole and also inside of company organization. After the purpose for the quality problem has been stated then the target is needed to be defined and as many ideas as possible generated for solution or ideal systems for achieving the selected purposes in larger aspect of view (Nadler – Hibino 1996, 4). Within a systems framework, the target is to idealize and invent solutions that are beyond the current urgent needs and try to see in the longer future. Of course it is important to understand that those ideas fit also to the current situation and fulfill the purpose. The results of the brainstorming outcome are detailed recommendation to assure workability and implementation plan for recommended solutions.

When the people in the quality circles have these kinds of philosophical orientation skills, then there is time to take into use specific tools, techniques, and deployment processes to improve continual quality of service, processes and products. In the literature there are hundreds of different techniques developing ideas and/or solving problems, some of them are simple while others are more complex. This thesis is not going to list or introduce all those techniques. More information of tools for total quality management improvements can be found from the literature (Hoffner and co 1994; Nadler – Hibino 1996; Oakland 1993; Hutchins 2008 publications):

- Just-In-Time (JIT)
- Statistical Process Control (SPC)
- Total Participation
- Six Sigma

- Quality Circles
- Socio-Technical Work Systems
- Employee Owners
- Time-to-Market
- Voice of the customer
- Supply chain management
- Lean manufacturing
- Process re-engineering
- Improvements project
- Quality circles
- Quality systems and standardizations
- Quality function deployment
- Education
- Affinity diagram
- Interrelationship diagram
- System flow/tree diagram
- Matrix data diagrams
- Matrix data analysis
- Process Decision Program Chart
- Arrow diagram

5.1.2.1 Six Sigma

Six Sigma is a quality technique developed and introduced by Bill Smith at Motorola in 1986 to identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes (Antony – Kumar 2011, 200). Six Sigma and quality applications to business processes rely on the fact that processes can be measured, analyzed, controlled and improved. Measurable metrics and measurement are vital to implementing Six Sigma analytic techniques. Six Sigma is widely recognized as a methodology that applies statistical and non-statistical tools and techniques to maximize an organization return of investment through eliminating defects in process. Six Sigma is changed from being the statistical analysis tools to being company-

wide strategy for business process improvement. Organizations have included Six Sigma as part of their business strategy and in the strategic review process to become globally competitive, increase market share and enhance customer satisfaction. (Antony – Kumar 2011, 13).

Figure 5 shows the goal of Six Sigma, how it is to reduce the number of process defects or errors. A defect is a customer experience with the process, service or product that is outside of the customer expectations or requirements. Six Sigma endeavors to reduce the number of defects to below a target level by measuring the performance of the process.

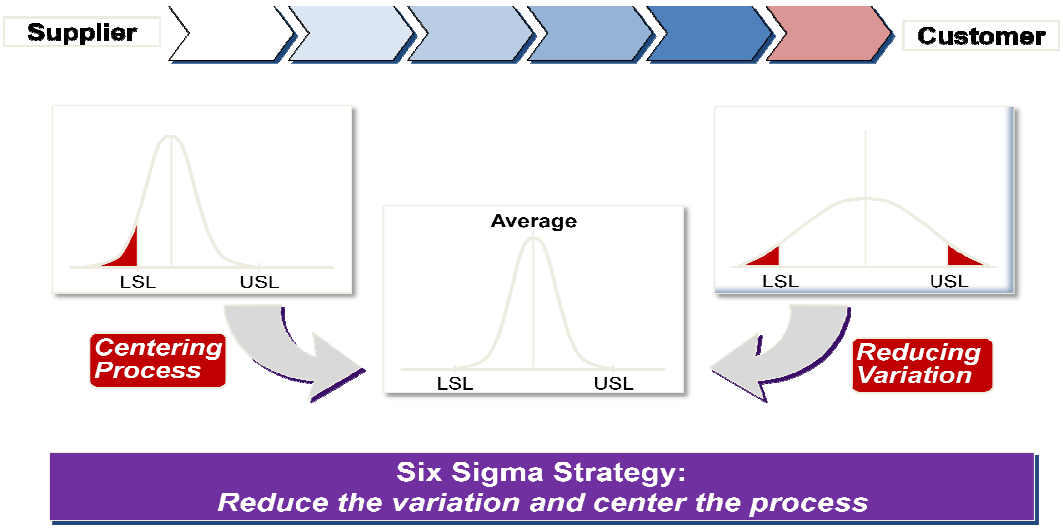

FIGURE 5: *Six-Sigma strategy to reduce the variation and center the process*

Six Sigma, is a methodology to identify, reduce, and potentially eliminate process variances or poor performance that create errors which is impacting the customer. Six Sigma uses a variety of statistical techniques to identify the problems and sources of error, and ultimately to design a solution that will eliminate the errors (Probst – Case 2009, 7).

5.1.2.2 PDCA method

Plan, Do, Check and Act (PDCA) business management principle method, see figure 6, is internationally recognized approach to business management de-

veloped by Shewart and Deming for the continuous Improvement of business in the 1940-1950's (Wikipedia, PDCA).

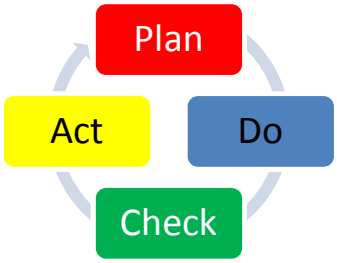

FIGURE 6: *PDCA business management principle*

- Plan: Is the process of defining the targets and identifying key areas where to focus on work or root causes or improvement levers
- Do: This is process to define change actions and implement actions
- Check: Monitoring process the progress or change in action
- Act: Institutionalize and deploy the change, take counteractions and mitigate the risks.

5.1.2.3 Lean management practice

Lean is set of management practices based on Toyota Production System. It was another quality method for manufactures to respond Japanese manufacturers and their manufacturing techniques to resolve their manufacturing problems in production. The drive of this system is eliminating waste and non-valued activities through continue improvement of process manufacturing and practicing respect for people and thereby cost reductions and customer satisfaction. Lean manufacturing was to reduce cost and enhance the speed of organization by minimizing seven types of waste overproduction, motion, transportation, inventory, extra processing, waiting and defect (Antony – Kumar 2011, 14.)

Lean manufacturing thinking is philosophical part of the process and it defines that everyone is involving in continuous improvement by employing focus on customer, synchronizing flow and eliminating waste and add value, quality is

built in the system and redesigning and business strategy is flexible and adaptive.

5.1.2.4 Lean Six Sigma

One powerful variation of quality management is combination of three management processes of Six Sigma quality technique, Lean production method developed and PDCA business management principle. This method has been called Lean Six Sigma quality management process which has shown results in terms of cost, quality and delivery by focus on process performance. The fundamentals of Lean Six Sigma method are to turn unstable and unnecessary process to an improved, robust and controlled process by reducing output variation to fulfill customer specifications and business requirements: Eliminating waste and non-value adding to achieve most efficient process setup continuously. The effective implementation of these three methods in practice demands top management commitment, cultural change in organization, good communication down hierarchy, new approach to production and to serving customers and a higher degree of training and education of employees. (Antony – Kumar 2011, 175-189.)

The improvement efforts of Lean Six Sigma are based on the 'Voice of the Customer' (Probst – Case 2009, 7). Customer voice is a tunneling focus to initiate the problem points and that way to create value and less waste with high stability and accuracy to fulfill customer satisfaction and to gain high revenue and profitability. A value stream is the set of all specific actions required to bring a product or service from concept to the finished good being delivered into the hands of the customer. Lean Six Sigma quality improvement efforts address those quality issues pointed by customer that impact the customer.

Executive leadership of quality improvement for a Lean Six Sigma initiative is the support of senior management. Lean Six Sigma as an organizational discipline will require a substantial investment of time and resources to be successful. For instance, Lean Six Sigma practitioners will require time to complete extensive training, and Lean Six Sigma projects are typically substantial in terms

of cost. This level of organizational investment requires senior leadership to allocate scarce resources.

Lean Six Sigma uses two forms of sub-methodologies to improve process quality. They are known by the acronyms DMAIC and DMADV. Process model can be seen in figure 7. Lean Six Sigma strategy is to find and reduce unwanted process variations and center the process. Understand the variation and what is causing that. It follows PDCA methodology circle and are being defined at five phases called DMAIC or DMADV project methodology. (Voehl – Harrington – Mignosa – Charron 2013, chapter 6.)

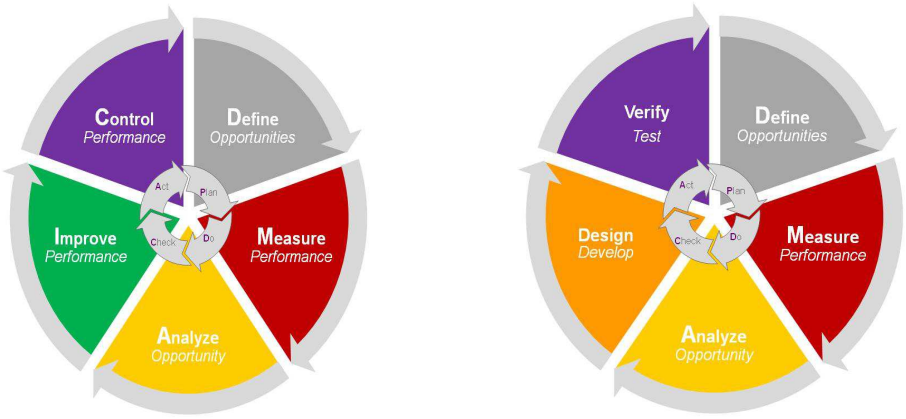

FIGURE 7: *DMAIC and DMADV methodology process description*

DMAIC comes from the words Define, Measure, Analyze, Improve and Control. The meaning behind those words can be defined as follows:

- Define the problem. Translate voice of the customer and understand correlation of the business by identifying and validating business improvement opportunities and processes. Determine process metrics. Understand the problem(s).
- Measure performance by verifying measurement system and sampling collected process data. Understand and measure variation and process lead time and process cycle efficiency. Determine baseline process capability. Measure the current state and identify influences.

- Analyze identifying process constraints and bottlenecks. Understand reasons for variation and develop potential root causes. Narrow and prioritize potential root causes. Confirm relationship of root cause to output. Understand root causes and related impact on output
- Improve and identify potential solutions addressing important root causes. Minimize risk and implement solutions. Develop full scale implementation plan. Confirm attainment of project goals. Develop and implement solutions for related root causes.
- Control process to ensure that any deviations are corrected before they are affecting unwanted defects. Document learning and implement statistical process control and visual virtual workplaces to continuously monitor the process. Evaluate results regularly. Identify new opportunities to improve processes and standardize and document the new processes.

DMADV comes from the words Define, Measure, Analyze, Design and Verify. The meanings behind those words can be defined as follows:

- Define and identify customer-focused design goals and requirements
- Measure and create measurements factors that will impact the ultimate process or service delivery, customer needs and process capabilities.
- Analyze the design options and design capabilities such that the implemented process, service or product will achieve the design requirements
- Design and develop and optimize the service process to meet the customer requirements
- Verify and test the process and transition to customer and test that the implemented process meets the target performance or customer specifications.

Whereas DMAIC can be thought as reactive practice, where use cases are relating performance data of the existing processes, product or service and analyze and correct them. DMADV is more like proactive process where processes, product or services can be designed with quality in mind. DMADV process

support development of new process that should perform far better quality as a result of the analytical design. (Voehl and co. 2013, chapter 6.)

Lean Six Sigma is more than a collection of methodology tool box. It is a philosophy than can be applied for continuous improvement to eliminating process waste and reduction of the problems which could be thinking of defects or variation of product or service quality. Lean Six Sigma concept is based on the voice of the customer by improving the customer's interaction with the organization which provides product, service or processes for customer. The test organization and in this context the customer is the entity that orders testing service or a product under test that the service process support. Mostly the customer is other enterprise organization of product program management. The customer expectations of performance of the provided service (or test process) is based on standards of end user voice which comes to the fore, but is effecting also the expectations of the program management organization of testing service quality.

5.1.2.5 Continual Service Improvement model

Service management is the concept of delivering value to customers. Value implies that whatever service provider has been promised to deliver to the customer the service facilitates the outcomes that customer wants to achieve and is willing to exchange something of value for the delivered service. Hence, service improvements are justified and can be measured in terms of the voice of customer. Lean Six-Sigma applies very well on this aspect of concept.

One possible key model improving organization service value from reactive model to proactive model is continual service improvement (CSI) practice. CSI is a formal proactive practice that addresses improvement opportunities for organization services, service management processes and the testing service lifecycle (Probst – Case 2009, 4). CSI model is developed by IT Infrastructure Library (ITIL) organization and this model can be found from version three.

Continual service improvement practice is proactively seeking service related issues and finding problems before them becoming issue for the customer. CSI can also identify areas for increased service or process efficiency and effectiveness. The organization ability to monitor service process quality against established expectations of customer is based on evaluation of performance variances and implemented corrective actions when problems occur over time. Services and processes provided by organization to customer must be reviewed continually to ensure balance of efficiency and effectiveness in order to support the strategies, goals and objectives.

Quality is the key objective of monitoring for Continual Service Improvement (ITILv3 2011a, 164). CSI should focus on exceptions and resolutions and understanding of how incidents or problems could be avoided in the future. Also measures, metrics and key performance indicators of the target areas of system under test give opportunities for continual improvement. The metrics are required continuously in improvement initiatives in order to control the improvement process and to make sure that the changes have resulted in the desired improvements (ISTQB 2011b, 32). Table 2 shows example of the testing metrics.

Testing can give confidence in the quality of the system if testing is properly designed and performed and found defects are fixed. Lessons should be learned from previous projects so continuous improvement can be implemented for the quality of future systems. (ISTQB 2011a,11.)

TABLE 2: *Types and examples of testing metrics by Lovin modified by Author for I&V purpose (Lovin and Yaptangco 2006)*

Type of metric	Example metrics
Operational	Execution progress for test cases Percentage of completed tests Number of tests that passed, failed, or were unable to progress because of blocking defects Number of outstanding defects (measured by severity and by component) Rate of defect discovery (measured by severity and by component) Rate of defects being fixed compared to the discovery rate Number of defect fixes requiring regression testing
Historical	Number of defects discovered per test hour Number of defects that escaped discovery in a previous test phase Number and percentage of valid defects discovered (the number defects found by testing divided by the total known defects) Number and type of defects reported by customers Comparison of the project's planned execution (time, headcount, and so forth) with its actual execution
Business	Duration of effort compared to a previous product of similar size or complexity Resource consumption compared to a previous product of similar size or complexity Number of defects found, phase during which the defects were found, severity of the defects, and comparison of these metrics with previous test efforts The lead-time of testing during test execution Number of defects that escaped discovery in previous test phases and comparison of this metric with previous test efforts

ITILv3 continual process improvement model can be used together with those statistical tools that Lean Six Sigma model offers to improve Integration &Verification organization service quality. In figure 8 CSI process model is started with service portfolio management that represent service strategy outlook that I&V organization provide to program management or the customer organization to be served.

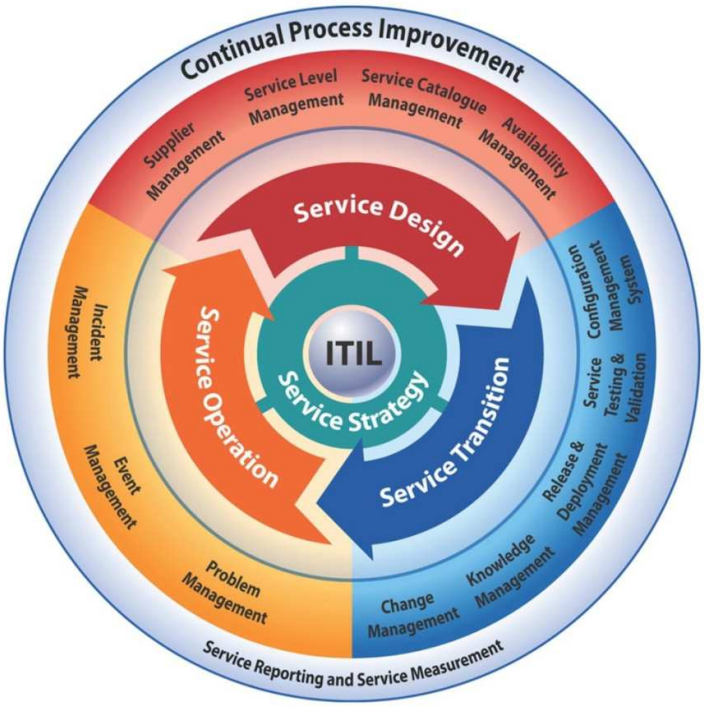

FIGURE 8: *Continual Process Improvement by ITILv3*

But before it can be started measuring the system it had to have well designed management system where all performance indication points are defined beforehand. Next chapters are describing the service management model for I&V and how to execute it.

5.2 Service portfolio management model for I&V

Service portfolio management could be thought of as a synonym of project portfolio management in this context whereas all I&V organization test work are handled under projects. The organization service can be designed with quality, defined by the process, to determine delivery and schedule capability of I&V organization to best achieve operational and financial goals at the same time giving tools for constraints imposed by customers, strategic objectives, or external real-world factors. Figure 9 shows redesigned model of ITILv3 service portfolio management model for I&V organization to respond the challenges what have been explained in detail in chapters three and four.

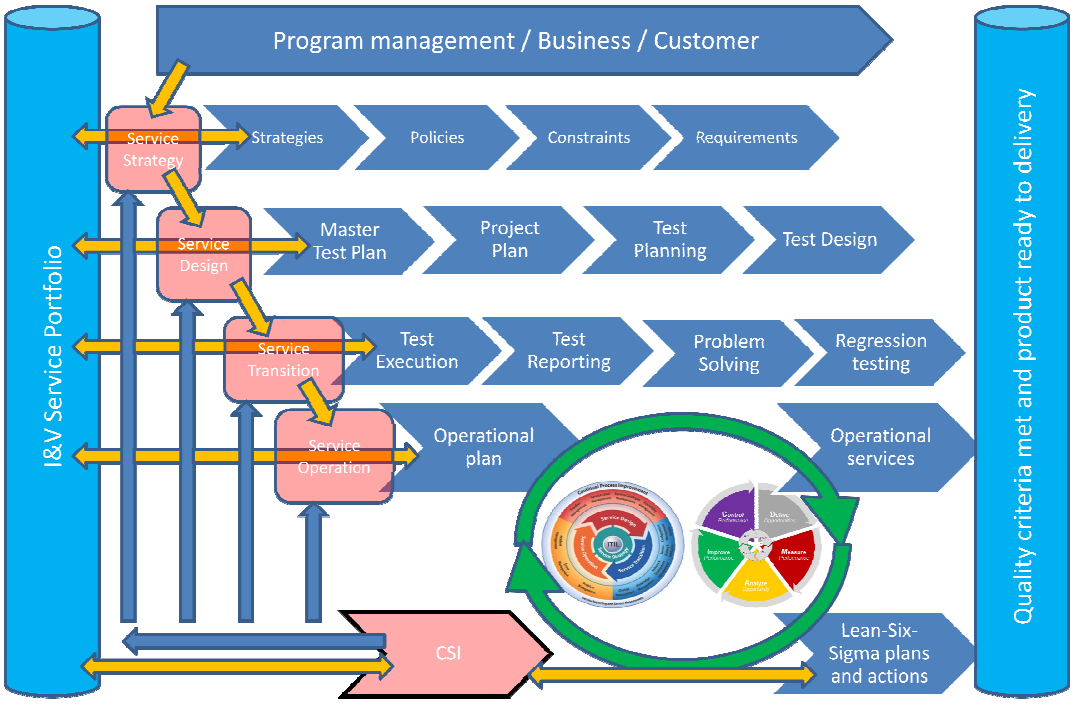

FIGURE 9: *Continual Service Improvement model, modified from ITILv3 model for I&V organization purpose by Author*

ITILv3 model defines the attributes that should be maintained in the service portfolio, such as service description, business case, value proposition, priority, risks and more, but there can be taken under consideration also attributes from the project portfolio models such as financials and resources. These key attributes are evaluated by senior management throughout the lifecycle of the project(s), from strategic analysis of new projects until the project is closed. This is more centralized process and provides transparent overview of the performance to monitor service progress versus strategic plan.

5.2.1 Service strategy and design

Requirement of the services and metrics of the strategy are defined to follow through I&V project. The service for test project is defined and analyzed based on risks and business impact which includes test line supplier management plan, project (service level) management plan, service catalog plan which in-

cludes all visible services for customer organization; reporting, communication, policies and test execution plan. Availability plan contains the information about the initiatives and aims of continual process improvement of service, this plan assure that infrastructure, tools, processes and roles are appropriate for agreed.

Service strategy and design process can be linking naturally to project planning where test project is part of service lifecycle of I&V business process but this phase of the process is targeting to manage group of enterprise-wide I&V projects, current or proposed ones. This gives tools for leaders to monitor, control and make decisions on objectives of service strategy. International Software Testing Qualifications Board (ISTQB) define that the most essential activities of test management relate to the test manager's ability to establish business value connection.

> Without value connections, no matter how well the test team performs as a matter of technical capability, no matter how excellent the management of the test team by the test manager, the test team and the test manager will fail. Therefore, the test manager must carefully evaluate the connection between stakeholder objectives and testing, and define goals and a mission of testing that relate to those objectives. Clarity about the test organization's mission and objectives is important. (ISTQB, 2011c, 12.)

Strategy and policy should show the mission and goals of the test organization, including the relationship to the organization's quality policy. It has to make sure that defined policy reflects what the test organization can actually achieve. The leaders of I&V organization have the key information available to prioritize right programs and projects. It can guide to make decision to strategically prioritize, plan, and control enterprise portfolios ensuring in-time delivery and improving ultimately bottom-line results. Executive leaders have process to identify problems earlier in the project lifecycle and visibility to take corrective actions before it would cause problems by allocating resources in response to rising crisis. Portfolio leading gives contingencies across the entire portfolio of projects and flexibility into resource allocation, which giving information of calculated impact on the wider business, so organization can quickly respond to escalating emergencies by moving resources from other activities.

Overall service (or project) portfolio management for senior executive leaders is to systematically review all projects, programs and whole service portfolio project management actions in a single integrated solution, meanwhile cutting of inefficiencies and continually improving management practices to ensure informed decision and governance. Service portfolio management is bringing together a unified view of organization services status to ensure all projects reach business objectives. Senior executive leaders have visibility to extend continuously best practices enterprise-wide to I&V project management organizations and provide guidance for project managers to capture best practices and efficiency in their actions to leading project teams. Also senior management can have understanding of future resource needs of organization to align those at the right time to ensure individual projects have fully potential and conditions to meet quality criteria in schedule. ISTQB determine terms of success of the test policy and strategy:

> The ultimate measures and perhaps the only ones that count are those that derive from key stakeholder's objectives for the test team in terms of effectiveness, efficiency, and satisfaction. The expert test manager should be able to evaluate metrics in these areas, and then improve the test strategy as needed. These evaluations and improvements should take into account both short-term and long-term perspectives, process and organization, and, people, tools, systems, and techniques. (ISTBQ 2011c, 16-17).

The virtual self-organizing teams needs clear constraints, as explained on chapter 4.5.3. If those are not clearly sets then quality of the system is also unclear and in many cases it does not reach such level as customer is expecting it to be. So it is very important that constraints and requirements are set and explained in details in the beginning.

5.2.1.1 Master test plan

Master test plan defines the integration and verification phases for the delivery of the product. The purpose of the document is to define:

- The interfaces and deliverables between different system components for tracking and management purposes.

- The needed integration steps and the test environments by entity Integration and verification project to verify the interoperability of the system components implementations.
- To define what kind of test strategies are used in entity Integration and verification.
- What are the test levels and areas, needed competence areas and how the testing is guided and controlled in such a way that resources are used in the most efficient way - to avoid overlapping work.
- To define what will be tested to ensure that no crucial part of the SW or HW shall be delivered to the customer untested.
- To define exit and entry criteria, responsibilities and approvals.

Test responsibilities of system components are divided among different teams, each one focused on a specific testing area. The aim is to create definitions to analyze the task dependencies so as to allow for efficient work across the entire program. Master test plan also defines testing content, schedule target, resources estimation and responsibilities in I&V testing project. And the document can be used for guideline when creating a project plan for different testing areas inside program. Testing tools, test automation, needed of training and reporting practices and metrics are also defined at a high level. (Gerrard Consulting 2013).

5.2.1.2 Project plan

Although test management focus on testing, there must be awareness of overall project planning purpose, which is outline project management governance, risk management, quality management, resource management, schedule and budget management, communication and also reviews and proper documentation level. Project plan could be a sub-project plan of certain test area and it could be linked to part of enterprise level product program plan, but also it could be master project plan depending of the nature of organizational project management practices. The project plan should include a specific description of the

test project and describe test project's deliverables and targets and it should be linkable to master program project plan schedule and aims.

CSI model requires that working model is measurable and statistical Lean Six-Sigma analyzing method can be used to improve total quality of service organization, which demand standardized project planning method into practice to function. ISTQB have defined the principles for test management project plan which gives good guidelines to create well defined project plan for test projects, more details can be found here: ISTQB 2011c, chapter 6.

5.2.1.3 Test plan

ISTQB defines that test planning is the activity of defining the objectives of testing and the specification of test activities in order to meet objectives and mission (ISTQB 2011a, 15). Test planning is one part of the recommended service design process to be implemented in the project plan. The scope of test planning is to provide the first effort estimation of features of product or system under test. The aim of test planning is to give the first insight what needs to be tested based on requirements and constraints of the customer needs. The plan is supposed to analyze integration and verification work together to estimate the required test execution efforts. The work estimation of the test planning is linked to project planning time estimation and should be done simultaneously. Test planning gives input for test designing and also finds the competence areas of needed test resources. The planning phase target also covers the test effort required for feature integration and verification and test automation.

Test planning is influenced by test policy of organization and it is following master test plan, also the scope of testing, requirements, risks, constraints, criticality and resources available. As the project and test planning progress the more details can be included in the plan. Test planning is continuous activity and is performed in all life cycle processes and activities. Feedback from test activities is used to recognize changing risk so that planning can be adjusted. (ISTQB 2011a, 49.)

Test plan should address the following key criteria's and it should be linked to test project plan:

- The scope and objectives of testing
- Features to be verified and those which are excluded
- Scheduling test analysis and design activities
- Scheduling test implementation, execution and evaluation activities
- Assign resources for the different activities
- Major milestones and dates
- Selecting metrics for monitoring and controlling quality criteria's and risks
- Defect reproduction estimation
- Regression test plan for defect reproduction
- Configuration management and version control
- Test reporting and summaries

5.2.1.4 Test design

The test design phase target is to create test cases and test data. It complements the service design phase and test design following strategic guideline of master test plan and the test plan. Test cases are consisting of certain input values, preconditions, constraints and requirements of the outputs done by requirement analysis. Test designing should produce expectation of results as part of specification of test case and include outputs of the wanted outcome. Figure 10 shows how the test design complement test plan and it can be divided for five sub-phases, requirement analysis, test design techniques, test analysis, test architecture design and test case writing.

FIGURE 10: *Test design and its sub phases*

Requirement analysis phase drills deeply into the specification and features of the product, which gives understanding of needed technical background for test activities and competence. Understanding of competence area is needed for example by human resource management, so test personnel skills requirement can be defined and proper focused training can be planned. Requirement analysis gives input for the test design techniques selection for a competence area design the test architecture and finally writing the test cases.

> The choice of which test techniques to use depends on number of factors, including the type of system, regulatory standards, customer or contractual requirements, level of risk, type of risk, test objective, documentation available, knowledge of testers, time and budget, development lifecycle, use case models and previous experiences with types of defect found. (ISTQB 2011a, 44).

There are several categories for test design techniques that can be selected. The purpose of test design techniques is to identify test conditions, test cases and test data. I&V test techniques classical selection is based on black-box test-

ing or white box testing. Black-box testing is called also specification-based testing where test conditions, test cases and test data are based on analysis of test basis documentation which includes functional and non-functional testing, but the test conditions do not use any information regarding of internal component or system to be tested. White-box testing also called structural-testing is based on the analysis of the structure of component or system. There are also many other categories which are combinations of the two models or are based on other methodologies but the idea of the test design techniques selection is to define method how to create test cases. (ISTQB 2011a, 39.)

A test analysis creates a readable test case plan where explained test case has individual identification code, understandable test case name, refer specification requirement(s) point(s), explaining what are inputs and outputs of the test instance. The output of test analysis is understandable document which point test environment equipment can be identified and invested. Also based on this document test environment architecture can be designed and topology diagrams can be drawn. Test analysis gives also input for test case writing and test automation planning which target is to finalize the design phase before test execution can be started.

Before the service transition phase can be started, all the plans of the service strategy and design phase should be reviewed with quality in mind. The review process should verify that are all plans are up to date and ask appropriate questions to check that are plans include all relevant information of release timeline, milestones and other important dates. Is there consideration for all known constraints, requirements, changes, problems and risks and are those impacts implemented in schedule, budget, resource reservation and technical plans? Do people have sufficient skills to do the job and is there plan for training? Plans include information of necessary equipment for test environment? And the people who should execute the plan understand and have requisite skills to do it? And at last the metrics should be defined to measure strategy and design phase goodness after I&V project is finished so improvement actions can be done and lessons learned can be shared for future projects?

5.2.2 Service transition

Many organizations deliver significant changes through formal projects, and the failure to ensure that projects address the full service management and operational requirements as well as the functional requirements can be a costly, or even fatal, mistake to an organization. Service transition ensures that the transition processes are streamlined, effective and efficient so that the risk of delay is minimized. It establishes assurance of the expected and actual service deliverables, and integrated elements that each service depends on to deliver and operates the service successfully. These elements include applications, infrastructure, knowledge, documentation, facilities, finance, people, processes, skills and so on. (ITILv3 2011b, 20.)

In large and complex software and embedded system products, there are many interdependencies to manage and conflicting priorities to resolve. Integration and verification work in virtual wide global environment particularly influence organization use of service and associated risks of required high quality. Most often large and complex programs have changes and when there is a change then there is complexity and risk. Service transition takes consideration of change management, quality assurance and risk management, and not forgetting effective program and project management. This leading and management process is not only focusing a one particular I&V project, but across all projects in I&V service portfolio to cover full and comprehensive view of test execution, reporting and problem solving activities.

The benefits of the service transition model, according to ITILv3, will enable the test project's costs estimation, timing, resources requirements and risks associated to project to be done more accurately. Senior leaders and project managers can have a real time window for the existing test environment and overall service and base their forecasting on real time data of performance. Changes can be higher in volume than it could have been before by using of controlled change management system without excessive amount of uncertainty and chaos. It is easier for people to adopt and follow the changes and management

knows exactly where and when changes are happening. Transition model enable assets to be shared and re-used across projects and it reduces delays and unexpected conflicts and deficiencies in test environments. Service transition model improves expectation setting for the project's customers, users, suppliers, partners and other projects. Service transition model increases confidence that new project (service) can be delivered by specification and high quality, but not causing service deterioration to existing services and this model ensures that new projects will be maintainable and cost-efficient. Service design stage defines source of the triggers that initiate work elements within the service transition stage but inputs can come from the business customers through a strategy change or from audit or Continual Service Improvement (CSI) or Six Sigma processes. CSI deliver inputs of suggested improvements to policy, practices and processes, which could be based on audit and other improvement exercises with customer and other stakeholders.

Figure 11 shows the recommended service transition model for I&V. It is based on five different management process model which are change management, knowledge management, release & deployment management, testing and verification management and configuration management system. The purpose of service transition is to give tool box for leaders and managers for executing created strategy and designed project plan with high quality which can be measured and control effectively and give value for business and customer satisfaction (ITILv3 2011b, 38). Capacity and ability to handle changes and releases across product program lifecycle can significantly improve integration and verification organization ability to react high quality requirements of customer. It enables the service provider to align the new or changed service with the customer business requirements and business operations. It should also be ensured that the business operation of the customer gets the maximum value in the given timeline. I&V organization ability to adapt quickly to new requirements and changed market conditions improve competitiveness and productivity in the high competitive market area where time and cost of product testing are key perfor-

mance indicators of organization survival in long run, this needs solid system for the five service transition management process model.

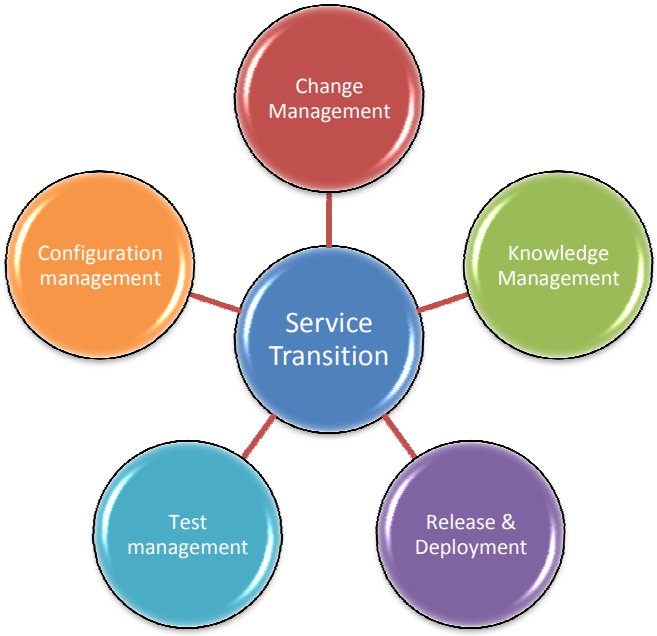

FIGURE 11: *Service transition model for I&V*

The service transition success of the leading and management point of view is implementation of service transition measurement. Monitoring and controlling the performance of the service transition management phases and lifecycle which includes test execution, reporting, problem solving and regression testing of releases stages should focus on the delivery of the new or changed service against the predicted levels of defects (on product under test or test environment), resources and constraints within the service design or release package.

ITILv3 service transition defines that measurements should therefore be aligned with the measures of service design stage defined targets of project scope and requirements. Measurements and control activities can concentrate for example for resource utilization against capacity which could be indicates of changed situation on project environment. During the project execution there could be unexpected changes from the customer, under or over planned resources, in-

creased or decreased productivity in staff (training or some people change) and so on. All the changes against the numbers and targets defined in the service design stage should be visible during execution phase of test project. There are also other measurement indicators which should be taken in the consideration when planning and implementing service transition management model for organization; those are costs against approved budget, time, capabilities, quality level of service (satisfaction rating of the customer organization which I&V service is targeted for), errors, incidents, changes and risks. Monitoring and controlling I&V test project execution phase by service transition model can give tools for proactive approach to react cost of testing and evaluation versus cost of incidents. It also defines tools to indicate operational problems that could cause delays or stakeholder's un-satisfaction. Controlling of the measured key performance indicators can give cost savings by changing the project and test plan defined on service design phase. Also reacting fast to urgent late incidents, changes and releases by sharing assets and test environments could save time and increase overall productivity to keep customer satisfaction on high level. Well designed and planned service transition model motivate staff and improve job satisfaction. It also improves communications and virtual team working between different groups and overall performance is enhanced.

5.2.2.1 Change management

Changes could arise from different reasons and from different stakeholders. Those can be any kind of reasons related to project scope and requirements, strategy, mission, operational, financial, and technical or human resources related issues. A change to the scope of a project or to the specification of a deliverable is made by a formal, proactive process. The change process embraces everything that results from the change required or new opportunity identified, and includes agreement on the change decision process, agreement on the need for change, and the decision to accept the change and its implementation. This applies for all kinds of changes. Change management identifies, describes, classifies, assesses, approves or rejects, realizes and verifies changes against legal and other agreements. Changes can be requested by any party and have

to be managed as both proposed and approved changes, as well as properly communicated to all relevant interested parties. For the management of a change, its direct and indirect effects on the whole project, program or portfolio and their contexts are taken into account. The impact of the changes on the project deliverables, configuration, time schedule, cost, finance plan and risks are determined by comparison with the project baseline. Once the changes have been accepted, the project plan is adjusted accordingly. (International Project Management Association 2012, 37)

The ISTQB is defining change management from the aspect of test management as follow: changes to project scope can influence the overall schedule, budget, features and quality goals of the project. Changes must also be managed in order to be tracked, scheduled and assessed regarding impact. A good change management system is a requirement for a well-managed project. The test manager, in particular, needs to track all changes that affect the original estimates and schedules. It is important to remember that these changes are not limited to additions or deletions of features. Any change that affects the testing aspects of the project must be considered. For example, if the development team does not receive a server they need for compatibility testing, the test team will be affected and may be expected to perform this additional testing.

> The test manager must be vigilant regarding any changes to the project that could affect the testing aspects of the project. If proper impact analysis is done for every change, the test manager must be included in the analysis. If little or no impact analysis is done by the team, the test manager should drive an impact analysis process and ensure adherence to that process. In agile projects, change is an accepted, even welcome, reality. In order to deal with the constant changes inherent in agile projects, the test manager must have a lightweight and quickly adaptable solution that will be flexible enough to handle the changes. Established agile practices help to guide this flexibility by providing simple yet efficient solutions. (ISTBQ 2011c, 49.)

Leading of service portfolio and service transition need to have knowledge of changes in the current projects and test project managers need to have understanding how changes affect current project scope or test execution. For example test environment changes could affect negatively to test results and project

outcome which could have direct influence for quality of product under test. ITILv3 change management model optimizes risk exposure, minimizes severity of risk impact so it can be successful from the first attempt (ITILv3 2011b, 77). High quality management requires executive management support to increase the success rate of changes. Quality of changes need implementing a culture that reduces unplanned work and reduces timescales to meet deadlines, saving money and analyzing testing actions. Senior management must define policies and standards for change request on how to make decision and implementation for required changes. Also, change policies need to be clear for external parties of I&V organization and there should be visible view what must be done and how it is effecting and what are consequences if the policy is not followed.

According to ITILv3 policies, support change management needs culture of change management across the organization where there is zero tolerance for unauthorized change. Change management is aligned with business, project management and teams, and all stakeholders which have relations to each other work progress. Changes need to have a prioritization policy and there has to be accountability and responsibility for changes through the service lifecycle to control probability of conflicting and disruption the business, production and test environment. This is preventing people from making unauthorized decision or changes on their work flows, scrum sprints or production and test environment. Change management is integrated with the whole process of the enterprise together to establish traceability of changes, detect and identify change related incidents. A performance and risk evaluation can be done for all changes that could affect service capability and progress efficiency. (ITILv3 2011b, chapter 4.2.)

The purpose of change management process is to ensure standardized methods and procedures are used for efficient and prompt handling of all changes to service assets and configuration items are recorded in the configuration management system (CMS) and overall business risk is optimized (ITILv3 2011b, 77-78). CMS process is to ensure that all changes what could relate to service (project) under execution, coming from internal or external stakeholder, are rec-

orded and then evaluated, authorized, prioritized, planned, tested, implemented, documented and reviewed in controlled quality manner. Those changes what could have wider impacts to I&V service or business program should be evaluated and decided by senior management team and project or test plans need to be adjusted by project managers according to changed scope. CMS purpose is to reduce failures, disruptions, defects, and rework to meet business timelines and milestones. The risks related to changes are evaluated and mitigation plans are created. All changes have estimations of quality, time and cost increase or decrease productivity of service (project). CMS notifying parties of what is proposed planned and implemented and who are under the change scope. It is also identify problems and resolving incidents caused by change. All new ideas and innovations what could cause new changes can be introduced and configuration, releases and implementation changes related to new ideas can be tracked and analyzed. The change management process must be connected to release and configuration management which help managers evaluate the impact of the change on current and planned services (project) and releases. (ITILv3 2011b, chapter 4.2.)

There are different kinds of process models for change management process. These process steps are defined by International Project Management Association institute and can be found on NCB 3.0 (International Project Management Association 2012, 30).

The process steps have to be defined to match the target organization working model and culture but should follow at least these process steps:

1. Decide on change management policy and process to be used.
2. Identify all proposed changes.
3. Analyze their consequences to the project.
4. Seek authorization for the changes, where necessary.
5. Get changes accepted or rejected.
6. Plan, execute, control and close approved changes.

7. Report status of changes after completion.
8. Monitor effect of changes against project baseline.
9. Document lessons learnt and apply to future projects.

Also ITILv3 Service Transition model gives example of change request process steps which can be found figure 12. ITILv3 model differ only a little form NCB 3.0 model by whereas changes are evaluated towards whole service portfolio and business impacts not only certain individual project. In figure 12 the term RFC refers to the word request for change.

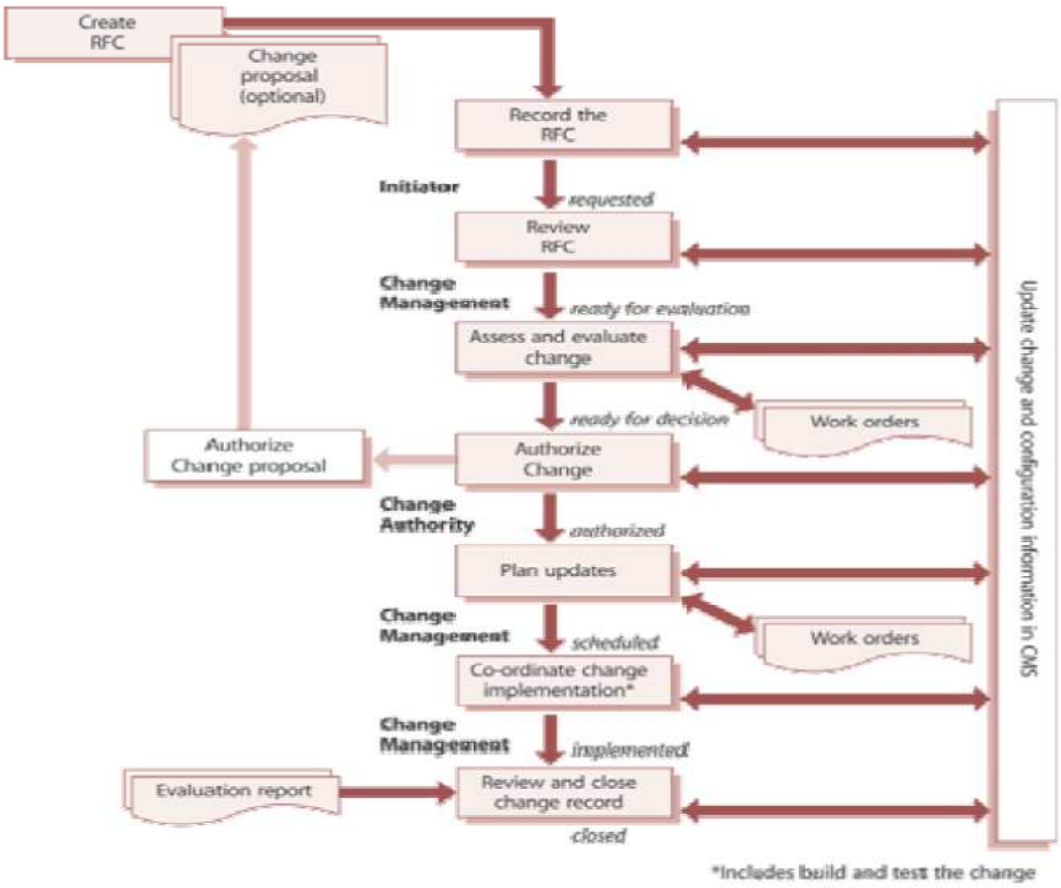

FIGURE 12: *Example of change request process by ITILv3 service transition model (ITILv3 2011b, 89)*

The change management must ensure that the key performance indicator (KPI) measures have specific meaning. While it is relatively easy to count the number

of incidents that eventually generate changes, it is infinitely more valuable to look at the underlying cause of such changes, and to identify trends. Better still is to be able to measure the impact of changes and to demonstrate the reduced disruption over time because of the introduction of change management, and to measure the speed and effectiveness with which the service provider responds to identified business needs. (ITILv3 2011b, 115.)

The selecting of proper KPI for change management enables monitoring and controlling of test project changes. KPIs of change management should follow numbers of implemented changes which are affecting project time, cost or quality. There should also be indicators of rejected request, unauthorized changes, backlog of change request, change success and fail rate, average time to implement change and incidents attributable to changes. Problem management and continuous service improvement models are related tightly to change management and its key performance indicators. Management should look at the underlying cause of changes, identify trends and be able to measure the impact, effectiveness and speed of changes to improve business value.

5.2.2.2 Knowledge management

> Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers. (Duhon 1998, 8-12.)

Knowledge management is about managing the knowledge or organization. Mostly leaders and managers ability to deliver quality of service rests on the ability of managers to respond and react for knowledge of the situation of teams and customers changing circumstances or behaviors. The knowledge can be categorized to three different groups: explicit, implicit and tacit information (Koenig, 2012.)

Explicit information or knowledge that is set out in tangible form, it is easy to communicate, store, and distribute and is the knowledge found in books, on the web, and other visual and oral means (Explicit knowledge 2013). Implicit infor-

mation or knowledge that is not set out in tangible form but could be made explicit, it is that which hasn't yet been "put together" either by expression, concept development, and assumptions that lead to principles, or through analysis of facts or theory. Implicit knowledge can be very different when the work task have been described, compared to how it is performed or observed by worker. When describing implicit knowledge to explicit knowledge, it may need to take some particular approach to explain this knowledge for tangible format. Tacit information or knowledge is such that one would have extreme difficulty operationally setting out in tangible form, it is integral to the entirety of a person's consciousness, is acquired largely through association with other people, and requires joint or shared activities to be imparted from one to another (Tacit Knowledge; IT toolbox 2013, Implicit Knowledge; Dienes - Perner 1998.)

"The purpose of knowledge management is to ensure that the right information is delivered to the appropriate place or competent person at the right time to enable informed decision" (ITILv3 2011b, 256). The quality of management decision is based on that reliable and secure information is available throughout the service lifecycle. And organization has ability to identify and produce knowledge that will help management to do decisions with high quality and effectively. During the service transition phase test management need to design a systematic process for organizing, distilling, storing and presenting information in a way that improves project and test reporting practices, generating new knowledge information, capturing and spreading information for stakeholders (ITILv3 2011b, 261).

Knowledge management and data information management deliver conformance of reliable data for monitoring progress, assessing status and decision making. The knowledge and information management system enable management review and audits which support decision making process of future projects and can enable corrective actions or changing the scope of project. There are several key performance indicators which can be selected by target organization needs but not listed all in this context. Those selected KPIs should support management to check responsibilities, and decision makers of the project

or systems, check consistency and deviations from plans, check adequacy of management procedures, test process effectiveness, indicate risks, evaluate risk impact mitigation plans and follow action items lists. (ISTQB 2012, 48.)

In addition knowledge management includes lesson learnt database system. The implementation of a lessons learnt system may arise many of difficult practical issues which should be defined before taking lessons learnt database in use. Lessons learn database target is to ensure that good practices can be repeated and poor practices are not repeated or try to be avoided in the future if possible. ISTQB recommends lessons learn database is including the following (ISTQB 2011c, 15):

- Was the user representation in the quality risk analysis sessions a broad enough cross-section? For example, due to late discovery of unanticipated defect clusters, the team might have discovered that a broader cross-section of user representatives should participate in quality risk analysis sessions on future projects.
- Were the estimates accurate? For example, estimates may have been significantly misjudged and therefore future estimation activities will need to account for this together with the underlying reasons, e.g., was testing inefficient or was the estimate actually lower than it should have been.
- What are the trends and the results of cause and effect analysis of the defects? For example, assess if late change requests affected the quality of the analysis and development, look for trends that indicate bad practices, e.g., skipping a test level which would have found defects earlier and in a more cost effective manner, for perceived savings of time. Check if defect trends could be related to areas such as new technologies, staffing changes, or the lack of skills.
- Are there potential process improvement opportunities?
- Were there any unanticipated variances from the plan that should be accommodated in future planning?

All these questions need to be carefully thought out and resolved, and the mechanisms of lessons learning designed and put in place before a lessons-learned system is launched. Inattention can easily lead to failure and causing insufficient efforts to improve right things which are relevant to overall service portfolio lifecycle.

5.2.2.3 Enterprise release and deployment management

Release management is the process of managing software releases. On enterprise level release and deployment management process cover of quarterly, monthly or weekly release windows for software releases, also prioritizing the contents of each release, understanding the complex dependencies of components and different teams, and tracking delivery as they meet the integrated delivery targets. Enterprise release management also contains the alignment of testing support for the coordinated release strategy.

The need for new software release can arise from new systems or major function blocks delivered through major programs or projects. It could also be routine minor enhancements in the form of change requests or defect founding form of the test organization defect reports or customer organization incident requests. The objective of enterprise release management is control changes in software in production between different teams and organizations that are continually developing and implementing new code for products. Release management is essential for software engineering management and it is necessary in order to minimize the risk of business.

Release management process allow higher throughput by absorbing higher rates of change to systems whilst maintaining service quality through when a unified well understood and controlled release process has been implemented. This allows increased productivity allocation of test environments to support releases and product development project timelines can be faster for customer environment.

The release management should be designed and implemented so that is enhanced agility and flexibility with all teams working together to achieve wanted outcome. The information of the changes and new emerging needs are able to quickly show the impact of schedule and risk factors to each team progress. The changes in each team work flow and near future activity plan are reflected via release management process to eliminate risk factors between teams of input information of each other progress of software components release plan and depends of overall release plan. Collaboration throughout information sharing and instant communication of schedules, changes, priority and status are metrics for management to lead organization to produce right software components just in time. The objective of release and deployment management is to ensure that there are clear and comprehensive release and deployment plans that enable the changes in projects to align their activities with these plans. A release package can be built, installed and tested efficiently to a deployment test environment successfully and on schedule. A new or changed requirement and its enabling software components and systems are capable of delivering the agreed requirements of customers in time. There is minimal unpredicted impact on the software developing, testing and support organization productivity. (ITILv3 2011b, 152.)

Release management can be built on software developing management tools, process and project management disciplines to have single view of release schedule for given time frame and run complex relational queries based on management requirements. Management can create metrics to follow critical components developing time line and priorities actions according to view. This gives tool for viewing of issues, risk, defects and deployment request of certain software components team release plan progress and move towards mature software configuration management process.

5.2.2.4 Test management

> In order to be a strong manager and effective leader, a test manager should strive to use appropriate management and leadership principles and techniques. Many of these are not specific to test management, but

> rather are general principles and techniques that are widely used for the management of technical teams or teams in general. (ISTQB, 2011c, 26-27)

Test management processes are concentrated and involved with testing activities to carry out value for part of program or business aimed at delivering system for internal or external use. Test manager responsibilities are to secure and utilize resources for testing to support the overall product development program and control test process including associated activities and work to support product development lifecycle in which testing occurs to secure quality of the final deliverable to customer. The stakeholders could have direct or indirect interest or involvement of testing activities and they could have direct or indirect effect by the quality of the deliverables produced by the program. Usually test management has to evaluate quality of test work and products produces outside of testing organization in the context of larger set of product development lifecycle. That is why test management must take consideration in their planning and implementation with understanding of how other product development teams activities affect testing and how testing affects to other teams work. Successful testing depends on all stakeholders understanding that testing cannot give any absolute guarantees of failure free products but it provides a measured degree of confidence. The required degree of confidence varies depending on the customer's business requirements and pressures of an organization and ability of test management practices.

Relations of the test organization to other organizations depend on the type of project, chosen software development lifecycle and the other test stakeholders and other organizational and people related factors. Testing activity is closely interconnected to requirements engineering and systems engineering where test manager and technical specialist need to consider requirements during the scoping and estimation of test effort. Also management practices have to take notice or be aware of change to the requirements and implement solid control actions to implement changes. Test manager have to have skills of project management practices to provide project plan, schedule and resource requirements to the program or business management. The test manager must have

understanding of changes in the program plan and proper process tools to adjust the test activities according to changed scope. The test manager and I&V organization must establish or support the test object delivery processes and mechanism for configuration management, release management and change management and plan and implement those in test management plan. The test manager should have processes and action plan to work with software development managers to coordinate the delivery of the test objects and participate in defect management. The test manager should have technical support process to ensure proper delivery of test results during test closure so that program management is aware of known failures and workaround after first test execution is ready and/or quality milestone is approved. Also the test manager should organize analyzing of failures in the product in order to improve and implement test process improvements. Test management process should include also technical documentation to ensure that test environment and used practices are well documented in professional way for feedback analyzing purpose to improve test process and test team work. (ISTQB 2012, 18-19.)

Test management practices should support strong information sharing and communication methods to ensure that the test team understands their group's role within project and their individual role within the test team itself. The testers and test leaders should have good interpersonal skills and communication needs to be constructive. Information and communication sharing methods are wise to standardize inside I&V service portfolio on those parts as possible by using report templates and information sharing channels like Microsoft SharePoint workspace for example. ISTQB defines that

> The test manager should create communication plan and method to share necessary information with the test team to have correct and current information so the team can successfully carry out their duties. In order to be an effective leader, the test manager must display strong active listening skills and communicate two-way so that informed decision can be made effectively. Information should be available via organization management tools that will provide current project status and important hot topics to all project stakeholders on those parts which are relevant to them. (ISTQB 2011c, 26.)

The process of managing problems and defects includes a large number of difficulties and challenges when projects are matrix based virtual organizations. In a service-oriented management model that describes the concepts of continuous service improvement model, and connections between problem management and other service support processes, a service would perform as designed each and every time it is executed as human or other factors come into play. In many cases, those factors are the result of errors or challenges in the service or a test management process supporting the service that must be addressed. (Jäntti, 2008, 3.)

When products are complex and development organization is large and dispersed, the testing management becomes challenging. Especially when there is pressure to bring software too early to testing, it could lead to a flood of failures. And that is an extra challenge for both sides, as test engineers need to verify fixes when they have been done, and development needs to understand which defects are the most important to focus on. “A large number of defect reports leads thus to increased communication needs and, presumably, to increased communication quality requirements” (Pääkkönen – Sajaniemi 2009, 7). The improved test management system contains quality data of various projects which enables better reporting mechanisms and more advanced reporting system by using common terminology across organizations to improve communication during problem solving and test reporting. “A common terminology with clear definitions for the terms increases honesty in expression” (Pääkkönen – Sajaniemi 2009, 9).

From the point of view of the test management the quality of service portfolio needs to be considered by senior leaders for creating service level key performance metrics based on test management process in use for continues improvement of test management practices in the organization. The target is to reduce the impact of incidents and errors in live that are attributable to newly started services (or project). There is also a target to have more effective use of resources and more intensive involvement with the program (or business). Reduced delays in testing that can impact the business and increase mutual un-

derstanding of the new or changes in the project. Improving the understanding of roles and responsibilities associated with the test organization between the program management and business, can be achieved by measuring of changes in the project scope and measuring budget and resources requirements. ITILv3 Service transition model defines also several key performance indicators for test management (ITILv3 2011b, 241-243):

- Test planning, preparation, execution rates
- Incident, problem, event rates
- Issue and risk rate
- Problem resolution rate
- Resolution effectiveness rate
- Stage containment – analysis by service lifecycle stage
- Repair effort percentage
- Problems and changes
- Late changes by service lifecycle stage
- Inspection effectiveness percentage
- Residual risk percentage
- Inspection and testing return on investment
- Cost of unplanned and unbudgeted overtime to the business
- Cost of fixing errors in live operation compared to fixing errors early in the lifecycle
- Operational cost improvements associated with reducing errors in product returns.
- Effort and cost to set up a testing environment
- Effort required to find defects – i.e. number of defects (by significance, type, category etc.) compared with testing resource applied
- Reduction of repeat errors – feedback from testing ensures that corrective action within design and transition (through CSI) prevents mistakes from being repeated in subsequent releases or services
- Reduced error/defect rate in later testing stages or production
- Re-use of testing data

- Percentage incidents linked to errors detected during testing and released into live
- Percentage errors at each lifecycle stage
- Number and percentage of errors that could have been discovered in testing
- Testing incidents found as percentage of incidents occurring in live operations
- Percentage of faults found in earlier assessment stages – since remedial costs accelerate steeply for correction in later stages of transition
- Number of known errors documented in earlier testing phases.

From the point of view of the test management critical success factors include the understanding the different stakeholders perspectives that underpin effective risk management for change impact assessment and test activities and building a thorough understanding of risks that have impacted or may impact successful service transition of services and product releases. The test management should encourage a risk management culture where people share information and take a pragmatic and measured approach to risk mitigation. Quality is built into every stage of the service lifecycle using a structured framework and issues are identified early in the service lifecycle. The target is to develop test management models which are reusable and those can be used for new test projects in future. (ITILv3 2011b, 243-244.)

5.2.2.5 Configuration management

No organization can be fully efficient or effective unless it manages its assets well, particularly those assets that are vital to the running of the customer's or organization's business (ITILv3 2011b, 118). During service transition stage configuration management should be planned and implemented. And from the testing perspective it is important to maintain integrity of the products of the software or system throughout project lifecycle. All items of the product or system testing need to be identified, version controlled, tracked for changes, related to each other and related to development test objects so that test items,

documents and tests can be uniquely identified and reproduced when necessary. The configuration management supports business and customer control objectives and requirements and efficient after sales (service management) processes by providing accurate configuration information from test process activities and development items. It providing accurate configuration information and authorize change and releases, resolve incidents and problems and minimize the number of quality compliance issues caused by improper configuration of test environment, product or system. Configuration management objective is to define and control components of test services and test environment and maintain accurate configuration information on the past, current and planned state. It ensures that selected components of the system product are identified and maintained. All changes to those are controlled and all releases into environment and operation use are done on the basis of formal approvals or documented way. All these actions are providing test leaders better forecasting and planning of changes, and all approved changes and releases can be planned and implemented reliably. Incidents and problems related to test execution, environments and product or system under test can be linked together. And it gives possibility to identify cost for a service. The configuration management system maintains the relationships between all service components and any related incidents, problems, known errors, change and release documentation and may also contain corporate data about employees, suppliers, locations and business units, customers and users. The configuration management system typically contains configuration data and information that combines into an integrated set of views for different stakeholders through the service lifecycle. It therefore needs to be based on appropriate web, reporting and database technologies that provide flexible and powerful visualization and mapping tools, interrogation and reporting facilities. (ITILv3 2011b, 118-124.)

Figure 13 shows the basic concept of the configuration management model for I&V organization. This picture is not comprehensive but gives basic understanding of relationship of components connected together.

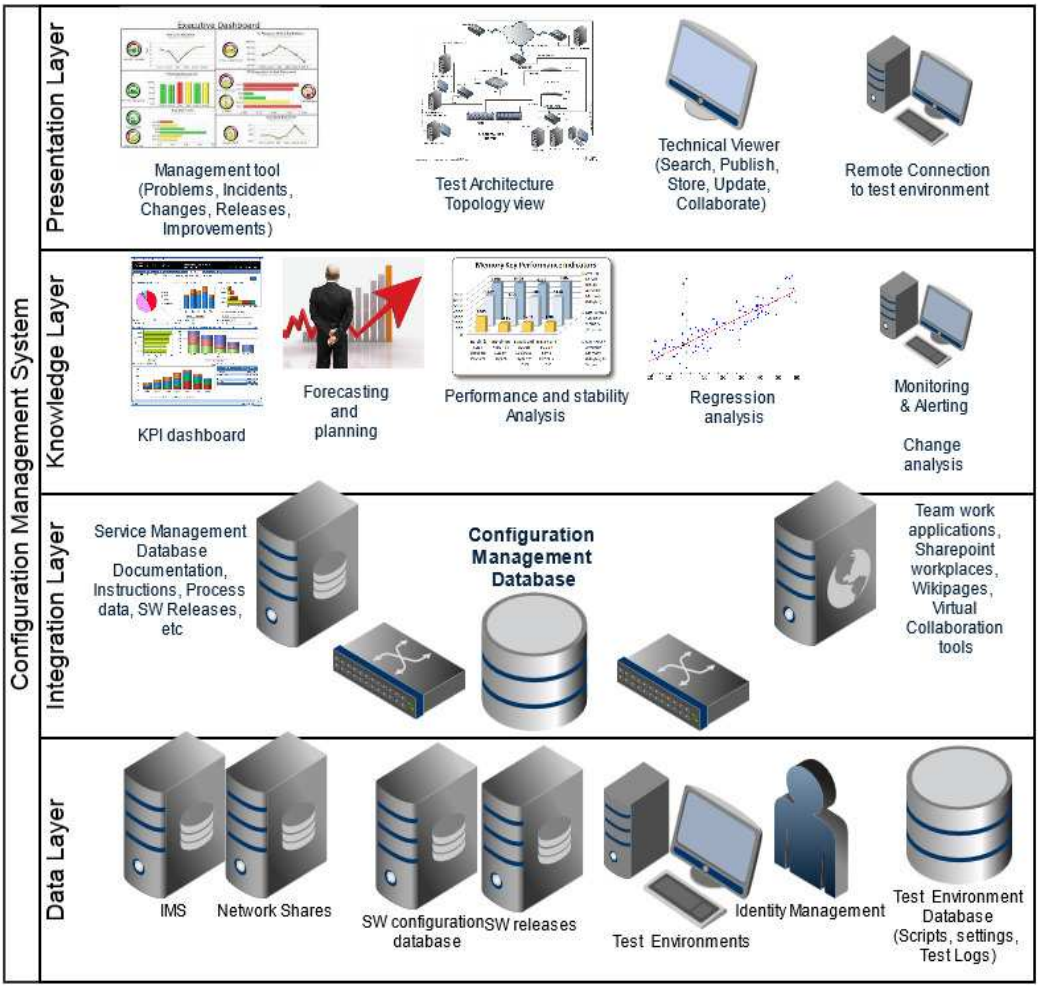

FIGURE 13: *Example of Configuration management for I&V purpose*

An example of asset and configuration management plan contents contain information from the I&V service as follows:

- Applicable services (project, product, system etc.)
- Environments and infrastructure
- Geographical locations of test environments, components and products.
- Link to policy, strategy, business, service management and contractual requirements
- Summarize requirements for accountability, traceability, audit ability
- Link to product and system requirements
- Link to project and test plans

- Policies
- Standards, e.g. ISO/IEC 9100, ISO/IEC 14000
- Internal standards relevant to configuration management, e.g. hardware standards, software standards, testing standards.
- Organization for configuration management:
    - Roles and responsibilities
    - Change and configuration control responsibilities
    - Authorization – for establishing baseline, changes and releases.
    - Asset and configuration management system and tools
    - Selection and application of processes and procedures to implement Asset and configuration management activities, e.g.
- Configuration identification
- Version management
- Test environment management
- Supplier management
- Configuration change management
- Release and deployment
- Build management
- Test management
- Establishing and maintaining configuration baselines
- Reference implementation plan, e.g. data migration and loading, training and knowledge transfer plan.
- Relationship management and interface controls, for example: with financial asset management , projects, suppliers, and development management

Configuration management system contains also integration to enterprise resource management system components such as incident and event management systems, release management systems, information management systems, project and portfolio management systems and other relevant databases which are important for I&V project management and test management. (ITIL, 2011b, 130.)

5.2.3 Output of service transition model

As described earlier service transition is based on five different management process models which are change management, knowledge management, release & deployment management, testing and verification management, and configuration management system. There are several performance indicators which are relevant to follow to make sure that testing service fulfills the targets. The final outputs from service transition are approved released package of product or system under test and associated documents for the customer and/or community to whom testing services are delivered following successful service transition. Also outputs from service transition are continual service improvement proposals and observations on changes required improving processes within service transition and those which influence also for service design and strategy stages in I&V service portfolio model. It is essential to recognize that raising risks and issues are identified which may directly influence to processes or may affect elsewhere within or outside service transition. Understanding of business needs in the context of the testing service one should be aware to avoid any potential impact for final outputs.

The key to continual service improvement and Six Sigma quality improvement action is the ability to measure and report against the performance of processes, services or projects. Mostly in I&V organizations there has been more emphasis on capturing technology metrics especially at the software components defects level and less emphasis on service metrics. Captured service performance process metrics must be evaluated towards performance baseline or benchmark designed in service design and transition stages. These metrics are captured and those report on the wellbeing of the service level of organization and identify potential improvement opportunities if the quality is lacking. The improvement opportunity could be the subject of Six Sigma project. In order to apply Six Sigma there is requirement of measured process data and those processes are repeatable. Otherwise Six Sigma methodology has little applicability. (Probst – Case 2009, 14.)

5.2.4 Service operations

> The purpose of service operation is to coordinate and carry out the activities and processes required to deliver and manage services at agreed levels to business users and customers. Service operation is also responsible for the ongoing management of the technology that is used to deliver and support services. (ITILv3 2011a, 33.)

Daily operations of processes have to be properly controlled and managed because otherwise there will be little value of well-designed and well implemented plans. Also improvements cannot be possible if day-to-day activities to monitoring performance, metrics and data gathering are not systematically done during operational service. On-going management processes that are active to testing service and technological services which are integral part of the management of the service themselves, including of infrastructure and environments of test service, and people who drive and decide how this will be done need execution plan, monitoring and controlling during service operation. According to ITILv3, ultimately, it is people who manage the technology, processes and services and "failure to recognize this will result in the failure of projects" (ITILv3 2011a, 33). The key of service success surround on processing labor time and skills available and every lifecycle provides value to business. The operation of service reflecting plans, designs and optimizations which has been done in earlier stages, are executed and measured. Service operation plan and execution is responsible for enabling the business to meet its objectives by performing plans and processes defined on other stages from a customer point of view where actual value is seen. Technology and its components which support testing service functional delivery is part of service operation effective daily execution. The principle is based on effective managing of daily aspect on operations of all performance roles of personnel maintaining a perspective of the greater context of project. (ITILv3 2011a, 33-39.)

It is more than repetitive execution of a standard set of procedures or activities which are designed to deliver agreed level of services but the reality is ever-changing environment what needs to be managed without losing agreements of targets. The testing service to business must provide a timely and state of quali-

ty to allow business to conduct its own activities and customer's needs to be met. It is important that personnel are trained and not only how to perform test activities but also how to improve processes, understand business and solutions under development, understand customer business, have product and technology knowledge, have skills working across boundaries, improve information sharing and seeking, know how to influence others, have skills for planning and organizing, have outstanding problem solving skills and improved communication skills including networking ability.

> A critical element of being a proficient service provider is placing as much emphasis on recruiting and training staff to develop competency in dealing with and managing customer relationships and interactions as they do on technical competencies for managing the environment (ITILv3 2011a, 56).

The communication has big role in operational stage; it must be professional, objective and effective between testers and other stakeholders. "Diplomacy and objectivity are required when providing feedback, particularly constructive feedback, on the work products of others". Communication should be focused on improving quality both in products and the processes used to achieve agreed level of service. The audience is wide and it includes test team members, management, external groups and customers so communication must be effective for target audience and should be viewed as opportunity to promote quality and quality processes. It is also important that quality documentation is produced by all personnel and management promotes quality of it and its importance. (ISTQB 2012, 76.)

Service operation primary tasks in testing organization are handling request, incidents and problems management, events management and manage day to day operations of hardware and software used in testing environment. This concept is shown in figure 14.

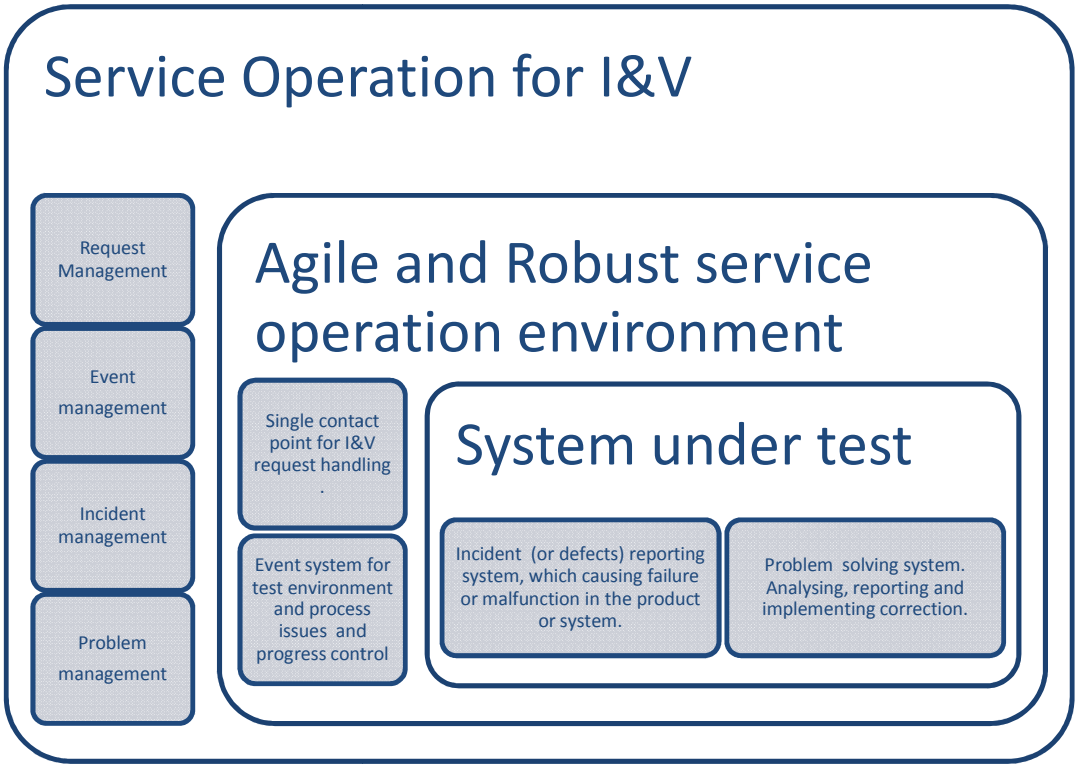

FIGURE 14: *Service Operation for I&V, modified model from ITILv3 by author*

5.2.4.1 Request management

The request management helps the I&V service provider interact with an internal customer via a single contact point and provides professional experience for requesting testing related services. Service request could come from development, external stakeholders, business or program management which is needed to receive, review, clarify, analyze the impact, create related change or work order, allocate resources, request to start implementation, provide status update, notify resolution and request closure and final save the related documentation or results. Figure 16 describes basic request process model.

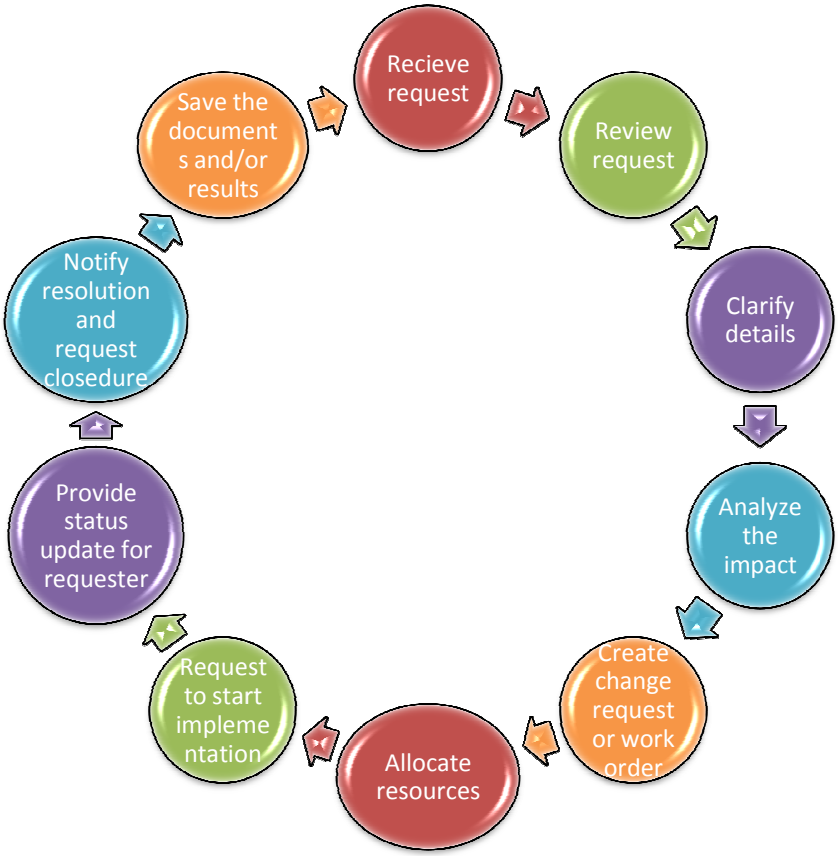

FIGURE 16: *Request process model*

Request fulfillment is the process of dealing with service request which are smaller and low-risk changes, but gives link to create bigger change request for upper layer service transition layer if necessary. “Smaller, often standard, changes can be handled through a request fulfillment process, but larger, higher-risk or infrequent changes must go through a formal change management process” (ITILv3 2011a, 36). Implementing request management portal offers value for customer by improving customer satisfaction with end-to-end visibility of the process lifecycle and enables to implement process metrics to follow up request amount and improve possible problems or lacks in service delivery process.

5.2.4.2 Event management

Event is a piece of data that provides information of one or more system resources or it could be manually reported results or action of the test team member or notification that action has occurred. Event can be generated by people, automated tools or process. In the context of I&V services event management should be considered as management system to notice such kind of events which are not directly reported via incident and defect reporting system. Those events can relate to test environment issues or problems which are affecting work flow and progress negatively, but are not direct failure of software, hardware of system components of test environment.

“An event can be defined as any detectable or discernible occurrence that has significance for the management of the test environment or the delivery of test service and evaluation of the impact a deviation might cause to the services” (ITILv3 2011a, 67). Its purpose is to detect, investigate and determine correct control actions and provide early mechanism to avoid problems that may infect project or certain task schedule, outcomes or budget or test service quality. It may include the organization’s objectives for managing events, assigned roles and responsibilities, ownership of tools and processes, critical success factors, standards, and event-handling procedures. “The linkages between the various departments within the organization required handling events and the flow of this information between them is the focus of event management” (Bhe – Glasmacher & co. 2004, 4). In the context of the test service management, event management can be linked to risk management and problem management processes, since events are used to report problems or deviations against the plan, committed work task or normality. Figure 17 shows how the event management can be considered as reactive process of handling risks or problems and risk management process as proactive method where problems are beforehand investigated and mitigated based on statistic historical data. Also there is linkage between event management and change management as, when some event is so major that it causes wide impact to project it should be trigger as change request. But “an event cannot provide value to an organiza-

tion in managing its system resources unless the event is acted upon, either manually by a support person or automatically by software" (Bhe – Glasmacher & co. 2004, 6).

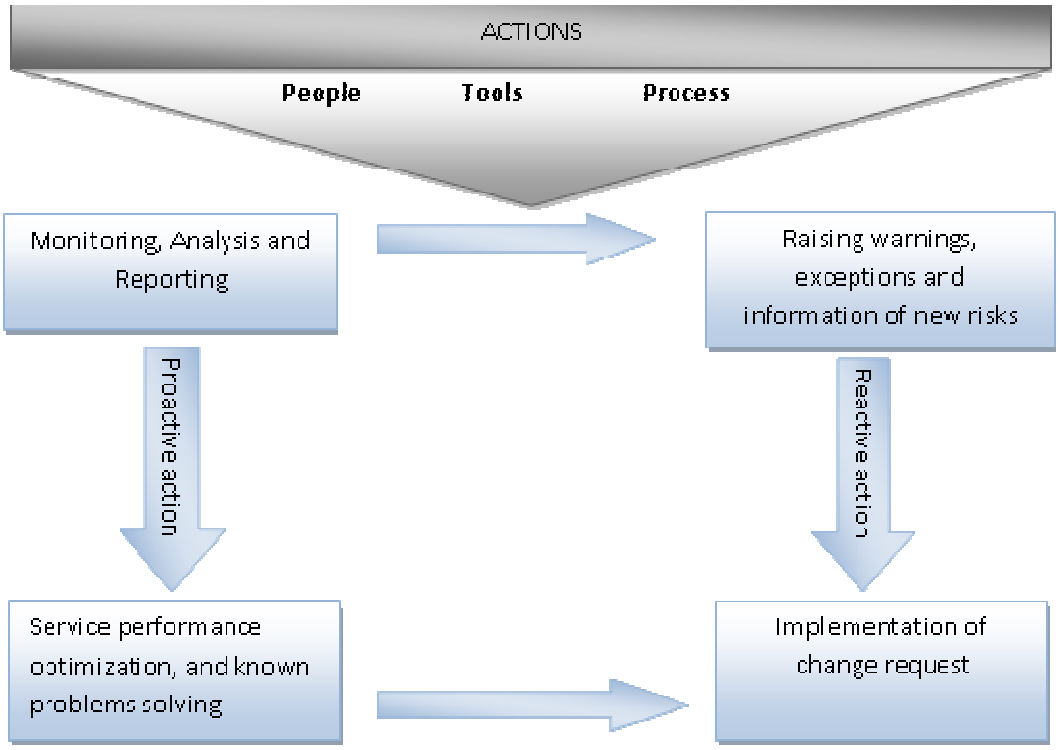

FIGURE 17: *Event management and its relation to other process*

The event can be information, warning or exception in process, work flow or test environment tool or system. The event flow begins at the point of generation of the event, known as the event source, which can be generated by person, automated tools. The source of an event may be the failing system itself, as in the case of a router that sends information about its health to an event processor. An agent that runs on the system to monitor and report error conditions is another type of event source. The monitoring and control system can be automated process tool or just normal project management tool to follow reported action points and minutes of the meeting. It depends a lot on data available which kind of system can be used or there can be implemented separate event management system to handle all personnel and automated tool generated events.

Event management tools can supply a variety of different metrics for test management. For example, traceability from requirements to test cases and a snapshot of currently available tests, planned tests and current execution status (passed, failed, skipped, blocked, in queue) can be taken at any time. When defined events are collected it gives opportunity to use static analysis tools such as Six Sigma to help detect and report maintainability issues. Analyzed data can supply valuable information from the operational performance of the system and help the test manager understand what to improve. (ISTQB 2011c, 69.)

For example, metrics to monitor events or activities according to approved test plan may include the following criteria:

- Number of test executed against the planned
- Ratio of failed and passed tests against the planned number of test cases
- Total number of found defects sorted out by severity, priority, current state and affected subsystem or some other classification
- Number of change required, accepted, and implemented against the plan
- Project plan metrics against the plan, cost, schedule and other objectives than above listed
- Product quality or risk status
- Test process blocking events or planned changes needing confirmation
- Regression and automation test status

5.2.4.3 Incident management

In ITIL terminology, an incident is defined as: “An unplanned interruption to a service or reduction in the quality of a service. Failure of a configuration item that has not yet impacted service is also an incident, for example failure of one test tool. Incident Management is the process for dealing with all incidents; this can include failures, questions or queries reported by the user, by technical staff, or automatically detected and reported by event monitoring tools.” (ITILv3 2011a, 86.)

The goal of the incident management process is to restore operation and minimize the impact on testing productivity and ensure that the best possible level of service and quality is maintained. Incident management is linked to event management tools and can be used to report events which are causing interruption to service or failure of configuration item in the test environment.

The most important function of incident management includes defect management process which is important for organization to control quality of product or system under test. Incident and defect management process tool used to manage testing work are important not only to the test team but all teams involved in the development of product and managing the project. Information gathered by the incident management allows manager and other project stakeholders to gain insight on the state of a project throughout the development lifecycle, and by collecting and analyzing data over time. It can help locate areas of potential improvement for testing and development processes. The earlier each incident or defect is detected and removed lower the overall cost of quality for the system. (ISTQB 2012, 52-53.)

There are various standards and documents, such as ISO 25000, IEEE 829 and IEEE 1044 for example, to gather incident and defect reporting. Incident and defect reporting that could affect service or product quality should produce enough information about these defects so developers (or other work product authors) can fix them prior to release. Incident (and defect) management process could be containing following steps, see figure 18. Incident identification, which is done by some test team member, is stage where the defect, error or failure is noticed in the product or system under test or if it is defect or failure in test environment. The next step is to analyze the impact the defect or failure and find out the system component which is causing the incident. After analyzing is done the next step is the evaluation of the defect or failure impact against the requirements of the product or system and prioritizing the effect of the defect or failure to product or system. Incident is reported to the incident management system and moved to corresponding development of test team who is responsible for fixing of the malfunctioning component or system. Development

team starts to investigate the reported incident and makes root cause analysis for the defect, if there are difficulties to find root cause or the reported incident is effecting also to other competence area teams then the responsible teams create problem report which is moved to be taken care of in problem management process. Otherwise development team makes correction. Then the next step is to verify the correction by tester. If the verification is passed the incident report can be closed with root cause analysis report. Correction is then delivered to official release which is tested in the regression test phase.

FIGURE 18: *Incident management process*

Interfaces in the incident management are problem management, configuration management and change management. Incident management is the part of the overall process of dealing with problems in the organization. Configuration management provides the data used to identify test environment faulty equipment and to assess the impact of an incident and it can be used to audit the test environment infrastructure when working to resolve an incident. Incident management is related to change management by detecting and resolve incidents that arise from failed changes. (ITILv3 2011a, 100.)

Incident management techniques also include a defect analysis, and it includes activities such as defect prevention, defect discovery, defect resolution. Defect prevention is the analysis of historical data of the past and implementation actions to prevent those same defects in the future. Defect discovery techniques describe the defect finding techniques and/or test cases to be documented and brought to the attention of the test teams and developers acknowledge. Defect resolution is method or process to prioritizing and scheduling the fix. All defects are prioritized and especially during development phase defects which are blocking the testing progress are reported and prioritized to highest possible class for development team to fix. (Jäntti 2008, 26.)

Incident management process model focus only on fixing the defect, and does not give guidance how to manage and solve complex problems occurred in the service or the product.

5.2.4.4 Problem management

The basic concept or problem management is based on incident management, problem management and change management. ITILv3 defines the problem management process primary objectives to prevent problems and resulting incidents from happening and minimize the impact of incidents that cannot be prevented. Problem management activities are focusing on diagnosing the root cause of incidents and finding solution for the problem. After solution for the problem is known the problem management ensures that it is implemented through controlled process like change management or release management process. Change management process ensures that resolution impact is analyzed, implemented and tested in a controlled manner. (ITILv3 2011a, 111.)

Incident and problem management are separate processes but they are closely related to each other. Mostly these two processes use the same tool and similar categorization of impact and priority coding systems which ensure effective communication when dealing with related incidents and problems. Incident management process can be thinking of the first level of defect fixing process where as root cause is trying to be found and solution for that is inside of one a

certain component development team. The second support level is the problem management process which aim is to find root cause for the problem that has not been discovered during incident management process. (Jäntti 2008, 48-49.)

There are also close connections between problem management and other service management processes than incident management and change management process. Information about the problems and the related workarounds and solutions is linked to knowledge management and tools, so the organization is able to reduce number of impacts of incidents over time (ITILv3 2011a, 111). “In problem management, organizations create and share knowledge concerning software products, technologies, customers, and development partners” (Jäntti 2008, 40). The main principle of knowledge management is support the problem solving. Integrate the workflow of knowledge into problem solving process and document problem solutions in a structured way. Also, it is able to collect, search, share and improve information, and produce just-in-time solutions through a knowledge base (Consortium for Service Innovation 2013). Configuration management should provide information of software and hardware configuration details for problem management team. Also configuration management system can link incidents to items where problems have been found and this information can be used as prevent incident in the future by using data in defect analysis process.

As Jäntti has stated, traditional defect management face some challenges compared to service management model which is terminology in use and also lack of known practical examples of models (Jäntti 2008, 40). ITILv3 service management framework concept is using terminology of incident management, known errors, problems and change request. Those are used in different ways in software engineering models. Also link between changes, incidents and problems are quite difficult to point in real life so it is often unclear to teams how these three are related to each other’s. Knowledge and dispersed information and how to use the information provided by knowledge management and how to create articles during problem solving process is mostly process and resource related issue. One of the challenges is communication links between custom-

ers, problem management, product development management, test management and incident management. How good is the process of solving problems, which are coming from the different kind of direction, customer side or the internal test teams. Often, the incident is sent to wrong fault group by tester because there are several software problem solving teams and tester does not know which contact person is the correct one for a particular situation. Therefore, incidents and problems might pass through a long decision chain, thus lengthening the problem resolution time or even causing a situation in which customers may not find a solution to their problem. (Jäntti 2008, 41.)

ITILv3 is a de facto standard in industry for service management. It is, however, a very general standard, and hence of little help when implementing a problem management process on all support line levels (Kajko-Mattsson 2002a, 1). The solution for problem management challenges could be of corrective maintenance maturity model (CM^3) problem management model for the enterprise level problem management process which gives wider tools to solve problems of customers and product development (Kajko-Mattsson 2001). CM^3 Problem Management is a very detailed problem management process model. It has been developed at ABB and evaluated for its industrial relevance within 17 non-ABB organizations (Kajko-Mattsson 2002b, 13).

> Service-oriented problem management provides a systematic approach for managing problems and defects. It creates a bridge between customer-oriented problem management and development-oriented defect management activities. Organizations should focus on proactive problem management, such as using problem reviews and knowledge bases. (Jäntti, 2008, page 52.)

The evaluation results of CM^3 model have shown that the model is realistic, down-to earth, and that it appropriately reflects the current industrial reality (Kajko-Mattsson 2002a, Chapter 2). CM^3: Problem management provides process model allowing visibility into the problem management process for software organizations by structuring the problem management process into two main levels named as Front-End Support and Back-End Support, see figure 18. Front-End Support stage personnel assist the customers in their daily operation

problems. Also personnel who are working in front-end support communicate problems and changes from customers to back-end support by doing first line problem management tasks. The Back-End Support is product research and development organization who develop, test and solve problems of the products according to the requirements as request by the customer and delivered them with according to quality criteria. The Front-End Support model consists of two phases which are namely problem reporting and problem analysis. Problem analysis includes two supporting sub-phase for reporting quality and problem owner selection and first level of problem investigation. Supervision of problem management phase makes decision to move or reject problem ticket to back-end support. If the problem cannot be resolved in the front-end support then there should be created problem analyzing and resolving phases and related sub-phases. Supervision of problem management stays in front-end support line until customer problem has been resolved and closed. The Back-End support process has three main phases are namely as problem reporting, problem analysis and problem resolution. The problem reports are coming from test organization. The next phase is the analyzing phase which consists of quality check of problem report and primary team selection that responsible is to start investigation. Problem administration and engineering selection phase is for creating problem solving team and managing work throughout to end. But the supervision of back-end problem management stays in Front-End support process and it is filtering the information and communicating issues to customer only those part what is relevant customer to know. Three other sub-phase of problem analysis are for problem investigation, problem cause identification and root cause analysis. The problem resolution phase of the Back-End process model handle change process of the product which consists of design, decision and implementation. For a detailed process description of CM^3 problem management can be found from: “M. Kajko-Mattsson, 2002, Problem Management within Corrective Maintenance, Chapter 2 in Advances in Software Maintenance Management: Technologies and Solutions” and also form “M. Kajko-Mattsson, 2007, Evaluation of CM3: Front-End Problem Management within Industry”.

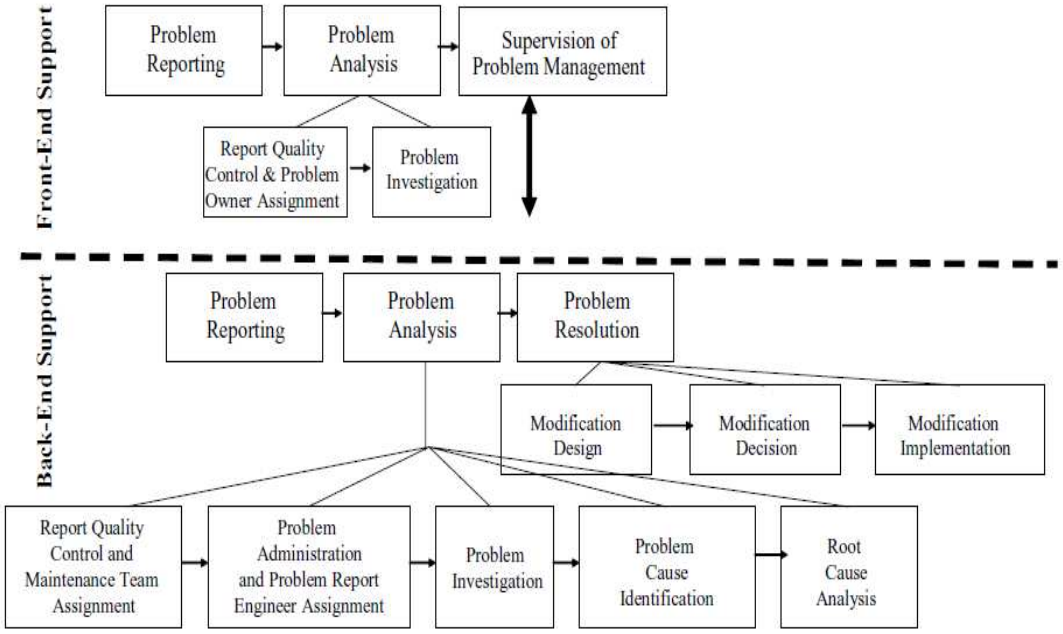

FIGURE18: *Process phases in CM3: Front-End Problem Management and CM3: Back-End Problem Management (Kajko-Mattsson 2007, 4)*

“Problem management process is one of the most important processes within software engineering” (Kajko-Mattsson 2002b, 13). It should be formal and disciplined to identify weak points for continual improvement of engineering practices. The problem investigation should be focused on finding the root cause of the problem with the appropriate level of resources and expertise depending of nature of problem (impact, severity and urgency) by using problem solving techniques that are appropriate for the certain problem. There are many techniques available and some of those techniques are described in more detail in ITILv3 Service Operation chapter 4.4.5.5 Problem Investigation and Diagnosis.

Problem management is dependent on the incident management process and tools and these two processes should have formal interfaces and common working practices. It is important that problems are identified and resolving is started as soon as possible to avoid any work flow related delay. The problem management process should be formalized and known to all personnel and the problem administration should implement some of problem solving techniques

to find the root cause of the problem. There are several problem solving techniques to find root cause of problems like Kepner and Tregoe method, Ishikawa Diagrams and 5-Whys. More details of problem solving techniques can be found from ITILv3 Service Operation book appendixes C and D. But first, it is important that team understand the business impact of the problem and the team is organized, managed and committed to schedule before starting to implement any problem solving techniques to find the root cause (see chapter 5.1.2).

ITILv3 and ISTQB define some metrics that can be used for analyzing problem management efficiency in I&V and make quality actions according to category, impact, severity, urgency and priority levels (see ITILv3 2011a, 124; ISTQB 2011c, 70):

- The total number of incidents/problems recorded in the period
- Percentage of defects rejected by development
- The percentage of problems resolved within targets (and the percentage that are not)
- The number and percentage of problems that exceeded their target resolution times
- The backlog of outstanding problems and the trend (static, reducing or increasing)
- The average cost of handling a problem
- The number of critical and major problems (opened and closed and backlog)
- The number of Known Errors added to the database
- Percentage of critical defects that escaped to production

5.2.4.5 Service operation model metrics

One of the challenges in service operation model implementation is relating to use of virtual teams and matrix organization models (ITILv3 2011a, 306). Because teams are located globally in different time zones and cannot share in-

formation physical meetings, virtual organization management model needs solid reporting of project task, work orders and progress towards different stakeholders and therefore reporting capabilities should contain good standard of reporting format to minimize risks of misunderstanding. IT tools integration, which supports recommended service operation model, should be implemented to support knowledge transfer between virtual teams where they are most needed for supporting business. The tools should have an integrated configuration management system (CMS) to allow linking to incident, problem, change and known errors as appropriate to relevant attributes of product or test case. The CMS allows dashboard type technology to see overall information of certain project for management and test personnel. It also gives possibility for customized views of specific levels of interest groups. Daily communication between different stakeholders and especially virtually is complex and difficult. That's why it needs to be planned and it needs investment and commitment from the management to make sure that organization starts to follow up the process.

5.3 Summary

The customers expect high quality products, where I&V teams have to respond with all organization levels to verify the quality of the developed products and systems, to benefit company and also end customer. The virtual way of working requires solid and understandable work process which supports high quality performance. The fundamental of TQM is in figure 4 which is giving tools for leading virtual organization quality.

A virtual way of working with high quality should have solid continual improvement process models as explained in figure 9. Those have been called in thesis as service oriented process model for I&V organization portfolio management.

Two different models are introduced to cover process variation and service level improvements, see figures 7 and 8. The process improvement has to be continual and the overall work process system need to be fine-tuned after the root causes for the problems has been found. Small quality improvement can be done quite easily but high world class quality can be achieved only with excel-

lent leadership, strategy management, focusing on customer needs, knowledge management, people and competence management and process management. When there is the need to improve organization quality, it has to be done defining metrics, measuring them, analyzing the data, improving according to findings, and controlling the results.

6 CONCLUSION AND DISCUSSION

In this thesis the focus was on virtual high quality management system for integration and verification testing organization in large enterprise by using existing research material. The study was started with questionnaire and interviews of selected target group of managers and specialists of test organization. The existing theories were studied based on the results of interviews and pointed out the three key models to execute high performance quality with virtual teams.

In global enterprise, where research and development work has been split in different geographical locations, collaboration has been done via information technology tools. Different culture between nations and different organizational cultures inside enterprise, have affected virtual collaboration. Virtual team members are creating imagination of each other team member's behavior based on their assumptions and meta-assumptions of their own cultural background and experiences of other people. Based on this imagination and experience during collaboration, people's trust level of each other is born and developed. Effective virtual leadership includes traditional people leading and resource managing skills but especially virtual leader should put focus on effective communication and using technology that fits the situation. Target is to build community which is based on mutual trust, respect and fairness among virtual project team members. The manager should establishing clear and inspiring shared goals, expectations, purpose and vision which are led by example with a focus on visibility. The results should be measurable and management actions should focus on coordination and collaboration across organizational boundaries. The research of literature has shown that high quality virtual performance requires solid and understandable work process and tools to be successful.

TQM model, which support those fundamental issues of virtual collaboration and which support special features of I&V testing organization, has been found to be model which is developed by Oakland in 1993. The top quality performance is achieved, when people from different organization communicate with

and help each other in the problems, and management is committed which is then extended to all level of organization. There are recognized three fundamental key issues of TQM which are supporting virtual leading and collaboration in I&V organization and three key components for giving framework to implement TQM. The fundamental issues of TQM are excellent communication of leaders and managers, full commitment of whole organization, and understanding how to develop organization culture towards high quality. In addition, there should be understanding of relationships of the whole supplier customer chain and how organization processes are relating to each other in the chain. The key components for high quality framework are a documented understandable quality system for organization, quality and problem management tools and techniques, and teamwork and processes to execute actions. The quality management system should be implemented in a way which meets the specific organizational requirements. The framework of the organization has to be implemented in such a way that is support the organization working model and giving overall TQM framework to achieve world-class performance and results. The processes of the framework should be monitored and improved by gathering and using data in never-ending improvement cycle. In this thesis there are introduced couples of methods like Lean Six Sigma, CSI and quality circle methods but, the managers must understand which method is suitable to use improving the organization problems. All methods are not suitable for all kind of problems. The world-class organizations need to create the framework model and this requires skillful leadership and commitment.

TQM framework model for supporting virtual high quality performance in I&V organization has been created based on mostly existing models of ITIL and recommendations of ISTQB. This developed model is called service oriented process model for I&V organization portfolio management. The model is showing relations to business organization and customer. It is showing four different main processes which are handling I&V strategy, designing, transition from the design to execution and operational level models to handle hectic daily work.

This model also has shown how those four main processes are related to continuous process improvement like CSI and Lean Six-Sigma.

This framework model cannot be claimed to be as the perfect framework model for testing organization because several other systems have been developed such as Test Maturity Model Integration and Test Process Improvement models, but in this research the target was to find and introduce framework model which is answering for research questions and support theories of TQM model of virtual work. Introduced service oriented process model for I&V organization quality management has couple of features what those other models do not directly point out. One is the visual illustration of framework model which is understandable and support those functions what are important for leading test organization in virtual way. This model describes clearly the steps how to improve test process and relations to each other stages. Based on this understanding the model helps to guide management to define controllable system for managing service portfolio of I&V.

In this thesis, an overall work process system has been praised, which could resolve all those research question problems that have been set up in the beginning. Working in complex virtual product development is not similar like on a production line. It could be, if the humans and business environment would act perfectly, but the reality is showing something more complex. The illustrated model is incomplete on behalf of those parts, but it could give possibility to rise up organization quality level one step further in the path of quality awarded winners. What is missing from this thesis is more deep analysis of theories how to lead projects in innovative complex organization. Innovative atmosphere requires human-centered leadership model which is opposite model to theory of work process model where leading is based on fact-based management. In this thesis, recommended work process model is not giving answer for all possible leading and managing problems what could be coming in front of managers when executing complex I&V projects in the large enterprise. However, this model gives possible tools for continuous process improvement and it definitely does not exclude other management models.

The future of I&V testing is showing to take step towards virtual feature driving development model which is an iterative and incremental software development process initiated by Jeff de Luca in 1997 (Feature-driven development 2013). This model differs from traditional project models where as embedded systems features are developed cross functional and cross component teams give responsibility to more for small self-organized teams. Challenges in this new model are related to self-organizing, virtual working and cross-disciplinary approach. This thesis is responding the some of those challenges, but this new feature driving development model should be studied more deeply, before conclusions of its suitability can be made.

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QUESTIONS OF ORGANIZATION LEVEL OF DYNAMIC VIRTUAL LEADING

Interpersonal Skills	Average	Variance
Opportunities to build networks and relationships:		
People/Teams are introduced to others in the virtual organization, and there are directories of skills, knowledge, and experience.	3	0
Forums bring people together across business lines and functions (for example, at training, meetings, seminars, bulletin boards, and intranet sites.)	3	2
People are encouraged by their managers to spend time to build networks and relationships.	3	5
Staff understand virtual matrix to collaborate rather than compromise by order because:		
Organization understand the criteria for virtual working models.	5	1
There are established rules for escalation.	5	1
There are defined parameters for acceptable risk and those have been defined and illustrated by example.	3	0
Managers who share resources work well together:		
Expectations, objectives, and priorities are jointly set.	4	2
Managers make the time to align their agendas and create clarity for the people who report to them.	4	2
When priorities change, the managers resolve conflicts so that they neither drop onto the matrix manager nor have to be escalated up.	4	0
A culture of virtual teamwork, demonstrated by:		
Joint accountability, both when things go well and when they go wrong.	3	2
Frequent giving of credit to others.	4	5
Recognition of those who demonstrate collaborative behaviors.	4	5
Sharing of information effectively	5	1
Work Processes		
Clarity around how work flows across the organization:		

Virtual work processes have been mapped with the actual people in the matrix positions to anticipate and clarify gray areas and new ways of working in virtual teams.	4	2
Clarity around how information flows across the organization:		
There are formalized processes for how decisions are made, conflicts are resolved or escalated, problems are solved, and information is communicated.	3	0
Clarity around roles and responsibilities in virtual teams:		
Everyone understands the expectations of their role and others' roles, the boundaries between roles, and the purpose and expectations of the various new coordinating roles.	4	5
Overlaps among roles are minimized.	4	5
Inputs and output between roles are defined and understood. (Job descriptions done and shared among teams)	2	2
Management Processes		
Governance mechanisms resolve issues quickly and at the right level:		
Councils, committees, and steering committees have been chartered and operate effectively to cut across the normal hierarchy and get the right people talking to one another about customers, objectives, conflicts, resources, and performance on a regular basis	3	5
Efficient and effective meetings:		
The right people are invited to ensure that perspectives along all dimensions of the virtual matrix are represented when needed.	5	1

Meetings are structured and facilitated to result in outcomes that meet both I&V and joint venture needs.	5	1
There is minimum management "rework":		
When decisions are made, they "stick," and are not reopened or revisited.	5	1
Decisions are communicated and supported consistently by managers.	5	1
Managers have built a high enough level of trust that decisions can be made by the minimum number of people necessary.	3	2
There are upward feedback mechanisms that inform managers of how well they are doing.	3	5
There is a clear process for objective setting and performance management:		
Performance appraisal gathers relevant input and makes clear the weight of each manager's input.	4	5
Peer feedback mechanisms promote a culture of collaboration and measure, "How easy am I to work with?"	3	2
The reward systems make heroes of those who demonstrate the values and give incentives for team and collaborative behavior.	3	8
Communication		
Information,		
How well reporting requirement is imposed on team members, is it perceived as autocratic or self-organized by teams	3	0

How good start-up activity has been done, where team members can meet each other, do some team building, develop goals and measures, and clarify roles and responsibilities	3	5
The vision, goals and the strategy of the virtual team project is so clear that it can be communicated easily	4	1
Explicit and tacit information sharing is known and recognized by individuals and teams	4	2
Managers can ensure interactive information sharing and involve all employees and stakeholders into communication	4	1
Actors		
Weak signals are rising from the tacit knowledge, and they indicate employees' feelings which direct their actions. There are systems to recognize weak signals at an early phase to make proactive, corrective actions.	2	0
Communication is based on interactive dialogue (supportively, equality and regularity) and done by example	4	5
Team members take part responsibility of updating and relevancy of information	4	2
Team members have become active communicators in the company and their role should be strongly supported by the management.	4	5
Sharing		
System is encouraging employees to share their knowledge among virtual teams	4	5

Group discussions, experience sharing and observation are essential for information sharing, which are regular and common in virtual team and between teams	3	8
Shared information is understandable, right timed and based on facts	3	1
Information flow both horizontally and vertically around the organization, and managers easily link experts together	4	2
Information is shared with everyone so that they can be involved in the process and interpretation of the information	4	2
Feed-back system		
Feedback system encourages team members in the virtual organization to be involved in the work process and share information and new ideas with each other continuously	4	2
Organization can react immediately to the needs for changes or emerged ideas, and improve its performance accordingly.	3	2
Organization monitors and measures weak signals, which arise from the organization's tacit knowledge or from outside of the organization	3	1
Gathered feedback is analyzed, actions are taken, implemented and followed regularly	3	5
Conflict Resolution		
Individual has ability to recognize the presence of conflict.	4	2
There are solid known processes to identify the source of conflict	4	2

Virtual teams appropriately resolve conflict without escalation to top managers	3	1
Collaborative Problem Solving		
Problems solving organization, ability of an organization to use individuals and teams to solve complex problems of the company		
Individuals are continuously improving their problem solving competences and changing their behavior according to new knowledge and cooperating with the other members of the organization.	4	5
Problem solving methodologies are widely known in teams and those are used systematically to help structure their efforts	3	8
Teams seek to understand the impact of their solution on the larger organization as a whole and how it can affect the organization's long - term outlook	3	2
Teams have knowledge to establish certain ground rules or micro practices before starting to solve the problem in order to overcome these psychological barriers virtually	4	5
Goal Setting and Performance Management		
Realistic, specific, and obtainable team goals are sets, these are more common than rare	4	1
Goals are monitored, evaluated, and provided feedback to the team in accomplishing these goals	4	0
Planning and Task Coordination		
Project planning are done with the teams	4	1

Task plans and schedules are reviewed together and agreed to reach commitment to matter	3	0
Task delegation is done understandable way and process like manner	4	1
Trust level		
Inside or between the teams, overall trust among virtual collaboration		
Do we keep agreements or renegotiate if we cannot?	4	1
Do we have clear and explicit expectations regarding measurable results and objectives?	4	0
Do we act with mutually serving intentions without hidden agendas?	4	2
Do we share job-related information that is pertinent to getting the job done?	5	1
Do we speak our minds and tell the truth, even when others disagree?	4	0
Do we openly admit and take responsibility for the mistakes we have made?	4	1
Do we gossip or participate in unfair criticism about other people?	4	1
Do we have confidence in our abilities to keep up with the changing demands of our jobs?	4	1
Do we acknowledge the skills and abilities of others?	4	0
Do we help each other learn new skills?	3	2
High-performing virtual organizations		
Clear direction (the why and how of doing the work)—influence through mission, values, strategy, etc.		

How clear is the direction that collaboration is required as part of the strategy—and is essential to success?	4	1
Knowledge and skill needed to perform the work—influence through recruitment and selection, training, etc.		
Do people have the technical and interpersonal skills they need to collaborate effectively across boundaries?	4	1
Support and resources to do the work—influence through technology, work processes, etc.		
Do work processes incorporate time zone and other boundary conditions? Is technology leveraged to support collaboration efficiently?	4	1
Willingness to do the work (the driver of performance)—influence through performance management, recognition, coaching process, etc.		
How well (What) practices have been put in place to keep people informed, give helpful feedback, and recognize success as a total network?	4	1

QUESTIONS OF ORGANIZATION MATURITY LEVEL OF TOTAL QUALITY MANAGEMENT

Internal Readiness Factors		
Commitment to Principles	Average	Variance
Management practices of ethics and morality match their statements about organization values, are understood by all within the organization, and form the basis for all decisions. These values raise the organization from the level of laws to one of mutual respect.	4	1
Trust		
One person can believe what another says. Actions of one person or group are treated with credibility and integrity by others. People are not suspicious of one another	5	0
Employment Conditions		
Job security is high; physical working conditions are people-oriented (i.e., noise, dust, heat/cold are greatly minimized); pay levels are competitive; safety is emphasized; career/promotion paths are known	4	2
Policy Commitments		
Explicit statements are made to guide actions of all organization members toward seeking improvement in human capabilities and performance, generating interest in continuing change, sharing gains from improvements, lowering the level of decision making, and so forth	4	2
Resource Commitments		

The organization is willing to provide professional facilitation services for all organizational roles and functions, allocate management time to the TQM effort, and coordinate and allocate resources	4	0
Open Communications		
People are not threatened; data and information are shared; placing blame is not the objective of communications; decision making is shared; free discussion of uncertainties and ambiguities takes place; confidences are maintained.	4	0
Conduct toward Improvement and Change		
People perceive change as necessary to organizational health. They are willing to modify organizational structures if needed, focus on purposes and measures of effectiveness, seek to motivate others to search for change, and feel that work produces one form of life's satisfactions. Evaluations of efforts are received favorably; new goals and opportunities are sought to provide control over the change process; people seek to understand the nature and purposes of change in relation to other purposeful activities; and learning of all types is encouraged	4	0
Data and Information		
Measures of organizational performance serve as a base of comparison (e.g., cost benefit ratio) for proposals and implemented changes; timelines are prepared to ensure availability of resources; measures describe extent of resource availability; linkages are established with sources of new ideas and research results; and so on	4	0

Organizational Flexibility		
People can cope with discontinuities and adapt to technological advances; they are willing to experiment and deal with conflicts of all types. The organization is characterized by a close alignment of customer/client/user needs, a degree of decentralization, complexity of processes and capital investments, compatibility of organizational levels and group norms toward directions and goals, and cohesiveness in actions	4	2
Continues Improvement level		
There is understandable system to measure and improve processes and services of I&V organization	3	2
Level of formal proactive practices that addresses improvement opportunities for I&V services is implemented and followed	3	1
Overall I&V organizational ability to monitor a process or services against established expectations of business lines; to evaluate performance variances; and to take corrective action as needed to meet performance goals or to improve performance over time	4	0
Improvement opportunities are validated in comparison to the business and I&V vision, strategies, goals and objectives continually.	4	2
Estimate how good testing services are currently being delivered as well as the effectiveness of the testing lifecycle itself.	4	0
Estimate how effective and efficient quality management processes are at the moment; define, measure, analyze, improve, control	3	0

Defined targets are in line for I&V services such as availability and reliability, and key performance indicators (KPIs) for I&V processes are set; provide a means for a I&V organization to track progress from the baseline to the defined targets.	3	0
There are clear roadmap how I&V teams develop quality and where it is today. There are plans to close this gap through the work of an improvement project teams.	3	2
To measure whether the gap is closed requires ongoing validation measurements and assessment. Management knows were the desired outcomes achieved, what is the level at the moment?	3	1
Level of the management process system, ensuring that changes are embedded in the all I&V organization levels.	3	0
Quality Risks of testing activities		
What is the level of planning, preparation, execution of testing, practicing, to allocate effort for each quality risk item based on the level of risk and failure analysis?	3	1
What is the level of planning, preparation, and execution of testing; test managers and testers attack systematically the quality risks in risk priority order, starting with the most important quality risks first and working their way down to the less important ones. They are documented and supported systematic way to work and improve quality of products	3	1
There is a planned system during test execution to reduce/ increase the time or resources available for testing by management; priority order, starting with the least important tests.	4	0

Test line environment control and configuration management is transparent through I&V organization; Test equipment and environments are documented, configuration setups are known and problem situations can be supported even remotely based on documented environments	3	2
Information on present and past reliability of test lines and, in particular, unreliability or failures of test equipment components and systems are known.	4	0
Test line operators operation failure levels are known and data can be analyzed to find improvement points?	3	2