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Contents

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) together form a system for worldwide standardization as a whole. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC1.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types :

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts ;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard ;

— type 3, where a technical committee has collected data of a different kind from that which is normally published as an International Standard (“state of the art”, for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/IEC TR 15504-7, which is a Technical Report of type 2, was prepared by Joint Technical Committee ISO/IEC JTC1, *Information technology*, Subcommittee SC7, *Software engineering*.

ISO/IEC TR 15504 consists of the following parts, under the general title *Information Technology - Software Process Assessment:*

— Part 1 : *Concepts and introductory guide* (informative)

— Part 2 : *A reference model for processes and process capability* (normative)

— Part 3 : *Performing an assessment* (normative)

— Part 4 : *Guide to performing assessments* (informative)

— Part 5 : *An assessment model and indicator guidance* (informative)

— Part 6 : *Guide to competency of assessors* (informative)

— Part 7 : *Guide for use in process improvement* (informative)

— Part 8 : *Guide for use in determining supplier process capability* (informative)

— Part 9 : *Vocabulary* (normative)

Annexes A to C of this part of ISO/IEC TR 15504 are for information only.

Introduction

The needs and business goals of an organization are often centred around achieving enhanced customer satisfaction and greater competitiveness. For organizations with a dependence on software, these key management concerns become drivers that initiate software process improvement throughout the organization with goals of higher software quality, lower development and maintenance costs, shorter time to market, and increased predictability and controllability of software products and processes.

Software process improvement is best considered as a continuous process, where an organization moves continually around an improvement cycle. Within this cycle improvement is accomplished in a series of steps or specific improvement actions such as introducing new or changed practices into software processes or removing old ones. An important step in the improvement cycle, however, is the execution of some form of data gathering to establish the initial state, and subsequently to confirm the improvements.

This part of ISO/IEC TR 15504 provides guidance on using software process assessment as the primary means of understanding the current state of an organization's software processes, and on using the results of the assessment to formulate and prioritize improvement plans. This guidance is embodied within a general framework for the use of process metrics in software process improvement.

The improvement framework is built on the framework for quality improvement embodied in ISO 9004-4.

This part of ISO/IEC TR 15504 is primarily aimed at the management of an organization considering or undertaking a software process improvement programme, possibly as a result of a process capability determination; members of improvement teams, particularly leaders and facilitators; software engineers; and external consultants helping organizations to undertake software process improvement.

This process improvement guide addresses the following topics:

— an overview of process improvement – the factors which drive software process improvement and general principles which underpin it;

— a methodology for process improvement – an eight step model for improving software processes within a continuous improvement cycle;

— cultural issues – aspects of organizational culture that are critical for successful process improvement;

— management – software process improvement from a management perspective including an overall framework for process measurement.

Annexes provide supplementary information including examples of the use of the process measurement framework; an illustrative case study of application of this guide; and mappings between the steps in the model described in this guide and ISO 9004-4.

Information technology — Software process assessment — Part 7: Guide for use in process improvement

1 Scope

This part of ISO/IEC TR 15504 provides guidance on using software process assessment as part of a framework and method for performing software process improvement in a continuous manner. The guidance covers:

a) invoking a software process assessment;

b) using the results of a software process assessment;

c) measuring software process effectiveness and improvement effectiveness;

d) identifying improvement actions aligned to business goals;

e) using a process model compatible with the reference model defined in ISO/IEC TR 15504-2 as a framework for improvement;

f) issues related to organisational culture in the context of software process improvement;

g) dealing with management issues for software process improvement.

The guidance provided does not presume specific organizational structures, management philosophies, software life cycle models or software development methods. The concepts and principles are appropriate for the full range of different business needs, application domains and sizes of organization, so that they may be used by all types of software organizations to guide their improvement activities.

An organization may select all or any subset of the software processes from the reference model, for assessment and improvement in the light of its particular circumstances and needs. The guidance provided can also be used with other process models.

The guidance provides a framework for implementing improvements in a continuous manner. However, there is no reason why the organization could not employ the guidance for a single cycle of improvement activity.

2 Normative reference

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO/IEC TR 15504. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO/IEC TR 15504 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC TR 15504-9 :1998, *Information technology – Software process assessment – Part 9 : Vocabulary.*

3 Terms and definitions

For the purposes of this part of ISO/IEC TR 15504, the definitions given in ISO/IEC TR 15504-9 apply.

4 Overview of process improvement

4.1 Drivers

The needs and business goals of an organization are often centred around achieving enhanced customer satisfaction, greater competitiveness and improved business value associated with delivery of software or information systems. For organizations with a dependence on software, these key management concerns become drivers that initiate software process improvement throughout the organization with goals of higher software quality, lower development and maintenance costs, shorter time to market, and increased predictability and controllability of software products and processes.

4.2 Process improvement basics

Improvements to the software process may start at any level in the organization. However, senior management leadership is required to launch and sustain a change effort and to provide continuing resources and impetus, although ultimately, everyone in the organization is involved.

In summary:

— software process improvement demands investment, planning, dedicated people, management time and capital investment;

— software process improvement is a team effort;

— effective change requires an understanding of the current process and clear goals for improvement;

— software process improvement is continuous – it involves continual learning and evolution;

— software process changes will not be sustained without conscious effort and periodic reinforcement.

4.3 General principles

The needs and business goals of the organization determine the software process improvement goals that help to identify improvement actions and their priorities. Software process improvement is accomplished in a series of steps or specific improvement actions such as introducing new or changed practices into software processes or removing old ones. A process model may be used to identify practices to be included to improve the capability of each process. Achievement of process improvement goals should be measured quantitatively.

The general principles of software process improvement are:

— software process improvement is based on process assessment results and process effectiveness measures;

— software process assessment produces a current process capability profile which may be compared with a target profile based on the organization's needs and business goals;

— process effectiveness measures help identify and prioritize improvement actions that support organizations in meeting their needs and business goals, and in achieving software process goals;

— software process improvement is a continuous process. Improvement goals identified and agreed within the organization are realized through a process improvement programme that continues through multiple cycles of planning, implementing and monitoring activities;

— improvement actions identified within a process improvement programme are implemented as process improvement projects;

— metrics are used for monitoring the improvement process in order to indicate progress and to make necessary adjustments;

— software process assessment may be repeated in order to confirm that the improvements have been achieved;

— mitigation of risk is a component of process improvement and should be addressed from two viewpoints:

  — the risk inherent in the current situation;

  — the risk of failure in the improvement initiative.

Software process improvement plans and records may be used to support process capability determination, when the proposed process capability needed to meet a contractual requirement exceeds the currently assessed profile (see ISO/IEC TR 15504-8).

4.4 Process improvement context

The context for software process improvement and its major interfaces are shown in figure 1. The interfaces are as follows:

— the organization's needs and business goals which are main stimuli for process improvement;

— industry norms and benchmarks providing reference information for improvement planning;

— improvements in the organizational unit's (OU's) software processes as a result.

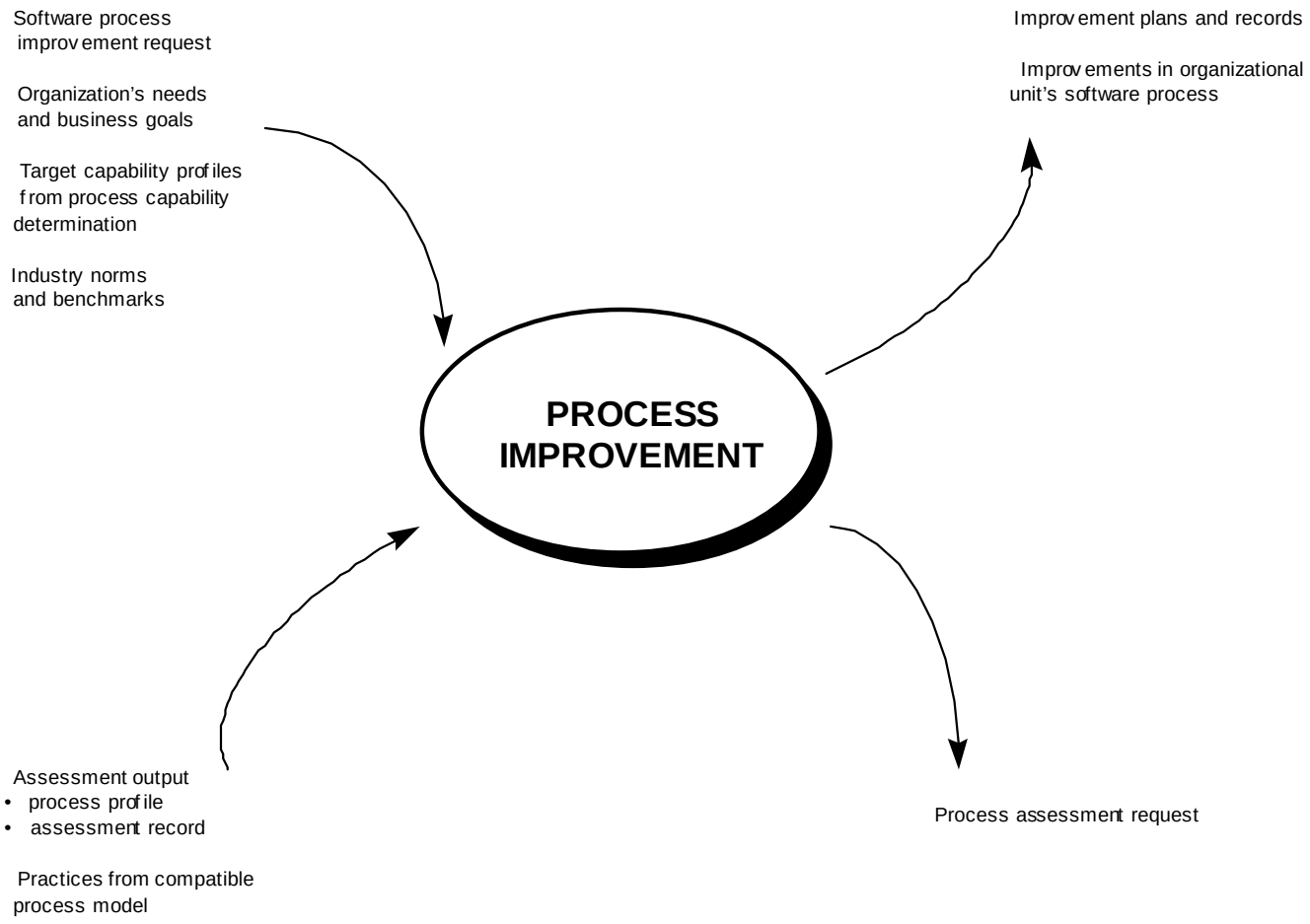

Figure 1 — Process improvement context

Process improvement uses other components of ISO/IEC TR 15504 as follows:

— process assessment (as described in ISO/IEC TR 15504-3 and ISO/IEC TR 15504-4) is performed to establish the current capability;

— the assessment results consist of process profiles and all the contextual information held in the assessment record;

— the process model compatible with the reference model in ISO/IEC TR 15504-2 is used as a framework to define processes to be improved, set priorities and identify improvement actions;

— existing improvement initiatives may need to be adjusted to support a new target capability resulting from a process capability determination (see ISO/IEC TR 15504-8);

— improvement plans and records may assist in establishing customer confidence during process capability determination (see ISO/IEC TR 15504-8).

5 Guidelines for software process improvement

When an organization is well motivated and managed for software process improvement (see clauses 6 and 7), it undertakes and implements a number of process improvement activities. Software process improvement benefits accumulate permanently when an organization pursues process improvement activities in a consistent and disciplined series of steps based on data collection and analysis.

Figure 2 illustrates the steps for continuous software process improvement using the components of ISO/IEC TR 15504.

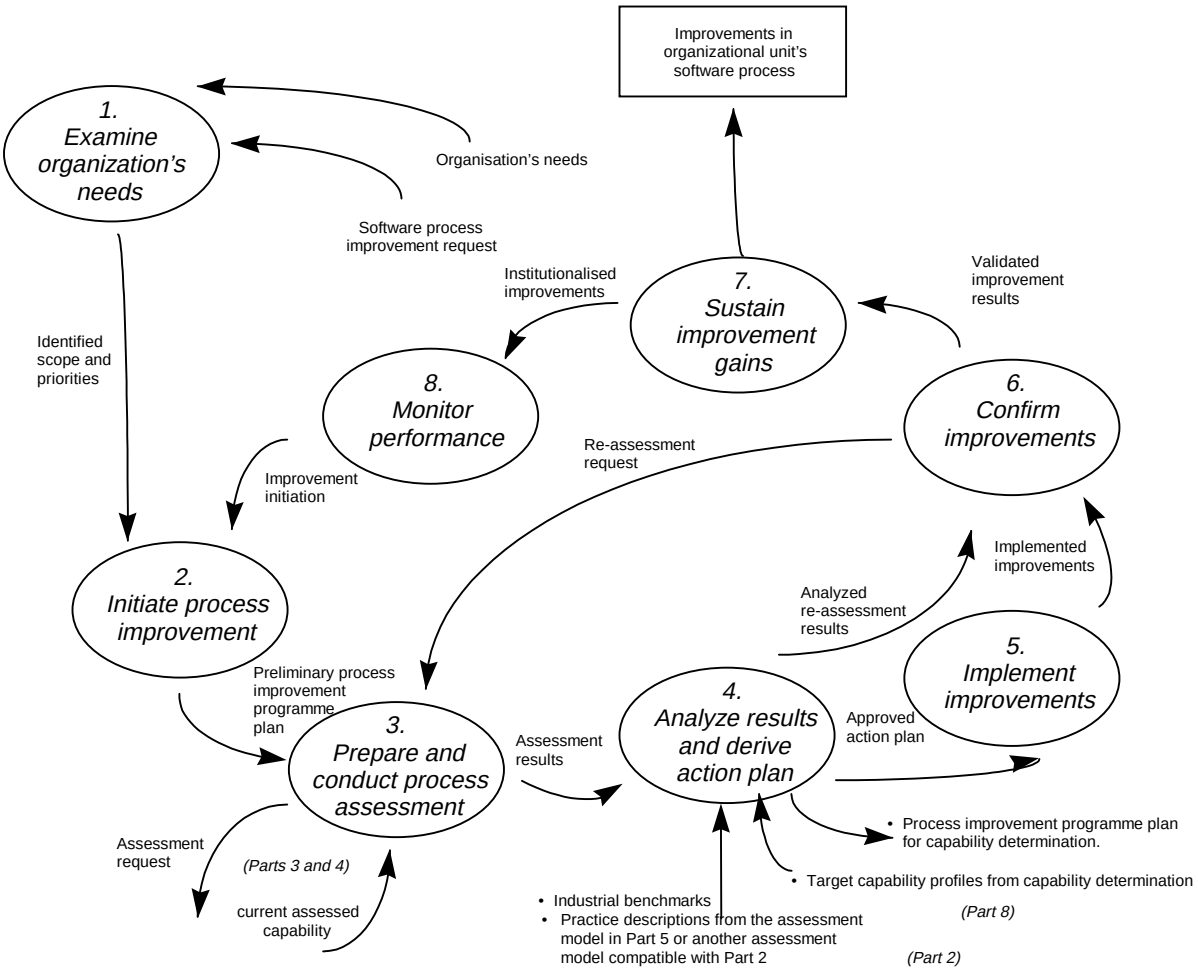

Figure 2 — Software process improvement steps

A comprehensive process improvement programme may identify improvement goals to be attained over several iterations of the improvement cycle. It may contain several process improvement projects, concerned with implementing improvement actions.

The steps in the improvement cycle are described in detail below in terms of their activities and tasks.

5.1 Examine the organization's needs and business goals

A process improvement programme starts with the recognition of the organization's needs and business goals, usually based on one of the main drivers identified in 4.1. This recognition could be derived from any of the following:

— formulation of a mission statement or a long-term vision (see 7.1);

— analysis of organization's business goals;

— analysis of the organization's current shared values (see 6.2);

— the organization's readiness to undertake a process improvement programme;

— data on quality costs;

— other internal or external stimuli.

External stimuli that may trigger a process improvement programme include:

— declining market share;

— marketing analysis;

— feedback from customers;

— competitiveness changes in the market;

— requirements to meet specific industry benchmarks;

— new requirements from society.

Internal stimuli that may trigger a process improvement programme include:

— declining or unsatisfactory profitability;

— declining staff satisfaction;

— senior management/ownership change.

From an analysis of the organization’s needs and existing stimuli for improvement, the objectives of process improvement may be identified and described in terms of quality, time to market, cost and customer satisfaction, and business value with information services, along with predictability and control of the delivery of information services and related risks.

The final stage of the preliminary definition of the goals for the improvement programme is setting the priorities of the process improvement objectives.

The improvement goals direct the choice of the processes to be assessed, the definition of improvement targets and ultimately the identification of the most effective improvement actions.

After the analysis of the organization’s needs and business goals, it is essential to build executive awareness of the necessity for a process improvement programme. This requires both managerial and financial commitments. The objectives of such a process improvement programme should be clearly stated and understood, and expressed

using measurable process goals. The process improvement programme should form part of the organization's overall strategic business plan.

The executive decision to undertake improvement, together with the identification of a preliminary process improvement programme budget and the main process improvement priorities, enable the improvement process to progress through the following steps:

a) initiate process improvement (see 5.2);

b) carry out a software process assessment in the sectors where improvement is believed to be beneficial (see 5.3);

c) complete the process improvement programme plan with the action plan resulting from analysis of assessment results (see 5.4);

d) implement improvements according to process improvement project plans (see 5.5);

e) confirm the improvements (see 5.6);

f) sustain the improvement gains by maintaining the new, improved level of performance until stability has been reached (see 5.7);

g) monitor performance to continue the process improvement programme (see 5.8) comparing results against the measurable goals of the process improvement programme plan developed in 5.2 and 5.4.

5.2 Initiate process improvement

The process improvement programme should be considered as a project in its own right, and planned, resourced and managed accordingly (see process MAN.2 *Project Management* in ISO/IEC TR 15504-2). A process improvement programme plan should be produced at the beginning of the programme and subsequently used to monitor progress. The plan should include the relevant background and history and the current status, if possible expressed in specific, numerical terms. The improvement goals derived from the organization's needs and business goals provide the main requirements for the plan. The plan should include a preliminary identification of the improvement scope in terms of both the organizational boundaries for the improvement programme and the processes to be improved.

The plan should cover all the process improvement steps, although initially the plan may only give outline indications of the later stages. It is important to ensure that key roles are clearly identified, that adequate resources are allocated, that appropriate milestones and review points are established, and that all risks associated with the plan are identified and documented in the plan. The plan should also include activities to keep all those affected by the improvement informed of progress.

5.3 Prepare for and conduct a process assessment

5.3.1 Prepare assessment input

This step gives guidance on how to define the assessment inputs needed to carry out a software process assessment as described in ISO/IEC TR 15504-3.

5.3.1.1 Sponsor

Preparation for an assessment begins with the identification of a sponsor for the assessment. The sponsor is a senior manager, who is committed to the process improvement programme, requires the assessment to be performed, and provides resources for it. The sponsor ensures that the process assessment inputs (purpose, scope, constraints and responsibilities) are adequately defined so as to meet the needs of the process improvement programme. It is likely that the assistance and advice of a competent assessor will be of help to the sponsor in formulating these inputs.

The sponsor has the authority to ensure that the assessment can be carried out effectively, and takes ownership of the assessment output. The sponsor must be committed to the concepts of process improvement through process assessment.

5.3.1.2 Competent assessor

The responsibility for ensuring that an assessment is conducted in accordance with the provisions of ISO/IEC TR 15504 is vested in the competent assessor who leads, or is part of, the assessment team. A key factor in selecting an assessment team, and particularly the competent assessor, is credibility with the management and staff of the organizational unit. Depending on the local circumstances, a competent assessor drawn from outside the organizational unit may appear to be more credible on account of a more independent viewpoint.

5.3.1.3 Assessment purpose

The overall purpose of the assessment is to provide information about the process capability of the organizational unit in the form of the assessment results. The statement of assessment purpose will guide the assessment team during the conduct of the assessment, particularly with regard to the amount, nature and content of the information they should capture during the assessment to aid improvement. The purpose statement should make clear that the assessment is being done as part of a process improvement programme, and should contain clear descriptions of quality improvement goals (see 7.3.4 and 5.1) and specifically the goals whose attainment is expected to be dependent on the assessment results. All the information on the improvement background defined in the previous steps 5.1 and 5.2 should be made available.

5.3.1.4 Assessment scope

The assessment scope defines the boundaries for the assessment, both organizationally and in terms of the processes to be included.

From an improvement point of view the process improvement programme may address an entire organization, part of an organization, a single project, or even a part of a project. A process assessment, however, addresses an organizational unit with a coherent process context, particularly the application domain, size, criticality and complexity, and quality characteristics of its products and/or services. If the process improvement programme spans different organizational units with different types of operation, then each of them should be assessed separately.

The broader the scope of an assessment, the greater the assessment effort needed to arrive at a representative result. Therefore, the sponsor may wish to limit the scope to those processes that are expected to have the greatest potential for improvement. Priority should be given to the processes or process categories that initially appear to affect achievement of improvement goals derived from the organization’s needs and business goals. This initial evaluation may change after an assessment is performed and the data is analysed. The scope statement should include any assumptions or expectations in the process improvement programme plan about the strengths and weaknesses of process categories, single processes, or practices.

The sampling of the implemented processes should be done by picking out representative selections that provide a reliable picture of the current status of the software process. Therefore, it is useful to assess projects that are considered both as the worst examples and as the best examples of the organization's current process performance. In this way the variability between the worst and the best cases of the organization can be found and taken into account in the improvement.

The scope is defined initially in terms of the processes operated and understood by the organizational unit. Ultimately, however, the organizational processes need to be mapped to the processes in the process model compatible with the reference model, to enable the assessment team to conduct the assessment. The mapping may be undertaken by the assessment sponsor, or by the assessment team. If an organizational process cannot be mapped on one of the processes in the process model, it should be defined as an extended process.

In addition to specifying the processes to be assessed, the scope should clearly identify the sampling strategy, the organizational unit and its characteristics, and the product or service characteristics (process context). The product or service characteristics, in particular, provide the context within which the assessment team will judge the adequacy of the implemented practices and affect the validity of comparisons with other industry benchmarks.

5.3.1.5 Assessment Constraints

The sponsor may wish to restrict the freedom of choice of the assessment team in defining the sampling strategy for the assessment, in selecting individuals for interview, and in how information may be used. Any restrictions,

which may be positive or negative (for example, to include or exclude specific instances of the process) are documented as the assessment constraints.

Similarly, the sponsor may wish to place constraints on which individuals are to be interviewed by the assessment team. For process improvement, the process owners of each assessed process should always be involved in the assessment.

Ownership of results and confidentiality of information may be an issue in many organizations. Whatever the situation, the assessment constraints should include a clear statement about how the information and assessment results may be used, and hence the confidentiality arrangements that apply.

5.3.2 Conduct a process assessment

A process assessment, as described in ISO/IEC TR 15504-3, is initiated using the assessment input prepared as described in 5.3.1. The assessment delivers its results as the assessment output which consists of:

a) the current process profile;

b) the assessment record (ie. any information which is pertinent to reviewing the results of the assessment including, in particular, reference to supporting evidence for the process attribute ratings);

c) additional information for process improvement (for definition of goals, metrics and targets, see clause 7.3 and practical examples in Annex A).

The additional information may include :

a) existing best practice that could be adopted and institutionalized in the organization;

b) experiences about the previous adoption of specific methods or tools in the organization;

c) cultural issues that might either foster or jeopardize improvement initiatives;

d) organizational issues that might affect the potential benefits of process improvement;

e) training needs.

The assessment output will show not only which processes are at a relatively low capability level, but also the degree of variability across the organizational unit. Both aspects are useful in determining priorities for an improvement programme.

The assessment record should be retained with the results, both as an aid to subsequent understanding, and in case there is a later need to verify that the assessment was carried out in accordance with the provisions of ISO/IEC TR 15504.

5.4 Analyse assessment output and derive action plan

Information collected during the assessment, in particular the capability level and process attribute ratings, is analysed in the light of the organization's needs to:

— identify areas for improvement;

— set qualitative software process goals, and quantitative improvement targets;

— derive an action plan, and integrate it with the process improvement programme plan.

Management should approve the areas for improvement, the goals and targets, and the updated process improvement programme plan, thereby committing the organization to undertake the planned improvements. The decision should be communicated clearly to all affected staff.

5.4.1 Identify and prioritize improvement areas

Improvement areas should be identified and prioritized based on a number of factors as outlined in figure 3. The factors in detail are:

— the assessment output, which shows weak and strong areas of the assessed processes;

— the organization's needs, which provide general improvement goals (see 5.1) to be achieved through the improvement programme;

— effectiveness measures (see 7.3), which, if already in place, identify improvement priorities for the organization generally related to the improvement drivers described in 4.1;

— industry norms and benchmarks that provide a basic comparison framework for assessment results;

— risks related to either not achieving the stated improvement goals or failure of improvement actions.

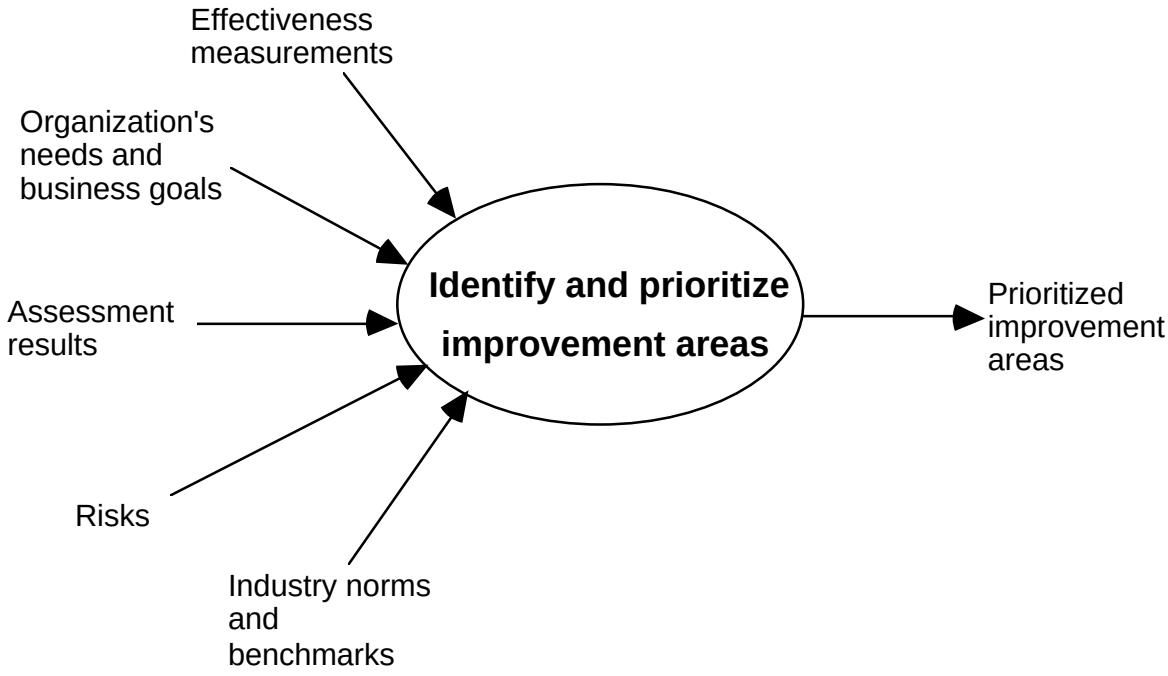

Figure 3 — Identifying and prioritizing the improvement areas

5.4.1.1 Analyse assessment results

Analysis of the assessment results provides information about the current strengths and weaknesses of the process and indicates opportunities for improvement. The analysis may be performed using process capability level ratings and process attribute ratings together with the assessment context information.

The strong points are identified as the processes with the highest process capability level ratings. Strengths may support process improvement as follows:

a) strong processes may provide experience of good practices that could be adopted and institutionalized in the organization;

b) processes with the highest process capability level rating within a process category or a set of interrelated processes may show an opportunity for improving the effectiveness of the rest of the process category or set of interrelated processes.

The weaknesses may be:

a) processes with low process capability level ratings;

b) processes with missing practices that are needed to enable the process to achieve a process purpose aligned with a specific need of the organization;

c) unbalanced process attribute ratings within capability levels that are necessary to achieve a specific need;

d) low process attribute ratings across assessed processes that may indicate weakness in specific process categories (for example low scores at process capability level 2 may show weaknesses in the Management and Support process categories).

The variability of process capability ratings across the organizational unit should be evaluated in the light of the process context to identify specific improvement actions.

Similarly, the process capability level ratings of related processes should be compared. Improvement actions may be identified to correct any imbalance.

5.4.1.2 Analyse the organization's needs and improvement goals

The processes and their relationships should be analysed in order to evaluate which processes have direct impact on the improvement goals identified in the process improvement programme plan. Specific relationships between single processes should be considered in order to identify processes which should be addressed together to fulfil certain improvement goals. In this way, a priority list of processes to be improved may be derived. The processes in this list with low process capability level ratings may provide the best opportunity for improvement.

5.4.1.3 Analyse effectiveness measurements

Organizations with previous experience in process improvement may already have effectiveness measurement in place. Where these are related to the existing organization's needs and derived improvement goals, it may be worth analysing the current measurements to get a better understanding of what improvement is needed (see 7.3).

5.4.1.4 Analyse the risks in not achieving improvement goals

The impact on the organization's needs and business goals of failing to achieve improvement goals should be evaluated in order to understand the urgency and to set the priority of improvement initiatives. The risk analysis will provide hints on prioritizing improvement areas and will help to gain commitment and funding to carry out the improvement actions as needed.

5.4.1.5 Analyse risks of improvement action failure

The potential risks of failure of an improvement action should be analysed in order to support the definition of improvement priorities and to assure the proper commitment and organizational support. These risks may be related to specific organizational issues, to specific time frames, to cultural issues, to commitment or to funding issues. More precisely the risks may derive from:

— existing schedule constraints;

— existing psychological or cultural barriers, possibly derived from previous experiences;

— organizational issues preventing the successful execution of improvement actions.

The risk mitigation strategy may be influenced by hints from the assessment on where to find the main improvement potential. This potential may be:

— in organizational areas or processes with positive capability to change;

— synergistic with existing contractual commitments or well-understood customer expectations.

5.4.1.6 List improvement areas

A prioritized list of improvement areas may be provided as a combined result of analysing all the factors listed above. The selected improvement areas define the scope of the improvement actions to be identified. The scope could include:

— processes to be included;

— organizational boundaries for improvement;

— processes or projects to be either included or excluded in the improvement initiative.

5.4.2 Define specific improvement goals and set targets

Targets for improvement should be quantified for each priority area. These may be either target values for process effectiveness, or target capability profiles, or combinations of the two. They should be set in the light of the organization's needs, using the approach outlined in section 7.3. This will typically require the iteration of a number of steps until a set of targets has been identified which meets the organization's needs, which can be objectively measured, and which can reasonably be achieved. The key steps are:

a) to define qualitative goals for each priority area for improvement;

b) to devise suitable metrics to measure achievement of these goals;

c) to set appropriate target values for these metrics, taking due account of risks.

For definitions of goals, metrics and targets, see clause 7.3.4.

More mature organizations, and those which have already made use of this methodology during previous improvement cycles, may already have established goals, metrics and targets. These should be reviewed for their continuing suitability and adjusted as appropriate in the light of a current assessment of the organization's needs.

When setting capability levels as targets for processes, the following points should be considered:

— it is desirable for related processes to be at the same capability level, unless there are over-riding considerations;

— it is generally unrealistic to seek to increase the capability of a process by more than one level in a single cycle of improvement, since each level builds on the capabilities of the ones below it.

5.4.3 Derive action plan

A set of actions to improve software processes should be developed. Such actions, taken together, should meet the process goals and quantified targets set in the previous step (see 7.3). Possible improvement actions may interact, support each other or work against each other: such effects should be analysed. Care should be taken to select a set of actions which support each other in achieving the complete set of goals and targets. It is also desirable to include some improvement actions which yield clear short term benefits, particularly if the organization is new to process improvement, in order to encourage acceptance of the process improvement programme.

When carrying out this task the organization should:

a) evaluate a number of scenarios to arrive at a set of actions which best meets the organization's needs (risk reduction and incremental approach can be considered);

b) use the indicators of process performance and process capability in the compatible process model being used, or the Base Practices and Management Practices of Part 5, as a basis for improvement actions;

c) define success criteria for each action and how progress will be measured (the metrics used to set the targets provide suitable measurements);

d) evaluate initial estimates of costs and benefits, schedule and risks for the proposed actions;

e) identify responsibilities for the actions, and agree the responsibilities with those affected by the actions;

f) identify recruitment and training needs.

The set of agreed actions should be documented as an action plan containing the following information:

— improvement actions with associated process goals and improvement targets;

— responsibilities for actions;

— initial estimates of costs, benefits and schedule (detailed estimates are made at 5.5.2 below);

— risks to products and to the organization if actions are taken or not taken and the implications for any schedule changes.

The action plan is a tactical plan, developed to meet the organization's needs, which should be integrated with the process improvement programme plan (originally developed at a strategic level during step 5.2). The process improvement programme plan should be reviewed at this point and updated if necessary. The updated process improvement programme plan should be approved by management to ensure that the organization is committed to implementing it.

5.5 Implement improvements

The updated process improvement programme plan is implemented in order to improve the organization's software process. Implementation may be simple or complex depending on the contents of the action plan included in the updated process improvement programme plan and the characteristics of the organization.

In general several process improvement projects will be initiated, each concerned with implementing one or more process improvement actions. Such projects will often not only cover initial implementation of improvements as described in this section, but the subsequent steps 5.6 and 5.7. Four main tasks are involved in each process improvement project:

a) selecting the operational approach to implementation;

b) preparing and agreeing the process improvement project plan (a detailed implementation plan);

c) implementing the process improvement actions according to the process improvement project plan;

d) monitoring the process improvement project.

5.5.1 Operational approach to implementation

Where there are alternative operational approaches to implementation, they should be evaluated and the most suitable selected. For instance, it may be possible to implement a given action either in small steps through piloting in a selected unit, or throughout the whole organization at the same time, or somewhere between these two extremes. Among the factors to consider are costs, time scales, and risks.

5.5.2 Detailed implementation planning

A process improvement project plan should be developed, including the following:

— the objectives of the process improvement project;

— a description of the approach to implementation;

— the organization and responsibilities;

— the time schedule and resources;

— risk management, including assessment, monitoring and mitigation;

— monitoring policy;

— specification of success criteria, including process goals and improvement targets.

The process improvement project may need to carry out a deeper analysis of improvement opportunities than that already carried out in step 5.4. Where appropriate, the plan should include:

— further collection and analysis of data to establish the underlying causes of unsatisfactory current effectiveness measurements and process profiles;

— evaluation of alternative proposals for eliminating the causes, including analysis of costs and benefits;

— arrangements to capture cost and resource usage data, for instance if it is desired to carry out cost-benefit analysis.

Those implementing the actions and those affected by them should be involved, or be consulted, while developing the plan and in evaluating alternatives, in order to draw on their expertise and to enlist their cooperation.

5.5.3 Implementing improvement actions

It is critical for successful improvement that due account is taken of human and cultural factors. In particular the following should be considered:

a) how management can give support and leadership (see 6.1);

b) what changes may be needed in values, attitudes and behaviour (see 6.2);

c) how to establish commitment to goals and targets (see 6.3);

d) how to foster open communication and teamwork, including implications for organizational structures and reporting lines (see 6.4);

e) whether changes are needed to recognition and reward systems (see 6.5);

f) what education and training is required (see 6.6).

5.5.4 Monitoring the process improvement project

The process improvement project should be monitored by the organization's management against the process improvement project plan in order to:

— ensure tasks progress as planned, and initiate appropriate corrective action if they do not;

— check that achievement of the planned goals and targets continues to be both realistic and relevant to the organization's needs;

— gather data on effort and resources expended, in order to improve estimates for future process improvement projects;

— evaluate the impacts of the implemented improvement actions on the process attribute ratings and capability level ratings.

Records should be kept for use both to confirm the improvements (see 5.6) , and to improve the process of process improvement (refer to the *Process Improvement Process*, ORG.2.3 in ISO/IEC TR 15504-2).

5.6 Confirm improvements

When the process improvement project has been completed, the organization should:

— confirm that the planned goals and targets have been achieved and that the expected benefits have been delivered;

— confirm that the desired organizational culture has been established;

— re-evaluate risks associated with the improved process;

— re-evaluate costs and benefits.

Management should be involved both to approve the results and to evaluate whether the organization's needs have been met. If, after improvement actions have been taken, measurements show that process goals and improvement targets have not been achieved, it may be desirable to redefine the process improvement project or activity by returning to an appropriate earlier step.

5.6.1 Improvement targets

Current measurements of process effectiveness should be used to confirm achievement of process effectiveness targets (see 7.3). The possibility of having introduced desirable or undesirable side effects should be investigated.

A further process assessment should be used to confirm achievement of targets expressed as process capability levels. The scope of this re-assessment should be related to the scope of the initial assessment. The scope might cover only the processes affected by the improvement actions, particularly where these had a narrow focus. Where several improvement projects were undertaken, however, consideration should be given to a re-assessment of wider scope to check for potential side-effects arising from the parallel improvement actions.

5.6.2 Organizational culture

The effect of the improvements on organizational culture should be reviewed to establish that desired changes have taken place without undesirable side-effects.

5.6.3 Re-evaluate risks

The organization should re-evaluate the risks of using the improved process to confirm that they remain acceptable, and to determine what further actions are required if they are not.

5.6.4 Re-evaluate cost-benefit

The costs and benefits of the improvements may be re-evaluated and compared with earlier estimates made at step 5.4 and 5.5. These results are useful to support planning of subsequent improvement actions.

5.7 Sustain improvement gains

After improvement has been confirmed, the software process needs to be sustained at the new level of performance. The improved process should be used by all those for whom it is applicable. This requires management to monitor institutionalization of the improved process, and to give encouragement when necessary. Responsibilities for monitoring should be defined, as well as how this will be done, for instance by using appropriate effectiveness measurements (see section 7.3).

If an improved process has been piloted in a restricted area or on a specific project or group of projects, it should be deployed across all areas or projects in the organization where it is applicable. This deployment should be properly planned and the necessary resources assigned to it. The plan should be documented as part of the process improvement project plan or the process improvement programme plan as appropriate. Consideration should be given to:

a) who is affected;

b) how to communicate both the changed process and the benefits expected from it (note: changes should be properly documented and approved);

c) what education and training are necessary;

d) when to introduce changes to the different areas, taking business needs into account;

e) how to ensure that the changes have been made (for instance by conducting audits);

f) how to ensure that the improved process performs as expected (for instance by monitoring capability levels and/or effectiveness measures - see section 7.3).

5.8 Monitor performance

The performance of the organization's software process should be continuously monitored, and new process improvement projects should be selected and implemented as part of a continuing process improvement programme, since additional improvements are always possible.

5.8.1 Monitoring performance of the software process

The performance of the organization's software process should be monitored as it evolves over time. The effectiveness and conformance measures used for this should be chosen to suit the organization's needs and business goals (see 7.3). Management should regularly review their continuing suitability. The risks to the organization and its products from using the software process should also be monitored and action taken as risks materialize or become unacceptable.

5.8.2 Reviewing the process improvement programme

The process improvement programme should be reviewed regularly by management to ensure that:

— both the improvement programme and individual improvement projects, including their goals and targets, remain appropriate to the organization's needs;

— further improvement projects are initiated when and where appropriate as previous improvement projects have been completed;

— the process improvement process is itself improved in the light of experience;

— continuous improvement becomes and remains a feature of the organization's values, attitudes and behaviour.

Further process assessments can be an important component of the continuing improvement programme, for instance in the following circumstances:

— where a long term goal to achieve higher capability levels is to be approached by stages;

— when changing organizational needs indicate a requirement to achieve higher capability levels;

— when there is a need to give a fresh impetus to improvement.

The extent to which improved processes have been institutionalized should be considered before scheduling further process assessments. It may be more cost-effective to delay assessing a process until improvements have been fully deployed, rather than expend resources assessing a process which is in transition, when the results can be difficult to interpret.

6 Cultural issues

Software process improvement should be strongly supported by leadership, communication and motivation throughout the whole organization. Improvement actions can only be carried out efficiently if the appropriate cultural issues are acknowledged and addressed at all levels. Moreover, major problems found in software processes often arise from cultural issues. Consequently, cultural issues should be one of the factors considered in prioritizing improvement actions.

6.1 Management responsibility and leadership

The successful use of this part of ISO/IEC TR 15504 to improve software processes requires the same high degree of management leadership and commitment as any other approach to process improvement and organizational change. The responsibility for leadership and for creating the environment for continuous process improvement

belongs to all levels of management, but particularly to the highest. Senior management should be aware of how the success of the organization depends on quality software and the ability to improve software processes.

The commitment of middle management may pose a particular risk to successful process improvement, particularly in less mature organizations. Largely concerned with meeting project commitments in the short term, middle management may pay little attention to process improvement benefits, which tend to be medium to long term, and often resent diverting scarce project resources to process improvement projects. A mitigation strategy to counter the risk is to ensure that senior management is committed to the costs and impact of process assessment activities and improvement actions on the projects to which they are applied.

Process assessment can identify areas of weakness in management responsibility and leadership as being a risk to the software process in general. An appropriate response is to raise the awareness amongst senior and middle managers of importance of software and software process improvement, possibly through training initiatives. Furthermore, analysis may suggest the need to change the role of middle management. Instilling teamwork principles and placing the emphasis on communication could change the relationship between middle managers and development teams from enforcement to facilitation, and from imposing ideas to helping teams develop their own ideas. The management approach should take account of the specific characteristics of software staff and software development work. Software production, requiring educated staff and high intellectual engagement, provides better results in a cooperative environment.

6.2 Values, attitudes and behaviour

Effective process improvement often implies a new set of shared values, attitudes and behaviour, which may include:

— focusing attention on both external and internal customer satisfaction;

— targeting employee satisfaction by establishing an appropriate recognition system (see 6.5);

— involving the entire software supply chain in process improvement, from suppliers to customers;

— demonstrating management commitment, leadership and involvement by communicating purpose and goals;

— emphasizing process improvement as a part of everyone's job and helping everybody to gain an understanding of how individual activities can be beneficially channelled towards the common goals of the team;

— considering quality, cost and time scale goals as priorities to improve processes;

— establishing open communication with access to data and information;

— promoting teamwork and respect for the individual;

— objectively measuring process performance and making decisions based on realistic metrics agreed by all parties in the organization (see 7.3).

Process assessment can help an organization to understand which changes are necessary in values, attitudes and behaviour. If current values, attitudes and behaviour do not contribute to meeting the organization's needs, the process improvement programme should include appropriate cultural change.

6.3 Process improvement goals and motivation

The organization's needs should be analysed to yield goals for improving the software process (see section 7.3). Targets should be set either in terms of use of good software engineering practice (increasing process capability levels), or in terms of the effectiveness with which the process meets the organization's needs (process effectiveness measures), or a combination of both. Less mature organizations are likely to emphasize the former and more mature organizations the latter. Industry benchmarks can be used as a reference to set appropriate improvement goals.

Staff motivation to achieve these goals will be strengthened if progress is made visible through regular measurement. Furthermore, the goals have to be understandable, challenging and pertinent. Strategies to achieve

improvement goals should be understood and accepted by everyone. Goals should be reviewed regularly and must reflect any change in the organization's needs.

6.4 Communication and teamwork

When analysing assessment results it is important to look for organizational, language, and personal barriers that are causing a lack of communication and teamwork, thereby interfering with the effectiveness and efficiency of the software process. Communication and teamwork require trust and skills. Good teamwork skills improve the ability to perform activities with the high degree of parallel work typical of software projects. Training should be considered as a means of improving the quality and effectiveness of teamwork skills.

Before conducting an assessment, agreement should be reached over ownership and confidentiality of the results and other information gathered during the assessment. This will help to build the necessary trust for effective process improvement. It is important that the individuals and groups responsible for the processes which are being assessed understand that the objective is to improve the processes, and not to assign blame to individuals. It is also necessary to communicate and discuss the assessment findings with the assessees before finalizing any recommendations. Unless this is done, individuals or groups may reject the findings, and may resist changes arising from the findings, thereby jeopardizing the outcome.

6.5 Recognition

The recognition process and reward system may help to encourage attitudes and behaviour necessary for successful process improvement (see 6.2). The definition of an appropriate recognition and reward system, consistent with the effort needed to achieve the improvement goals, should therefore be considered when planning improvement actions (see 5.4). The reward system should be designed in such a manner that it recognizes group performance and teamwork and avoids promoting destructive internal competition.

6.6 Education and training

On-going education and training are essential for everyone. Education and training programmes are important in creating and maintaining an environment where process improvement can flourish.

The effectiveness of education and training should be regularly assessed. Training separated from the use of the newly acquired skills is rarely effective. The assessment results include ratings related to the extent to which staff have received suitable training in the processes they use, which should be taken into account when planning improvement actions (see the *human resource management process,* ORG.3 and the process attribute *Process resource attribute 3.2* in ISO/IEC TR 15504-2).

Training in process improvement concepts, specifically, will increase the organization's readiness for process improvement (see process attribute 3.2 applied to the *Process Improvement process*, ORG.2.3). Important concepts that should be covered include process and quality concepts, process improvement concepts, process management skills, tools and techniques for process improvement, cultural change skills and supporting skills.

Process assessment concepts should be explained to all levels of the organization (from management to staff) being assessed. The assessors should have the necessary competencies and appropriate education, training and experience as defined in ISO/IEC TR 15504-6. Untrained assessors are less likely to produce objective, consistent and reliable results on which to base a successful process improvement programme.

7 Management

The full potential of software process improvement can only be realized when applied and coordinated within a structured framework. This requires software process improvement to be organized, planned, and measured, and all process improvement activities to be subject to management review. It is very unlikely that permanent long-term changes will result without consideration of the managerial implications of software process improvement.

7.1 Organizing for process improvement

For software process improvement to be performed effectively, the entire organization should be involved. The general organizational principles for quality improvement described in ISO 9004-4 apply to software process improvement.

Responsibilities for process improvement activities are divided between different roles of:

— senior management;

— process improvement programme;

— process improvement projects;

— process owners; and

— organizational units.

Note that in real organizations these responsibilities will be allocated across the actual management structures and individuals; in many organizations (particularly small ones), the responsibilities of different roles may be combined in the same individual. The differing responsibilities are reviewed below.

7.1.1 Senior management

Senior management involvement is needed to translate the broad understanding of the needs and business goals of the organization into the investment in software process improvement, and to provide the necessary commitment and decision making.

The responsibilities of senior management include:

— defining the mission, objectives and needs of the organization (input to step 5.1);

— preparing the business plan, including software process improvement goals, resource estimates and time scales;

— approving the process improvement programme plan (see 5.2 and 5.4);

— assigning responsibilities for process improvement projects;

— ensuring that the appropriate resources to support process improvement are provided;

— monitoring improvement results to ensure targets have been met (see 5.6);

— initiating and supporting activities aimed at institutionalizing improved processes (see 5.7);

— regularly reviewing the overall process improvement programme to ensure its continued appropriateness to the business (see 5.8);

— fostering changes in values, attitudes, and behaviour to support software process improvement (see clause 6).

7.1.2 Process improvement programme management

Processes interact with each other and flow across organizational boundaries. Therefore, a process improvement programme must have an overall process view, which covers entire processes to be improved. Managing the programme can be done by assigning software process improvement responsibilities across these boundaries. Typically this can be organized by setting up a cross functional action team or establishing an organizationally independent software engineering process group to deal with all software process issues.

Process improvement programme management responsibilities across organizational boundaries include:

— establishing systematic software process measurements including both software process assessments (see 5.3), and effectiveness measurements;

— evaluating measurement results;

— setting software process improvement targets, and agreeing these with the process owner and the organizational units involved (see 5.4);

— identifying improvement actions and gaining the agreement of the process owner and the organizational units involved (see 5.4);

— naming the project leader for each process improvement project;

— participating in development of process improvement project plans with those responsible for each improvement project, the process owners and the organizational units involved (see 5.5);

— monitoring the progress of improvement projects towards their targets (see 5.5);

— supporting continuation of software process improvement (see 5.8);

— reviewing the software process improvement process itself in the light of the lessons learned(see 5.8).

7.1.3 Process improvement project management

Process improvement actions defined by the process improvement programme management and approved by the process owners will be managed as improvement projects by applying a general project management approach. Improvement projects are managed by a project leader named by the process improvement programme management.

Process improvement project management responsibilities are:

— preparing and updating the process improvement project plan in consultation with the owner of the process to be improved and representatives of the organizational units involved (5.5);

— obtaining the approval of the process owners for the process improvement project plan and the changes to the processes (5.5);

— acquiring sufficient physical and human resources for implementing the process improvement project plan (5.5);

— organizing the implementation project in consultation with the owners of the process to be improved and representatives of the organizational units involved (5.5);

— monitoring and controlling the implementation process (5.5);

— reporting the status of the implementation for both the process owners and senior management (5.5).

7.1.4 Responsibilities of the process owners

Each process should have a process owner who is responsible for the whole improvement activity inside the organizational unit. Software process improvement aims to increase satisfaction of both external customers and internal personnel, therefore their viewpoints should also be taken into account by the process owner. Awareness of software process improvement issues as well as collaborative communication are required at all organizational levels (see clause 6): this is one important part of the process owner's responsibility. Process owners, as representatives of the customers of the improvements, should be involved in the whole improvement cycle.

Responsibilities of a process owner include:

— providing information and measurements on the current process status (see 5.3);

— identifying what external customers and internal personnel need from their direct supplier;

— promoting awareness and collaborative communication between internal users and external customers about the improvement action;

— support for planning of the process improvement programme and process improvement projects (see 5.4 and 5.5);

— approving the process improvement project plans;

— participating in improvement activities (see 5.5);

— monitoring and confirming the improvement results (see 5.5).

7.1.5 Role of the organizational unit

The processes and practices within an organizational unit are the targets of software process improvement. The staff of the organizational unit will be affected by the changes and so it is important to engage them in the improvement activities. Their opinions and viewpoints should be considered when planning the improvements so they can provide useful feedback on the results of the improvement.

Responsibilities within the organizational units involved in software process improvement include:

— collecting measurements on the practices/processes instantiated within the organizational unit (this includes participation in assessments (see 5.3));

— implementing improvement actions on the organizational unit’s processes (see 5.5);

— monitoring progress of improvement actions (see 5.5).

7.2 Planning for process improvement

The planning of a software process improvement programme is an iterative activity that extends for the entire life of the programme, starting from the definition of improvement goals and continuing through all phases of the improvement cycle.

Three main levels of planning should be performed, resulting in the following documents:

a) business plan;

b) process improvement programme plan;

c) process improvement project plan.

7.2.1 Business plan

A software process improvement programme should meet the organization's needs and business goals, usually by aiming at improving quality, increasing cost control, reducing time to delivery, reducing risk, or some combination of these. Management should set overall improvement goals which may impact the whole software process. The organization's business plan should include software process improvement goals as well as resource forecasts and time constraints for the implementation of process improvement. The business plan should include an overall evaluation of the risks to the organization if the current software process is not improved. Such evaluation may cause the organization to undertake the process improvement programme. The reasons for including this preliminary improvement planning in the business plan are firstly to align improvement with the organization's needs and business goals, secondly to ensure the availability of required resources, and thirdly to ensure the success of the organization's improvement strategy. At this level, process improvement programme planning is the responsibility of the organization's senior management.

Software process improvement goals and constraints (time and resources) stated in the business plan should be considered when:

— examining the organizational needs (see 5.1);

— defining the preliminary process improvement programme plan (see 5.2);

— completing the process improvement programme plan based on the assessment findings (see 5.4);

— confirming the improvement (see 5.6);

— monitoring process performance when an improvement cycle has been completed (see 5.8).

7.2.2 Process improvement programme plan

The process improvement programme plan is the document that addresses the entire process improvement programme defined to meet the goals stated in the business plan. It controls continuous improvement activities throughout the organization, and can be maintained through more than one improvement cycle. The process improvement programme plan will be owned by the process improvement programme management (7.1.2).

Due to its nature, the process improvement programme plan is an evolving document that is updated through three main stages as:

a) a preliminary process improvement programme plan;

b) the updated process improvement programme plan itself;

c) the ongoing process improvement programme plan.

When a process improvement programme is initiated, the improvement areas, actions and related risks, together with a budget and time schedule, are identified and defined in a preliminary version of the process improvement programme plan (as a result of step 5.2). This information will be revised after the process assessment, based on the assessment findings (see 5.4). The plan is then completed with the target profile, gap analysis information and possibly with current and target effectiveness measurements. Resource budget and schedule are revised. The overall organization for the process improvement programme is defined. The plan will also include a risk evaluation with descriptions of the risks if the process improvement programme is not undertaken, the risks if it is, and mitigation strategies to be adopted. Finally the action plan derived from analysis of assessment results (see 5.4.3) is attached to complete the process improvement programme plan.

The process improvement programme plan is then used for monitoring the implementation of the improvement actions (see 5.5). It is continuously updated to reflect the actual status of the improvement actions. If the improvement targets are revised, the process improvement programme plan should be updated accordingly.

The process improvement programme plan can be used as an input to a process capability determination activity (see ISO/IEC TR 15504-8). Based on the target capability of the process capability determination and the current capability obtained from the assessment, the process improvement programme plan may be tuned in order to meet the contract requirements. The process improvement programme plan can be used by the customer to establish a level of confidence in the supplier's processes. It can also be used by the supplier organization to identify the capability to be offered to the customer (the “proposed capability” described in ISO/IEC TR 15504-8).

7.2.3 Process improvement project plan

Improvement actions defined in the process improvement programme plan will be implemented as projects. When the improvement actions are complex and involve more organizational units, they might need to be implemented as several separate improvement projects. Each identified improvement project will be planned and the results are documented as process improvement project plans.

Typically process improvement projects are unique and innovative efforts for the organization that may require new types of resources and the adoption of new viewpoints. The human inertia of the organization may render the project more difficult to carry out. Therefore, process improvement projects often involve higher risks than projects that are repetitive in nature. As risks are situational and exist in different forms in different improvement steps or activities, a careful and detailed risk analysis should be performed in each step of each project.

Risk analysis at this stage includes reviewing and updating the risk descriptions and mitigation strategies included in the process improvement programme plan. All process improvement project plans should be prepared in consultation with appropriate people at the appropriate level in the organization, and with suppliers and customers

of the organization (see section 7.1). Involving everyone greatly increases the opportunities for improvement and the chances of success.

Typically a process improvement project plan should contain:

a) a detailed definition of the objectives and scope of the improvement action to maintain traceability with respect to the requirements defined in the process improvement programme plan;

b) a detailed and concrete description of the improvement results to be attained in the project;

c) a detailed time schedule and work breakdown structure;

d) a detailed resource estimate;

e) approval criteria for intermediate and final results of the improvement action.

7.3 Measuring process improvement

The role of measurements is crucial in software process improvement. Measurements are needed to show quantitatively the current status of processes and practices against a general understanding of software engineering best practices, and to show to what extent software processes are effective in achieving the organization's needs and business goals.

Best practices provide a general model of the software industry but cannot directly reflect specific characteristics of a single organization. Each organization has its own specific needs and business goals that will influence the selection of industry best practice for use in improvement.

Process effectiveness measures, and process attribute and capability level ratings address different facets of understanding of the process. All may be considered from the organization’s point of view and used together in process improvement.

7.3.1 Process attribute and capability level ratings

The primary output of a process assessment is the set of process profiles containing process attribute ratings and the assessment record. The process attribute ratings may be used to provide a process capability level rating according to the capability level scale in ISO/IEC TR 15504-2. The process attribute and capability level ratings provide a view of how the organizational unit’s processes conform to the model of good practice contained in the reference model. However, the essence of the rating scheme is that the ratings represent more than just conformance: attributes are rated within the specific context in which the processes operate. The process context and other elements of the assessment input ensure that the assessment results are directly related to the organization.

The assessment results, therefore, provide immediate pointers to potential areas for improvement using the reference model as the route map. Analysis of the results (step 5.4) yields a view of the strengths and weaknesses of the assessed processes. Where several projects are assessed, the results can provide a view of the relative strengths, weaknesses and differences between projects, and can highlight systematic weaknesses.

The assessment, however, will be conducted with a compatible assessment model which contains more detail than the reference model in part 2. In particular, the assessment model will contain sets of indicators of process performance and process capability. These indicators, and the record of the evidence supporting the process attribute ratings, provides a much richer picture of the implemented practices than the process attribute ratings alone.

The information gained from the assessment allows an organization to understand the current state of its processes and to set improvement targets expressed quantitatively as process capability levels and process attribute ratings to be attained for individual processes. This information may either strengthen the initial improvement goals defined for the process improvement programme, or cause them to be revised.

Once the improvements have been implemented (see 5.5), their effects may be confirmed through a reassessment (see 5.6).

7.3.2 Effectiveness measures

An assessment provides ratings based on defined purpose statements of a model compatible with the reference model. The ratings are judged against process context. However, businesses may define different priorities for their process goals. Therefore, measures of process effectiveness may also be needed.

Effectiveness measures address the extent to which the software process achieves goals derived directly from an analysis of the specific circumstances, needs, and business goals of the organization. Effectiveness measures support the choice of processes to be improved and the monitoring of improvement results.

Effectiveness measures are usually defined based on the characteristics of process output. As an example, the effectiveness of a planning process may be related to its efficiency, its accuracy, its reliability or its repeatability, or some combination of these. Since organizations have unique circumstances and needs, the choice of effectiveness measure will differ between different organizations. Whichever one is chosen, however, its value may be measured and compared to a target value or threshold as a means of measuring improvement.

7.3.3 How to use process attribute ratings and effectiveness measures

Capability levels, based on process attribute ratings, and effectiveness measures may be used together to support software process improvement. An improvement goal might be stated and effectiveness measures identified to quantify the goal. Process attribute ratings from an assessment may provide the analytical information to identify a number of areas for improvement which together would support the achievement of the stated goal.

For instance, considering example 1 in Annex A, it can be seen that the goal of obtaining a large market share for an innovative product might be achieved by reducing the time to market, or improving product quality or both. Reducing time to market can be achieved by establishing reuse in the software organization, and reinforcing configuration management and project management. Improving product quality could be achieved by improved testing and quality control, but possibly also by establishing a proper reuse strategy. Evaluation of the current process profile leads to an understanding of strengths and weaknesses and the choice of the most cost effective improvement action. The choice of improvement areas, priorities and actions is non-deterministic: many factors such as previous investments, existing culture, previous success or failures and so on should be taken into account.

7.3.4 Framework for measuring processes

By making use of both capability levels and effectiveness measurements, the organization's management can ensure that investment in process improvement is as cost-effective as possible. Organizations are recommended to set software process targets expressed either in terms of use of recognized good software engineering practice (ie. increased process capability level), or in terms of the effectiveness with which the process meets the organization's needs, or a combination of both. Less mature organizations are likely to emphasize the former and more mature organizations the latter.

Figure 4 illustrates a framework for measuring processes, which may be applied with both capability level/process attribute ratings and effectiveness measurements and in integrating them to fulfil the improvement purpose.

The entities in this model are as follows:

— The **software process goal** is an aim or objective of all or part of the software process. A software process goal should be defined, wherever possible, such that a single software process metric can be used to judge the degree to which the goal is achieved;

— A **software process metric** is a quantitative measure of the degree to which a software process goal is met. Software process metrics include both effectiveness measures and process capability level ratings as defined in ISO/IEC TR 15504-2;

— The **software process target** is a desired value of a software process metric;

— A **software process improvement action** is an action planned and executed to improve all or part of the software process. A software process improvement action can contribute to the achievement of more than one software process goal;

— The **software process current measurement** is the value of a software process metric before implementing an improvement action;

— The **software process improvement result** is the value of a software process metric after taking a software process improvement action.

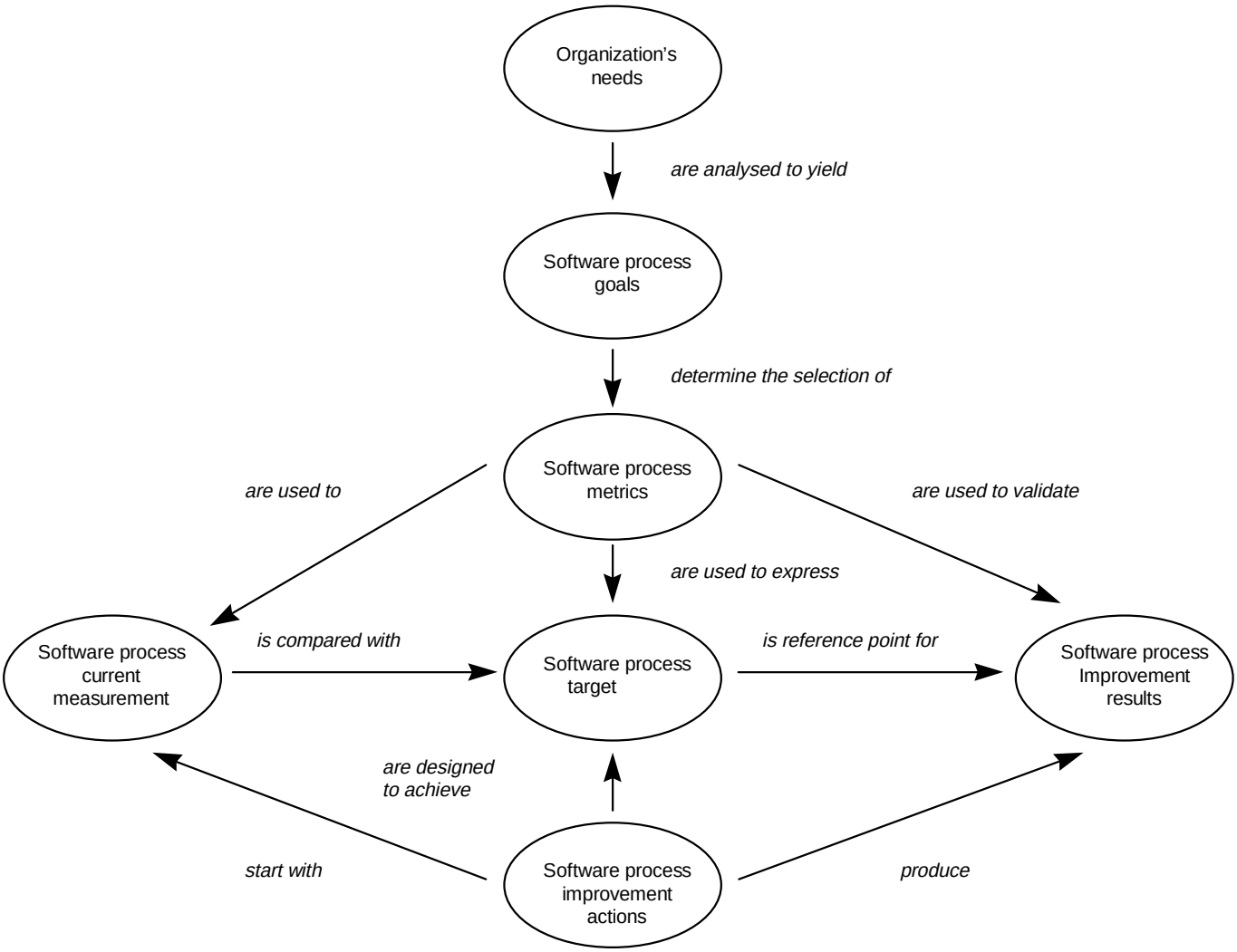

Figure 4 — Process measurement framework

When using the framework to measure capability levels :

— the software process goal corresponds to the purpose statement of the process in ISO/IEC TR 15504-2;

— the software process metric corresponds to the rating mechanism defined in ISO/IEC TR 15504-2;

— the current measurements, targets and results are expressed as process capability level ratings.

When using this framework to measure effectiveness, the organization should:

— analyse its circumstances and needs, to identify and define a set of qualitative goals for its overall software process. Software process goals should be chosen to have the most direct and critical impact on meeting the organization's needs which is possible when the general goals are further decomposed and refined to correspond to single processes and individual or team responsibilities. Note that each goal applies to all or part of the organization's overall software process: this may be a single process in the process model compatible with the reference model, or several related processes, or even a single practice;

— devise an appropriate way to measure whether each software process goal has been achieved. This is termed a software process metric. It may be necessary to iterate between the definition of goals and metrics until satisfactory metrics are found to measure the achievement of each qualitative goal;

— use the software process metrics to express a software process target for each defined software process goal. A software process target is a numerical value quantifying the extent to which the goal is achieved, and is chosen to meet the organization's needs. Its value may be better than the current value for the process (in which case it is a target for improvement), or it may be the same as the current value (in which case it is a steady-state constraint on improvement), or in some cases it may be worse than the current value due to previously incorrectly set targets;

— select software process improvement actions, which taken together as a package are designed to achieve the complete set of software process targets. In general, many actions may affect achievement of each target, and each action may affect the achievement of several targets;

— monitor the progress of the software process improvement actions by comparing current values of the metrics against the targets as appropriate;

— validate the software process improvement results (the metric values achieved after the actions have been completed) by comparing them against the targets.

The organization will normally use a mixture of effectiveness measures and capability levels to set targets for improvement. Capability levels will indicate the most promising improvement areas according to the distance between the organization's practices and the baseline; on the other hand, effectiveness measures of the processes will provide information about the efficacy of the organization's processes compared to the needs.

7.4 Reviewing process improvement activities

In general, regular reviews of improvement activities should be conducted at all levels of management to ensure that:

— the improvement organization is functioning effectively;

— plans for improvement are adequate and are being followed;

— measurements for effectiveness and for improvement are appropriate and adequate, and indicate satisfactory progress;

— software process assessments are conducted when it is appropriate to do so;

— a reasonable balance between opportunity for improvement and risk to the organization is maintained;

— the results of the review are fed into the next planning cycle.

Appropriate actions should be taken where any discrepancies have been identified.

Annex A
(informative)

Application of the process measurement framework

A.1 Overview

Section 7.3 explains how to use process measures for improvement. The following table gives examples of how the process measurement framework can be applied.

Table A.1 — Use of process measurement framework

Organization needs	Software process goals	Software process capability metrics	Software process effectiveness metrics	Software process targets	Software process results
Example 1					
Obtain a large market share for an innovative product to secure additional financing.	1) Short software process time to market; 2) High software quality (i.e. high reliability); 3) Good Engineering and Support processes and reuse strategy.	Capability levels of all processes in the ENG and SUP process categories and the infrastructure process, ORG.4.	Calendar time from requirements to delivery	Raise level 1 ENG, SUP and ORG.4 processes to level 2.	All processes at desired capability level.
Example 2					
Improve quality in order to increase market share.	ISO 9001 compliance	Capability level of processes which map to ISO 9001.	Number of post delivery defects	Capability levels necessary to achieve ISO 9001.	All processes at desired capability levels. Compliance to ISO 9001 checklist.
Example 3					
Compete with fixed price contracts	accurate estimation achieve process purpose for the project management process, MAN.2	Capability level of MAN.2	% of projects complete within 10% of plan	90% of projects complete within 10% of plan MAN.2 at Level 2	67% of projects complete within 10% of plan MAN.2 at Level 2

Annex B
(informative)

Application of the improvement methodology

B.1 Introduction

The example below follows the 8-step model described in clause 5, and shows how to use the process measurement framework in figure 4 as part of this model. Of necessity, some of the detail is omitted, but the principal steps of the process and measurement should be clear. The example describes the whole process, and includes discussion of the process measurement framework within the description of the process steps.

B.2 Example: MovieViews' drive for higher quality

B.2.1 Step 1: Examine the needs of the organization (see 5.1)

MovieViews is a medium-sized company which produces interactive multimedia software for PCs. Unfortunately, even though quality assurance personnel provide independent review of all products, defective products have been distributed and unhappy customers have called the company to report problems. The company needs to reduce and finally eliminate defects which affect customer satisfaction.

The new Managing Director, Mandé Taylor, realized the employees had no sense of personal contribution to the quality of the company's products or understanding of the company vision. As a first step, she wrote a document describing the mission of the company, goals for all aspects of the way the company wants to do business, expectations for the content and quality of the products, and the type of work environment to be supplied for all employees. Mandé organized a series of meetings first with the executives and then with the entire staff to illustrate and discuss the content of this document.

Mandé worked with all executives to build their awareness of the possibilities for growth and profitability in MovieViews, and help them to see their part in the future of the company. She knew a software process improvement programme was instrumental in improving the quality of their products: it was not enough to concentrate solely on finding defective products before the customer saw them. Working with groups of employees to understand the problems, a simple qualitative software process goal was defined:

> *"Improve our ways of developing and upgrading software so that we can produce software products with fewer defects at no higher cost or length of time to market."*

B.2.2 Step 2: Initiate process improvement (see 5.2)

Mandé immediately understood the need for precise data to get a reliable picture of the current status. First she asked the executives to prepare a report containing information on the number and types of error for each family of product, and the phases in which the errors were detected.

On completion of the report, it was immediately clear that the data were not comparable and that there were significant differences between different families of products. As a result Mandé realized that the company did not have a common way of producing software.

She immediately established a team to coordinate an improvement programme to address the problem. The team included herself, the Director of Quality Assurance, Doq, the Engineering Director, Ed, the Software Application Manager, Sam, and the Marketing Director, Mark.

Each team member was charged with reporting back to his or her department on the status of the Process Improvement Programme and to make its success a personal issue. This sense of commitment was conveyed to the other employees. Mandé made *"Status of the process improvement programme"* the first item on the agenda of

each of her staff meetings. She discussed it at board meetings and made sure that the subject was discussed at the local user group meetings.

Mandé had been recruited from a company with a successful process improvement record. Consequently, she knew that it was essential to reserve resources for process improvement. She decided to include defect reduction as a major goal in the company's annual business plan, and to set aside a budget for improvement and staff training.

At this point, Mandé had two major problems:

a) she did not know where the defects were actually generated and consequently which parts of the software process to improve;

b) she did not know how much the company could improve in the near future (one year), without compromising the production deadlines for new products or reducing the support levels for the existing ones.

Knowing that a plan was needed to make the improvement effort cost-effective, Mandé decided to chair the improvement team herself and make the preparation of an overall process improvement programme plan the first priority for the team.

A preliminary version of the process improvement programme plan addressed the following:

— How does the company take the goals defined in the business plan and map them to the goal of producing a quality software?

— Where should improvement efforts be directed?

— What are the constraints on software process improvements (resource availability to implement improvements, time scales for improvements, etc.)?

— What are the specific implementable, measurable goals that can be derived from the broader software process goal?

— What historical information exists that might help in understanding the current problems, and where improvements are most needed?

— What methods of communication and review will enable every employee to understand the progress in improvements, and the process improvement team to understand what actions need to take place?

— What are the characteristics of the company culture that support change?

— What are the characteristics that may need to change for improvements to happen and persist over time?

As a starting point for the improvement programme it was decided to undertake a process assessment to get a better picture of the current situation.

B.2.3 Step 3: Prepare for and conduct a process assessment (see 5.3)

Before the assessment actually took place, all the technical organizations worked to collect measurements of the software processes as they were currently being performed. Since product quality had been identified as a serious problem, each software engineer was encouraged to keep track of time spent:

— on correction of problems identified by customers;

— for requirements analysis, design, and documentation before starting to code;

— on correction of problems identified by the developer.

These measurements were used to raise the awareness of each software engineer of how much time was being spent correcting problems and how much of this time might be better spent in preliminary activities to prevent those problems from happening.

After the company executives had approved the preliminary version of the process improvement programme plan, they agreed that the Engineering Director, Ed, should sponsor the assessment. They also agreed to assign ownership of the assessment and its results to the Application Manager, Sam.

Ed and his team decided that, although training was taking place on many aspects of software processes and their assessment, no employee was qualified to act as a competent assessor. Therefore a contract was established with an external consultant, Cas, a competent assessor. Cas worked with the process improvement team to develop an assessment purpose which read, in part:

> *"The purpose of this assessment is to identify those activities in the software processes which contribute significantly to the inclusion of defects in our software products. This is part of a continuous process improvement programme to reduce the number of defects through the enhancement of worthwhile but inadequate processes, the replacement of inefficient processes and the addition of new processes ".*

The three projects that develop the most important product families (Blueball, Purplepillow, and, Pinksquare) were selected for assessment. Amongst these, Pinksquare had shown the best results and Blueball the worse. It was decided to assess all the processes involved in software production in these units, including the entire life cycle and the supporting activities.

Two major constraints were placed on the assessment. Firstly, project Purplepillow had important delivery dates to meet for the next release of the product. The assessment was to create minimal disturbance to Purplepillow's schedule, even at the expense of depth of coverage. Secondly, the survival of Blueball in the marketplace was dependent on re-engineering the product. An in-depth assessment of the Blueball re-engineering project was essential.

An assessment team was appointed, including Cas, a representative of the Quality Assurance Unit, and an expert from each project in order to provide a good understanding of the needs and characteristics of each project and product family. It was decided to interview some of the marketing staff since customer support was performed within the Marketing Unit, and these staff had the most direct contacts with the customers.

Based on the assessment scope defined by the improvement team, the assessment team decided to assess the following processes:

Customer-Supplier Process Category (CUS)	
CUS.3	Requirements elicitation process
CUS.4.1	Operational use process
CUS.4.2	Customer support process

Engineering Process Category (ENG)

all processes

Management Process Category (MAN)

all processes

Support Process Category (SUP)

all processes

Even though the executives agreed that assessment was a worthwhile activity, they were concerned about the time that would be taken for performing it. Process improvement team members planned to devote about 10% of their time to improvement activities. The assessment team members expected to work almost full time for a month to complete the assessment.

During the assessment, records were kept of comments made by interviewees, procedures described by the software engineers, questionable practices, and the opinions of interviewers and interviewees.

B.2.4 Step 4: Analyse assessment results and derive action plan (see 5.4)

The process improvement team analysed the results of the assessment, primarily looking at findings which could be related to product quality. Feedback from the assessment indicated that software was being developed without a clear understanding of requirements, so that the software engineers spent a lot of time going back and making corrections once they did understand the requirements. One conclusion was that last minute changes had the

potential to introduce defects into the software. In addition, system testing activities were not performed in a systematic way.

Detailed analysis showed that there was a satisfactory situation in the area of project management: most of the processes were at capability level two and some even at capability level 3 with no significant differences between the projects. Design activities seemed to be satisfactory: ENG.1.3, ENG.1.4, ENG.1.5 and ENG.1.6 were all at level 2.

The problem areas appeared to be related to requirement definition and system testing. The process profiles (process attribute ratings) and capability levels for these processes were:

	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	CL
CUS.3 Requirements elicitation										
Blueball	N	N	N	N	N	N	N	N	N	CL0
Purplepillow	P	P	P	N	N	N	N	N	N	CL0
Pinksquare	L	L	L	N	N	N	N	N	N	CL1
ENG.1.1 System requirements analysis and design										
Blueball	P	P	N	N	N	N	N	N	N	CL0
Purplepillow	L	P	L	N	N	N	N	N	N	CL1
Pinksquare	L	L	P	N	N	N	N	N	N	CL1
ENG.1.2 Software requirements analysis										
Blueball	L	P	P	N	N	N	N	N	N	CL1
Purplepillow	L	L	P	N	N	N	N	N	N	CL1
Pinksquare	L	L	L	N	N	N	N	N	N	CL1
ENG.1.7 System integration and testing system										
Blueball	F	P	P	N	N	N	N	N	N	CL1
Purplepillow	F	L	P	N	N	N	N	N	N	CL1
Pinksquare	F	L	L	N	N	N	N	N	N	CL2

These results were supported by the detailed records from the assessment. In particular, the indicators of process performance highlighted the weaknesses in the practices at the performed level (capability level 1), whilst the indicators of process capability provided the insights into the process attributes at the managed process level (capability level 2).

The improvement team decided to address these processes as the main priorities for the improvement programme.

The assessment team recommended that MovieViews should plan increases in capability levels for the selected processes throughout the company: first ensure each of the process was fully performed, and then concentrate on raising each process to capability level 2.

A major goal of the improvement team was to evaluate how process improvement might affect product quality. A set of metrics was established to achieve this goal. As the level of defects was the main issue, a program of measurement of defects was put in place to provide visibility of improvement. The key measures were to be:

— the number of open problem reports from customers during each reporting period of two weeks [what is the magnitude of the problem?];

— the number of problem reports from customers per product [where are the worst problems?];

— the distribution of problem reports within product by type and severity [do we have many small problems (probably systemic process problems), a few major problems (might be isolated process implementation problems), or some combination of both?].

A target was established to show all employees the goals for these metrics:

— percent of time spent on rework <5%;

— percent of time spent on new projects >50%;

— percent of time spent in reviews >5%;

— percent of time spent in testing, or quality assurance activities <10%;

— number of problem reports from a customer open per reporting period decreased to no more than one;

— no single product with more than one problem report from a customer/1,000 lines of code opened against it;

— no Class 1 (the most severe) problem reports from a customer on any product.

In addition it was decided to use the time cards of personnel in the Software Applications Group and Engineering Department to track costs related to non quality. The time cards were used to measure:

— any scheduled tasks;

— each phase of development;

— rework;

— new projects;

— education and training;

— reviews and other quality management tasks.

This data could be used to derive useful information, including information about quality and cost.

Information About Quality

— the percentage of time on rework reflected the quality of work (especially rework for which MovieViews was not getting paid or rework created just because someone was careless);

— the percentage of time on new projects indicated how far ahead they were looking towards new business;

Information About Cost

— time spent in reviews, testing or other quality assurance activities - the cost of quality.

Measurements were taken to show the current status. The figures were:

— 35% of time spent on rework;

— 10% of time spent on new projects;

— <1% of time spent on reviews;

— 10% of time spent on testing and other quality assurance activities;

— 40 customer-generated problem reports were open and distributed as follows:

	Problem classification		
PRODUCT	**Class 1**	**Class 2**	**Class 3**
Pinksquare (Large application)	2	0	1
Purplepillow (Medium application)	0	18	4
Blueball (Small application)	6	5	4

Process improvement actions were identified and documented in an action plan. These included:

— the introduction of a systematic approach to the collection and analysis of customer needs;

— the definition of a clearer interface between staff supporting the customer and staff designing the products;

— the introduction of a systematic approach to system and acceptance testing;

— the introduction of formal reviews to be held on completion of each of these processes;

— a mechanism to monitor the implementation of the improvements.

The team made an interim presentation to senior management which was well received. Management approved the updated process improvement programme plan, including the action plan and the revised budget and schedules, and authorized the start of the process improvement projects.

B.2.5 Step 5: Implement improvements (see 5.5)

This was the first action plan to be implemented. Others would be implemented on a regular schedule as defined in the process improvement programme plan.

Three improvement projects were created: one to carry out improvements on requirements definition; a second on system and acceptance testing; and a third on reviews. Each project established its own project plan describing the strategy to be adopted to implement the improvement.

The first project looked initially for possible changes in the organization, and then to the establishment of a clear procedure to communicate user expectations to the development group.

The second project set out to collect the good practices from the Pinksquare project and to generalize them for transfer to other projects.

The third project hired an experienced consultant to brief them about the practical experiences in putting reviews in place within industrial organizations and to help them to identify the best way of introducing reviews within MovieViews.

Each of the improvement projects was piloted in one of the three product development projects and measurements were taken to get preliminary confirmation of the benefits derived from the selected improvement actions.

B.2.6 Step 6: Confirm improvement (see 5.6)

Even though the targets were not quite achieved, the improvement team was encouraged by the results of the pilot projects, and decided it was worth proceeding. At least the team was confident about the reliability of the data collection, and project staff could see the benefits. The team presented the experiences of the pilot projects in seminars to the entire staff.

Tracking already showed a decrease in product defects as a result of increasing reviews and awareness of the need for the reviews. Some further reorganization was needed, however, to move from reliance on product checking to process reviews. A cost-benefit analysis showed that the cost of process improvement was less than the gain from fewer customer complaints and more products sold to the distributors.

The changes introduced in the pilot projects were carefully reviewed and documented in procedures that were distributed to all units to be used as a reference to plan their own projects.

B.2.7 Step 7: Sustain improvement gains (see 5.7)

Once reviews, including formal preparation and documentation of the results, were being routinely scheduled as part of the software process, the simple metric of whether or not reviews were held was expanded to track data such as the number of changes required as a result of the review; and the hours required by the software staff to make these changes. This, combined with the product data measurements, enabled MovieViews to continue to refine and improve the software process as part of a continuous improvement program.

The review goals were enhanced to include the evaluation of how the newly established processes were being applied. Data collected within reviews started to be used to monitor these processes within the entire organization.

B.2.8 Step 8: Monitor performance (see 5.8)

Senior management continued to be involved with the process improvement programme. Further assessments were planned to confirm the improvements and to identify new ones.

Annex C
(informative)

Mapping to ISO 9004-4

C.1 The guidance on software process improvement described in this part of ISO/IEC TR 15504 builds directly on the guidance of ISO 9004-4. This annex provides the mapping between the clauses of this document and ISO 9004-4.

Table C.1 — Mapping to ISO 9004-4

ISO/IEC TR 15504-7		ISO 9004-4	
5.	Methodology for software process improvement	6	Methodology for quality improvement
5.1	Examine the organization's needs and business goals	6.1	Involving the whole organization
5.2	Initiate process improvement	6.2	Initiating quality improvement projects or activities
5.3	Prepare for and conduct a process assessment	6.3	Investigating possible causes
5.4	Analyse assessment results and derive action plan	6.4	Establishing cause and effect relationships
5.5	Implement improvements	6.5	Taking preventive or corrective actions
5.6	Confirm improvements	6.6	Confirming the improvement
5.7	Sustain improvement gains	6.7	Sustaining the gains
5.8	Monitor performance	6.8	Continuing the improvement
6.	Cultural issues	4.2	Environment for quality improvement
6.1	Management responsibility and leadership	4.2.1	Management responsibility and leadership
6.2	Values, attitudes and behaviour	4.2.2	Values, attitudes and behaviours
6.3	Process improvement goals and motivation	4.2.3	Quality improvement goals
6.4	Communication and teamwork	4.2.4	Communications and teamwork
6.5	Recognition	4.2.5	Recognition
6.6	Education and training	4.2.6	Education and training
7.	Management	5.	Managing for quality improvement
7.1	Organizing for process improvement	5.1	Organizing for quality improvement
7.2	Planning for process improvement	5.2	Planning for quality improvement
7.3	Measuring process improvement	5.3	Measuring quality improvement
7.4	Reviewing process improvement activities	5.4	Reviewing quality improvement activities

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