Tool Support for Software Process Assessments

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DECLARATION

I declare that certain documents within this thesis were either contributed to or written in their entirety by persons other than myself. These documents are listed below together with the contributing parties. The extent to which the responsible person(s) contributed to the respective documents is indicated.

Document name	Responsible person(s) and extent of contribution made
MSC: 'Investigation into common data requirements for software process assessment and ISO 9001 compliance.	Gee, Clinton for his research work in the mapping of the ISO 9001 and ISO/IEC 15504 via the intermediate ACL model (Chapter 11) See Chapter 20: Project and Publication History, for more information.

I declare that apart from those areas credited to the parties listed above; this thesis is my own work. It is being submitted for the degree of PhD Electrical Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before any degree or examination in any other University.

Richard Him Lok

15th day of   August   2005

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1.1   Thesis Abstract

Software process assessments are currently being conducted by organisations using de facto assessment standards such as ISO/IEC 15504, ISO 9001, CMM and BOOTSTRAP. These assessment standards require practical tools and support mechanisms to enable them to be effective and efficient in their execution. This thesis is a study of the functional composition of such automated tools and investigates the viability of creating mappings between the software process models that would allow the assessment data to be translated between models. The result is a model for creating automated assessment tools and a methodology for using data mappings to translate and compare assessment data between software process models in these assessment tools.

1.2   Background and Relevance

Software process assessment has been established as an essential part of the software development life-cycle for organisations wanting to determine the capability levels and consistency of its software processes as well as improving upon them. In the past, an assortment of software process assessment standards - such as the SW-CMM, ISO 9001 and Bootstrap - have been used in internationally for evaluating software quality.

Now the contemporary international assessment standard is ISO/IEC 15504 (formerly known as SPICE, or Software Process Improvement and Capability dEtermination) has the potential to be a global solution for organisations in presenting a unified process assessment framework.

However - much time, effort, skill and resources have been invested by organisations in conducting assessments using the older software process assessment models. For many companies, embracing the ISO/IEC 15504 standard requires the migration of existing assessment data and assessor skills onto the new model standard. Although compatibility with other assessment models is being built into the ISO/IEC 15504 framework, there are at present no clear migration paths or support tools existing for this purpose.

In this context there are significant benefits to finding a data conversion process or results mapping method that can feasibly be created between the ISO/IEC 15504 and other process models - not only to migrate legacy process assessment data, but to also allow assessors the ability to evaluate organisational processes across multiple process model assessment frameworks.

1.3   Thesis Hypothesis

The ISO/IEC 15504 is the current new international standard for software engineering process system assessment and improvement. This process assessment framework has resulted from an international collaborative effort which has worked on developing an ISO-ratified assessment model standard. As a result, the framework has incorporated the collective experience and improved understanding of software engineering processes gained in the development of CMM, BOOTSTRAP, ISO 9001, and other pioneering software process models such as Trillium.

As such, it has been designed to replace or supersede these earlier software process model standards as a more comprehensive, flexible framework. The ISO/IEC 15504 in turn uses the ISO/IEC 12207 standard as its default process reference model, but is designed to be flexible as so to accommodate the usage of other conformant software process models.

Many companies from a wide spectrum of industries have used the earlier software process assessment standards to assess and measure their internal software-based processes. With the standardisation and acceptance by the industry of ISO/IEC 15504 as the framework of choice for software process measurement and improvement, companies would find the increasing need to convert their invested efforts in such assessments to the ISO/IEC 15504.

With the software industry moving towards the adoption of the ISO/IEC 15504, the hypothesis of this thesis is that:

1. Mappings can be created in a repeatable process between the ISO/IEC 15504 process reference model and the process models belonging to other software process assessment standards - given that these other process models are structurally compatible to the ISO/IEC 15504 across a definable set of elements.

2. These mappings of process models can be used to automate the conversion of assessment data in order to create a viable data translation process of legacy assessment data to the ISO/IEC 15504 assessment model.

3. This hypothesis forms the basis for an investigation to establish whether a practical conversion algorithm or programmable process can be implemented within an assessment tool between the old and new process models.

4. A selection of primary assessment standards as mapping candidates will be chosen, based on those established standards which have the most significant market share in terms of user base, number of assessments conducted, internal training and research investment. The reasoning is that the greatest value of this work would be derived from being able to convert legacy assessment data from these prevalent software process models.

1.4 Profile of the Author's Background in the Subject Area

The author, Richard Him Lok, has been involved with the ISO/IEC 15504 standard from the first release of the emerging international standard, within a university-based context, since the year 1995. Together with the Software Engineering Applications Laboratory (SEAL) of the University of the Witwatersrand, he has presented related papers at three ISO/IEC 15504 Working Group conferences in Prague, Brighton and Los Angeles towards a Masters degree.

During this period where the ISO/IEC 15504 was being collaborated on and defined as an international standard, Richard Him Lok designed and developed an automated software process assessment tool based on this standard. This product was initially called the SEAL of Quality (SOQ) assessment tool and was implemented as a distributable, Windows-based shareware application which was made available for prospective ISO/IEC 15504 assessors.

The basic function of the assessment tool was to support the user in performing software process assessments using the ISO/IEC 15504 process model, allowing assessment ratings and details to be easily captured and managed within a structured database system. The tool would calculate the aggregation of ratings and display the assessment profile results in graphical reports. The assessor

is also able to tailor the process model in order to reflect the software processes of the client organisation - in accordance with the allowances of the ISO/IEC 15504 standard.

As the ISO/IEC 15504 standard evolved, so too did the assessment tool - and several versions of the software product was released to the global community as shareware. All that was required to unlock the full capabilities of the tool was for the user to submit a registration to the SEAL organisation. A subsequent evolution of the tool extended the database to include the SEAL's ISO 9001 Audit Checklist, and thereby form a mapping to the ISO 9001 process model.

The tool is currently being released and distributed by the Software Process Improvement Laboratories (SPIL) organisation, whose aim is to enhance enterprise effectiveness through process capability measurement and improvement. It has since been renamed to the SPIL Assessment Tool (SPILAT) and is currently active in the South African software industry.

Richard Him Lok currently works at Datacentrix as the Workflow Solutions manager and functions as a business process architect across client projects. This work involves the analysis and automation of business processes across an array of industries with web-based systems implemented with K2.net Workflow Software.

1.5   Thesis Objectives and Context

1.5.1   Thesis Goals

The practical focus of this thesis is to achieve the following goals:

- To analyse the patterns in functionality of process assessment tools and understand the scope and potential of their benefits towards organisations and assessors.

- To understand the fundamental implementation requirements of an automated assessment tool. Achieving this goal involves an understanding of the functional composition of assessment tools in order to create a practical requirements design.

- To design a model of basic user processes, as well as the high-level algorithms and data structures that should be realised in an automated assessment tool for supporting efficient and effective software process assessments.

- To create model data structures that will allow a software application to store data representations of different process reference models - to perform evaluations against diverse software process assessment standards.

- To investigate and find methods for creating data mappings between process reference models of different assessment standards, using the common data structures implemented. If we can map and unify the existing major assessment standards of today via a common data model, we can take the next step into converting data between standards.

- To investigate the viability and usefulness of converted assessment data between the software process assessment standards, using the ISO/IEC 15504 as the primary focal model.

- To investigate the feasibility of automating that process with a programmable algorithm. The intent is to produce a repeatable methodology for creating mappings between the process models of the assessment standards.

1.5.2   Thesis Context

These goals are to be investigated and accomplished under the following context:

- The SPIL Assessment Tool (SPILAT) shall be used as a point of reference in terms of an actual automated process assessment tool. Where detail on the specifics of an implementation is required, then the functional design of this software tool shall be used.

- Although multiple process assessment standards will be considered and investigated in this thesis, the main assessment standard that we will focus on in terms of relevance will be the ISO/IEC 15504.

1.5.3   Desired Outcomes

The resulting outcomes of this thesis would ideally be the following:

- To provide a model for the design and basic functionality required to implement a supporting process assessment tool for any present or future process model assessment framework as far as possible.

- To provide a methodology for the end-to-end management of process assessment data. This includes the methods for implementation of the assessment data storage with database structures, the results data calculations and the algorithms for measurement and reporting.

- To provide a methodology for the translation of assessment data from one process model to another, thereby allowing process assessments to be related and compared – even if they are from different process models and measurement frameworks. This therefore involves the provision of a methodology for mapping one process model to the structure of any other process model.

1.5.4   Alternatives Methods

Other methods that have been considered, but discarded as impractical for this thesis are the following:

- To implement a new process assessment tool specifically for this project to demonstrate the potential or limitations of pedantically implementing the methodologies described. However, this is a prohibitive exercise in term of resources and time - relative to the fact that the SPIL Assessment Tool was also constructed by the author and provides an ideal frame of reference for this thesis.

- To physically create and capture mappings between all of the selected process model candidates in a database structure in order to illustrate the full potential or limitations of usage of these mappings for data translation. However, this was discarded as the focus is on the development of a process mapping creation methodology and there are texts available of authors that have actually created the mappings that can be referenced for this purpose. This effort would involve the capturing of each process model into a database structure, and then systematically mapping between each process item of each process model.

- As software development is in part a creative process in terms of the features and functionality created within the assessment tools, this thesis does not seek to prescribe but rather to provides models and methodologies as patterns and techniques that one can use to understand the factors and issues that underlie the implementation of a tool for supporting any current or future process assessment model framework.

1.6   Thesis Structure

This thesis is structured into the following chapters:

Chapter 1 – Introduction

The first chapter outlines the topic and scope of the project, and places the relevance of the project within the context of the software industry and the process assessment domain. The thesis hypothesis, targeted goals and desired outcomes are set out.

Chapter 2 – Software Process Assessment Models

A selection of four major Software Process Assessment standards with more established, significant market share and customer base of assessment are profiled with their background and process model structures in order to create the foundation for the rest of the project. The four software process assessment frameworks selected as candidates for tool support and assessment data mapping are ISO/IEC 15504 (SPICE), SW-CMM (Capability Maturity Model), ISO 9001 and BOOTSTRAP.

Chapter 3 – Software Process Assessment Tools

The last releases of the existing automated software process assessment tools which are based on the four selected process model frameworks are reviewed in this section. The aim is to analyse and create functionality profiles of each assessment tool in order to build a comparative feature specification table. From this we can establish common functionality patterns that exist between the current assessment tools available on the Market.

Chapter 4 – The Role of Automated Tools in Software Process Assessments

The potential for automated tools and their common benefits within the software process assessment process are identified in a structured process analysis method. This is done by first analysing the assessment processes of the ISO/IEC 15504, and then distilling the activities of these processes into a generic assessment methodology using the Universal Modelling Language (UML) with Use Case Diagrams and Use Case Descriptions, and build a model for the implementation of an automated assessment tool.

Chapter 5 – Tool Benefits for Software Process Assessments

This chapter focuses in detail on the potential benefits that can be derived using software tools which implement functionality that automates and supports the functions of an assessor. We examine the tasks and responsibilities typically assigned to an assessor through the assessment exercise, and the potential opportunities for implementing tool functionality related to these tasks and requirements. The subjects of assessor audits and questionnaires/forms are reviewed, and the requirement for tools that support multiple process model frameworks is discussed in order to discover the relevance of process model data mapping.

Chapter 6 - Functional Compatibility for Process Model Mappings

To select which process models are viable candidates for creating data relationships between them, the historical development of the software process assessment domain is reviewed, as well as the interrelated relationships between the existing process models and their evolution path. Various comparison techniques for determining and establishing whether two given process model frameworks are functionally compatible are reviewed in this chapter, an exercise involving a Functional Comparison between two Process Models is described as a Case Study exercise.

This Case Study uses the Framework Mapping comparison technique to establish the validity of creating a data mapping between the ISO 9001 and the SW-CMM process model frameworks. Similarities and differences are analysed, and an intuitive guess at the outcome of a data mapping is discussed.

Chapter 7 – Process Model Data Commonalities

This section sets out to analyse and compare the process level structures between the four frameworks, so as to determine the structural relationships and understand the data composition of each process model. The aim is to prepare the basis for developing mappings between the process models implemented through database table structures.

Chapter 8 – Performing Process Model Mapping

The viability and effectiveness of developing data mappings between process reference models are investigated in this chapter. The potential permutations of mappings between models are described using relational set notation - and an analysis of the mapping coverage for each of the Process, Capability and Assessment entities is performed. Two mapping exercises are performed and described as case studies in this chapter:

- **Mapping Process Models via an Intermediate Model-** A complete mapping exercise between the ISO 9001 and the ISO/IEC 15504 that was implemented by the author using the ISO 9001 Audit Checklist tool as an intermediary mapping model, is described here as a case study. The effectiveness of implementing the mapping in assessment tool with an automated translation process is discussed.

- **Mapping Process Models via Inspection -** A recent mapping exercise between the SW-CMM and the ISO/IEC 15504 that was performed (with the involvement of the author) through a process of inspection and validation is described here as a case study. The validation and verification role played by the South African team is discussed, as well as the effectiveness of the mapping in terms of data translation.

Chapter 9 – Assessment Tool Database Selection

In the requirement for the creation of a database structure to fit the data structures of the process models, this chapter has a look at the types of physical database implantation that is suitable for an assessment tool to be implemented with mapping and translation capabilities. This is a precursor to the following chapter where the design of a universal tool database is undertaken.

Chapter 10 –Designing a Universal Process Model Database

This chapter focuses on the method of designing a database system with a generic structure that is be able to store all four primary process models in a common set of tables. In order to create this 'universal' process model database, the structures of the primary models must be rationalized. For this purpose, UML Class Diagrams are created for each of the four process models in order to depict all the related entities of their hierarchical structures.

Chapter 11 – Assessment Tool Data Interchange Specification

A detailed structural design of the 'Universal' process model database is illustrated in this chapter as a result from the structural consolidation of the process models. The additional benefit of the database design as a potential process model data exchange specification standard is discussed here as well.

Chapter 12 – Methodology for Automated Data Mapping

A procedural method of creating a data mapping between two process models will be formulated in this chapter, including the determination of compatibility, verification and validation, as well as the possible levels of automated translation. This methodology results from the culmination of the work and research done in all the preceding chapters.

Chapter 13 – Process Assessment Tool Design

Wrapping up the support for software process assessment is a discussion on the important elements of the design of an assessment tool, based on the development experiences of the author in implementing the SPIL assessment tool. A look at the potential future enhancements of the tool due to new advancements in software technology is covered in this chapter.

Chapter 14 – Conclusion

In the final chapter the findings of the project are summarised in this chapter along with their potential value. The viability of the thesis hypothesis is analysed, and the potential scope for continuation of research and work beyond the scope of this project is discussed.

Chapter 15 – Appendix

The following supplemental information is described in this section:

- Profiles of Software Process Assessment Tools

- Related Process Assessment Tools

- ISO/IEC 15504 Process Assessment Questionnaire Examples

Chapter 16 – Glossary

A dictionary of abbreviations and terms used in this document is presented.

Chapter 17 – Bibliography

All the literature and readings that were researched and referenced for this text are listed in this section. Journal extracts and technical papers are listed as well as software manuals and guides used. Usage of the Internet has been extensive for this research as new information and knowledge bases on process models can be found readily at their respective organisation's websites, as well as the availability of assessment tools as downloadable trial software. This section also includes a description of the project background, publication history and other related projects.

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2 Software Process Assessment Models

2.1 Introduction

2.1.1 An Existing Proliferation of Process Models

The software industry has over the past decade built up a variety of assessment model frameworks and international measurement standards in order to evaluate their customer, organisational, engineering and supporting processes for software.

The scope and purpose of these process model frameworks range from generically scoped international standards to focused frameworks for specialised process areas. These existing frameworks include ISO 9001, ISO 9000-3, Trillium, SW-CMM, CMMI, TickIT, ImproveIT, CAE (Canada), BEA (Europe), MBNQA (USA), BOOTSTRAP and ISO/IEC 15504.

Out of this proliferation of software process models, we shall focus on a select few frameworks, chosen for their relationship and their relevance against the ISO/IEC 15504 standard. These process models are also considered to be the primary 'de facto' representatives of the more established assessment standards in the industry.

2.2 Selection of the Process Model Candidates

The following software process assessment frameworks have been selected as being the primary candidates for investigation. They are presented in this section in the order that they were developed and introduced onto the market:

1. ISO 9001 – The ISO 9001 series comprise standards on quality management and quality assurance that are adaptable to any manufacturing or service industry. ISO 9001 has been constructed to represent an international consensus on good management practices regarding the delivery of quality products and services.

2. SW-CMM – The Capability Maturity Model for Software is a popular framework that describes the key elements of an effective software process. The standard describes an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process.

3. BOOTSTRAP – The BOOTSTRAP model is a methodology developed by a European research project in the ESPRIT programme for software process assessment and improvement. Although usage of BOOTSTRAP is dwindling, the process model is included for a comparison against an older, historic model in order to broaden the variety of process model frameworks for the research and literature survey.

4. ISO/IEC 15504 - The objective of ISO/IEC 15504 standard is to assist the software industry to make significant gains in productivity and quality, while at the same time helping purchasers to get better value for money and reduce the risk associated with large software projects and purchases. The standard uses the ISO 12207 as the Process Reference Model to deal with software processes such as development, management, customer support and quality - and is aimed at being suitable for use in the primary contexts of process assessment, process improvement and capability determination.

The scope of this thesis will focus on the selection of process model frameworks. The reasons for the selection of these models are explained in detail in chapter 6, 'Functional Compatibility for Process Model Mappings'.

These process models frameworks will be used as the evaluation criteria for the investigation of current assessment tools; for the investigation of process model mapping creation, as well as being used for the design and implementation of a universal software process model database. However, the central emphasis will be on the ISO/IEC 15504 standard.

2.2.1 Profiling the Selected Process Model Frameworks

In this chapter, each of the selected software process model frameworks is summarised in a profile consisting of background, structure and the application of the measurement framework. The aim is to provide the base foundation of knowledge for the structure and organisation of each process model for the rest of the thesis, and allow us to perform high-level comparisons between the structures of the process reference models.

Part of the research goals in this chapter is to also investigate for each process model the stated or inherent support for software-automated process assessment tools (also known as assessment instruments).

For readers requiring more detailed information on these primary process assessment standards, further reading can be obtained through the references specified in the Appendix section.

2.3 ISO 9001 (ISO 9000 Family)

2.3.1 Background

The ISO 9000 family is a group of quality management standards consisting of ISO 9000:2000, ISO 9001:2000, and ISO 9004:2000. This suite of international standards for quality systems was developed between the years 1991 to 1994. Currently, the prevailing standard is ISO 9001:2000.

The ISO 9000 family has been constructed to represent an international consensus on good management practices regarding the delivery of quality products and services.

In particular, ISO 9001 was developed as a model for quality assurance and management for design, development, production, installation and servicing. The simplicity if its measurement framework has allowed ISO 9001 to be the most popular process model in the software industry. The standards are not particular in focus to any industry or product but are as such adaptable to software processes for any manufacturing or service industry.

2.3.2 Model Structure

The ISO 9001 model has the following elements:

- 20 main topic areas
- with 177 management issues
- inside 3 categories (management, product management and development management))

2.3.3 Application of the Process Model Framework

ISO 9001 is an international "quality management system" standard i.e., a standard used to assess an organisation's management approach regarding quality. The standard's focus is directed internally at an organisation's processes and methods and externally at managing (controlling, assuring...) the quality of products and services delivered. Thus, when viewing the key factors affecting the outcome of software development (shown below in figure), ISO 9001's focus is on all factors except "technology".
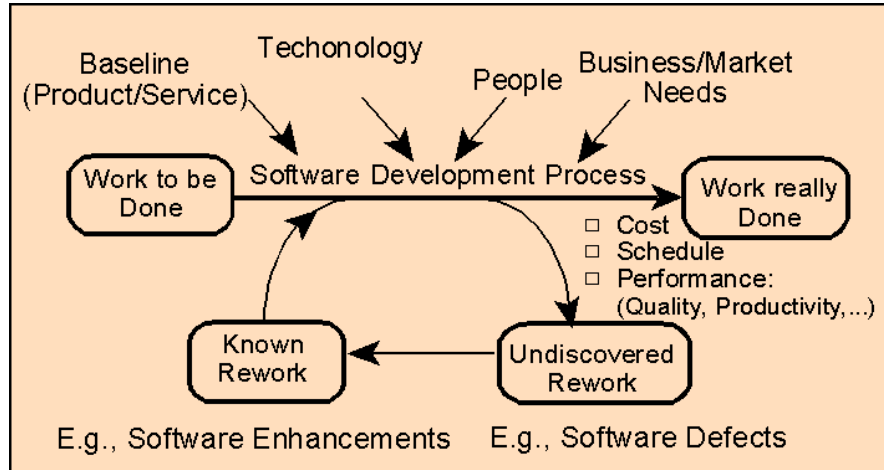
Figure 1.   KEY FACTORS OF THE ISO 9001 MODEL

Since ISO 9001 is a generic international standard which was adopted on a country-by-country basis and written for use by the widest possible audience, the framework provides the base requirements (what needs to be done) and does not issue specific prescriptive solutions (how to do it). Being so broadly focused, the ISO 9001 standard does not offer details about its application to specific domains of expertise. To assist in the application of the standard for specific domains, a series of guidelines are available; e.g., ISO 9000-3 is a guideline for the software development industry.

ISO 9000-3 provides "guidance" on implementing an ISO 9001 compliant set of processes (collectively referred as a "quality system" or as a "quality management system"). ISO 9000-3 is an international guideline which is intended to provide guidance for software development, supply and maintenance environments. The guideline is primarily written for "custom" (contract driven) software markets. It can easily be adapted for other market needs such as commercial-off-the-shelf (COTS), internal software development, etc.

ISO 9000-3 virtually mirrors the provision of ISO 9001--it does not add to, or otherwise change, the requirements of ISO 9001. Also, ISO 9000-3 is not intended to be used as an internal/external audit tool. Its intent is to guide software organisations with their ISO 9001 implementation and process change efforts: in short, software organisations are audited against ISO 9001 (not ISO 9000-3).

2.3.4 Inherent Support for Assessment Instruments

The ISO 9001 standard makes no specific provision for tools save the following general statement:

6.6 Tools and Techniques

The supplier should use tools, facilities and techniques in order to make the quality system guidelines in this part of ISO 9000 effective. These tools, facilities and techniques can be effective for management purposes as well as for product development. The supplier should improve these tools and techniques as required.

This is a blanket statement pointing out the obvious. The guideline has described generic engineering management and development processes and is recommending that tools, facilities and techniques should be identified to implement those processes.

2.4 Capability Maturity Model (SW-CMM)

2.4.1 Description

The Capability Maturity Model for software (CMM) is the result of work at the Software Engineering Institute (SEI), Carnegie Mellon University, Pennsylvania. The work was initiated by the US Department of Defence because they experienced considerable problems on delivery being on time and within budget when acquiring software defence purposes. The first version of CMM was published in 1991 while the most widely used CMM version 1.1 is from 1994.

The CMM is a framework that describes the key elements of an effective software process. It describes an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process. The CMM covers practices and processes for engineering and managing software development and maintenance. When followed, these key practices are intended to improve the ability of organisations to meet goals for cost, schedule, functionality and product quality.

The customer and supplier can both apply the CMM. The customer may use the model to assess the maturity level of a supplier, while a supplier may use the model as a framework on which to plan improvements of its software process.

2.4.2 Model Structure

The CMM Process Model defines 5 levels of software process Maturity, based on an organisation's support for certain Key Process Areas (KPAs). Level 1 (initial) describes an organisation with an immature or undefined process. Level 2 (repeatable), Level 3 (defined) defined), Level 4 (managed), and Level 5 (optimizing), describe organisations with successively higher levels of software process maturity.
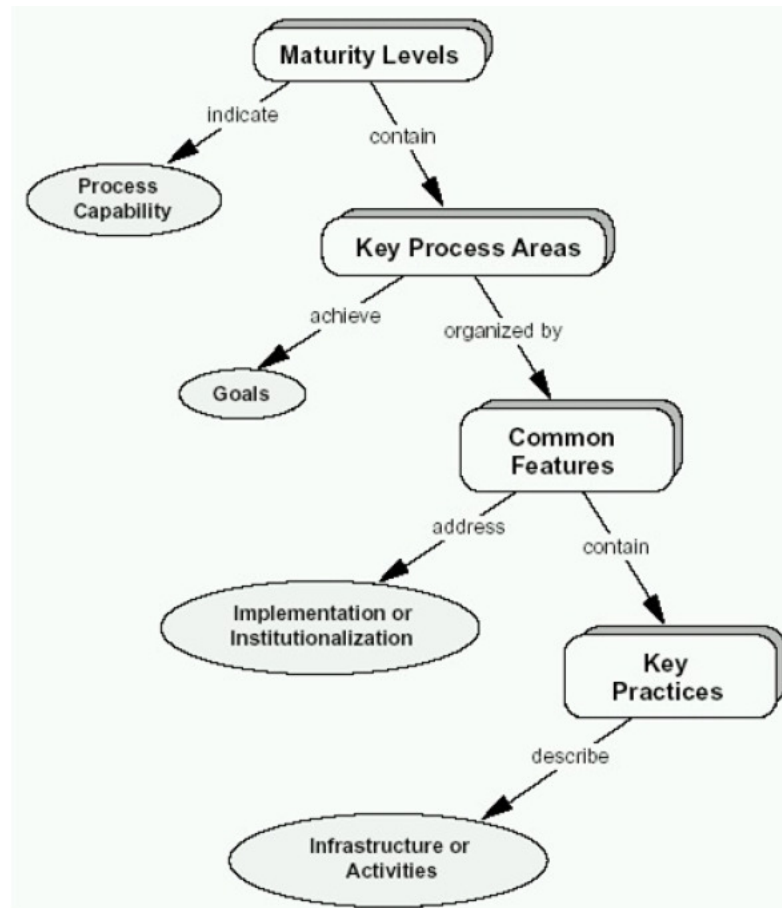
Figure 1. STRUCTURE OF THE CMM PROCESS MODEL

The associated KPAs for these levels are:

- Level 2: requirements management; software project planning; software project tracking and oversight; software subcontract management; software quality assurance; software configuration management

- Level 3: organisational process focus, organisational process definition, training program, integrated software management, software product engineering, inter-group coordination, peer reviews

- Level 4: process measurement and analysis; quality management; defect prevention

- Level 5: technology innovation, process change management

The primary goal for most organisations is to achieve a Level 3 maturity at minimum.

One instrument that is provided for assessing an organisation's current maturity level is a software capability evaluation (SCE), which determines whether the organisation "says what it does and does what it says" by evaluating its software process (usually in the form of policy statements) and project practices. The organisation's process captures the "say what you do," and project implementations (specific tailoring and interpretations of this process) should demonstrate the "do what you say."

The CMM model has the following elements:

- 18 Key process areas

- with 150 key practices

- Is grouped into 5 increasing levels of process capability maturity (initial, repeatable, defined, managed, and optimizing)

Figure 2. **THE FIVE MATURITY LEVELS OF THE CMM WITH KEY PROCESS AREAS**

2.4.3 Application of the Model / Standard

An assessment is normally carried out by a team headed by a professional assessor combined with professionals added from the software engineering and management areas in the organisation to be assessed. Project Managers are typically appointed to represent the particular organisational areas in the assessment. Local members of the assessment team are ideally chosen to be independent of the projects and are trained in the fundamentals and specifics of CMM.

The assessor team will conduct interviews and reviews documentation onsite to evaluate the maturity of each process area. These evaluations are based on professional judgement and results in a list of findings that seek to identify the strengths and weaknesses of the process. Finally, when all the relevant process areas have been addressed, the maturity level of the organisations can be computed.

The following points are characteristic of the CMM:

- It is based on industry "best practices", documenting and reflecting state-of-the-art ways of working

- The concept of processes is fundamental to the framework

- Process improvements are dealt with on a systematic, uniform basis and in small increments

- Relevant process capabilities are structured into five levels, each building upon the previous level

2.4.4 Internet Resources

- http://www.sei.cmu.edu/cmmi/

2.5 CMM Integration (CMMI)

2.5.1 Description

The CMM Integration (CMMI) Project was conceived as an initiative to integrate the various CMM frameworks into a set of integrated models and associated products. The idea was to improve the usability of the CMM beyond its initial success for software engineering alone.

CMMI is intended to support process and product improvement. It is a model which integrates disciplines such as systems engineering and software engineering, i.e. systems development work. CMMI was designed with the capability to expand in both disciplines and life-cycle coverage. The source models that served as the basis for the CMMI include: CMM for Software V2.0 (Draft C), EIA-731 Systems Engineering, and IPD CMM (IPD) V0.98a.

2.5.2 Model Structure

The CMMI, like its predecessor, describes five distinct levels of maturity:

1. Level 1 (initial) represents a process maturity characterized by unpredictable results. Ad hoc approaches, methods, notations, tools, and reactive management translate into a process that is predominantly dependent on the skills of the team in order to succeed.

2. Level 2 (managed) is characterized by repeatable project performance. The organisation uses foundation disciplines for requirements management; project planning; project monitoring and control; supplier agreement management; product and process quality assurance; configuration management and measurement/analysis. For Level 2, the key process focus is on project-level activities and practices.

3. Level 3 (defined) is characterized by improving project performance within an organisation. Consistent, cross-project disciplines for Level 2 key process areas are now emphasized to establish the activities and practices on an organisational level.

   Additional organisational process areas include: Requirements development; Technical solution; Product integration; Verification; Validation; Risk management; Organisational training; Organisational process focus; Decision analysis and resolution; Organisational process definition; Integrated project management

4. Level 4 (quantitatively managed) is characterized by improving organisational performance. Historical results for Level 3 projects can be exploited to make trade-offs, with predictable results, among competing dimensions of business performance (cost, quality, timeliness).

   Additional Level 4 process areas include: Organisational process performance; Quantitative project management

5. Level 5 (optimized) is characterized by rapidly reconfigurable organisational performance as well as quantitative, continuous process improvement.

   Additional Level 5 process areas include: Causal analysis and resolution; Organisational innovation and deployment

2.5.3   CMMI Representations

There are two versions of the CMMI – Continuous and Staged Representations:

- In the Continuous version of the CMMI model, the main organising components are called Process Areas, of which each has specific goals and practices. These Specific Practices provide an organisation with guidance on what to implement and assist in achieving the associated goals of the process area. Generic Goals and Generic Practices, which apply to multiple process areas, are also included in the reference. These practices provide guidance to help achieve the generic goals.
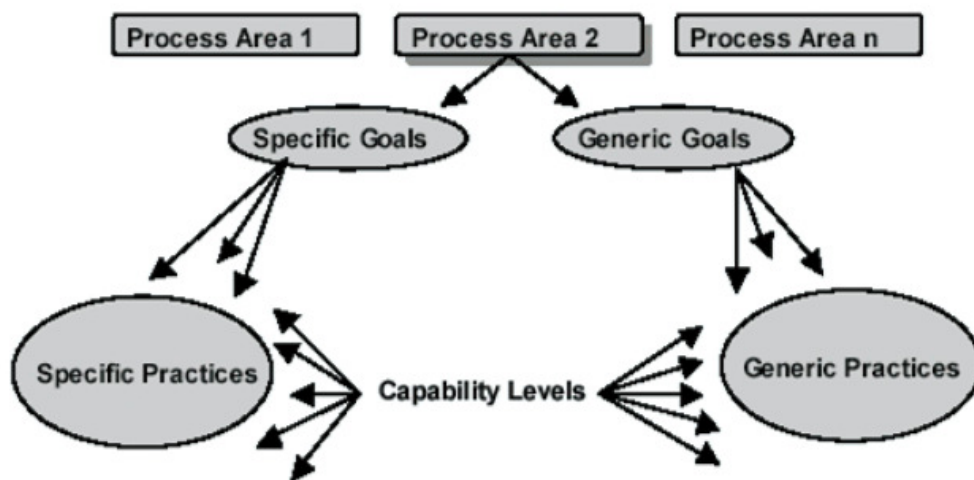
Figure 3.   CMMI CONTINUOUS REPRESENTATION MODEL

- In the Staged representation of the CMMI model, the top-level components are called Maturity Levels which are each decomposed into constituent parts. With the exception of Maturity Level 1, the decomposition of each maturity level ranges from abstract to summaries of each level down to their operational definition in specific practices and amplifications. Each Maturity Level is composed into several Process Areas, and each Process Area is organised into five sections called Common Features. The Common Features contain the Key Practices that when collectively addressed, accomplish both the Specific and Generic Goals of the Process Area..
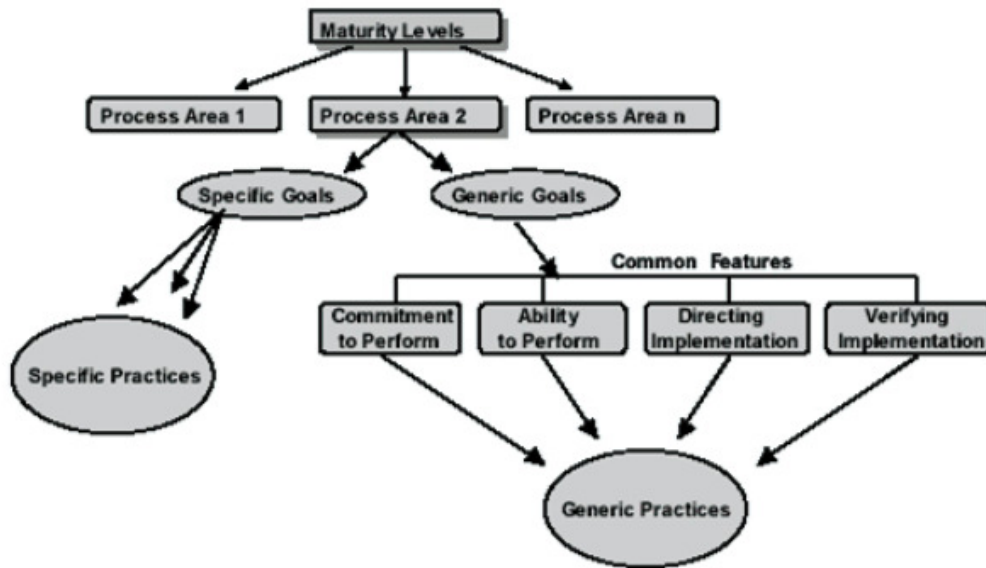
Figure 4.   CMMI STAGED REPRESENTATION MODEL

In both representations, as an organisation achieves the Generic and Specific Goals of a Process Area, it is increasing your process capability and reaping the benefits of process improvement.

2.5.4   Internet Resources

- http://www.sei.cmu.edu/cmmi/

2.6   BOOTSTRAP

2.6.1   Background

BOOTSTRAP is a European methodology developed by a European research project in the ESPRIT programme for software process assessment and improvement. The methodology integrates together the SW-CMM and ISO 9001 standards. A classical software life cycle model (ESA PPS-05) that was standardised by the European Space Agency was also adopted as a reference model for the development life cycle. Models with both process and capability dimensions originated from extending the BOOTSTRAP process model. In 1993 the project partners formed the BOOTSTRAP Institute with their legal office in Italy, to continue the development and transfer of the methodology into the software industry.

The more recent releases of BOOTSTRAP have seen the methodology adopting new features of the ISO/IEC 15504 standard in order to become compliant. BOOTSTRAP version 3.0 is based on the ISO 12207 Process Reference Model with process categories and processes.

2.6.2   Model Structure

The BOOTSTRAP model has the following elements:

- Process Categories
- with 9 attributes

- And 201 quality systems attributes.

- The 5 capability levels (originated from the CMM)

BOOTSTRAP 3.2

Organisation
- Business engineering
- Human Resource management
- Infra structure management

Methodology

Technology
- Technology innovation
- Technology support for life cycle processes
- Technology support for life cycle independent processes
- Tool integration

Life cycle dependent
- Development definition
- System requirements analysis
- System architecture design
- Software requirements analysis
- Software architecture design
- Software detailed design
- Software implementation and testing
- Software integration and testing
- System integration and testing
- Maintenance
- Migration
- Retirement

Life cycle independent

Process related
- Process definition
- Process improvement
- Process assessment
- Measurement

Management
- Management
- Project management
- Quality management
- Risk management
- Subcontractor management
- Reuse management

Support
- Documentation
- Configuration mgt.
- Quality assurance
- Verification
- Validation
- Joint Review
- Audit
- Problem resolution

Customer Supplier
- Acquisition
- Customer need management
- Supply
- Software operation
- Customer support

Figure 5.   STRUCTURE OF THE BOOTSTRAP PROCESS MODEL

The BOOTSTRAP framework is presented as an assessment model including three dimensions: a Process Dimension, a Capability Dimension and a Technology Support Dimension. The Process Dimension is called the BOOTSTRAP process model. It integrates requirements from several standards like ISO 9001 (1989), ISO 9000-3(1991), ISO 12207 (1995), ISO/IEC 15504 (1993), ESA PSS-05-0 (1991) and the CMM.

The BOOTSTRAP process architecture reflects a tree structure that contains: Process Categories, Processes and Best Practices. The BOOTSTRAP 3.0 architecture contains three main process categories:

- Organisation
- Methodology
- Technology

2.6.3   Application of the Model / Standard

BOOTSTRAP assessments are conducted according to the following steps:

- Background Information Collected:
    - The organisation the assessment is performed
    - The SPU - the software producing unit

- o   The project(s) - the project(s) that are assessed
- Evaluation Performed:
  - o   To rate each Process by scoring Base Practices and Process Attributes with a rating scale of: Not adequate - Partially adequate - Largely Adequate - Fully Adequate - Not Applicable
- Profiles Created:
  - o   ISO/IEC 15504 Profile
  - o   Process Attribute Profile
  - o   Capability Profile
- Assessment Reports Generated:
  - o   Self-Assessment Report contains assessment results: Background information, SPU and project(s) profiles
  - o   Assessment Answer Report: Process checklist with ratings

The BootCheck assessment results can be used in various ways:

- To baseline the current position
- To support the SPI programme
- To assist in an externally supported programme
- To be the initial step in seeking ISO 9000 registration
- To benchmark the performance against industry best practice

The results can be presented according to three Best Practice models:

- Organisation Maturity Level Evaluation - A broad assessment of organisational maturity according to BOOTSTRAP approach.
- A Process Capability Evaluation - A mapping against the ISO/IEC 15504 assessment model, which is the emerging ISO Standard for software process assessment
- An ISO 9000 Gap Analysis Results - An assessment of likely state of ISO 9000 compliance

The collected data can be analysed and developed as an improvement plan specifically for the organisation.

2.6.4   Inherent Support for Assessment Instruments

BOOTSTRAP is the only process model that has an assessment instrument developed for it by the organisation that created the process model. The Bootcheck assessment instrument software is offered free for download on the website of the Bootstrap Institute (http://www.bootstrap-institute.com) for use on performing BOOTSTRAP-based evaluations.

No other tools by third parties were found that implemented BOOTSTRAP as a process model. This serves to indicate that either the Bootcheck application is functionally sufficient for the requirements of most evaluations, or that the creation of similar software tools for BOOTSTRAP is not encouraged by the Bootstrap Institute.

2.7   ISO/IEC 15504

2.7.1   Background

Originally known as the Software Process Improvement and Capability dEtermination (SPICE) standard, the ISO/IEC 15504 was developed as an internationally collaborative project within the ISO/IEC/JTC1/SC7/WG10 and initially resulted in a Technical Report (TR) suite, followed by its release as a full international standard. The ISO/IEC 15504 was also developed as a continuous, two-dimensional Process and Capability model following on from the BOOTSTRAP framework, as a software engineering process model:

- Process Dimension
    - Process Categories
        - Processes (P1, … Pn)
- Capability Dimension
    - Capability Levels (CL1, .., CL5)
        - Process Capability Attributes

- Where each process will receive a Capability Level rating.

The development of ISO/IEC 15504 has taken place in parallel with empirical studies of its use performed by the SPICE project. To date, over 3000 assessments using ISO/IEC 15504 have been performed world-wide.

The ISO/IEC 15504 Software Process Assessment Standard initially comprised of nine parts (or a set of nine guide documents) some of which were normative or prescriptive; the rest being informative. This has recently been consolidated into five parts in the move to become a full international standard.
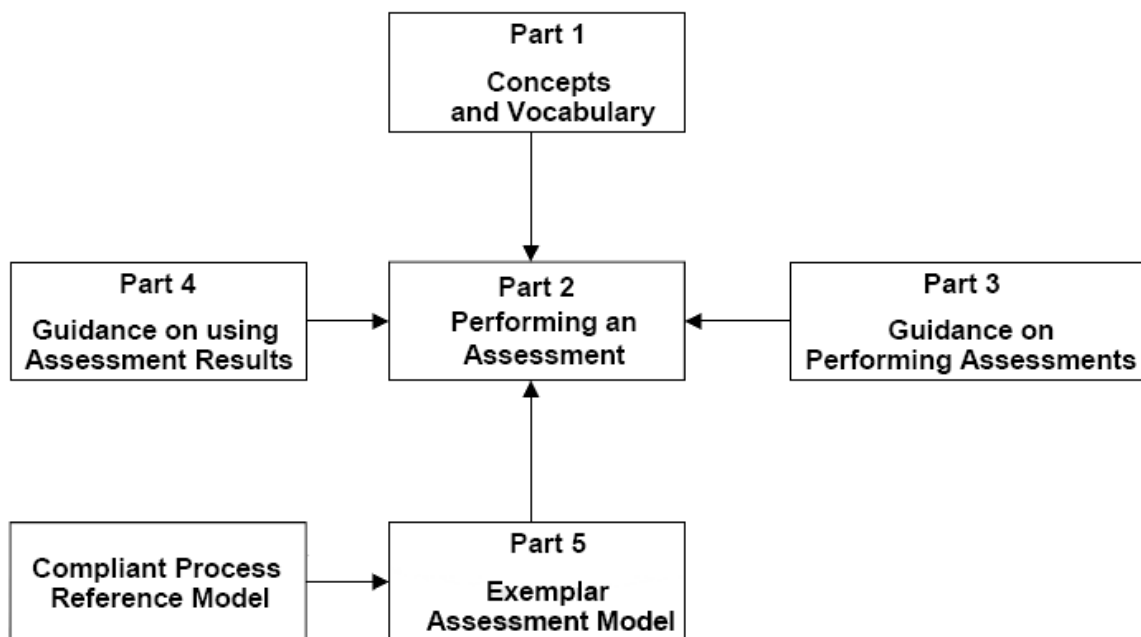
Figure 6.   Document Structure of the ISO/IEC 15504 Standard

The full set of five documents representing the ISO/IEC 15504 standard are the following:

- Part 1 – **Concepts and Vocabulary** is an entry point into ISO/IEC 15504. It describes how the parts of the suite fit together, and provides guidance for their selection and use. It explains the requirements contained within ISO/IEC 15504 and their applicability to the performance of an assessment. It also contains a consolidated vocabulary of all terms specifically defined for the purposes of ISO/IEC 15504.

- Part 2 – **Performing an Assessment** defines the two dimensional reference model for describing the Processes and Process Capability used in a process assessment. The reference model defines the set of Processes in terms of their purpose and outcomes, and describes the measurement framework for evaluating the Capability of the Processes through the assessment of Process Attributes structured into Capability Levels. The conformance requirements for establishing the compatibility of different assessment models with the reference model are defined. It also defines the requirements for performing an assessment in such a way that the outcomes will be repeatable, reliable and consistent.

- Part 3 – **Guidance on Performing Assessments** provides guidance on performing software process assessments, interpreting the requirements of ISO/IEC 15504-2 and ISO/IEC 15504-3 document parts for different assessment contexts. The guidance covers the selection and use of a documented process for assessment; of compatible assessment models; and use of a supporting assessment instrument or tool. This guidance is generic enough to be applicable across all organisations, as well as for performing assessments using a variety of different methods and techniques, ideally supported by a range of tools. It also describes the competence, education, training and experience of assessors that are relevant to conducting process assessments. It describes mechanisms that may be used to demonstrate competence and to validate education, training and experience.

- Part 4 - **Guidance on Using Assessment Results** describes how to define the assessment inputs and use the assessment results for the purposes of process improvement and process capability determination. The guide includes examples of the application of process improvement in a variety of situations. It addresses process capability determination in both straightforward situations and in more complex situations involving, for example, - future capability. The guidance on conducting process capability determination is applicable either for use within an organisation to determine its own capability, or by an acquirer to determine the capability of a (potential) supplier.

- Part 5 - **Exemplar Assessment Model** provides an exemplar model for performing Process Assessments that are based upon and directly compatible with the reference model in ISO/IEC 15504-2. The assessment model(s) extend the reference model through the inclusion of a comprehensive set of indicators of process performance and capability.

The ISO/IEC 15504 is currently a full international standard. The Process dimension of the model has since been removed to Amendments made to the ISO 12207 AMD1 and AMD2. The recent changes to the standard also saw the introduction of the Process Reference Model.

The normative part of the Guidance to Conducting Assessments includes a set of requirements for the collection of data. The informative part to conducting assessments allows for other existing compatible methodologies to be implemented, providing that a clear mapping exists between the attributes of that methodology to the ISO/IEC 15504 reference model.

2.7.2 Model Structure

The default ISO/IEC 15504 Process Reference Model is represented by the ISO/IEC 12207 (with amendment Amd-1 applied) standard and has the following elements in the Process Dimension:

- 6 process categories with
- 49 processes

The Capability dimension has:

- 6 capability levels with
- 9 process attributes altogether

2.7.3 Application of the Model / Standard

One of the primary benefits that ISO/IEC 15504 provides is the ability to compare "apples against apples". A customer will be able to judge "an organisation assessed under the SW-CMM model against an organisation assessed under, say, the Trillium or Bootstrap model". In view of the software vendor, a customer would not need to change their software process improvement model of choice (e.g., SW-CMM, Trillium, Bootstrap ...) nor should they need to re-educate their Software Engineering Process Group on any new assessment framework.

This is attributable to the following parts of ISO-15504:

- ISO/IEC 15504-2   is a common base for different software process improvement models
- ISO/IEC 15504-3   is the minimum requirements for performing assessments

Existing software process improvement models (like SW-CMM, Trillium, etc) need only be cross-referenced with ISO/IEC 15504-2 (note: SEI has already released a high-level cross-reference)

Existing assessment frameworks (like SEI CBA-IPI, SEI SCE, or a consultant's own assessment framework) need only be cross-referenced with ISO/IEC 15504-3. (Note: the FAA has already cross-referenced their FAA-iCMM® Appraisal Method.)

Having cross-referenced the customer's assessment framework and software process improvement model of choice, then "comparing apples against apples" is possible.

2.7.4 Inherent Support for Assessment Instruments

This standard directly recognises the necessity of (automated) tools to execute an assessment, with regard to the complexity and volume of work required to complete the exercise. This is a significant allowance relative to the preceding assessment standards.

A general description on the requirements of an assessment instrument is given in various paragraphs spread throughout the initial section of *Part 3: Guide to performing assessments* of the ISO/IEC 15504 standard:

4.6 Assessment instruments and tools

In any assessment, information for the documented assessment process will need to be collected, recorded, stored, collated, processed, analysed, retrieved and presented. This will be supported

by various instruments and tools. For some assessments, the support tools and instruments may be manual and paper-based (forms, questionnaires, checklists, etc.). In some cases the volume and complexity of the assessment information is considerable resulting in the need for computer-based support tools.

Regardless of the form of the supporting instruments and tools, their objectives is to help an assessor perform an assessment in a consistent and reliable manner, reducing subjectivity and contributing to the achievement of valid, useful and comparable assessment results. In order to achieve these objectives, the instruments and tools need to make the process assessment model and its indicators accessible to the assessors.

5.2.2 Data Collection

The information gathering may be organized as part of a regular manual monitoring or reporting mechanism used by one or more projects. Alternatively, information collection may be automated or semi-automated through the support of an instrument or tool. An instrument could be used continuously throughout the development life cycle, for example, at defined milestones to measure adherence to the process, to measure process improvement progress, or to gather information to facilitate a future assessment.

2.8 Summary

The sequence in which these process model frameworks were released is as follows:

1) ISO 9001

2) SW-CMM

3) BOOTSTRAP

4) ISO/IEC 15504

Within each of these frameworks, there have been a number of release iterations which refine the base structure of the system. Once a process model framework is released, the base structure tends to remain the same for compatibility with existing assessments performed. Typically, only with the release of a new framework by the same organisation will the model structure be modified or redesigned (e.g. SW-CMM to CMMI).

From the history of the creation and growth of these frameworks, we can observe the following high-level patterns and trends:

1. Successive frameworks will build on the experience, knowledge, structures and data of the preceding ones (e.g. BOOTSTRAP was designed with the integration of ISO 9001 and SW-CMM factored in the methodology; the foundation of ISO/IEC 15504 also expanded on the BOOTSTRAP framework).

2. The scope of the assessment tends to expand significantly in successive process models e.g. SW-CMM has Process Levels over ISO 9001's Main Topic Areas; BOOTSTRAP has multiple Process Categories for different areas of the business organisation.

3. The complexity of the measurement framework tends to increase significantly, especially at the base rating level, e.g. from a simple Yes/No Compliancy to a set of

Fully/Largely/Partially/None scales. The measurement of processes extends to the Capability dimension for the ISO/IEC 15504.

4. Despite the fact that these process models are based on software quality processes, the initial measurement frameworks (ISO 9001, SW-CMM) had no explicit allowance for assessment instruments in the form of software. The Bootstrap organisation implemented their own assessment tool, thereby providing implicit support for a single tool. The ISO/IEC 15504 more fully recognises the benefits of automated assessment applications by allowing inherent support for any number of these tools.

5. Although each of the models and measurement frameworks are based around the concept of processes, the variance in structures between models (i.e. how they are organised in terms of levels – practices, processes, categories) differ significantly enough that the mapping of processes between models can be a challenge.

These observations tend to indicate that because the process models and measurement frameworks improve on each other and expand greatly in scope and complexity with each successive generation, automated assessment tools cannot be generically built to cater for future models and requirements. In fact, they are challenged to cater for more than one current process model framework. If they are, it would have to be at a single process level – and thereby lose much of the functionality and content detail, structural categorisation and scope of the process model frameworks.

3 Software Process Assessment Tools

3.1 Introduction

This chapter analyses the functionality makeup of a large selection of software process assessment tools currently available on the market by creating a profile for each assessment instrument and performing a comparative analysis on a tabulation of the functional elements. The common purpose of these software-based assessment instruments is to perform process evaluations based on one or more of the selected primary software process models (i.e. Bootstrap, SW-CMM, ISO 9001, and ISO/IEC 15504).

3.1.1 Research Method

This analysis exercise was performed by collecting, investigating and profiling each available assessment tool or instrument currently on the market. Most of the software was found over the Internet and downloaded - as vendors typically make them available for trial either in a 'Shareware' format that is limited in functionality or useable for a limited time period.

The assessment tools that were found to support the BOOTSTRAP, SW-CMM, ISO 9001, or ISO/IEC 15504 process models were installed on a computer and inspected. The key characteristics and features were then captured on a tabular matrix of common functionality items for comparison.

3.2 Profiling an Automated Assessment Instrument

3.2.1 Definition of an Automated Assessment Tool

In broad terms, a software application or program that automates and adds value to the paper-based assessment methodology of a process model can essentially be considered as an automated assessment tool. An automated tool makes it easier to store and calculate large amounts of data and assess processes while allowing the assessor to capture assessment data and evidence in real-time. Automated tools can also chart processed data and present detailed or summarised results on graphs and reports.

The ISO/IEC 15504 standard is unique in that it has specific references that make allowance for such tools, which are also known as Assessment Instruments. In Part 3 of the ISO/IEC 15504 standards document it states:

In any assessment, information will be collected, recorded, stored, collated, processed, analyzed, retrieved and presented. Instruments and tools can provide valuable support in collating the evidence used by the assessor to assign ratings to the process attributes for each process assessed, and in recording the ratings as the set of process profiles.[ISO/IEC 15504-3, 9]

3.2.2 Profiling the Assessment Tools

The following procedure was used to review a selection of assessment tools:

1. The list of assessment tool 'candidates' was compiled and located on the Internet by using search engines and systematically browsing the hyperlinks from websites related to

software process assessment topics and to each of the software process models, as well as references from associated literature.

2. Most of the candidates are assessment tools that have at either a shareware or trial version of the product for download and evaluation - if not being available free of charge for full usage. Most of the products found have some form of downloadable version, and the rest were chosen if they had extensive and detailed description of the product and it's usage.

3. Each software tool obtained was installed, worked with to achieve a level of familiarity, and analysed against the following requirements checklist:

   • The vendor of the software

   • The type of tool or format, i.e. software tool, spreadsheet, methodology + tools

   • The associated website of the tool where more information is available, and where the software may be downloaded

   • The list of process models that the tool inherently supports

   • A description of the tool including the background and purpose

   • The intended manner of usage of the tool in the form of high-level operational procedures

   • A list of the significant features of the tool

   • Screenshots that depict the main operating functionality or working modes of the application were captured to provide illustration for each profile.

4. These details were then tabulated for the functionality comparison (see next section).

The application profiles of the software process assessment tools investigated and referred to in this section are presented in the Appendix.

3.3   Comparison of Functionality in Assessment Tools

3.3.1   Product Functionality

A comparative analysis of the automated assessment instruments reviewed was performed mainly by inspection. The following functions and features were found to be common to most of the software tools:

1. The primary purpose of these tools is to capture and store assessment data, especially in the form of ratings, commentary, and evidence – typically at the lowest structural level of the process model (e.g. Base Practices for ISO/IEC 15504) and aggregated upwards.

2. The majority of the assessment tools are found to be developed for the Microsoft Windows platform, which assumes that the assessors are either mostly working in such environments, or using notebooks with Windows installed.

3. Most of the tools are geared for deployment on the Microsoft Windows platform – with Windows 95/98 being the most common version of the Operating System at the point of release. It is found to be the lowest common denominator platform with the minimum functionality level required to host an assessment tool software application.

4. All of the tools can perform some level of rating calculations and aggregations, according to the requirements of the assessment standard adhered to.

5. All of the tools can generate some form of assessment results report; most of the reports can depict the assessment results graphically (bar charts, etc.)

6. The more mature, advanced tools allow some level of customization of the Process Model framework, recognising that some organisations would need to tailor their own measurement frameworks.

7. All tools necessarily have to store the process model(s) in a data repository in order to display the descriptions of the process elements as the user navigates through an assessment. This also allows the tool to serve as a Process Model reference tool where the user can browse through or search on the process model text.

8. The level of information detail stored on the process model elements can vary due to one or more of the following reasons:

   • The purpose of the tool is meant to be in a supporting role or as an assistant to the documentation, and not a replacement;

   • There are copyright issues with copying the information outright, in the above regard that it would replace the physical documentation;

   • The process model information is extensive and may change from time to time as new draft versions are released, and the tool developers do not have the resources to maintain updates of the information. They may rather allow the user to tailor the model and perform their own maintenance.

3.3.2   Product Development and Distribution

The majority of the tools currently in existence have been created by:

   a. Organisations aligned to one or more process assessment standards

   b. Academic institutions that may have an interest in developing the associated process model standard

   c. Consulting firms which offer assessment services using one or more assessment standards and therefore have an interest in automating the assessment procedure as to allow their assessors to perform it efficiently.

There has not been a major software organisation that has developed and released an assessment tool as a large scale commercial product. The reason for this would likely be that at present the market is not large enough to warrant such a commodity.

As a result, most of these assessment tools are released to users in one of the following methods:

   • Freely, as a supporting tool to increase the attraction and market share of the assessment standard. The main method of access would be as a downloadable installation file via a website or FTP server. A user registration may be required by the authoring organisation - which may be interested in tracking the usage of the tool

- As shareware, with usage on a trial period basis. The main method of access would be as a downloadable installation file via a website or FTP server. Registration of the tools would either involve a transactional payment, or at a minimum - the submission of a user registration form for usage tracking.

- The tool is given to the customer as an inclusive part of the assessment package by a consulting company when conducting an assessment paid for by a client organisation.

3.4   Summary

The assessment tools tend to focus on the storage and assessment automation for a single process model; or at most two process models. This is due to the following observations:

1. Tools are more effective in terms of functionality when they focus on one domain or process model (i.e. not be a Jack-of-all-trades). It may not be possible to extend the same automation functionality for all process models (e.g. Capability Dimension ratings capture, results aggregations and reports would apply to ISO/IEC 15504, not for the other process model frameworks)

2. There is no standard or de facto model for a mapping between any of the process models; therefore a comparison between two process models using a given proprietary mapping would always be subjective. It is also not possible to allow the user to specify at what level mapping would occur between process models (e.g. would CMM KPAs map to ISO/IEC 15504 Base Practices or Processes?) as such changes would involve structural changes at a database table level.

3. The organisations that develop the assessment tools typically do so in order to support their assessment methodology. Therefore these assessment organisations are typically focused on using a single process assessment framework for their methodology.

The above reasons are practical considerations that a vendor has to factor into the design and implementation when creating an automated assessment instrument. Part of the scope of this thesis is to investigate the viability of implementing a software tool that has no such restrictions. We will attempt to reach the ultimate extension for such a tool by providing a tool design, database structure, measurement algorithms and implementation methodology for creating such a tool that supports multiple process model frameworks, and allows organisations to compare assessment results between them.

3.5 Comparison Chart of Software Process Assessment Tools

Product Name:	Boot Check	CMM-Quest	IME Toolkit	Wizard	CMM Live	IP Manager	STEP	SPICE Vision	SPICE 1-2-1	SPiCE-Lite
Tool Type:	Program	Program	Spread-sheet	Program	Program	Program	Program	Program	Program	Program
Version:	3.12	1	1	5	2.5		2	1.5	2	3
Organ-isation:	Bootstrap Institute	HM & S	Management Info Systems	Process Focus	Process Focus	Process Focus	SPI Laboratory	Novotis	HM & S	HM & S
Windows 95/98/ME:	Y		Y	Y			Y	Y	Y	Y
Windows NT/2K:	Y		Y	Y	Y	Y	Y	Y	Y	Y
Windows XP:	Y	N	Y	Y			Y	Y	Y	Y
Bootstrap:	Y	N	N	N	N		N	N	N	N
CMM:	N	Y	Y	Y	Y		N	N	N	N
ISO 9001:	N	N	N	N	N		Y	N	N	N
ISO/IEC 15504 / SPICE:	Y	N	N	N	N		Y	Y	Y	Y

Calculate ratings	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Capture comments:	Y		Y				Y	Y	Y	Y
Compare assessments:	N		Y				Y	Y	N	N
Generate reports:	Y		N				Y	Y	Y	Y
Graphs and charts:	Y		Y				Y	Y	Y	Y
Modify process model:	N		Y				Y	Y	Y	N
Online help:	Y		Y				Y	Y	Y	Y
Shareware mode:	Y		N				Y	Y	Y	Y
Database type:	MS Access	Proprietary	MS Excel	Proprietary	Proprietary	Proprietary	SQL Anywhere	Proprietary	Proprietary	Proprietary
Multiple languages:	N	N	N	N	N	N	N	N	Y	Y
Save / Open Assessment							Y	Y	Y	Y
Import / Export Data:				Y			Y	Y	N	N
Multi-user	N	N	N	N	N	N	N	N	Y	N

Table 1. **TABULATED CHART OF ASSESSMENT TOOL FUNCTIONALITY FOR COMPARISON**

4   The Role of Automated Tools in Software Process Assessments

4.1   Introduction

The fundamental purpose of an automated tool in a process assessment exercise is to increase the efficiency of the assessment process that is conducted on one or more process models. In this chapter we will investigate the scope of potential benefits and value that a tool may bring to a process assessment exercise by reviewing the functionality that they provide throughout its lifecycle.

Software Process Assessments are currently being utilised for such purposes as:

1. Rating the level of process capability or the maturity of its processes

2. The identification and tracking of process improvement activities,

3. The selection and monitoring of suppliers,

4. Portfolio Management, e.g. for risk analysis during the proposal phase.

Originally, with the advent of CMM version 1.0 and BOOTSTRAP version 2.3, only a fixed set of criteria and generic assessment procedures were available. Now, to complement the release of the new ISO\IEC 15504 standard, more process assessment tools have become generally available to both occasional and dedicated assessors.

We will investigate the potential value of using automated software tools to evaluate software processes and manage assessment data - by breaking down the assessment process and identifying the common areas for automation.

4.1.1   Research Method

In this chapter the process model assessment lifecycle will be analysed in detail for tool automation opportunities through the following parameters:

*   Focus on the usage of assessment tools relevant to the ISO/IEC 15504 standard

*   The operational processes involved in conducting a software process assessment will be modelled in UML (Universal Modelling Language), so as to identify the activities that can potentially be automated.

*   The common, reoccurring features found in existing assessment tools will then be systematically identified and confirmed.

The products profiled in the previous chapter are taken as a representative sample of current assessment tools, such that in this chapter we can conduct a comparative analysis on these tools.

4.2   Usage of Assessment Instruments and Tools

There are two basic forms of instruments for performing assessments, i.e. manual paper-based tools and automated software applications. Different assessment methodologies plan for and depend on different types of tools.

The ISO/IEC 15504 makes provision for assessment instruments or tools by recognising that a large amount of information will be collected, recorded, stored, collated, processed, analysed,

retrieved and presented for a given process assessment instance. In the main, software applications can support these processes by collating and recording evidence that support the details of the artefacts and work products that substantiate the assessor's assigned ratings as well as the actual assessment ratings.

In ISO/IEC 15504 Part 3: Guidance on Performing an Assessment, Chapter 9 of the document describes a selection of actors and modes of usage for assessment tools and instruments:

- *by assessors capturing information;*

- *by process owners or organizational unit representatives during preparation for and prior to an assessment capturing information for subsequent processing;*

- *by organizational unit representatives continuously throughout the development life cycle, and at defined milestones to measure process adherence, process improvement progress or to gather information to facilitate a future assessment;*

- *after the assessment to retrieve or organize the assessment information to facilitate process improvement planning or analysis for capability determination;*

- *in a distributed approach for self-assessment throughout an organization;*

- *when sampled work-products and process information are collected incrementally and reviewed prior to the commencement of on-site assessment activities, such as interviews;*

- *to assist the assessor with the processing of the assessment information collected;*

- *to store and retrieve assessment results, making the results more useable for process improvement planning or capability determination analysis;*

- *to assist the assessor with post-assessment analysis of the results such as the analysis of process improvement results against past performance history, or of a supplier profile against an established target profile;*

- *to collect information incrementally and in a distributed manner, to collect information incrementally at set milestone check points in the performance of a process or when a number of organizational units are to be assessed incrementally;*

- *to generate result profiles or help in the performance of gap analysis.*

4.3   Modelling the Assessment Processes with UML

In order to identify the potential areas of automation within the assessment process, it is important to trace each step of execution though the exercise. The execution of the procedures used by an assessor can be described in detail through UML Use Case Process diagrams:

- Each UML diagram will specify the role player who will perform the process. The main Role Player (or Actor) of the Use Case diagrams is the Assessor for each Use Case.

- The main process activities are made up of one or more actions. For each of these diagrams, Use Case Descriptions are written to decompose the procedures of activities into simple step-by-step English sentences describing the actions of the Actors.

4.4 UML Modelling the IEC 15504 Assessment Processes

In ISO/IEC 15504 Part 3: Guidance on performing an assessment, the document describes the assessment process in an informative exemplar in the Annex section. These processes are depicted here in UML Activity Diagrams, Use Case Diagrams and Use Case Descriptions.

The following Use Case Diagrams and Use Case Descriptions illustrate the detail of the ISO/IEC 15504 assessment process. The potential opportunity for automation in each activity if the Use Case Descriptions are identified in this exercise.

4.4.1 Use Case Process A.2: Initiating the Assessment

The assessment process begins by identifying the sponsor and defining the purpose of the assessment (why it is being carried out), the scope of the assessment (which processes are being assessed), what constraints, if any, apply to the assessment, and any additional information that needs to be gathered. The assessment participants and the assessment team are chosen and the roles of team members are defined. All assessment inputs are defined and approved by the sponsor.
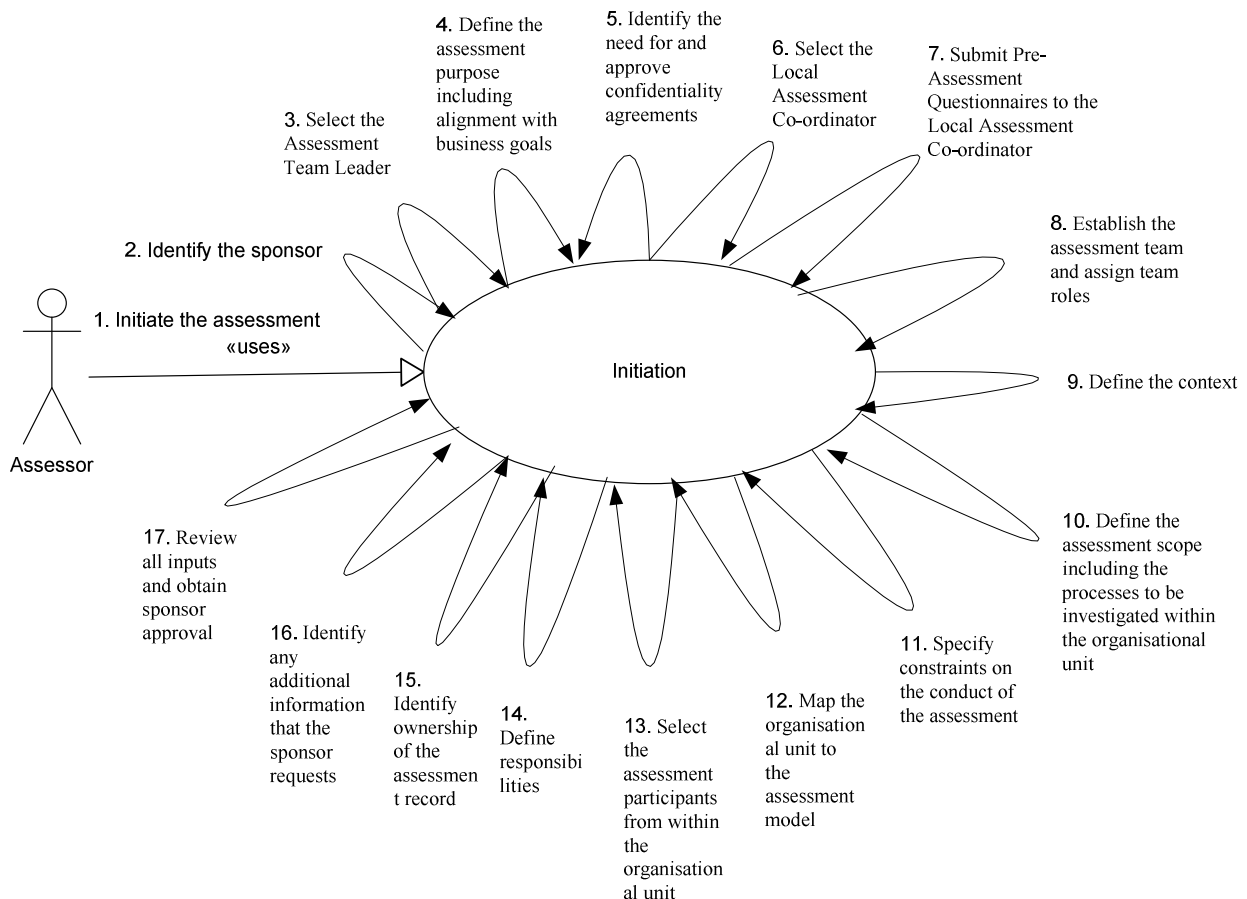
Figure 7. USE CASE DIAGRAM – INITIATING THE ASSESSMENT

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4.4.1.1   Use Case Description

1. Identify the sponsor of the assessment. [Potential Tool Automation Functionality: Information Recordkeeping]

2. Select the Assessment Team Leader, who will lead the exercise and ensure that the persons nominated possess the necessary competency and skills. [Potential Tool Automation Functionality: Information Recordkeeping]

3. Define the assessment purpose including alignment with business goals (where appropriate). [Potential Tool Automation Functionality: Information Recordkeeping]

4. Identify the need for and approve confidentiality agreements (where necessary), especially if external consultants are being used. [Potential Tool Automation Functionality: Information Recordkeeping]

5. Select the Local Assessment Co-coordinator (LAC). The LAC manages the assessment logistics and interfaces with the organizational unit. [Potential Tool Automation Functionality: Information Recordkeeping]

6. Submit Pre-Assessment Questionnaires to the Local Assessment Co-coordinator. The Pre-Assessment Questionnaires (PAQs) help structure the on-site interviews by gathering information about the organization and projects of the assessed unit. [Potential Tool Automation Functionality: Information Recordkeeping]

7. Establish the assessment team and assign team roles. Normally, the team should consist of two assessors (depending on resource and cost). Assessment team members should ensure a balanced set of skills necessary to perform the assessment. The assessment team leader should be a competent assessor. [Potential Tool Automation Functionality: Information Recordkeeping]

8. Define the assessment context. Identify factors in the organizational unit that affect the assessment process [Potential Tool Automation Functionality: Information Recordkeeping]. These factors include, at a minimum:

    •   the size of the organisational unit,

    •   the application domain of the products or services of the organisational unit,

    •   the size, criticality and complexity of the products or services

    •   the quality characteristics of the products.

9. Define the assessment scope including the processes to be investigated within the organizational unit, the highest capability level to be investigated for each process within the assessment scope and the organizational unit that deploys these processes. [Potential Tool Automation Functionality: Information Recordkeeping]

10. Specify constraints on the conduct of the assessment [Potential Tool Automation Functionality: Information Recordkeeping]. The assessment constraints may include:

    •   availability of key resources,

    •   the maximum amount of time to be used for the assessment,

- specific processes or organisational units to be excluded from the assessment,

- the minimum, maximum or specific sample size or coverage that is desired for the assessment,

- the ownership of the assessment outputs and any restrictions on their use,

- controls on information resulting from a confidentiality agreement,

11. Map the organizational unit to the assessment model. Establish a correspondence between the organizational unit's processes specified in the assessment scope and the processes in the assessment model. Identify any conflicting terminology between the organizational unit and the assessment model. [Potential Tool Automation Functionality: Assessment Data Capture]

12. Select the assessment participants from within the organizational unit. The participants should adequately represent the processes in the assessment scope. [Potential Tool Automation Functionality: Information Recordkeeping]

13. Define the responsibilities of all individuals participating in the assessment including the sponsor, competent assessor, assessors, local assessment co-coordinator and participants. [Potential Tool Automation Functionality: Information Recordkeeping]

14. Identify ownership of the assessment record and the person responsible for approving the assessor logs. [Potential Tool Automation Functionality: Information Recordkeeping]

15. Identify any additional information that the sponsor requests to be gathered during the assessment. [Potential Tool Automation Functionality: Information Recordkeeping]

16. Review all inputs and obtain sponsor approval. [Potential Tool Automation Functionality: Print out Assessment Record, signoff documents]

4.4.2   Use Case Process A.3: Planning the Assessment

An assessment plan describing all activities performed in conducting the assessment is developed and documented together with an assessment schedule. Using the project scope, resources necessary to perform the assessment are identified and secured. The method of collating, reviewing, validating and documenting all of the information required for the assessment is determined. Finally, co-ordination with participants in the organisational unit is planned.
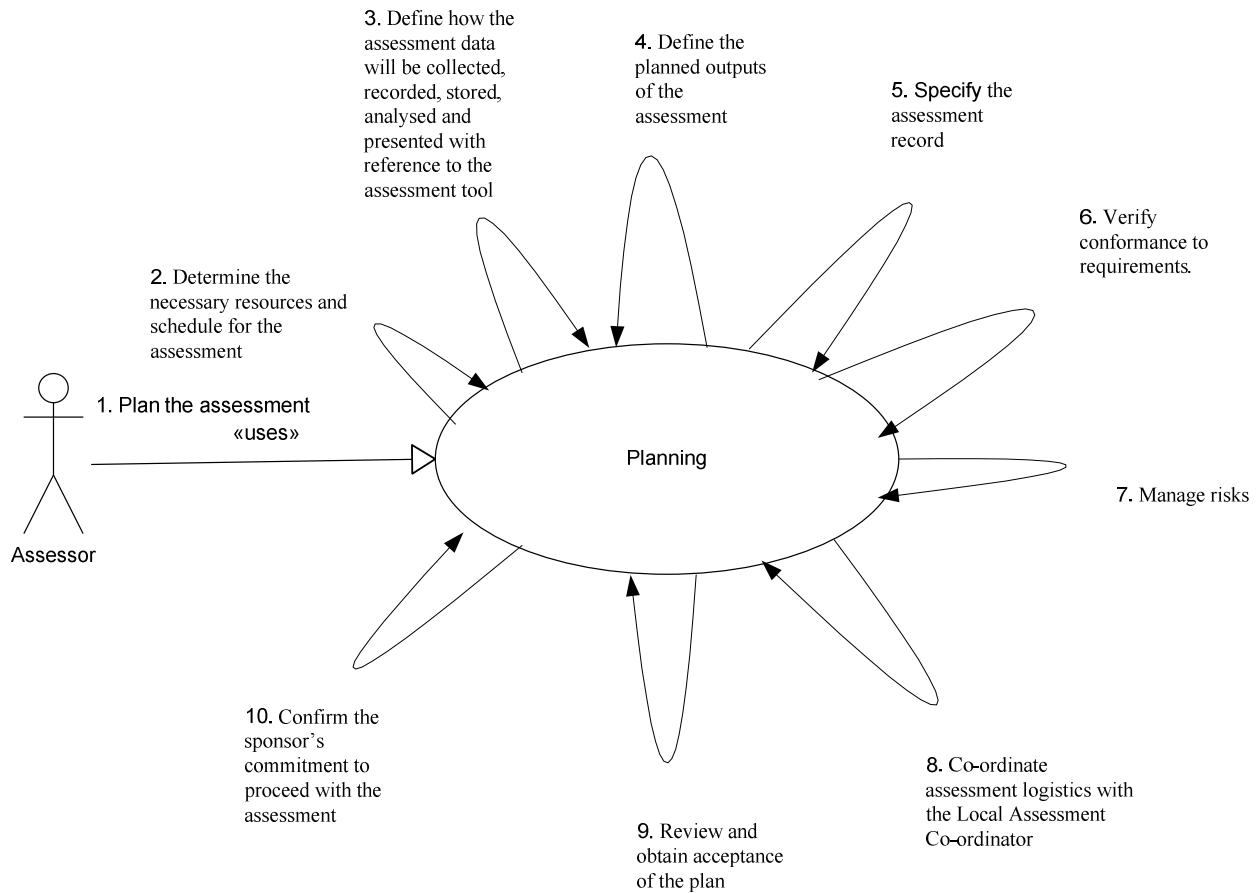
Figure 8. USE CASE DIAGRAM – PLANNING THE ASSESSMENT

4.4.2.1   Use Case Description

1. Determine the necessary resources and schedule for the assessment. From the scope, identifying the time and resources needed to perform the assessment. Resources may include the use of equipment such as overhead projectors, etc. [Potential Tool Automation Functionality: Information Recordkeeping]

2. Define how the assessment data will be collected, recorded, stored, analyzed and presented with reference to the assessment tool. [Potential Tool Automation Functionality: Select Process Assessment Framework and configuration settings]

3. Define the planned outputs of the assessment. A report of the assessment results shall be part of the outputs. [Potential Tool Automation Functionality: Select Process Assessment Framework and configuration settings]

4. The assessment record will also be specified. [Potential Tool Automation Functionality: Information Recordkeeping]

5. Verify conformance to requirements. Details how the assessment will meet all the requirements in the standard. [Potential Tool Automation Functionality: Information Recordkeeping]

6. Manage risks. Potential risk factors and risk mitigation strategies are documented and tracked through assessment planning. All identified risks will be monitored throughout the assessment. Potential risks may include changes to the assessment team, organizational changes, changes to the assessment purpose/scope, lack of resources for assessment, and confidentiality. [Potential Tool Automation Functionality: Information Recordkeeping]

7. Co-ordinate assessment logistics with the Local Assessment Coordinator. Ensure the compatibility and the availability of technical equipment and confirm that the identified workspace and scheduling requirements will be met. [Potential Tool Automation Functionality: Output reports, signoff documents]

8. Review and obtain the acceptance of the plan. The sponsor identifies who will approve the assessment plan. The plan, including the assessment schedule and logistics for site visits is reviewed and approved. [Potential Tool Automation Functionality: Output reports, signoff documents]

9. Confirm the sponsor's commitment to proceed with the assessment. [Potential Tool Automation Functionality: Information Recordkeeping]

4.4.3   Use Case Process A.4: Assessment Briefing

Before the data collection takes place, the Assessment Team Leader ensures that the assessment team understands the assessment input, process and output. The organisational unit is also briefed on the performance of the assessment.
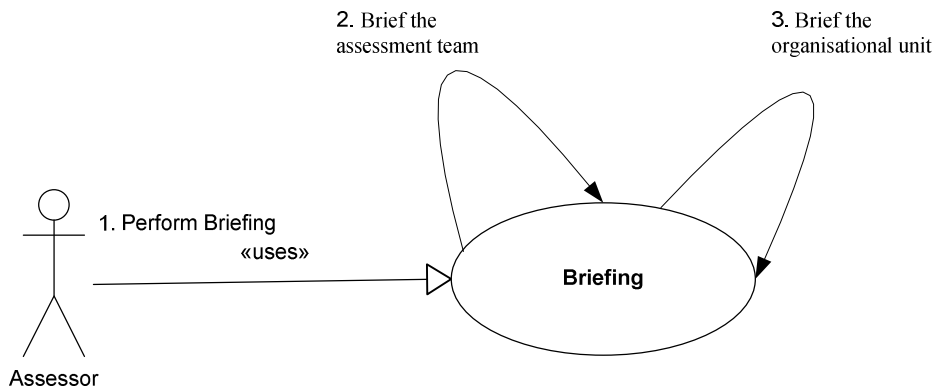
Figure 9.   USE CASE DIAGRAM – ASSESSMENT BRIEFING

4.4.3.1   Use Case Description

1. Brief the assessment team. Ensure that the team understands the assessment inputs and outputs, and is proficient in using the assessment tool. [Potential Tool Automation Functionality: Output reports, signoff documents]

2. Brief the organizational unit. Explain the assessment purpose, scope, constraints, and model to be used. Stress the confidentiality policy and the benefit of assessment outputs. Present the assessment schedule. Ensure that the staff understands what is being undertaken and their role in the process. Answer any questions or concerns that they may

have. Potential participants and anyone who will see the presentation of the final results should be present at the briefing session. [Potential Tool Automation Functionality: Output reports, signoff documents]

4.4.4   Use Case Process A.5: Data Acquisition

The data required for evaluating the processes within the scope of the assessment is collected in a systematic and ordered manner. The strategy and techniques for the selection, collection, analysis of data and justification of the ratings are explicitly identified and demonstrable. Each process identified in the assessment scope is assessed on the basis of objective evidence. The objective evidence gathered for each attribute of each process assessed must be sufficient to meet the assessment purpose and scope. Objective evidence that supports the assessors' judgement of process attribute ratings is recorded and maintained in the Assessment Record. This Record provides evidence to substantiate the ratings and to verify compliance with the requirements.
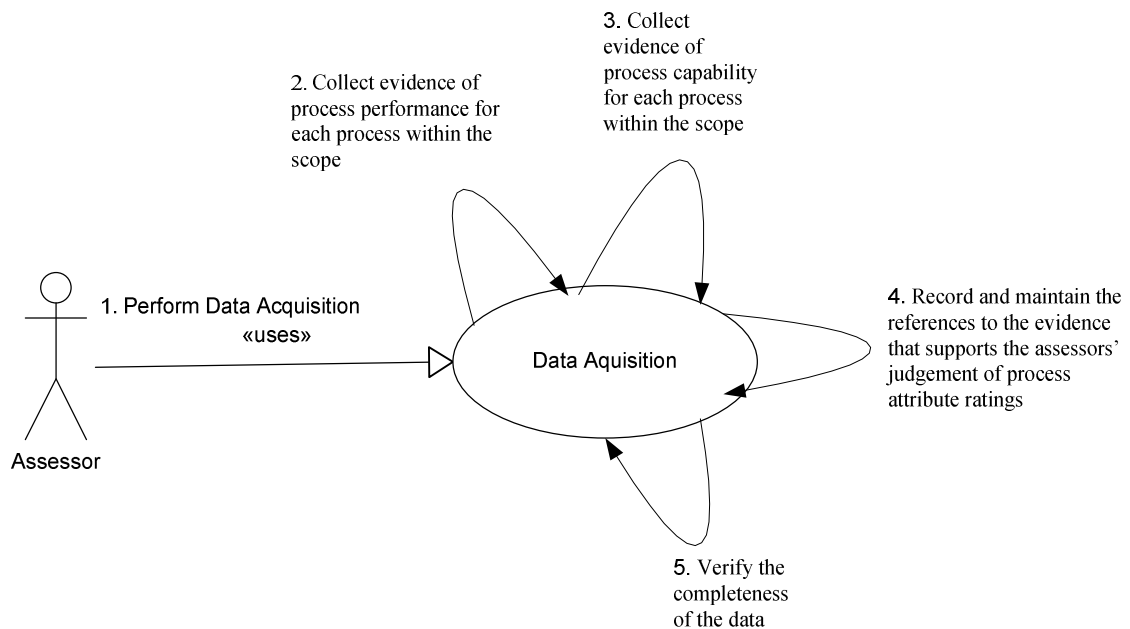
Figure 10. Use Case Diagram – Data Acquisition

4.4.4.1   Use Case Description

1. Collect evidence of Process Performance for each process within scope. Evidence includes observation of work products and their characteristics, testimony from the process performers, and observation of the infrastructure established for the performance of the process. [Potential Tool Automation Functionality: Capture Assessment Results]

2. Collect evidence of Process Capability for each process within the scope. See above. [Potential Tool Automation Functionality: Capture Assessment Results]

3. Record and maintain the references to the evidence that supports the assessors' estimation of Process Attribute ratings. [Potential Tool Automation Functionality: Capture Assessment Results]

4. Verify the completeness of the data. Ensure that for each process assessed, sufficient evidence exists to meet the assessment purpose and scope. [Potential Tool Automation Functionality: Capture Assessment Results]

4.4.5   Use Case Process A.6: Data Validation

Actions are taken to ensure that the data is accurate and sufficiently covers the assessment scope, including seeking information from first hand, independent sources; using past assessment results; and holding feedback sessions to validate the information collected.
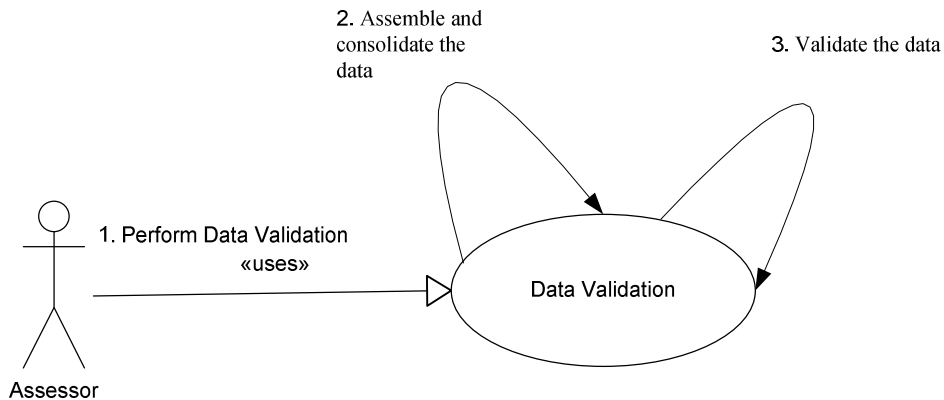
Figure 11.   USE **C**ASE **D**IAGRAM **– D**ATA **V**ALIDATION

4.4.5.1   Use Case Description

1. Assemble and consolidate the data. For each process, relate the evidence to defined process indicators. [Potential Tool Automation Functionality: Capture Assessment Results]

2. Validate the data. Ensure that the data collected is correct and that the validated data provides complete coverage of the assessment scope. [Potential Tool Automation Functionality: Output reports, signoff documents]

4.4.6   Use Case Process A.7: Process Rating

For each process assessed, a rating is assigned for each process attribute up to and including the highest capability level defined in the assessment scope.
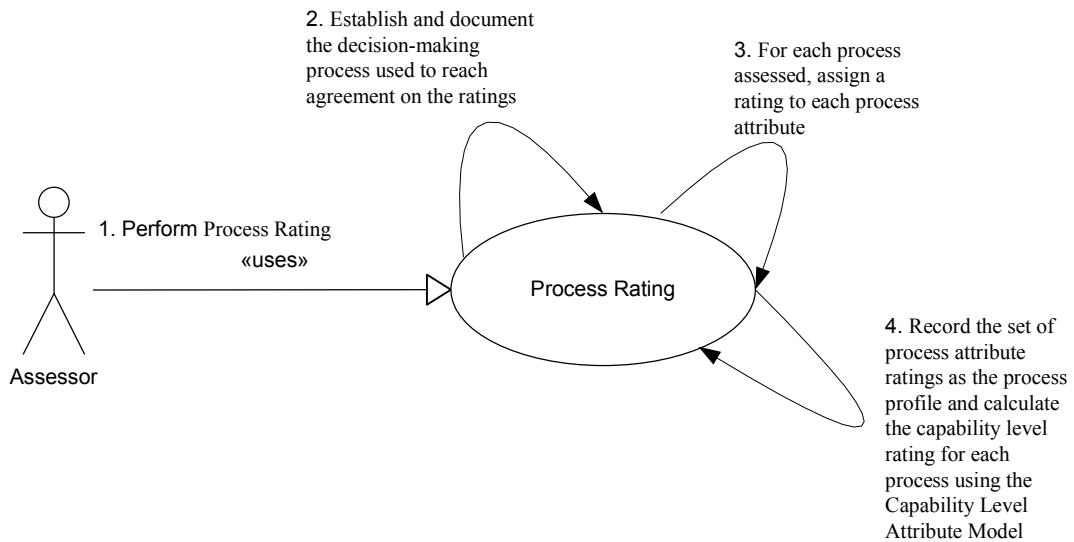
Figure 12. USE CASE DIAGRAM – PROCESS RATING

4.4.6.1   Use Case Description

1. Establish and document the decision-making process used to reach agreement on the ratings (e.g. consensus of the assessment team or majority vote). [Potential Tool Automation Functionality: Information Recordkeeping]

2. For each Process being assessed, rating has to be assigned to each Process Attribute. Use the defined set of assessment indicators from the assessment framework to support the assessors' judgment. [Potential Tool Automation Functionality: Capture Assessment Results]

3. Record the set of Process Attribute ratings as the Process Profile and calculate the capability level rating for each process using the Capability Level Attribute Model. [Potential Tool Automation Functionality: Capture Assessment Results, aggregate assessment data]

4.4.7   Use Case Process A.8: Reporting the Results

During this phase, the results of the assessment are analysed and presented in a report. The report also covers any key issues raised during the assessment such as observed areas of strength and weakness and findings of high risk.
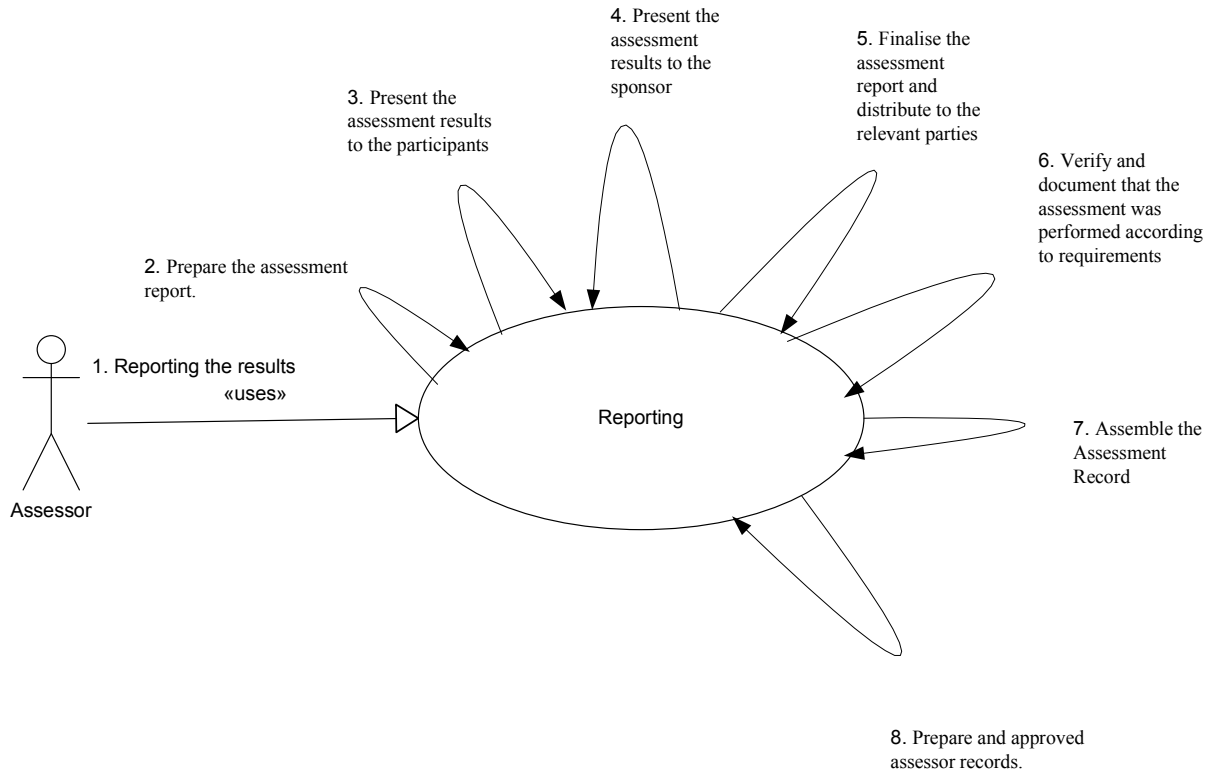
Figure 13. USE CASE DIAGRAM – REPORTING THE RESULTS

4.4.7.1   Use Case Description

1. Prepare the assessment report. Summarize the findings of the assessment, highlighting the process profiles, key results, observed strengths and weaknesses, identified risk factors, and potential improvement actions (if within the scope of the assessment). [Potential Tool Automation Functionality: Output summary and detailed reports]

2. Present the assessment results to the participants. Focus the presentation on defining the Capability of the Processes assessed. [Potential Tool Automation Functionality: Output summary and detailed reports]

3. Present the assessment results to the sponsor (or organizational unit management). [Potential Tool Automation Functionality: Output summary and detailed reports]

4. Finalize the assessment report and distribute to the relevant parties. [Potential Tool Automation Functionality: Output summary and detailed reports]

5. Verify and document that the assessment was performed according to requirements. [Potential Tool Automation Functionality: Information Recordkeeping]

6. Assemble the Assessment Record. Provide the Assessment Record to the sponsor for retention and storage. [Potential Tool Automation Functionality: Output summary and detailed reports]

7. Prepare and approved assessor records. For each assessor, records to prove the participation in the assessment are produced. The records are approved by the sponsor or

his/her delegated authority. [Potential Tool Automation Functionality: Output summary and detailed reports, signoff documents]

4.4.8   Activity Diagram: The Complete Assessment Process

The following Activity Diagram summarises the high-level activities of the assessment process. In an analysis of the activities in all the processes, we can find that each activity can be automated as a feature in an assessment tool in terms of either capturing and storing the information input (activities in blue), or outputting the assessment data in aggregated calculation profiles, charts and reports (activities in yellow).
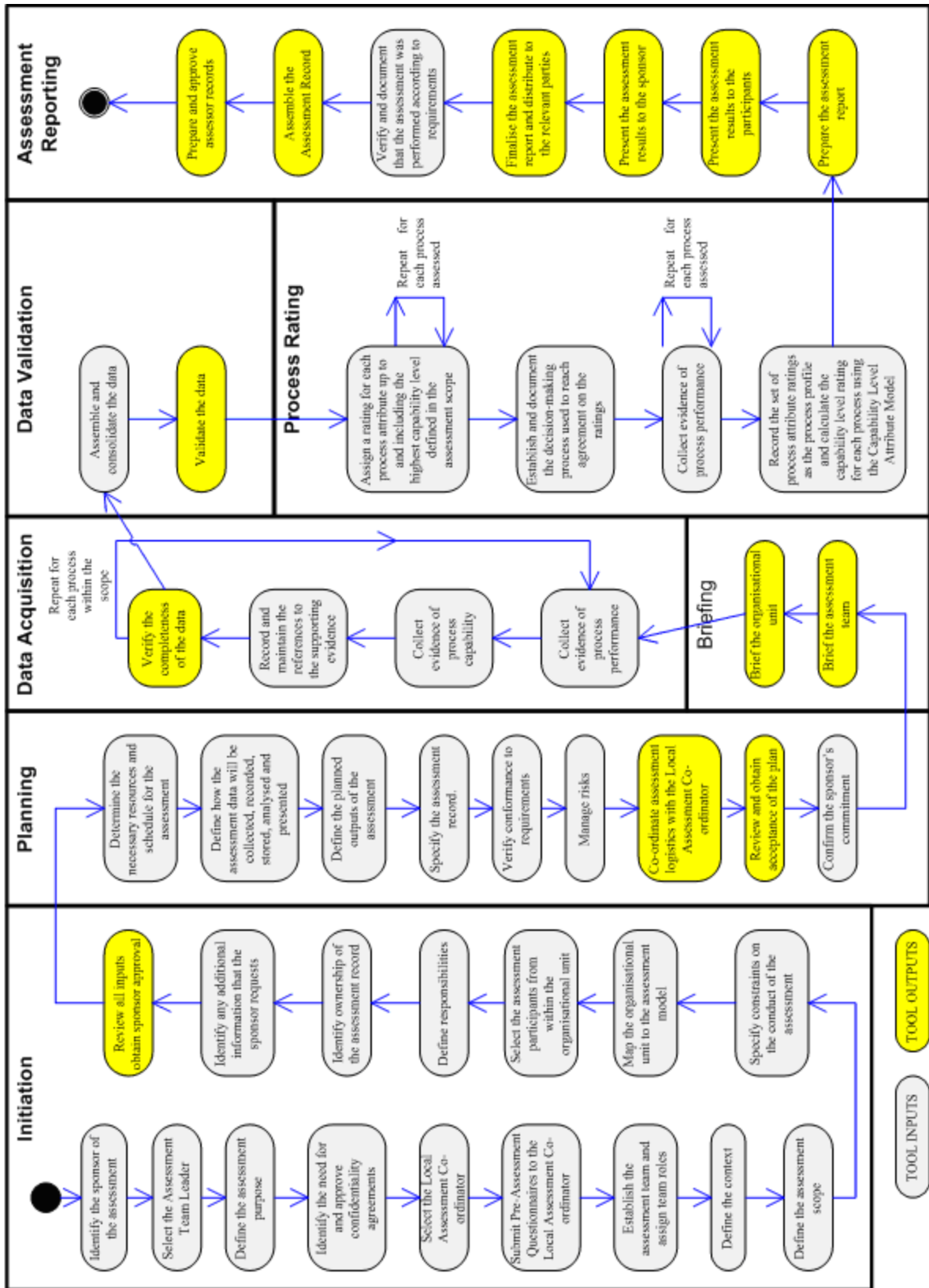
Figure 14. ACTIVITY DIAGRAM – THE ASSESSMENT PROCESS

4.5 UML Modelling the Generic Assessment Processes

In this exercise we describe the condensed activities of the assessment processes in broader terms so as to expand the scope of the tool functionality and be non-specific to any single process model assessment framework. The aim is to create Use Case Descriptions for generic processes that will be applicable to all four of the selected process model assessment frameworks.

The generic assessment processes can be arranged in the following sequence:-

1. Conducting the Assessment

2. Assessing a Process Instance

3. Assessing the Processes

4. Interviewing the Process Stakeholders

5. Auditing the Evidence

Within the steps of these Use Case Descriptions, we also identify the potentially automatable activities which can be implemented in an assessment tool to enhance the assessment process.

4.5.1 Use Case Process: Conducting the Assessment

4.5.1.1 Use Case Description

1. The assessor is assigned to conduct a new process assessment and makes the initial preparations (time and materials arrangements, contract agreements, etc.) for the task.

2. The method of assessment, including the process model and the process assessment measurement framework, is selected for the exercise.

3. The assessor interviews the Project Sponsor or Project Manager to obtain and capture the requirements and the scope of the assessment as a new assessment project. [Potential Tool Automation Functionality: Detailed Process Instance requirements information and the assessment scope details can be captured and stored]

4. The details of the Process Instance are setup and captured within the assessment tool. [Potential Tool Automation Functionality: Multiple process instances can be assessed at the same time. All assessment details on the Process Instances can be captured, stored, and retrieved for comparison]

5. The assessment is then performed on the Process Instance (as in Use Case Process: Assess Process Instance).

6. After the assessment of the Process Instance is completed, reports are generated for analysis, feedback and presentation of the results back to the customer. [Potential Tool Automation Functionality: graphical and statistical ratings reports can be generated from aggregated assessment results data]

Use Case Process: Generic Assessment Processes
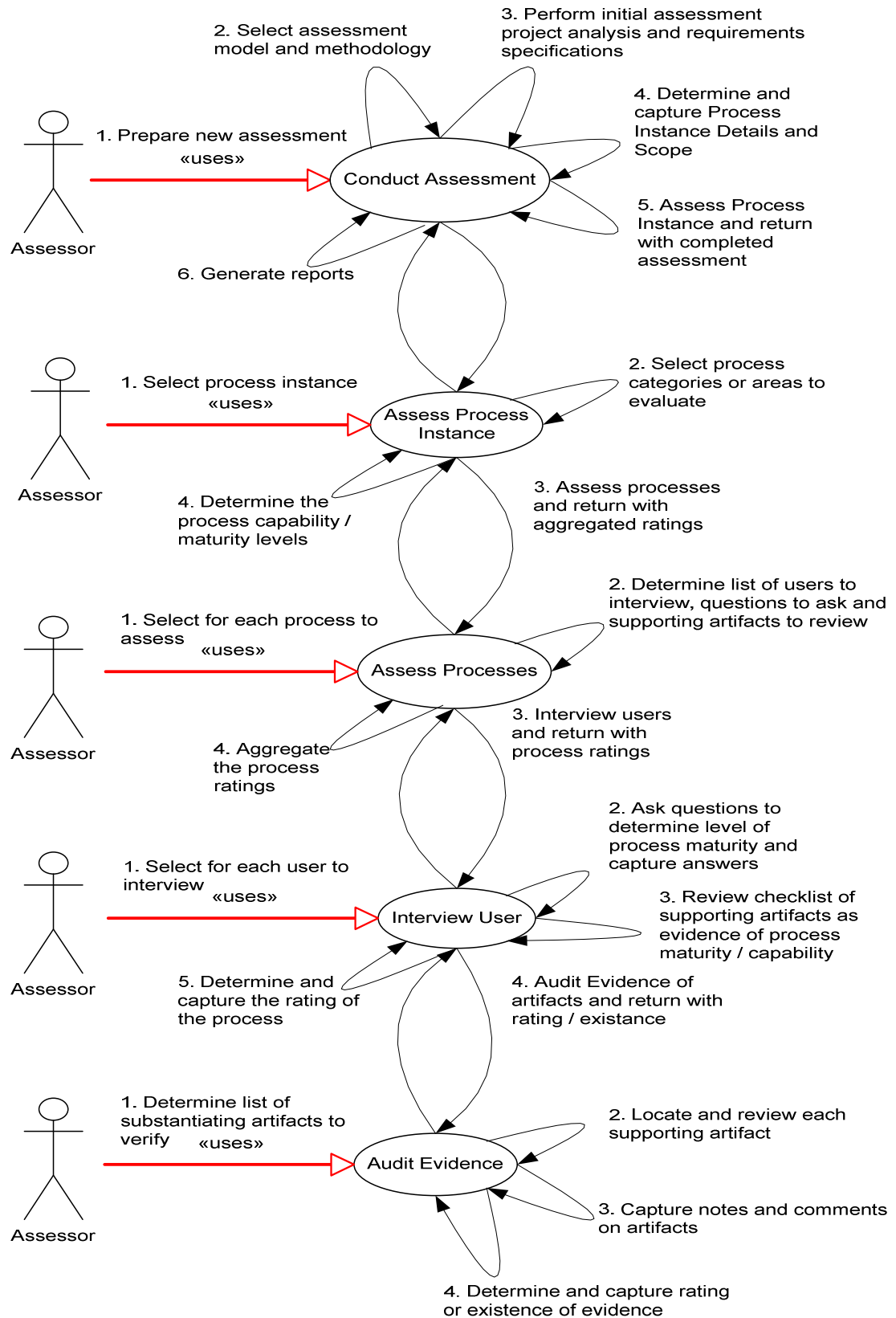
Figure 15. USE CASE DIAGRAM – GENERIC ASSESSMENT PROCESS

4.5.2 Use Case Process: Assessing a Process Instance

4.5.2.1 Use Case Description

1. The assessor selects the Process Instance within the organization to evaluate

2. The Process Categories or high-level areas are selected for evaluation. [Potential Tool Automation Functionality: tools can store the complete process model in a database and allow for partial assessment or narrowing the scope of the assessment. It may also allow the assessor to expand and/or customize the process model to the client's environment or industry]

3. For each Process Category or area to be assessed, the assessment is performed on all the applicable processes (as in Use Case Process: Assess Processes).

4. After the assessment of all the processes are completed, the calculated process ratings may be further aggregated upwards for each Process Category or area to determine their level of Capability or Maturity. [Potential Tool Automation Functionality: calculation of the aggregated results from the captured assessment ratings]

4.5.3 Use Case Process: Assessing the Processes

4.5.3.1 Use Case Description

1. For each process, the assessor evaluates and calculates the rating of maturity or capability level [Potential Tool Automation Functionality: tools can track the processes and practices yet to be assessed, as well as those completed, and allow the assessor to complete the assessment in whatever order is convenient]

2. An assessment plan should be formulated with the list of users to interview, the questions to ask and the supporting artefacts to review [Potential Tool Automation Functionality: software tools can store the complete reference process model and allow easy retrieval of the applicable process model data and information. Tools can present checklists of questions and artefacts for the user to systematically work through]

3. Each user involved in the process is interviewed (as in Use Case Process: Interview User).

4. After the required information on the capability of the process is obtained and the evidential artefacts are verified, the ratings determined for the process or practices can be aggregated. [Potential Tool Automation Functionality: tools can store the assessment rating for each process, practice, and artifact or work products, and make the aggregation calculations on demand.]

4.5.4 Use Case Process: Interviewing the Process Stakeholders

4.5.4.1 Use Case Description

1. For each person to be interviewed, the assessor should schedule a time and venue to interact with the person. Other methods of information gathering are via e-mail or telephone, although a face-to-face session is preferred.

2. The list of applicable questions to determine the process rating is applied in the interview, and the answers and comments are captured. [Potential Tool Automation Functionality: tools will store the responses for each question and person interviewed]

3. The list of artefacts supporting the capability / maturity level of the process is reviewed and the existing artefacts are recorded for investigation. [Potential Tool Automation Functionality: tools will store the existence and location of each artefact to be verified]

4. Each supporting artefact is audited as evidence of the process capability / maturity (as in Use Case Process: Audit Evidence).

5. After the artefacts are verified, the rating of the process is determined based on the artefacts and the user responses.

4.5.5   Use Case Process: Verifying the Evidence

4.5.5.1   Use Case Description

1. For each artefact to be reviewed, the assessor determines the location and availability of the item with the users.

2. The artefacts are located and reviewed by the assessor.

3. Notes and comments for each artefact are captured by the Assessor.

4. The rating or existence of the artefact reviewed is determined and captured by the assessor. [Potential Tool Automation Functionality: as most of the process-supporting artefacts are likely to be electronic documents files (MS Word; MS Excel; MS PowerPoint; PDF files, etc), a Document Management system can be implemented to maintain a central repository of process-related artefacts]

4.6   Extending the Assessment Process for Conversion

After an assessment has been completed for a given process model framework, it is possible for the results to be translated to another process model framework if a mapping is available between the two process reference models.

Translating assessment data from the first process model to the second one typically results in a subset of results as mappings between processes will typically not be 1-to-1 for all the processes in each model.

However, for an organisation that wishes to assess its processes against two process model frameworks, a considerable amount of data can be 'reused' and a head start gained in the second assessment exercise.

4.6.1.1   Use Case Description

1. The assessor selects an initial Process Model Assessment Framework (e.g. ISO/IEC 15504) to perform the process instance assessment with.

2. After completion of the initial process assessment, an alternate Process Assessment Framework could be selected to be performed against the same Process Instance. This would allow an organisation to be certified on more than one Process Assessment Certification (e.g. ISO 9001).

3. The automated assessment tool would translate the Assessment Data of the initial Process Assessment Framework to the Process Model of the Alternate Process Assessment Framework using a data mapping of the two process models.

4. The user would then be able to complete the Assessment Record (i.e. the Initiation information specific to the alternate Process Assessment Framework) and then capture the remainder of the Assessment Data. Depending on the completeness of the mapping correlations, the user would have a 'head start' on the assessment data left to capture. This would also minimise redundancy in the assessment of processes.

The process flow of this automated assessment tool is illustrated in the Activity Diagram (Figure 16).

4.7   Summary

By analysing the assessment processes of the ISO/IEC 15504, we can find an opportunity for tool automation in almost every activity of each process. The main types of system functionality that are identified for implementation are:

1. Assessment data input (capture assessment scope; organisational and process instance information; assessment ratings)

2. Assessment data processing (aggregation of ratings and results)

3. Assessment data output (data presentation, reports)

4. Process model referencing (view process model content)

5. Process mode customisation (tailor the process model)

6. Process model data conversion (process data mappings, translation of data)

Once an assessment has been completed, the assessment results can be converted to another process model framework if a mapping is available. Only the processes not covered by the mapping would need to be evaluated in order to determine the capability / maturity level of the organisation against the second process model. Process model mappings can therefore provide an organisation significant additional value and time saving from the assessment exercise.

Activity Diagram: Tool Assessment Processes for Multiple Process Assessment Frameworks
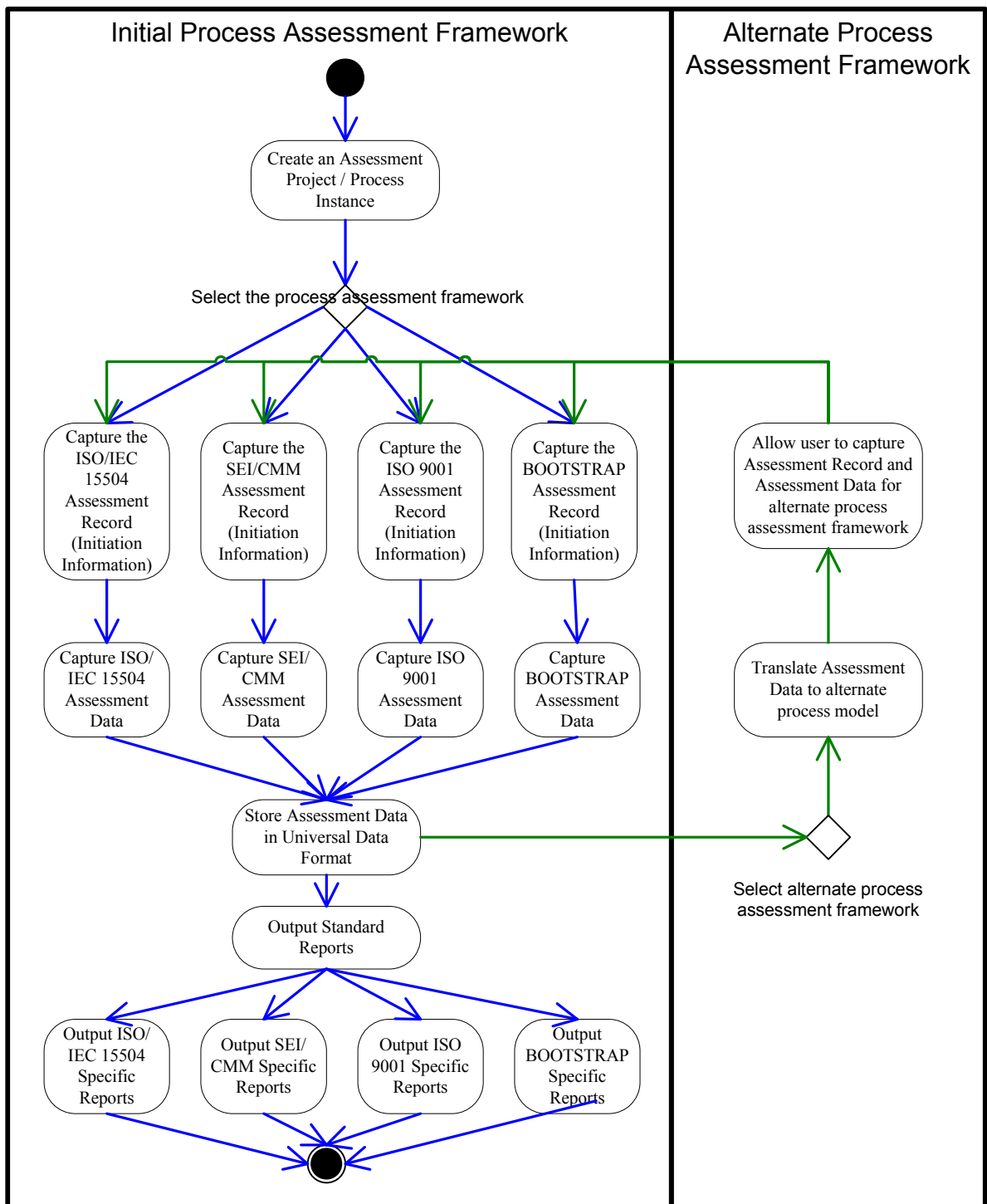
Figure 16. ACTIVITY DIAGRAM – TOOL ASSESSMENT AND TRANSLATION PROCESSES

5 Tool Benefits for Software Process Assessments

5.1 Introduction

In an assessment, both the process requirements and the process performance within an organisation are required to be analysed and profiled. Assessments are conducted by means of single person and group interviews, workshops and investigation of existing documents (e.g. operating instructions standards and procedures, the associated work products, etc). A standard base practice item is typically evaluated and confirmed within a few working days.

Assessors are required to facilitate the publishing of the relevant facts, analyse the results and assist in the identification of measures for improvement. External Assessors are used to guarantee objectivity and comparability of the capability ratings. Assessors generally operate in an IT consultant mode for a client company.

On completion, the assessment results should be output and reported in such a way that not only software experts, but also management and non-involved parties, can quickly and easily obtain a view of the organisation's software engineering skills and capabilities – as well as being able to measure against past, current and industrial instances of process assessments.

Software tools that support these areas of assessment can add significant value to the accuracy and efficiency of the process model's assessment methodology and measurement framework by automating its execution.

5.1.1 Research Method

The preceding chapter focused on functionality for performing the assessment on a process model. In this section we examine the functionality that is focused on the role of the assessor. The task requirements for assessors and their responsibilities in an assessment are investigated in order to identify where software can enhance, accelerate or optimize the assessment process in a practical, user-friendly interface.

5.2 Defining the Role of the Assessor

The role of the assessor is well defined in ISO/IEC 15504. As this is the most recent process model framework (which builds on the previous ISO 9001/CMM/BOOTSTRAP frameworks) we will use their definition of the role as a basis.

The ISO/IEC 15504-3 describes the role of the Competent Assessor as:

The competent assessor is responsible for ensuring that the assessment achieves its purpose and that it is conformant with the requirements of ISO/IEC 15504-2. It is therefore imperative that the competent assessor selects an appropriate documented assessment process. Where the documented assessment process is selected by the assessment sponsor, then it is the responsibility of the competent assessor to ensure that assessors or users are competent in its use.

The ISO/IEC 15504-3 describes the role of the Assessor as:

The rating activities are performed solely by the competent assessor and assessors. Other personnel may participate as assessment team members providing specific expertise or

supporting clerical work. They may support assessors in formulating the judgement but will not be responsible for the final rating of process attributes.

The following table from ISO/IEC 15504 Part 7: Guide to the Competency of Assessors, breaks down the role of the assessor relative to the approach of the assessment. The corresponding functionality (from the previous chapter) that can potentially be implemented on an automated assessment tool is added to this table as well.

Self-assessment approach	Independent assessment approach	Potential Tool Functionality
Is task and people oriented.	Is task oriented.	Provide checklist of tasks
Guides the assessment.	Controls the assessment.	Documented assessment procedures in the form of online help guides or Wizards
Agrees a rating.	Delivers a rating.	Capture and aggregate ratings
Promotes discussion.	Regulates discussion.	Capture notes and comments from multiple participants
Works with projects.	Works separately from projects.	Maintain data for separate assessment projects
Uses Organizational Unit's business goals.	May be indifferent to Organizational Unit's business goals.	Capture and display business goals on screens of assessment forms to remind assessors of the
Influences through results obtained, relationships established and expertise.	Influences through position and expertise.	Display or print results in appealing and easy-to-read (charts, lists, etc.) formats for presentation to stakeholders
Seeks commitment.	Determines process adequacies.	Aggregate and display Results Profiles t
Is like being a change agent.	Is like being an auditor.	Allow the assessor to capture both assessment and auditing (see below) data

Table 2. THE ROLES OF THE ASSESSOR VS. THE ASSESSMENT APPROACH

5.3 Competence Standards for the Usage of Assessment Tools

The issue of instrument competence revolves around the trained and skilled usage of an assessment tool by assessors such that the collated information is able to be consistently collected, recorded, processes and analysed based on a reliable methodology. Competent assessors combine these skills with experience and training in the theory and principles of a process model to obtain accurate assessment ratings

In ISO/IEC 15504 Part 3: Guidance on Performing an Assessment, Chapter 9 of the document describes the requirements of competence in assessment tools and instruments by assessors. It does not prescribe a particular tool, but rather presents the considerations an assessor should factor into account when selecting an appropriate assessment instrument:

The selection criteria for the type of instrument and tool may be influenced by:

- *the scope and purpose of assessment;*

- *need of assistance in collecting and storing information including assembling the assessment input and recording it in a suitable form for transfer to the assessment output;*

- *availability of the compatible process assessment model through the defined set of indicators, at least for the scope of the assessment;*

- *ability to capture the information required to be used in the production of ratings as defined in ISO/IEC 15504-2;*

- *ability to capture and maintain supporting information as defined in the assessment input;*

- *support of the rating scheme defined in ISO/IEC 15504-2;*

- *support of representation of process profiles in forms that allow straightforward interpretation of their meaning and value;*

- *ability to store and retrieve assessment results for subsequent use in process improvement or capability determination;*

- *provision of appropriate segregation of different classes of information and data to enable the information and data to be used or distributed in different ways;*

- *ability to keep the captured information secure to meet confidentiality constraints;*

- *ability to perform dynamic scoping and tailoring to support specific cultural, organisational, sponsor, or assessment needs;*

- *in providing adequate configuration control of the instrument and the results collected;*

- *ability to split by process and job function;*

- *ability to tailor the process assessment model as required;*

- *portability considerations (usability for interviews, distributed inputs, simultaneous inputs);*

- *ability to handle multiple assessors' inputs;*

- *usability for interviews, self-assessment;*

- *ability to integrate with other tools (metrics, case, etc.);*

- *ability to maintain an audit trail of access to information input;*

- *real-time performance: speed of information input and retrieval;*

- *ability to call up practices required for specific interviews.*

5.4   The Assessment Process vs. the Auditing Process

The activities of an assessment can be considered as a repetitive cycle, which can be broken up into four phases:

- Plan – planning on what needs to be done

- Do – perform the assessment according to the plan

- Check – verify if the planned arrangements or objectives have been achieved

- Act - decide on next action and cycle again

The same systematic process cycle used for the Assessment of software processes (which is focused on events before the fact) can also be used for the Auditing of software processes (which is focused on events after the fact).
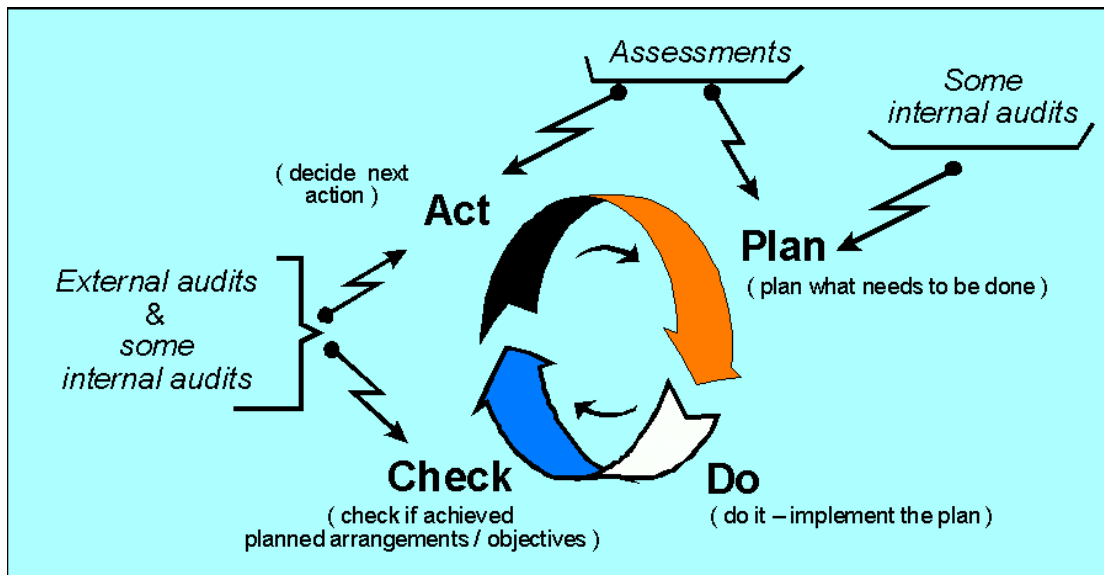
Figure 17. ASSESSMENT PDCA (PLAN, DO, CHECK, ACT) CYCLE

Both assessments and audits are applied as a management tool as opposed to a technical-review tool. The outcome of both is a report, and they both often use similar methods and techniques to perform their appraisal – therefore, the functionality to perform both can be incorporated into a tool with a minimum effort of change if either one is implemented.

We look at the key differences of the two processes that can affect a tool's design and functionality:

Topic	Assessments	Audits
Appraisal customer:	Internal (self-appraisal) or external customer	Internal (self-appraisal) or external customer
Purpose:	To determine areas for improvement (and optionally,	To determine effectiveness (suitability), capability, gaps,

	with people's view of recommended course of action).	need to improve, risks to proceed, and/or compliance (i.e., need for Corrective Action).
Motivation to improve:	Appraisal-customer imposed motivation; hence, internal appraisals are self-motivated.	Appraisal-customer imposed motivation; hence, internal audits are self-motivated.
Scope (determined by the appraisal's customer):	Software organisation (system), process, project, or function	System, process, project, function, product, service or work product
Type of appraisal:	1st, 2d and 3rd party; capability analysis or delta comparison analysis	1st, 2d and 3rd party; compliance, maintenance (surveillance), gap analysis, or follow-u
Applicable PDCA stage (see diagram above)	Typically triggered in the planning stage or act stage	Typically triggered in the check or act stage--e.g., compliance audits are triggered as part of the check stage and follow-up audits are triggered as part of the act stage. Note: When audits are internally triggered, they may be part of the planning stage--e.g., special audits like some gap analysis.
Focus	Before the fact	After the fact
Primary questions asked:	What is the current capability, competence and potential? What are the primary areas of weakness?	What is being done? By who, when, where and how? Is it what was expected? What are the risks?
Primary type of prevention encouraged:	Prevent occurrence	Prevent recurrence
Type of evidence collected:	1st party: Subjective and objective 2d and 3rd party: objective only	Objective (subjective evidence may be collected for internally triggered gap analysis)
Auditor/assessor independence	1s party: it is recommended that the lead assessor be independent of the scope being assessed. 2d and 3rd party: all assessors to	All auditors to be independent of the scope being audited.

	be independent of the scope being assessed.	

Table 3.   **A COMPARISON BETWEEN ASSESSMENTS VS AUDITS**

Notes:

- The Auditor/assessor style (e.g., impartial, collaborative) is dependent on the appraisal-customer (internal vs. external) and, the appraisal's purpose and potential impact/risks.

- The Audit/assessment duration and type of interaction (group vs. 1-on-1) depends on the purpose, scope and type of appraisal.

5.5   Process Assessment Questionnaires

Forms, questionnaires and surveys are common means of collecting and capturing data, and each process assessment standard has it's own unique information requirements that may need to be collected by the assessor – for instance:

- Information on the project or process instance being assessed

- Assessment detail on the processes or practices

- Classification and validation of artefacts, etc.

Automated tools can assist the assessment process by allowing the assessor to capture the information on forms, validate the data and store them as records in a database, and then index the data in order to allow the assessor to search and retrieve the data in an efficient manner.

Some examples of Process Assessment Questionnaires (for the ISO/IEC 15504) are presented in the Appendix.

5.6   Summary

From the comparison evidence it is clear that the primary purpose of the majority of automated assessment tools are to provide a level of data capture and storage of assessment results, the calculation of assessment ratings and the graphical representation of results in the form of reports and graphs. When compared with the implicit method of paper-based assessment described for each of the various assessment frameworks, such tools offer significant added value for the assessor and can become indispensable to any process assessment methodology.

A major next step in functionality for process assessment tools would be for a tool to work across different process models and correlate data between them through the use of process mappings. It has been established from the review of the assessment tools on the market that there is currently very little of this type of functionality. In fact, most assessment tools also only cater for a single process assessment model or measurement framework.

Therefore there exists an opportunity for the implementation of a process assessment tool that would be able to store multiple process models, and allow the user to build correlations between the process elements with process data mappings in order to:

1. Translate assessment data from one process model framework to another

2. Migrate legacy data from older process assessment frameworks to a newer one

3. Allow an assessment to be performed on more than one process model framework at the same time, and therefore allow an organization to achieve multiple compliancies on their processes.

This reasoning motivates the goal to find and establish the basis of a process model mapping methodology for accurately creating data associations between two or more process assessment model frameworks.

6 Functional Compatibility for Process Model Mappings

6.1 Introduction

In order to consider whether two given process models can have a data mapping between them, one first has to consider the functional compatibility of their process assessment frameworks. If the frameworks are incompatible or have relatively few relationships between them, then attempting to create a data mapping between the process models would serve little or no purpose.

Organisations that are trying to implement two process assessment methods (such as both the ISO 9001 and SW-CMM) concurrently are asking questions such as:

- "If we perform systems engineering according to the SW-CMM, or at an SW-CMM level 'x', are we ISO compliant?".

- At what specific level of maturity would an ISO 9001 compliant organisation be?

- Should the organisation's software quality management and improvement processes be

In order to determine whether two given process models are functionally compatible (and therefore it would be justified for a process model mapping to be created between them), we need to closely analyse:

a) The relationships between process assessment model, and

b) The requirements of each process assessment model in a functional comparison

- in order to understand the supplementary issues that may be present, and determine the contextual differences between them.

This would allow us to intuitively perform a Functional Gap Analysis to determine whether two given process model frameworks are functionally compatible for the mapping of processes.

6.1.1 Research Method

In this chapter we perform an exercise in analysing and determining the level of functional compatibility between two process model frameworks. This level should be established before a mapping can be created – creating a data model mapping would not make sense if the two frameworks are at cross purposes to each other or have vary different goals and outcomes.

The first step is to trace the history of process assessment models and look at the conceptual relationships and interdependency between the ISO/IEC 15504 to the other SW-CMM, ISO 9001 and BOOTSTRAP process models in order to determine the influence that these process models have had on each other's formation.

These relationships will allow us to identify the (general purpose) process model frameworks that have strongest correlations with each other, and therefore should be the best candidates for being compatible with each other on a functional level. We will also briefly look at other specialised process models that are potentially mapping-compatible.

Then we will inspect the different techniques that are available to perform a detailed comparison between process models frameworks in order to establish their level of functional compatibility.

As a case study to illustrate the concepts of a functional comparison, we will then perform the comparison within the context of comparing the ISO 9001 to the SW-CMM process models.

Once the level of compatibility between two process models is determined, we can intuitively quantify the opportunity for mapping.

6.2   Process Assessment History

The following table traces the growth and evolution of the process assessment domain:

Year	History
1985	Ron Radice and colleagues report on a "Programming Process Study" at IBM
1987	Humphrey and Sweet from the Software Engineering Institute (SEI) at Carnagie Mellon University report on the state of software development
	Initial release of the ISO 9001
	The SEI issues SEI-87-TR-24, it's first software development maturity questionnaire (SW-CMM)
1988	Initial release of AS 3563 (Software Quality Management System) standard
1989	Watts Humphrey publishes a book called "Managing the Software Process"
1991	Initial release of Capability Maturity Model for Software (SW-CMM) v1.0 by the SEI
	Initial release of ISO 9000-3
	Initial release of Improve-IT (this is the beginning of TickIT)
	Initial release of IEEE 1074
	Initial release of Trillium v1.0
	The International Standards Organisation (ISO) requests a study on process assessment
1992	EFQM/BEA: 1st Business Excellence Award (Europe)
	IEEE adopts the Australian AS 3563 as "IEEE 1298"
	TickIT V2.0 released
1993	SEI SW-CMM V1.1 released
	ISO accepts new work item on process assessment
1994	ISO 9001 re-released
	Trillium V3.0 released
1995	ISO 12207 released (initial release)

Year	History
	ISO/IEC 15504 (SPICE) initial "draft" released Initial release of Capability Maturity Model for Software Engineering (SE-CMM) v1.0 by the SEI
1996	IEEE/EIA 12207 released (this is ISO 12207 with extra guidance)
1997	ISO 9000-3 re-released SEI halts SW-CMM revisions in support for CMM Integration (CMMI)
1998	ISO/IEC 15504 (SPICE) released to public as "type 2" Technical Reports TickIT V4.0 released
2000	ISO 9000:2000 edition released The SEI CMMI SE/SW/IPPD V1.02 is released
2002	The SEI CMMI SE/SW/IPPD/SS V1.1 is released
2003	ISO/IEC 15504-2 and ISO/IEC 15504-3 is published
2004 – 2005	Full publication of the ISO/IEC 15504

Table 4.   HISTORY TRAIL OF PROCESS ASSESSMENT

6.3   Conformance of Process Assessment Models

A few process frameworks, like the ISO/IEC 15504, allow other process models to claim that they are conformant with the measurement framework, providing that they meet certain compliancy requirements that can be verified.

For ISO/IEC 15504, the basic requirements for such conformance are described in *Part 2: Performing an Assessment*. In *ISO/IEC 15504 Part 3: Guidance on Performing an Assessment*, Chapter 11 of the document describes the verification of requirements for conformance in process assessment models as a principle goal to achieve the market adoption of its common measurement framework. Verification would provide users with the necessary confidence in the results - that the assessment ratings are obtained and expressed in a repeatable, reliable format using the measurement framework.

As part of the requirements, a provider of a given process assessment model can facilitate the verification of model compatibility to the ISO/IEC 15504 by supplying the evidence in a document called the 'Demonstration of 15504 Model Compatibility' which would describe how each compatibility requirement is met or addressed. Verification can then be achieved by methodical inspection.

Such requirements for demonstrating ISO/IEC 15504 model compatibility include:

- Model Purpose

- Model Scope

- Model elements and indicators

- Mapping to the ISO/IEC 15504 measurement framework

- Translation of data to the ISO/IEC 15504 model as regards to purpose. Process outcomes and process capability

Of the requirements, the existence and accuracy of the assessment model mapping is the most important factor for demonstrating conformance.

6.4 Finding Conformance Between the Process Models

The early process models have evolved over time It is characteristic that many new standards (like the ISO/IEC 15504) are based on elements of other established process model frameworks.

Indications of process model conformance to the ISO/IEC 15504 can be found by analysing the origins and historical relationships between the process model assessment frameworks.

The chart below has been provided to given an overview of these interlinking relationships between process models.
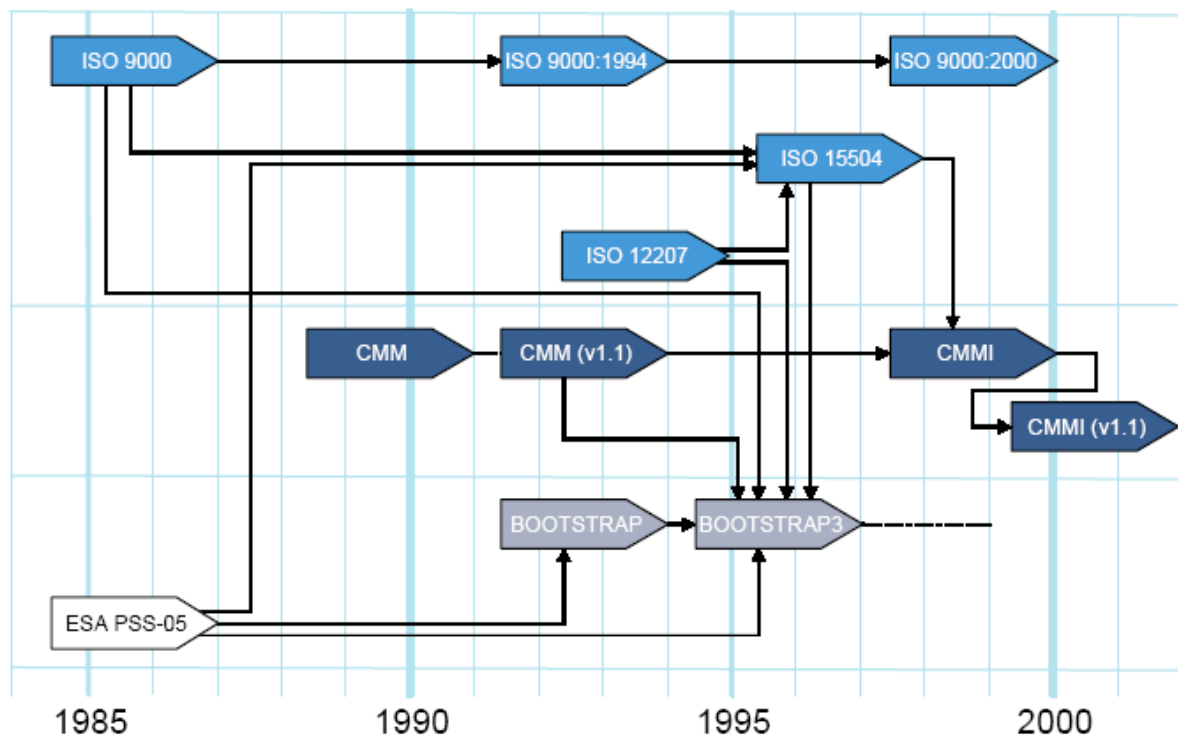
Figure 18. THE HERITAGE OF PROCESS MODEL STANDARDS

6.4.1 ISO/IEC 15504

The following extract is taken from ISO/IEC 15504 Part 1: Concepts and Introductory Guide:-

ISO/IEC 15504 incorporates the intent of the ISO 9000 series to provide confidence in a supplier's quality management whilst providing acquirers with a framework for assessing whether potential suppliers have the capability to meet their needs. Process assessment provides users with the ability to evaluate process capability on a continuous scale in a comparable and repeatable way, rather than using the pass/fail characteristic of quality audits based on ISO 9001. In addition, the framework described in ISO/IEC 15504 provides the opportunity to adjust the scope of assessment to cover specific processes of interest, rather than all of the processes used by an organisational unit.

ISO/IEC 15504 is related in particular to the following components of the ISO 9000 series:

- *ISO 9001 : 1994, Model for quality assurance in design, development, production, installation and servicing;*

- *ISO/FDIS 9000-3 : 1997, Quality management and quality assurance standards - Part 3: Guidelines for the application of ISO 9001:1994 to the design, development, supply, installation and maintenance of computer software;*

- *ISO 9004-4 : 1993, Quality management and quality system elements - Part 4: Guidelines for quality improvement.*

6.4.2 SW-CMM

The CMM has been linked in many ways to the ISO/IEC 15504 since the initiation of the SPICE project. The SW-CMM focuses on management and engineering practices related to the production and support of software – this is a subset of the ISO/IEC 15504 scope. Most ISO/IEC 15504 processes have some degree of coverage and relationship to the CMM for Software, especially since some of the key contributors of the ISO/IEC 15504 family set were from the SEI. The ISO/IEC 15504 in turn has contributed to the evolution of the CMM family set in its later releases.

An implicit purpose of the ISO/IEC 15504 was to provide organisations using more than one process improvement methodology - such as the CMM - with a framework that would allow the assessment ratings to be comparable.

There are strong direct structural relationships between SE-CMM and the ISO/IEC 15504, whereas the other models (like the SW-CMM version 2) are evolving to provide a more visible relationship between the two. This will result in an improved ability to perform assessments that are conformant to the ISO/IEC 15504, using standard CMM methods.

6.4.3 ISO 9001

A common usage of the ISO 12207 Process Reference Model within the software industry is to integrate it with the ISO 9001 family, thus turning the ISO 9000 generality into software production specifics. One standard that does this is the ISO/IEC 15504 standard. Besides this integration of standards, ISO/IEC 15504 focuses on assessing the maturity of software organisations.

6.4.4 BOOTSTRAP

BOOTSTRAP version 2, released in 1994, was one of the main background methodologies of the ISO/IEC 15504 standard for software process assessment.

BOOTSTRAP version 3 was initially released in 1997. The standard was revised according to the finalisation of the ISO/IEC 15504 standard. It revised to be compliant with the ISO/IEC 15504 and enables organisations to compare their assessment result to CMM capability levels. BOOTSTRAP therefore integrates elements from the following standards:

- ISO 9001

- ISO 12207 and ISO/IEC 15504

- A software development standard from the European Space Agency called ESA PSS-05 [ESA PSS-05]

- CMM

6.5 Other Potentially Compatible Process Models

There are other specialized process models which have been derived from the ISO/IEC 15504 and are therefore strong candidates for being mapping-compatible.

Three of these are:

- Automotive SPICE (Embedded Software)

- ISO/IEC 15288 System Lifecycle Process

- ISO/IEC 18529 Human Centred Lifecycle Process

- ISO 9001 Quality Management - developed by the European Space Agency

- IT Service Management

- OOSPICE (Component Based Development)

6.5.1 Automotive SPICE (Embedded Software)

This Process Reference Model is being developed by the Procurement Forum, Automotive SIG. It has the goal of being a common approach for manufacturers to assess and evaluate suppliers based on ISO/IEC 15504.

Manufacturers such as Audi, BMW, Daimler Chrysler, Fiat, Jaguar, Landrover, Opal, Porche, PSA, Renault, Saab, Volkswagen, and Volvo have participated in the development of this model.

6.5.2 The OOSPICE Project (Capability Assessment for CBD Methodology)

Component Based Development (CBD) is a key for improving time-to-market, productivity, quality and re-use in software development. The goal of OOSPICE is to investigate and report on current industry best practices. It will then use this information to define a process metamodel of CBD together with corresponding extensions to the ISO/IEC 15504 process assessment standard.

The result will be to bring software process assessment and improvement to coherent packages of software implementation. OOSPICE has nine partners in five countries, and university and industrial co-operation.

6.6 Techniques for Performing Functional Comparisons

There are four classes of methods, or techniques, to perform comparisons (Halvorsen, Conradie, 2002) between process model frameworks:

1. Comparing Attributes – the characteristics of each process model

2. Comparing Kernel Concepts – exhaustive mapping of the framework

3. Comparing Textual Phrases – perform a comparison bilaterally

4. Comparing User Needs vs. Framework Properties – map the needs and requirements

This provides us with a taxonomy with which to perform process model comparisons.

6.6.1 Comparing Characteristics

The comparison of characteristics involves the definition of an extensive list of relevant attributes. Each process model framework is then described in terms of these characteristics – typically in a tabular format for representation. This method is suitable for obtaining a general overview of the frameworks and can be used as a basis for the other methods of comparison. The drawback on this method is that it collects data on a high level and the comparison on the detail level must be stored in another area.

6.6.2 Comparing By Framework Mapping

The more structured process model frameworks consist of a (more or less) predefined set of requirements that deals with the content and focus of the framework. These kernel concepts and definitive statements can be mapped from one framework to the other for comparison. Whilst two given process model frameworks can be mapped against each other in specific detail, creating a common 'basis framework' solely for comparison purposes allows for multiple process models to be mapped and compared against their lowest common denominator set. This is beneficial for organisations that employ two or more process assessment methods/models.

This method allows the key concepts and attributes to be compared, as well as identifying overlaps and correlations (e.g. strong/weak/no links) between frameworks. The method is also flexible enough to allow for mapping to be performed on a high or low detail as required.

Note that this comparison method emphasises the mapping of concepts such as purpose, approach, etc. – and is not to be confused with the mapping of processes as described elsewhere in this text.

6.6.3 Comparing User Needs vs. Framework Properties

This method maps the needs of the user by comparing the organisational and environmental needs that have to be factored in when choosing the framework to use. These requirements, which can effectively filter out the incompatible frameworks, could be:

1. Requirements for certification compliance (such as a certain maturity level of CMM)

2. Specific management requirements and preferences (such as on quality management)

3. Cost effectiveness of the method and resources used

These requirements can vary between organisations, as well as within the same organisation, over time.

6.6.4 Comparing Textual Phrases (Bilateral Comparison Method)

The Bilateral Comparison method allows two given frameworks to be compared on a textual basis - often as a summary or explanation of findings from the other comparison methods. The approach is to perform the comparison from the viewpoint of one of the process model frameworks and describe the other framework in terms of that one.

This technique is convenient for assessors that have an intimate knowledge of one of the frameworks, as they can use familiar terms and concepts in order to effectively gain insight into the other.

The amount of detail used in the Bilateral Comparison method is typically between the first two comparison methods, depending on the scope and purpose of the comparison required.

6.7 Case Study: Performing a Functional Comparison between the ISO 9001 and the CMM

6.7.1 Purpose

A Functional comparison will be performed between the ISO 9001 and the CMM in order to:

1. Determine if there is an acceptable level of compatibility between the purpose, attributes and characteristics of the two process model frameworks

2. Identify any significant issues that may affect the compatibility of the frameworks, and their impact on the creation of a data mapping

6.7.2 Research Method

The Comparison by Framework Mapping method shall be used in this exercise to map the kernel concepts of the ISO 9001 and the SW-CMM frameworks, examining their definitive statements in detail. The key concepts that we shall analyse and compare are:

1. Stated Purpose

2. Scope of Coverage

3. Process Improvement Areas

4. Structural Elements

5. Assessment Results

6. Organisational Compliance

6.7.3 Comparison of Stated Purpose

The fundamental difference between ISO 9001 and the SW-CMM can be found within the stated purpose of each assessment standard:

- The ISO 9001 states that it is intended *"for use when conformance to specified requirements is to be assured by the supplier during design, development, production,*

installation, and servicing." In other words, when an organisation is intending to win business as a supplier of products to certain customers, it must look at ISO 9001 compliance or certification as a condition of being awarded future business. It is the intention of that customer to use ISO 9001 as part of its supplier selection criteria.

- The SW-CMM states that it *"is specifically developed to support an organisation's need to assess and improve their systems engineering capability"* and furthermore *"use of the model for supplier selection is discouraged."*

However, both documents claim that they should be used as guidance to the organisation, as well as a requirements document when developing its way of doing business. The ISO 9001 specifies it as *"They are generic and independent of any specific industry or economic sector,"* with similar claims from the SW-CMM.

6.7.4 Comparison of Scope of Coverage

If one looks at the scope of coverage between the two documents, we find that the scope of ISO 9001 is *"the production, installation, and servicing processes which directly affect the quality"* of the end product. In comparison, the SW-CMM covers all processes and work products (including internal work products) which an organisation must perform in order to achieve success in the systems engineering domain. Therefore the SE-CMM contains process areas, such as *'Manage Product Line Evolution'* and *'Manage Systems Engineering Support Environment'*, which are not addressed at all in ISO 9001 (i.e. it can be considered as a superset of ISO 9001).

6.7.5 Comparison of Process Improvement Areas

A significant gap between the two documents can be found in the area of process improvement. CMM has a heavy emphasis on continuous process improvement, while ISO 9001 addresses the minimum criteria for an acceptable quality system. This could be attributed in part to the fact that the CMM focuses solely on software processes, whilst the scope of the ISO 9001 encompasses not only software but hardware and services.

6.7.6 Comparison of Structural Elements

Although both frameworks relate to product development and the quality of the product, there are significant differences in the structure of the process models:

- The SW-CMM provides more detail on the design and development of the product and ISO 9001 goes into more detail on the quality aspects of the development process and the products themselves.

- The SW-CMM builds up to the concept of an organisational standard way of doing systems engineering at capability level 3, which is not addressed in ISO 9001.

- The SW-CMM model does not address test equipment or product storage; both of which are contained in ISO 9001.

6.7.7 Comparison Between Assessment Results

When performing assessments using the two frameworks, the following differing results shall be obtained:

- ISO 9001 – A compliance indicator making up an organisational level score

- SW-CMM – A scoring profile: This is composed of a set of scores (a separate score for each area examined).

The SW-CMM is also evaluating whether a systems engineering activity is taking place within the organisation regardless of the specific role of the person that is performing the job, the specific document that is capturing the results, etc.

The ISO 9001 in this regard provides more restrictions to the organisation in terms of stating specific roles and documentation contents. This will affect the level of subjectivity of a mapping link between two processes that may essentially be of the same procedure.

6.7.8 Comparison of Organisational Compliance

In the context of an assessment, the assessor has to make a comparison of the organisation's working processes to the ISO 9001 and the SW-CMM. The specifics of the comparison include the working processes, the appropriate SW-CMM process areas or the ISO 9001 paragraphs. The area for this detail would typically be found in the organisation's work processes – which should ideally contain the start and stop criteria, sequence of activities, the assignment of roles, etc.

In this regard, the ISO 9001 is more prescriptive than the SW-CMM framework in terms of stating who should perform an activity or where the results of an activity are to be captured.

However, it is possible for an organisation's working processes to be compliant to both assessment frameworks from the outset - if the reference material of both standards are used to develop the processes. A peaceful co-existence can be achieved by such forethought and planning.

6.7.9 Determining the level of Mapping Compatibility

6.7.9.1 Mapping Relationships

A preliminary deduction on a mapping between ISO 9001 and SW-CMM would be that there would typically be many-to-many relationships due to the fact that the two documents are structured differently.

An example is the ISO 9001 Training clause (4.18) which can be mapped to both the Training Program Key Process Area in SW-CMM and the Training and Orientation practices in all the Key Process Areas.

6.7.9.2 Coverage of Processes in a Mapping

Another deduction that would affect the mapping relationships would be an expectation of different accuracy levels for each direction of mapping between the two process models. The observation is that that although there are specific issues that are not adequately addressed in the CMM, in general the concerns of the ISO 9001 are encompassed by the CMM (i.e. it would form a superset)

However, the reverse is consequently less true, since ISO 9001 only describes the minimum criteria for an adequate quality management system rather than process improvement (as discussed previously)

Therefore the expectation is that the mapping from ISO 9001 to the CMM would be considerably more complete than the mapping from CMM to the ISO 9001 process model - which would have significant gaps in it.

6.7.9.3   The Affect of Detail Ambiguity in a Mapping

In creating mapping links between two process models, the most pervasive factor that will affect the mapping throughout would be the difference of the level of detail between the two models. The greater the difference, the greater the potential for ambiguity to occur between to process elements when a judgement is called for to apply an assessment rating.

In the case of the SW-CMM and ISO 9001, one can clearly see a strong correlation between the two models, even though some issues in ISO 9001 are not covered by the SW-CMM and vice versa. However, the level of detail differs significantly in that Chapter 4 of the ISO 9001 is about 5 pages long, and even the chapters (5, 6, and 7) in the associated ISO 9000-3 standard are about 11 pages – contrasted with the fact that the CMM documentation is over 500 pages long.

It is within this process of analysing the supplementary factors of a mapping that such issues can be identified and the expectations can be recalibrated for the accuracy of the mapping.

6.8   Summary

From an analysis of the history and relationships of the process models in the past two decades, the ISO 9001, the SW-CMM and the BOOTSTRAP frameworks are seen to stand out as the ones with the strongest relational links to the ISO/IEC 15504 process model framework. These three frameworks have significantly influenced the creation and development of the ISO/IEC 15504, and have in turn also been influenced by it.

We can therefore intuitively deduce that there would be solid correlations between the four frameworks in goals, concepts and process model structure. It is from this reasoning that we have selected these four frameworks as the primary process model candidates for this project to investigate the creation and implementation of data mappings between them.

The first step in the process of creating a data mapping between two process models is to confirm that the frameworks are compatible in purpose and function. The techniques described in this chapter should provide us with a method to do that – and the case study exemplifies such a process in practice.

The Case Study shows that a comparison between the ISO 9001 and the SW-CMM in keys areas reflect the pattern that whilst they may have their differences (the most significant being in the stated purpose), the frameworks are not at cross purposes to each other.

An examination of the mapping compatibility intuitively proposes that there will be many-to-many relationships between the two process models. Additionally, the SW-CMM covers more areas in scope than the ISO 9001 does - such that it can be considered as a superset of the ISO 9001.

It is acceptable then to consider that the two process model frameworks are functionally compatible, and therefore the development of a process model mapping between them would be a viable and beneficial exercise.

7 Process Model Data Commonalities

7.1 Introduction

In this chapter we review in detail the common structural elements of each of the four selected Process Models, examining their data composition and makeup in order to gain an understanding of the data mapping issues that may exist..

7.1.1 Research Method

The aims of this section are:

1. To create a set of tabularised comparisons across the structure levels between the process models so as to be able to gain an insight as to the ideal hierarchy levels where mappings could occur.

2. To perform an initial analysis on how the structural elements would be programmatically represented and structured within database tables.

7.2 Software Process Model Structures

7.2.1 Model Structure Comparison

Each of the four selected Process Reference models can be represented by the following structural dimensions:

- The Process Dimension
- The Capability Dimension
- The assessment ratings scales.

The rating scales is not really considered as a 'dimension' in any of the Process Reference Models, but in a software algorithm, it is also a scale of values that will be applied against the other dimensions – and therefore we can consider it a programmatic 'dimension'.

The dimensions of a given Process model are typically structured in hierarchical levels, in a linear fashion (i.e. each process level has one child level, not multiple). For example, the CMM has Process Levels which are made up of Key Practice Areas, which are in turn made up of Key Practices

In order to be able to compare the Process/Process Capability dimension at the same levels between different software process models - and therefore perform the mappings between the models – we will create a taxonomy of the structural elements. This can be defined in the form of a table for each of the Process and Process Capability dimensions, across each of the models.

This table of structural correlations is essentially created by inspection, in order to find the Process level of one model which best maps to a given Process level of another model. This method of inspection should also take into account that some process elements of one level from one model may map to process elements of another level of the second model.

As a basis, we will use the taxonomy comparison tables given by Wang and King [Software Engineering Processes: Principles and Applications, 2000] and build on them to establish

complete, one-to-one data mapping relationships between the levels. Adjustments that have been made to these tables for this purpose are denoted by underlined elements within the tables.

7.2.2   Correlation of Process Dimension Levels across the Reference Models

The Process dimension of the reference models is the most significant dimension. The Process dimension can be generically represented within each reference model using the following structural levels:

1. Practices Level – a practice is characterised by a software process activity or a sub-process that will fulfil one of the tasks of a process

2. Processes Level – a process is made up of a set of one or more sequential tasks or practices

3. Process Categories Level – a process category is a set of processes that are functionally consistent together

4. Process Sub-Systems Level – a subsystem is a set of process categories that make up a common domain as detailed above (i.e. development, management or organisation processes)

5. Process Systems Level – a system is a set of subsystems, or all the software processes that are described by a Process Model

The following chart depicts the Operating Complexities of the Software Process Models [Wang and King, Software Engineering Processes, Ch 12, Table 12.3] which maps out the elements of each structural level (along with their abbreviations and number of elements) between the process reference models. In this dimension are found the most elements (as opposed to the Capability and Rating dimensions), and therefore the most discrepancies when mapping across each level.

Process Model Level	SW-CMM [ID: 1]	BOOTSTRAP [ID: 2]	ISO 9001 [ID: 3]	ISO/IEC 15504 [ID: 4]
Practice [Level: 1]	Key Practices KPs: 150	Quality System Attributes QSAs: 201	Management Issues MIs: 177	Base Practices BPs: 201
Process [Level: 2]	Key Process Areas KPAs: 18	Processes 32	Main Topic Areas MTAs: 20	Processes PRs: 35
Category [Level: 3]	Process Levels 5	Process Categories 9	N/A	Process Categories PCs: 5
Sub-System	N/A	Process Areas	Subsystems	N/A

[Level: 4]		3	3	
System	SW-CMM	BOOTSTRAP	ISO 9001	ISO/IEC 15504

Table 5.   **COMPARISON BETWEEN STRUCTURAL LEVELS OF THE PROCESS DIMENSION**

The 'Practice' level is the lowest level and has the most elements; there is a total of 444 elements in this level.

The 'Process' level is the most significant level for consideration on mapping, but translations between models at this higher level can be ambiguous and subjective (and therefore be inaccurate) – especially if the practices that make up a process differ to lesser or a greater degree, for a process that is considered to be equivalent between the models.

7.2.3   Data Representation of the Process Dimension

By correlating the levels of the Process dimension, we can see that each model can be structured into five hierarchical levels of data or less. The following database table design can therefore be used to represent the Process Dimension of each model:

Field Name	Field Type	Nulls Allowed	Primary Key
System_ID	Integer	N	Y
SubSystem_ID	Integer	N	Y
Category_ID	Integer	N	Y
Process_ID	Integer	N	Y
Practice_ID	Integer	N	Y
Reference	Character	N	
Name	Character	N	
Description	Character	Y	

Table 6.   **DATABASE TABLE LAYOUT FOR THE PROCESS DIMENSION**

For this data table, the following conventions are applicable:

1. A unique key is formed from the first five ID fields in order to allow all the records on each level to be represented in the table. This can correlate to a similarity with the documented reference number, but since the reference number may not be a sequential numeric number, this is not mandatory.

2. The five levels of the model can be represented in the table with the lower fields set to zero (e.g. to represent a Process model, the ISO/IEC 15504 can by mapped to an ID of 1, and the other four fields are set to zero.

The following chart gives examples of populating the table with data with Process Dimension records from the CMMI model and the ISO/IEC 12207 model (of the ISO/IEC 15504 standard):

System_ID	SubSystem_ID	Category_ID	Process_ID	Practice_ID	Process Model Reference	Process Model Representation
1	0	0	0	0	ISO/IEC 15504	ISO/IEC 15504
1	3	0	0	0	F.3	Organisational Life Cycle Processes
1	3	1	0	0	F.3.1	Management Process
1	3	1	6	0	F.3.1.6	Measurement
1	3	1	6	3	F.3.1.6 (MEA) 3)	Outcome 3
2	0	0	0	0	CMMI	CMMI
2	1	0	0	0	CAR	Causal Analysis and Resolution
2	1	2	0	0	CAR SP	Specific Practices By Goal
2	1	2	3	0	CAR SP2.3-1	Record Data
2	1	2	3	6	CAR SP2.3-1/D.2.2	Rationale for Decisions

Table 7. SAMPLE RECORDS FOR THE PROCESS DIMENSION TABLE

7.2.4 Correlation of Capability Rating Scales Across the Reference Models

For the Capability dimension, the levels are correlated with the following Capability rating scales. The following table depicts the Modelling of Process Capability Scales [Wang and King, Software Engineering Processes, Ch 2, Table 2.5]:

Process Model Level	SW-CMM	BOOTSTRAP	ISO/IEC 15504	ISO 9001
0	-	-	Incomplete	Fail
1	Initial	Initial	Performed	Pass
2	Repeated	Repeated	Managed	Pass
3	Defined	Defined	Established	Pass
4	Managed	Managed	Predictable	Pass
5	Optimizing	Optimizing	Optimizing	Pass

Table 8.   RATING SCALES FOR THE PROCESS DIMENSION

Not all the Process Reference Models, such as the ISO 9001 model, make provision for a Capability Dimension – whether implicitly or explicitly - and in such a case the Capability rating achieved is considered to either have passed or failed the fulfilment requirements. For a direct data mapping, an assumption we have to make is that any type of Capability rating that is present (i.e. rating 1-5) translates into a Pass (as opposed to the 0-rating or no capability rating at all is a Fail). Therefore, we can adjust the original to translate to a 'Pass' for levels 1 through 4.

CMM and BOOTSTRAP are similarly aligned with ISO/IEC 15504, which caters for an additional 0-rating for processes that are not performed at all..

7.2.5   Correlation of Capability Level Positioning Across the Reference Models

The ISO/IEC 15504 the only standard that makes direct provisioning for the Capability dimension, with Process Attributes giving the Capability Levels (which in turn make up the Process Capability Profile) while it is inferred in the SW-CMM and BOOTSTRAP standards. The ISO/IEC 15504 Capability dimension essentially makes up the Measurement Framework for the assessment standard.

The measurement method differs as follows:

- For the CMM, BOOTSTRAP and ISO 9001 assessment models, Performance Ratings are given directly to the Processes and Practices

- For the ISO/IEC 15504 assessment model, Performance Ratings are given to the Process Attributes of a Process, based on the performance of the process practices or outcomes (which may also be rated). The measurement of Process Attributes for each process is to build up a consistent expression of results in the form of the Process Profile.

The Capability Dimension can be represented with structural levels that are similar to the Process dimension, but an additional Optimization level is added to the hierarchy to represent the

Capability Dimension. This Optimization level is required by the SW-CMM, BOOTSTRAP, and ISO 9001 standards for placement of the Capability ratings. The following table for the Modelling of Process Capability Scopes [Wang and King, Software Engineering Processes, Ch 2, Table 2.6] depicts this:

Capability Scope	SW-CMM	BOOTSTRAP	ISO 9001	ISO/IEC 15504
Practice	Performance Rating	Performance Rating	Fulfillment	Performance Rating
Process Attribute	N/A	N/A	N/A	Process Attribute
Process	Performance Rating	Performance Rating	Fulfillment	Capability Level
Category	N/A	N/A	N/A	Process Capability Profile
Optimization	Capability Level	Capability Level With Quadruples	Pass / Fail	N/A

Table 9.   COMPARISON BETWEEN STRUCTURAL LEVELS OF THE PROCESS DIMENSION

It is important to consider that the ISO/IEC 15504 Process Assessment model prescribes that mappings to other Process Reference Models be made at the process level, so that Process Attributes may be rated based on the practices and process performance.

7.2.6   Data Representation of the Capability Dimension

The following database table layout has been designed to capture the Capability dimension of the process reference models:

Field Name	Field Type	Nulls Allowed	Primary Key
System_ID	Integer	N	Y
Capability_Level_ID	Integer	N	Y
Process_Attribute_ID	Integer	N	Y
Reference	Character	N	

Name	Character	N	
Description	Character	Y	

Table 10. DATABASE TABLE LAYOUT FOR THE PROCESS DIMENSION

The following chart gives examples of populating the table with data with Capability Dimension records from ISO/IEC 15504 assessment model:

System_ID	Capability_Level_ID	Process_Attribute_ID	Reference	ISO/IEC 15504 Representation
1	0		ISO/IEC 15504	ISO/IEC 15504
1	2	0	Level 2	Capability Level 2
1	2	1	PA 2.1	Process Performance
1	2	2	PA 2.2	Process Management

Table 11. SAMPLE RECORDS FOR THE CAPABILITY DIMENSION TABLE

7.2.7 Correlation of Performance Rating levels across the Reference Models

The following chart depicts the Modelling of Practice Performance Ratings Scales [Wang and King, Software Engineering Processes, Ch 2, Table 2.4] and aligns the scales of ratings used to assess the degrees of performance in the Process Reference Models:

Degree of Rating	1	2	3	4
SW-CMM	Yes	No	No (Not applicable)	No (Unknown)
BOOTSTRAP	Complete/extensive	Largely satisfied	Partially satisfied	Absent/poor
ISO 9001	Satisfied	Not Satisfied	Not Satisfied	Not Satisfied
ISO/IEC 15504	Fully achieved (>85% – 100%)	Largely achieved (>50% – 85%)	Partially achieved (>15% – 50%)	Not achieved (0% – 15%)

Table 12. COMPARISON BETWEEN PERFORMANCE RATING LEVELS

Both the SW-CMM and the ISO 9001 reference models have absolute rating levels: Yes/No or Satisfied/Not Satisfied. Aligning these ratings against that of the other models, an applicable practice or process is either considered to be completely satisfied or achieved or it is not.

The SW-CMM model caters for two additional states: Not Applicable or Unknown. That the other (later) models do not also take these into account, we may surmise:

1. The other process reference models have been created so that all their practices and processes are assumed to be applicable; and

2. An 'Unknown' is not an acceptable rating value for determining the capability of an assessment; that all processes and practices must have determinable rating values. For a programmable algorithm, an 'Unknown' would translate into a 'Null' value in the database, and any calculation or aggregation involving a single null value would cause the result of the query to be null. However, it is also accepted that the initial data set that would represent all the practices and processes of an assessment would have to be initialised with nulls, and then these values would progressively be replaced by ratings as the assessment is carried out – the completion of the assessment would be true when all the records of the data set are non-null values.

An additional consideration for mapping on these two particular models is the issue of how to determine the comparative degree of rating for the similar 'No' and 'Not satisfied' ratings against the Degrees of Rating (2 - 4) of the other models. For example, should a 'Not satisfied' ISO 9001 rating correspond to a Largely, Partially or Not Achieved rating for ISO/IEC 15504? Should it take on a medium (Rating degree 3) or an absolute 'Not Achieved' (Rating degree 4) rating?

It should also be factored into account that the ISO/IEC 15504 has defined percentage brackets for each achievement rating level.[ISO/IEC 15504-2, 6.3], so a 'Yes' (CMM) or 'Satisfied' (ISO 9001) could translate to a >85%-100% rating. Using percentages would make the allocation of ratings more accurate with aggregation calculations.

It is clear that arbitrarily determining a mapping, or allowing a tool to let the Assessor decide the mapping would have a significant impact on the results of the Capability level determination, and could skew assessment comparisons between separate process instances.

The following table format has been designed to store Capability Performance Ratings for all the Process Assessment Models:

Field Name	Field Type	Nulls Allowed	Primary Key
System_ID	Integer	N	Y
Optimization_ID	Integer	N	Y
Category_ID	Integer	N	Y
Process_ID	Integer	N	Y
Capability_Level_ID	Integer	N	Y
Process_Attribute_ID	Integer	N	Y
Practice_ID	Integer	N	Y
Rating_ID	Integer	N	

Table 13. DATABASE TABLE LAYOUT FOR PERFORMANCE RATINGS

The Rating ID is linked to a unique Performance Rating scale according to the corresponding Process Assessment model. This will be examined in more detail in the following chapter when we analyse the concepts of creating mappings between process models – and includes the mappings made between assessment ratings.

7.3   Summary

An ideal mapping between two Process Reference Models would be comprised of a direct one-to-one relationship on each structural level between the Process and Capability dimensions. Although this direct relationship cannot be 100% achieved between any of the four primary models, a mapping between process models will be of value if it can cover the majority of elements in each dimension. We can obtain an indication of the extent of the effectiveness of a mapping by calculating the aggregation of the data mapping coverage of the dimensions.

The Capability and Rating dimensions are smaller data sets which for the most part have direct mappings between the models; and therefore have fairly stable coverage values. The Process Dimension however has a large number of Practice elements or factors to consider when to determine the correlations - and therefore the relationships for a mapping. These mappings will therefore be more subjective, and this fact is reflected in the average of 58% data coverage.

8   Performing Process Model Mapping

8.1   Introduction

In the previous chapter we reviewed the process models and explored the structural factors that require consideration when creating a mapping between two process models on the Process and Capability Dimensions.

In this chapter the considerations and implications of creating mappings are examined, with the practical context of the database table designs of the preceding chapter. This involves not only the mappings involving the Process and Capability dimensions, but also the Assessment Ratings Scales.

8.1.1   ISO/IEC 15504 Compatibility to Process Reference Models

With the ISO/IEC 15504 being the latest process assessment standard, there is a logical emphasis on mapping results from the older assessment models (CMM, ISO 9001, BOOTSTRAP) onto the ISO/IEC 15504 and vice versa. This is an important factor to take into account in constructing an approach to mapping.

The measurement framework of the ISO/IEC 15504 allows for the assessment model to use compatible process reference models other than it's default ISO/IEC 12207 reference model. It makes allowance for mapping onto these compatible reference models with the following paragraph from *ISO/IEC 15504 Part 2: Performing an Assessment:-*

> *A process assessment model shall provide an explicit mapping from the relevant elements of the model to the processes of the selected process reference model and to the relevant process attributes of the measurement framework.*

> *The mapping shall be complete, clear and unambiguous. The mapping of the indicators within the process assessment model shall be:*

> *a) the purposes and outcomes of the processes in the specified process reference model;*

> *b) the process attributes (including all of the results of achievements listed for each process attribute) in the measurement framework.*

> *This enables process assessment models that are structurally different to be related to the same process reference model.*

The ISO/IEC 15504 also allows for verification on the conformity of process reference models:

> *Since a process reference model may be the material produced by a community of interest, or a relevant International or National Standard, or Publicly Available Specification, verification of the extent to which such models meet the requirements of this International Standard may be through either demonstration of conformity or demonstration of compliance.*

> *The party performing verification of conformity shall obtain objective evidence that the process reference model fulfils the requirements set forth in ISO/IEC 15504-2, 6.2. Objective evidence of conformance shall be retained.*

NOTE 1: Conformity is fulfilment by a product, process or service of specified requirements. Compliance is adherence to those requirements contained in International Standards and Technical Reports which specify requirements to be fulfilled by other International Standards, Technical Reports or International Standardized Profiles (ISPs) (e.g. reference models and methodologies).

NOTE 2 This part of ISO/IEC 15504 is not intended to be used in any scheme for the certification/registration of the process capability of an organisation.

8.2 Mapping the Process Reference Model Elements

A process reference model can be represented by sets of related process elements (practices; processes; categories; etc.) and therefore a process system can be described as a relation using set theory. Thus the exercise of mapping between process systems may be reduced to a problem of mapping relational sets.

The following mapping scenarios represent the basic relational mappings that can occur between two process reference models.

8.2.1 One To One Mapping

In this mapping instance a single process element in Model A would map to a single process element in Model B to form a unique relationship. If all elements from Model A mapped to all the elements of Model B on a one-to-one basis, then this would allow us to create the ideal mapping between two process models.
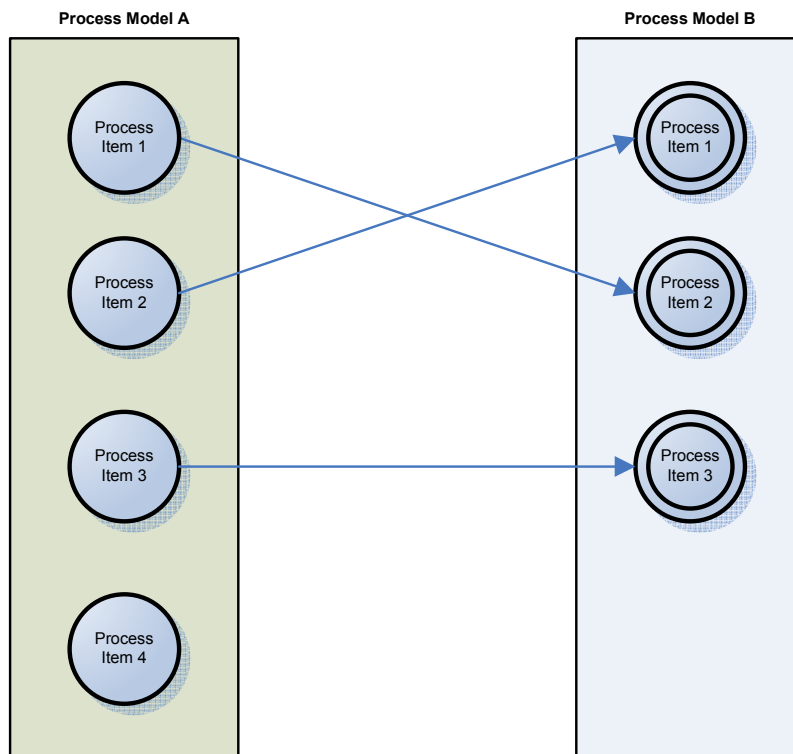

Figure 19. ONE-TO-ONE MAPPING / ONE-TO-NONE MAPPING

In practise however, one-to-one relations will only form a part of the relational mapping set. Also, some process elements may not have an equivalent process element and therefore cannot have a relational mapping between the models (One-to-None mapping).

8.2.2   One To Many Mapping

For this mapping variation, a process element in Model A could map to more than one (i.e. many) process elements in Model B.
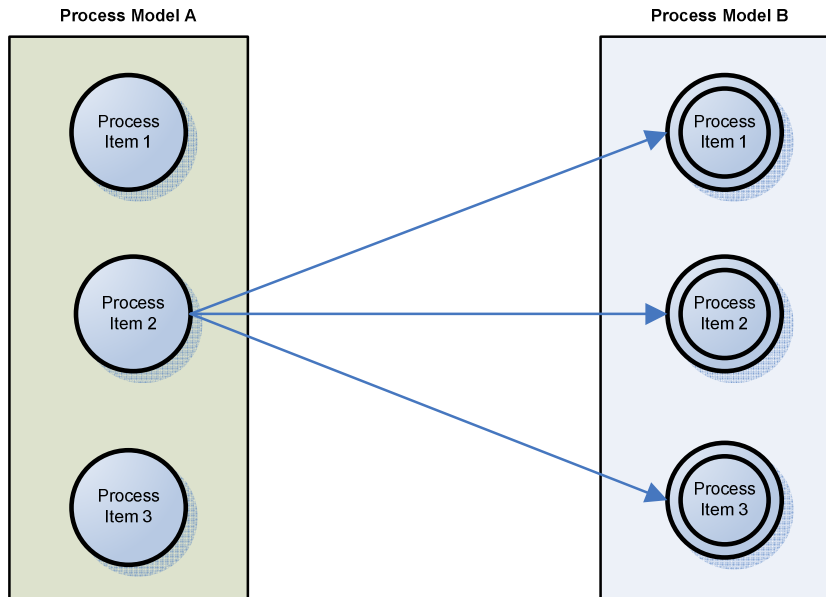

Figure 20.   ONE-TO-MANY MAPPING

This relationship would happen in the case where performing a process (element) described in model A is determined to be the equivalent of performing more than one process (element) from model B.

8.2.3   Many To One Mapping

In the reverse instance to the preceding mapping type, more than one (i.e. many) process elements in Model A could map to a single process element in Model B, forming a many to one relation.
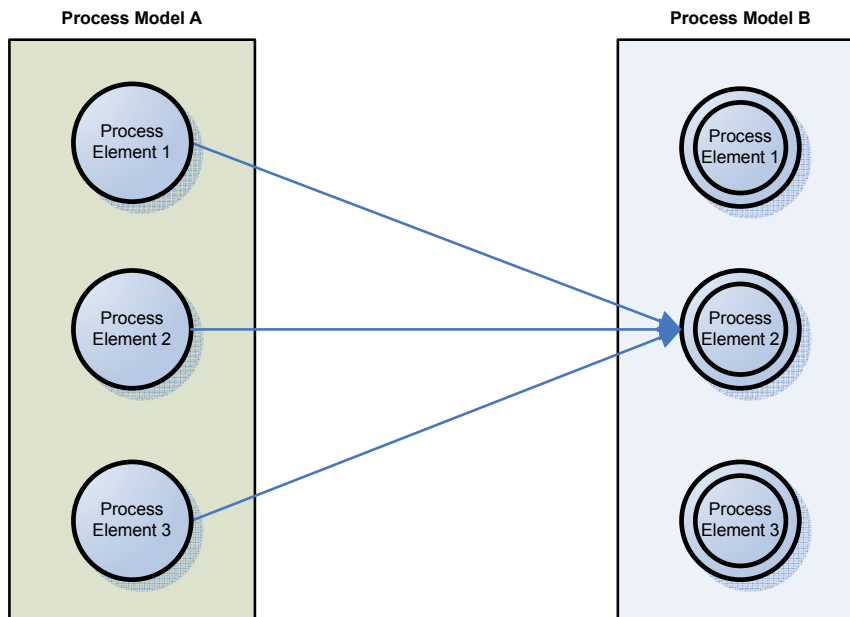
Figure 21. MANY-TO-ONE MAPPING

From this formalisation of relational sets used to describe the mapping between two given process models, it can be deduced that mappings between process systems are asymmetrical – i.e. that performing a mapping from the elements of model A is not necessarily equivalent to the same set of relations when mapping the elements of model B to model A. It therefore follows that a mapping between two models should be performed in both directions in order to obtain the complete relational set.

8.3   Creating Complete Relational Mapping Sets

Performing asymmetrical mappings will provide the full set of relationships between the process elements of two models. These complete relational mapping sets will fall into the following three categories:

8.3.1   Many To Many Mapping Set

A set of process elements in Model A can map to an equal number of process elements in Model B. However, the relational set will likely not only consist of one-to-one mappings, but also a mixture of many-to-one and one-to-many mappings.
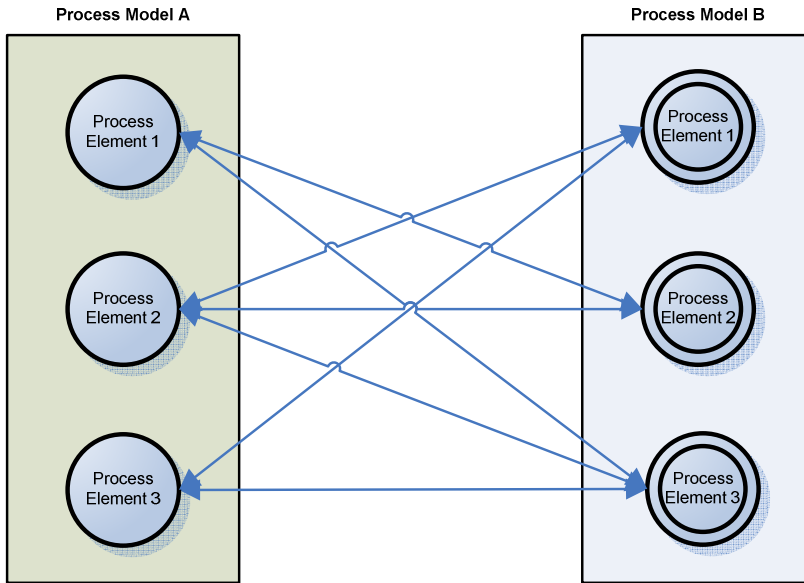
Figure 22. MANY-TO-MANY MAPPING

8.3.2 Many To More Mapping Set

A set of process elements in Model A maps to larger set of process elements in Model B
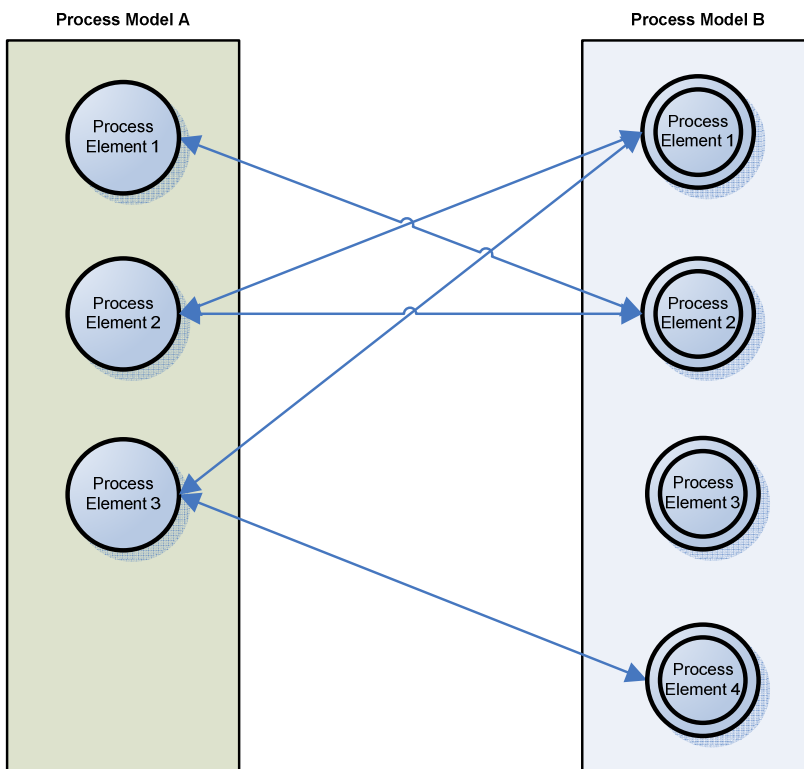

Figure 23. MANY-TO-MORE MAPPING

8.3.3 More To Many Mapping

A set of process elements from Model A maps to a smaller set of process elements in Model B
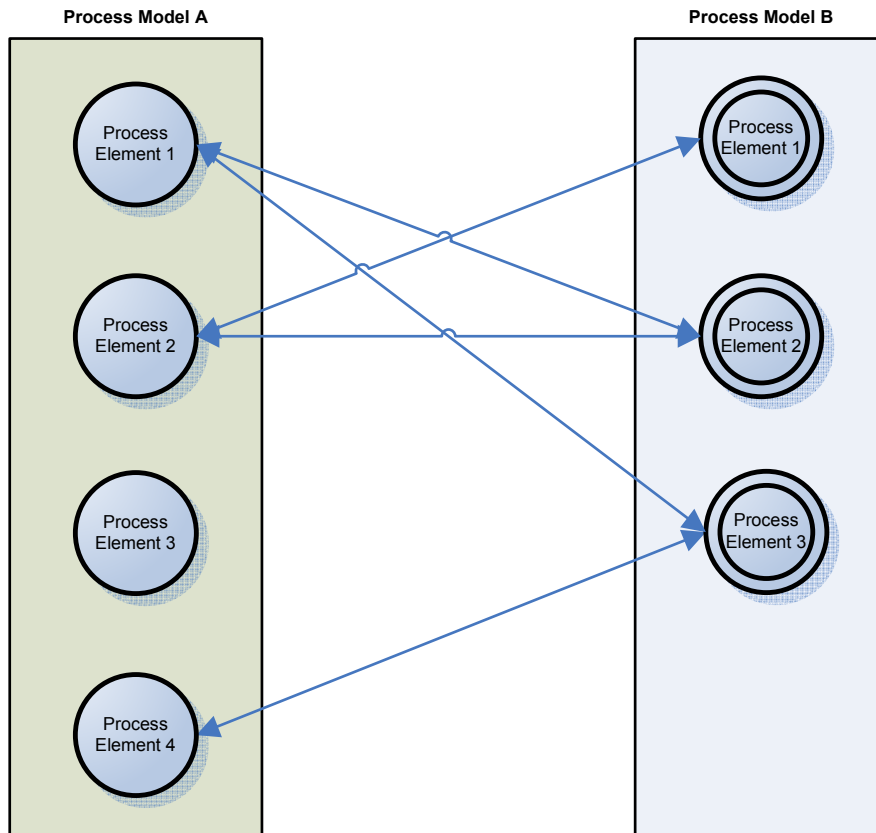

Figure 24. MORE-TO-MANY MAPPING

From these three mapping set outcomes we can conclude that the comparative number of process elements between two process models does not matter; for example a process model A with a larger number of process elements than a process model B could still have a smaller set of model A elements that map to a larger set of model B elements.

We can therefore deduce that in order to establish the true degree of effectiveness of a mapping, one cannot just look at the number of relations between two process models. Instead, we have to look at the actual process element coverage of the relational mapping set.

8.4 Data Mapping Coverage

8.4.1 Intended Domain and Process Scope

The *ISO/IEC 15504-3 Guidance on Performing an Assessment* document refers to the handling of coverage when an alternate Process Reference Model is used:

Since the choice of a Process Reference Model does not necessarily imply the use of one particular Process Assessment Model, an enterprise will generally still have a choice to make among Process Assessment Models that are compliant with the chosen Process Reference Model. One of the selection factors in the set of processes covered by the Process Assessment Model. For

example the situation depicted by the figure below shows that after the decision has been made to select Process Reference Model X, there are three Process Assessment Models to choose from. If we assume that the enterprise must be able to assess processes P1, P2 and P5, then the final selection is apparent since only Process Assessment Model 2 provides coverage for the needed processes. [ISO/IEC 15503-3, 8.2.2.3]

Process	Process Reference Model X	Process Assessment Model 1	Process Assessment Model 2	Process Assessment Model 3
P1	Y	N	Y	Y
P2	Y	Y	Y	N
P3	Y	Y	Y	Y
P4	Y	Y	N	Y
P5	Y	N	Y	Y
P6	Y	N	Y	Y
P7	Y	Y	N	Y
P8	Y	Y	N	Y
P9	Y	Y	N	Y
P10	Y	Y	N	N

Table 14.   DETERMINING THE COVERAGE OF ALTERNATE PROCESS MODELS

8.4.2   Data Mapping Coverage of the Process Dimension

The extent of mappings between two models can be represented by a Data Coverage table. This is built up of the number of correlations between two process reference models in both directions on the lowest common level (which may be the Process or Practice level). This would yield the percentage coverage of elements – which is calculated from using the following algorithm:

- If Model A has x elements all mapping directly onto a subset of Model B's y elements, then the coverage is 100%.

- If Model A's x elements is a superset of Model B's y elements then the ratio is y/x, which is multiplied by 100 to give the percentage coverage.

- If Model A has a subset n of it's x elements mapping onto Model B's y elements, then the coverage is 100% * n/x to give the percentage coverage

The Data Coverage table that follows uses the "Mapping Between Current Process Models" [Wang and King, Software Engineering Processes, Ch 11, Table 11.12] method to calculate the number of relationships between any two process models and gives the following values:

- The number of practices with correlations found (i.e. mapped) between the two models

- The percentage coverage of process elements between the two models

To From	ISO/IEC 15504	SW-CMM	BOOTSTRAP	ISO 9001
ISO/IEC 15504	201 100%	64 42.7%	59 29.4%	58 32.8%
SW-CMM	64 31.8%	150 100%	49 24.4%	51 28.8%
BOOTSTRAP	59 29.4%	49 32.7%	201 100%	75 42.4%
ISO 9001	58 28.9%	51 34.0%	75 37.3%	177 100%

Table 15.   DATA COVERAGE FOR THE PROCESS DIMENSION

The average coverage rate for the Process Dimensions across all the models is calculated to be 58.356%. Note that there may exist (now or in the future) other valid mappings between the process reference models. The Wang and King mapping is taken as an instance of such a mapping to illustrate the method of determining the data coverage algorithm.

8.4.3   Data Mapping Coverage of the Capability Dimension

The following table shows the coverage of capability data between the Process Reference Models using the above comparison table.

To From	SW-CMM (5)	BOOTSTRAP (5)	ISO/IEC 15504 (6)	ISO 9001 (2)
SW-CMM **(5)**	100%	100%	100%	100%
BOOTSTRAP **(5)**	100%	100%	100%	100%

ISO/IEC 15504 (6)	84%	84%	100%	100%
ISO 9001 (2)	100%	100%	100%	100%

Table 16. DATA COVERAGE FOR THE CAPABILITY DIMENSION

The average coverage rate for the Capability Dimensions across all the models is calculated to be 93%.

8.5 Mapping the Assessment Ratings Scales

For the translation of assessment results from two different Process Assessment Models, (e.g. a CMM assessment to be re-evaluated in ISO/IEC 15504 with a consistent basis) the Performance Ratings of the initial assessment has to be accurately converted on the target assessment model.

For this we have to establish a consistent scale of measurement for all four Process Assessment Models. This may be made possible by means of representing each of the different rating scales by using percentage terms as a common, consistent scale.

8.5.1 ISO/IEC 15504 Assessment Rating Percentage Scales

The process attributes and practices of the ISO/IEC 15504 are rated by the following levels of achievement: Not Achieved; Partially Achieved; Largely Achieved and Fully Achieved.

The corresponding percentage brackets of the ordinal Achievement rating scale and can be depicted by the following Practice Performance Scale [Wang and King, Software Engineering Processes, Ch 8, Table 8.3]:

Rating Scale	Description	Percentage Bracket
1	Not Achieved (N)	0 – 15% Achievement
2	Partially Achieved (P)	> 15% – 50% Achievement
3	Largely Achieved (L)	> 50% – 85% Achievement
4	Fully Achieved (F)	> 85% – 100% Achievement

Table 17. ASSESSMENT RATING SCALES FOR ISO/IEC 15504

8.5.2 CMM Assessment Rating Percentage Scales

The practices of the CMM assessment model are rated according to their performance and can be depicted by following the Practice Performance Scale [Wang and King, Software Engineering Processes, Ch 5, Table 5.3]:

Rating Scale	Description	Percentage Bracket
1	Unknown	-
2	Not Applicable	-
3	No	< 80% Performed
4	Yes	> 80% Performed

Table 18.   ASSESSMENT RATING SCALES FOR CMM

The 'Unknown' Performance rating is usually treated as a 'No' in an assessment, as it implies that no such practice exists (or can be found) in the assessed software development organisation.

8.5.3 BOOTSTRAP Assessment Rating Percentage Scales

The practices of the BOOTSTRAP assessment model are similar to CMM in that they are rated according to their performance and can be depicted by the following Practice Performance Scale [Wang and King, Software Engineering Processes, Ch 7, Table 7.3]:

Rating Scale	Description	Percentage Bracket
0	Not Applicable	-
1	Absent / Poor	0% - 33.2% Performed
2	Partially Satisfied	33.3% - 66.6% Performed
3	Largely Satisfied	66.7 – 79.9% Performed
4	Complete / Extensively Satisfied	>= 80% Performed

Table 19.   ASSESSMENT RATING SCALES FOR BOOTSTRAP

8.5.4 ISO 9001 Assessment Rating Percentage Scales

The Management Issues (MI's) of the ISO 9001 assessment model are given an absolute (Yes/No) rating according to their performance and can be depicted by the following Practice Performance Scale [Wang and King, Software Engineering Processes, Ch 6, Table 6.3]:

Rating Scale	Description	Percentage Bracket
0	Satisfied (Y)	50% - 100%
1	Not Satisfied (N)	0 – 49%

Table 20.   ASSESSMENT RATING SCALES FOR ISO 9001

The ISO 9001 Process Assessment model gives no clear indication of the Rating correlation to any percentage brackets. For the purposes of this exercise, we have assumed that anything below a 50% rating does not satisfy, while anything given a 50% or above indicates a satisfactory performance.

8.6   Translating Assessment Ratings

Using the given percentage brackets to indicate the rating thresholds, it would be an easy exercise to map assessment ratings between process models – provided that the assessor assigns ratings not in terms of the applicable scale, but as a percentage. However, this is not likely to be the case.

An assessor using a particular process assessment model would almost certainly use the appropriate rating scale for that model. One also has to cater for the requirement that an existing assessment (rated in terms of its process model rating scale) has to be translated for assessment in another process assessment model, with its own rating scale. Therefore we have to provide the mapping from one Process Model 'A' Rating Scale to another Process Model 'B' Rating Scale. For example, what does a BOOTSTRAP 'Complete / Largely Satisfied' map to in terms of an ISO/IEC 15504 Achievement rating?

It may be possible to represent each of the different rating scales by using percentage terms as a common and consistent scale, but the degree of translated rating accuracy is affected by the mapping of a given assessment rating to an exact percentage number.

For example, we could translate a BOOTSTRAP 'Complete / Largely Satisfied' rating into the following percentage ratings:

- A minimum threshold rating of 80%. This would then equate to a 'Largely Satisfied' rating in the ISO/IEC 15504 assessment rating scale.

- A median or average threshold rating of 90%. This would equate to a 'Fully Satisfied' rating in the ISO/IEC 15504 assessment rating scale.

A flexible assessment translation tool would for example, set the ratings to map to the average percentage number of each rating scale bracket by default, but perhaps allow an assessor to 'tweak' the assessment rating mappings between process assessment models.

8.7   Case Study: Mapping Process Models via an Intermediate Model

This case study will illustrate the method of a process model mapping by inspection used by the author in association with the SEAL organisation to create a data conversion structure that was implemented in their SEAL of Quality software process assessment tool to allow assessment data to be translated from the ISO 9001 model to the ISO/IEC 15504 and vice versa.

This process model mapping technique is intended to allow assessment data based on one framework (A) to be translated and converted onto another set of assessment results that is based on a different process model and framework (B) – provided that an accurate and proven intermediate process model (C) that is closely aligned (i.e. structurally compatible) to both process models in certain aspects, is used to bridge the data conversion.
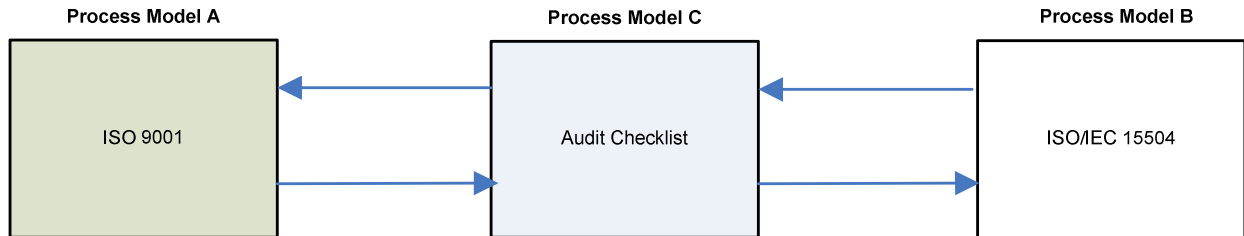

Table 21. **MAPPING VIA AN INTERMEDIATE PROCESS MODEL**

The direction of the mapping may be in one or both directions, but the coverage from the different directions is dependant on the process scope of the frameworks involved.

8.7.1.1   Research Method

The two models selected for mapping in this exercise are the ISO 9001 and the ISO/IEC 15504 (using the ISO 12207) process models. In performing the exercise, the South African ISO 9001 Audit Checklist model - which was developed by the SEAL organisation and the SABS (South African Bureau of Standards) - was used as the 'bridge' for mapping the process elements.

The exercise was conducted in an earlier period on the ISO/IEC 15504 TR (and thus an earlier process model version of the ISO 12207), which has subsequently been updated. However, the fundamental concepts of the technique is still valid for the creation of a data mapping.

8.7.2   Selection of Process Models

For this exercise, ISO 9001 standard has been selected as the source process model (i.e. assessment data will be converted from this process model).

This framework has been selected as the target process model (i.e. assessment data will be converted to this process model).

8.7.3   Process Model Structure Mapping

The key to finding a mapping between the two process models (ISO 9001 and ISO/IEC 15504) is to understand the structural similarities and differences between the elements and levels of the process and capability dimensions. The following sections illustrate the structural composition of each process model:

8.7.3.1   The ISO/IEC 15504 (SPICE) Process Model Structure

Process Dimension   **Capability Dimension**

- Process Categories
  - Processes

- Capability Levels
  - Process Attributes

- Base Practices

- Work Products

ISO/IEC 15504 has a two-dimensional structure incorporating a process and capability dimension. The Process Dimension is divided into Process Categories, with each containing its relevant processes. As indicators, each Process has Base Practices and Work Products which are graded for levels of Achievement (Not Achieved, Partially, Largely or Fully).

The Capability dimension is a grading of the Process dimension. The link from the Process to the Capability dimension is that each process is graded with a Capability Level of 0 to 5. This Capability Level is determined by the grading its Process Attributes with achievement levels and is in turn determined by the achievement levels of its Management Practices.

The elements of the Capability Dimension are applicable to each Process (i.e. the Base Practices, Process Attributes and Capability Levels are the same for each Process). The grading of the Base Practices of a certain process are determined by analysing the existence or achievement of the Work Products - which are on the lowest structure level of the process model.

8.7.3.2 The ISO 9001 Process Model Structure

- Clauses
  - Sub-Clauses

The ISO 9001 structure is a lot simpler in comparison to that of the extensive ISO/IEC 15504 process model. It has Clauses (correlated to Process Categories) for the different areas of Software Processes. The Clauses are detailed by its Sub-Clause paragraphs which are most similar to Processes. They are not exact structural matches however, and there are no deeper levels to match with the Base Practices and Work Products. Nor is there a Capability Dimension aspect of the process model.

8.7.3.3 The Need for Mappings Between Process Models

The primary use for a mapping between process models is for the conversion for assessment data to and from either model. In the case of a one-to-one mapping, conversion can be performed either way. With a one-to-many or many-to-many mapping, conversion may not yield valid results. This issue is explored further in later sections.

ISO 9001, being well established and entrenched in the software industry as the de facto standard for software process assessment, is to be superseded as an international standard by the newer

ISO/IEC 15504 process model. However, in practice this is far from a reality - given the massive investment in training and legacy assessment data by companies and organisations world-wide.

Companies will resist migration to another standard, citing the loss in time and money spent on ISO 9001. In this context a mapping between ISO 9001 and ISO/IEC 15504 could be used to convert legacy ISO 9001 assessment data to the newer, more technically superior ISO/IEC 15504 process model. Another reason might be for ISO 9001-proficient assessors to quickly adopt the new standard using their existing training, skills and experience; performing ISO 9001 assessments and converting the data as a starting point for ISO/IEC 15504 assessments.

8.7.3.4   Finding a Mapping Between The Process Models

Ideally, a mapping between process models should occur at each structural level on a one-to-one basis. However in this instance one of the process models does not have as many structural levels - i.e. the structures are not equivalent or similar. Therefore, the most accurate mapping between the process models would be at the lowest possible structure level. In this case, it is at the sub-clause level (ISO 9001) and the Process level (ISO/IEC 15504).
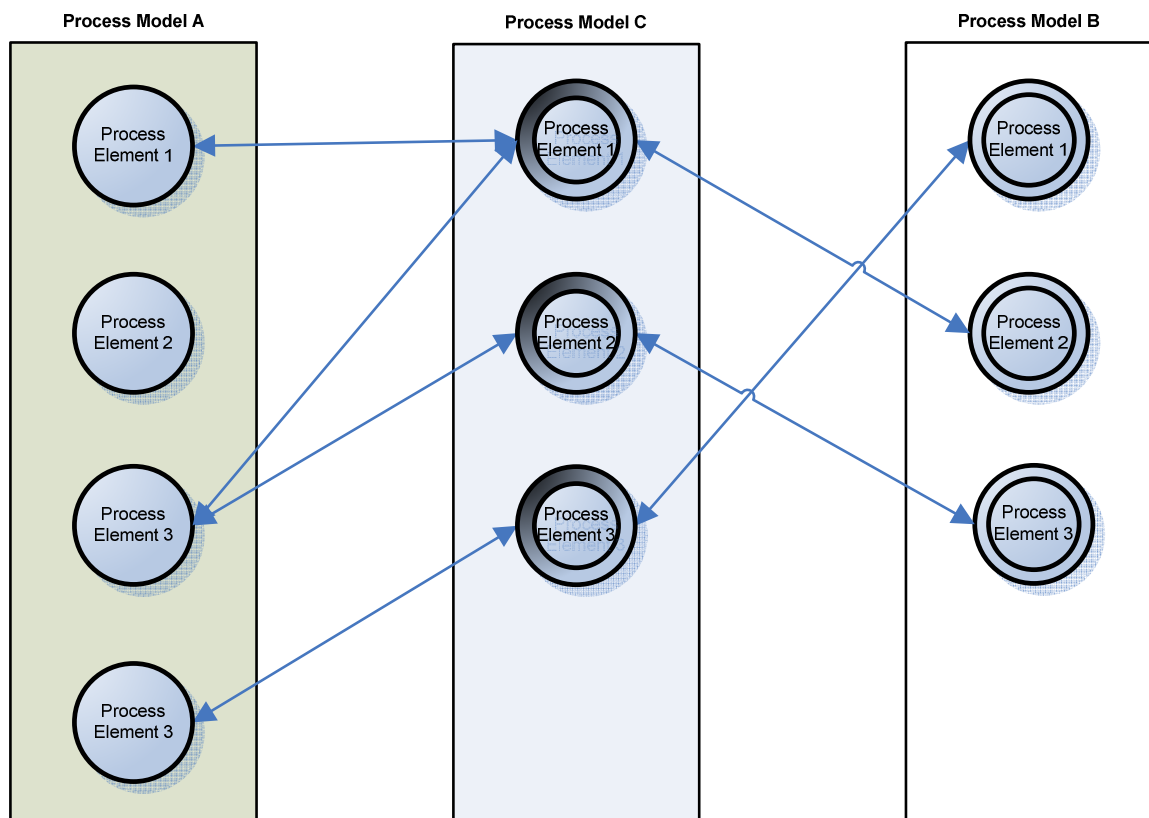

Figure 25. MAPPING ELEMENTS BETWEEN PROCESS MODELS

There are certain problems with performing a mapping at this level. One is that assessments at the equivalent level of detail cannot be performed: ISO/IEC 15504 assessments would be at a much more detailed level than ISO 9001 assessments - which are lacking indicators (Base Practices and Work Products). Hence once would be able to perform a translation of ISO/IEC 15504 (capability) gradings to ISO 9001 with confidence at the process level, but the reverse would not

be true. Repeatability of results would also be of a lower standard from ISO 9001 to ISO/IEC 15504.

Another factor is that the ISO/IEC 15504 process model is a much larger, detailed and complex model in scope than the ISO 9001, which leaves more room open to interpretation and to the experience of the assessor. Therefore, an ISO 9001 assessment would map only to a small subset of the ISO/IEC 15504 model. There also exist sub-clauses of the ISO 9001 that cannot be mapped to the ISO/IEC 15504 model. Hence an ISO/IEC 15504 assessment would not map to a complete ISO 9001 assessment, but only overlap (or intersect) it.

The advantage and motivation for this mapping though, is that a significant amount of relational links between the two models is evident and so assessment work performed using either process model can be translated into the other, forming a substantial base of grading from which to start off with - and to increase the repeatability of assessment results.

8.7.4 The ISO 9001 Audit Checklist (ACL)

The ISO 9001 Audit Checklist (ACL) was developed by SEAL (Software Engineering applications Laboratory of the University of the Witwatersrand, Johannesburg) and the SABS (South African Bureau of Standards) - and is a document-based assessment instrument that expands on the ISO 9001 process model standard. Thus the ACL is not a process model standard, but is merely based on one.

The ACL provides the user with a tabular list of Compliance Indicators in the form of questions to methodically answer on each sub-clause of the process standard – providing a practical and repeatable means of process assessment using ISO 9001.

Each Compliance Indicator question in the Audit Checklist can be answered with physical indicators such as work products. The Audit Checklist can thereby provide a mapping onto ISO/IEC 15504 at the work products level, if one associates its work products to each ACL question as indicators.

The following table illustrates an example of an ISO 9001-based Audit Checklist Compliance Indicator, with all the components of each record:

Audit Checklist Record Component	Example
ISO 9001 Sub-Clause Number	4.1.2.2
Audit Checklist Reference Number	A.1
ISO 9001 Section	Management Responsibility
ISO 9001 Clause	Organization – Resources
Audit Checklist Category	Questions From SABS ISO 9001
Compliance Indicator	Does the supplier identify resource requirements for management and for performing work and verification

	activities, including internal quality audits?

Table 22.   EXAMPLE OF AN ISO 9001 AUDIT CHECKLIST COMPLIANCE INDICATOR

Notes:

1. The full (unique) reference number of each Compliance Indicator is made up of the ISO 9001 Sub-Clause Number and the ACL Reference number – so the unique reference to the above compliance indicator would be: 4.1.2.2.A.1

2. The current release of the Audit Checklist originates from South Africa, and is based on the SABS (South African Bureau of Standards) version of the ISO 9001 standard.

8.7.4.1   The ACL Process Model Structure

The ACL has the following hierarchical process structure which is based on the ISO 9001 process reference model:

- ISO 9001 Clauses
    - ISO 9001 Sub-Clauses
        - ACL Sections
            - ACL Compliance Indicators

The Audit Checklist extends the structural levels of the ISO 9001 to provide a greater level of detail to each sub-clause. Each sub-clause is assigned a categorised (or sectioned) list of "Compliance Indicators" (which are in the form of questions) to answer and "check off" as process indicators of an ISO 9001 assessment. This adds a more consistent and practical extension to the assessment of the ISO 9001 process model and significantly enhances the repeatability of results.

This extension allows the ACL to be compatible with the ISO/IEC 15504 process assessment framework

8.7.4.2   Bridging the Process Models with The ISO 9001 Audit Checklist

The questions of the Audit Checklist facilitates the linking to (or mapping) of Sub-clauses to Processes and Work Products. Each ACL question requires physical proof of its answer in the form of a process artefact, i.e. required input or resulting output Work Products.

Hence a mapping between the two process models can be found at the Work Product level by finding associated work products for each ACL section and question. Work performed methodically on the ACL and ISO/IEC 15504 frameworks in this regard by SEAL projects have resulted in such a mapping being created.

- ISO 9001 Clauses
    - ISO 9001 Sub-Clauses
        - ACL Sections

        o   ACL Compliance Indicators

              ▪   ISO/IEC 15504 Processes - Work Products

The Work Product level is the most repeatable in terms of (achievement level) grading in that input or output work products are physical artefacts of a process that can be located, analysed and 'marked' more consistently and easily by assessors - and as indicators form a more accurate base to grade upwards with.

8.7.4.3 Mapping Links Between ISO/IEC 15504 and ISO 9001 Structures

If the questions of the ISO 9001 Audit Checklist are associated with ISO/IEC 15504 Work Products, links can be made between the two process models at the lowest level. At the same level, both the Base Practices and the ACL Compliance Indicators are similar in that they are both intangible or virtual indicators of process achievement. However, it remains to be seen whether a significant level of mapping is feasible between the Base Practices and the Compliance Indicators.

Since the ISO/IEC 15504 Process Model is the by far the larger in scope and detail, it makes sense to perform the direction of the mapping from the ISO/IEC 15504 Process Work Products onto each of the ISO 9001 Compliance Indicators.

ISO/IEC 15504		**ISO 9001**
Process Categories		ISO 9001 Clauses
Processes		ISO 9001 Sub-Clauses
		ACL Sections
Base Practices /	→	ACL Compliance Indicators /
Work Products	→	Work Products

For each Compliance Indicator of the Audit Checklist, work products that are physical input/output evidence of the indicator, are assigned to or associated with the Compliance Indicator. These work products are specific ones belonging to a corresponding ISO/IEC 15504 process.

8.7.4.4 Mapping The Process Models Using the Audit Checklist

The following table illustrates an example of an Audit Checklist compliance indicator linked to Process Work Products of the ISO/IEC 15504 model:

Compliance Reference	Compliance Indicator	ISO/IEC 15504 Process Category	ISO/IEC 15504 Process	ISO/IEC 15504 Work Product	Work Product Type	Work Product Name
4.1.2.2.A.1	Does the supplier identify resource requirements for management and for performing work and verification activities, including internal quality audits?	SUP	4	20	Input	Assessment / Audit Records
		SUP	7	20	Output	Assessment / Audit Records
		ORG	2	33	Output	Job Procedures, Practices

Table 23. EXAMPLE OF AUDIT CHECKLIST INDICATOR ASSOCIATED WITH WORK PRODUCTS

8.7.4.5   One-To-Many Mappings Between Process Models

Since the Clauses and Sub-Clauses of the ISO 9001 model are quite broad in scope, it is quite possible that in the mapping a given ISO/IEC 15504 Work Product may link to more than one Compliance Indicator. This is classified as a one-to-many mapping and allows data to be converted in one direction only.

If the data from an ISO/IEC 15504 assessment is the source (i.e. it is assessed first and converted to an ISO 9001 assessment), then the grading of a Process Work Product can be translated to the associated ACL Compliance Indicator Work Products. However, this is not feasible if the assessment is performed in the reverse direction - i.e. starting with an ISO 9001 assessment and translating it to an ISO/IEC 15504 assessment.

If more than one ACL Compliance Indicator is mapped to the same Process Work Product, it means that the same Process Work Product may be graded within different contexts - and hence receive different grades. This presents confusion and problems when the assessor has to assign the achievement level of the given Work Product - in relation to which Compliance Indicator will the assessor translate the achievement rating of the Process work product? Or all of them?

In practical assessment terms, for the assessor to unambiguously rate each Process or Compliance Indicator work product, the mapping has to be established on a one-to-one basis.

In analysis, there are two methods to complete a one-to-one mapping using the Audit Checklist (or any intermediate ISO 9001 process model extension):

One has to assume and accept that there is a unique Work Product for each ACL Compliance Indicator or a question that corresponds to a process work product. The final model mapping must be checked for relational duplicates and resolved.

The second methods involve extending the ISO/IEC 15504 work product set to add additional (but similar where needed) work products to make up for the double mapping. For example, if the Work Product: Project Plan maps to two Compliance indicators, the mapper may add another work product called 'Project Plan 2' to map to the second compliance indicator. Thus the mapping would remain one-to-one. Adding work products to the ISO/IEC 15504 Process model can be done in the scope of the rules for creating a compliant process model of itself.

8.7.5 Performing Process Assessments with the Audit Checklist

The following table illustrates an example of an assessment rating obtained using the Audit Checklist. The associated work products of a Compliance Indicator are rated, and then the Compliance Indicator itself is rated accordingly:

Compliance Reference	Compliance Indicator	Compliance? (F/L/P/N)	ISO/IEC 15504 Work Product Reference	Work Product Type	Work Product Name	Achievement? (F/L/P/N)
4.1.2.2.A.1	Does the supplier identify resource requirements for management and for performing work and verification activities, including internal quality audits?	L	SUP.4 – 20	Input	Assessment / Audit Records	F
			SUP.7 – 20	Output	Assessment / Audit Records	L
			ORG.2 - 33	Output	Job Procedures, Practices	L

Table 24.   AN ASSESSMENT RATING USING THE AUDIT CHECKLIST

8.7.6   Performing Process Assessment Translation

Given a mapping, the achievement results data of an assessment performed on either (Source) Process Model (ISO 9001 or ISO/IEC 15504) can be translated to assessment data for the other (Target) process model in an automated procedure:

- Since the translated data is at the Work Product level, assessment on the other model has to proceed from the equivalent Work Product (i.e. the lowest) level upwards. For example, if one performs an ISO 9001 assessment (i.e. the Source assessment) and translates the data to an ISO/IEC 15504 assessment (i.e. the Target assessment), that ISO/IEC 15504 assessment has to start from the work product level, even though for

ISO/IEC 15504 the assessor could start assessment from a higher level (The minimum assessment level for an ISO/IEC 15504-compliant assessment is from the Process Attribute level.)

- The translated assessment results / data from the Source assessment will only be a subset of the Target assessment. Whether the quantity of data translated is significant or not is dependant on the quality of the mapping and the inherent overlap (or intersection) of scope between the two process models.

- As the mapping allows translation of data at a single level only (as opposed to translation of data at more than one or all levels of the process model structures) the translated assessment data is seen as providing a starting point only, and not as a complete assessment conversion solution. In fact, it is far from it as the assessor has to perform assessment of all the upper levels of the process model. However, the work product level is the level that requires the most effort to assess - as it involves the identification, tracking, recording and grading of physical artefacts that may be scattered all over an organisation. The effort saved in re-assessment of these artefacts for the other process model should be substantially significant.

8.7.7 Implementing the Mapping Process

The resulting mapping structure was subsequently implemented in the SPIL Assessment Tool in the case where the following enhancements to the software had to be added:

- A data table structure for the Audit Checklist (ACL) to store it's records

- A mapping table for linking the ACL records with the ISO/IEC 15504 process model records

- Aggregation and data translation routines to populate one model from the data of the other.

- This feature allows an assessor complete the capture of the Audit Checklist form based on an ISO 9001 assessment and have the data translated to the ISO/IEC 15504 framework in an automated fashion.

8.7.8 Analysis

It obvious that establishing a mapping between two process models such as the ISO 9001 and ISO/IEC 15504 models is not a clear-cut process due to structural differences that cause a wide gap between these two models. However, it was found that these structural disparities can be bridged by an intermediary tool such as the Audit Checklist.

It is fortunate (in this instance of mapping) that such a tool as the Audit Checklist exists to allow one to methodically associate links between the two process models. The Audit Checklist extends the ISO 9001 process model to be on a similar footing with the ISO/IEC 15504 process model; and hence a mapping is possible.

The Audit Checklist allows a mapping to be created at the lowest level of detail – the work product level – which involves the rating of physical artefacts and is the best level for repeatability of assessment results. Without the Audit Checklist one would have to provide links at the ISO/IEC 15504 Process level and the ISO 9001 Sub-clause level; given the differences

between the nature of the two categorisations, the possibility for valid data translation and repeatability of results is low.

There are many issues and ambiguities that need to be resolved; this can only be possible through iterations of mapping and testing of the mapping. However, the baseline version itself is important for illustrating the strengths and weaknesses of a given mapping; for allowing users to trial the mapping framework and respond to it with practical suggestions and logically deducible criticisms.

Practically, it is unlikely that a mapping between the two process models could be established with a single instance of assessment, analysis and compilation by any one person or organisation dedicating itself to produce such a schema. Rather, a practical and useable version of the mapping framework would likely be built on an iterative process – of mapping evolution by trial and error - before achieving the 'best fit' for a translation of existing ISO 9001 process assessment data.

8.8   Case Study: Mapping Process Models via Inspection

This practical exercise will illustrate the method of a process model mapping by inspection that was used by the Australian-based Software Quality Institute (SQI) of Griffiths University, in order to prepare a data mapping from CMMI to ISO/IEC 15504-2:1998 for the Defence Material Organisation (DMO). This contract was initiated by a requirement by the Australian Defence Department to establish how suitable the CMMI was for managing the acquisition of software intensive systems from potential contractors and vendors.

The intention was to allow assessments to be performed in order to determine a vendor's process maturity; domain experience and expertise; history of performance and delivery – in order to provide objective and informed support for the selection of a contractor. These assessments would also be aimed to identify the weaknesses within a vendor's processes, such that process improvements can contractually be put in place in order to mitigate risk.

The CMMI framework has been identified as a potential model for this purpose, as it would allow the DMO to assess vendors for both their systems capability - as well as software engineering process maturity. What has to be ascertained is whether an ISO/IEC 15504-compliant appraisal and translation method can be adapted for use with the CMMI model in order to perform process assessments. The SQI was contracted to evaluate and determine the extent of these requirements within the locale of Australia.

8.8.1   Research Method

This method involves a systematic exercise of methodically comparing the Process Attributes of the two process reference models by review and inspection, and the procedure is underpinned by thorough, exhaustive double-checking and cross-validation by different members of the team.

This thesis' author Richard Him Lok took part in the validation and verification of the data mapping exercise in 2004 as part of the South African contingent of verifiers that were involved on request from the SQI. This team was led by Alastair Walker of the SPIL (Software Process Improvement Laboratory) organisation and consisted of 11 members from academic and commercial organisations whose backgrounds were related to the software quality area.

The initial data mapping was developed by the SQI in 2001 for the earlier version of the ISO/IEC 15504 TR. The mapping has subsequently been made current for the more recently released

version of the ISO/IEC 15504 and the ISO/IEC 12207 standard, which was updated with an Amendment document.

8.8.2 Establishing Compatibility to ISO/IEC 15504 from the Candidate Model

The ISO/IEC 15504 standard has been drafted to allow alternate process models that are compatible with its own reference process model to be used for assessments. These candidate models must be able to generate the ISO/IEC 15504 Process Profiles and meet certain compatibility criteria.

The CMMI model can be shown to meet these compatibility requirements in each of the specified areas:

- It is required that the candidate process model and measurement framework be purposely designed for process assessment. It is found that the CMMI documentation itself confirms this requirement.

- The scope of the candidate process model should also have a Capability dimension that matches a part or all of the Capability levels (including the associated processes) of the ISO/IEC 12207 reference model.

- The candidate process model should have basic elements that map to or roll up to the Processes and the Achievement Ratings of Process Attributes.

- The basic elements of the candidate process model must be clearly and unambiguously mapped to basic elements of the ISO/IEC 12207 Process Reference model and have indicators for the Capability Dimension as well as Process Performance.

- There should be a clear process to map and convert ratings from the candidate model to the Process Attribute Ratings of the Reference Model. A process profile can be thereby be created for each process instance assessment.

In analysing the structures of the two process models, it was determined that a more consistent mapping would be achieved by starting the mapping level at the lower Process Outcome level, thereby treating both the practices and sub-practices of the CMMI as ISO/IEC 15504 Indicators of performance. This also allows the CMMI to fulfil the last four compatibility requirements.

8.8.3 Creating the Model Mappings

In the exercise, a process model mapping was first created for the CMMI Continuous Representation, and was then followed by the creation of a mapping for the CMMI Staged Representation version.

Each sub-practice was systematically mapped to the corresponding ISO/IEC 15504-2 Document (i.e. the Process Reference Model based on ISO 12207) element. Most sub-practices were mapped to a unique Process Outcome or Attribute Achievement and then rolled upwards first to the Practice Level and then to the Goal Level. Elements of the ISO/IEC 15504 that were not mapped to were identified and used for further validation.

In summary, the mapping resulted in the CMMI Continuous Representation addressing all the ISO/IEC 15504-2 Processes (with certain exceptions) and therefore it also addresses the Process Attributes. The mapping is however not perfect and had issues and anomalies – such as some

Process Attributes do not map to any of the CMMI generic practices. These issues caused a problem with translation between the models.

The CMMI Continuous Representation mapping was then extended as a basis for the CMMI Staged Representation mapping, and this resulted in a more complete and useable mapping which could allow assessments to be translated into ISO/IEC 15504 Process Profiles.

This process of model mapping and validation was performed twice – once for the ISO/IEC 15504 in 2001, then again in 2004 for the recent revision of the standard.

8.8.4 The CMMI-Continuous to ISO/IEC 15504 Model Mapping

Capability Level	Process Attribute
1	PA1.1 Process performance
2	PA2.1 Performance management
	PA2.2 Work product management
3	PA3.1 Process definition
	PA3.2 Process resource
4	PA4.1 Measurement
	PA4.2 Process control
5	PA5.1 Process change
	PA5.2 Continuous improvement

Table 25.   MAPPING CMMI CAPABILITY LEVELS TO ISO/IEC 15504-2

Maturity Level 2	
CUS.1.2	Supplier Selection Process
CUS.1.3	Supplier Monitoring Process
CUS.1.4	Customer Acceptance Process
SUP.1	Documentation Process
SUP.2	Configuration Management Process
SUP.3	Quality Assurance Process
SUP.6	Joint Review Process
SUP.7	Audit Process
SUP.8	Problem Resolution Process
MAN.2	Project Management Process
ORG.5	Measurement Process
Process Attributes	PA1.1 PA2.1 PA2.2

Table 26.   EQUIVALENT CMMI MATURITY LEVEL 2 PROCESSES

Maturity Level 3	
CUS.1.2	Supplier Selection Process
CUS.1.3	Supplier Monitoring Process
CUS.1.4	Customer Acceptance Process
CUS.3	Requirements Elicitation Process
ENG.1.1	System requirements analysis and design process
ENG.1.2	Software requirements analysis process
ENG.1.3	Software design process
ENG.1.4	Software construction process
ENG.1.5	Software integration process
ENG.1.6	Software testing process
ENG.1.7	System integration and testing process
SUP.1	Documentation Process
SUP.2	Configuration Management Process
SUP.3	Quality Assurance Process
SUP.4	Verification Process
SUP.5	Validation Process
SUP.6	Joint Review Process
SUP.7	Audit Process
SUP.8	Problem Resolution Process
MAN.2	Project Management Process
MAN.4	Risk Management
ORG.2.1	Process establishment process
ORG.2.2	Process assessment process
ORG.5	Measurement Process
Process Attributes	PA1.1
	PA2.1
	PA2.2
	PA3.1
	PA3.2

Maturity Level 4	
CUS.1.2	Supplier Selection Process
CUS.1.3	Supplier Monitoring Process
CUS.1.4	Customer Acceptance Process
CUS.3	Requirements Elicitation Process
ENG.1.1	System requirements analysis and design process
ENG.1.2	Software requirements analysis process
ENG.1.3	Software design process
ENG.1.4	Software construction process
ENG.1.5	Software integration process
ENG.1.6	Software testing process
ENG.1.7	System integration and testing process
SUP.1	Documentation Process
SUP.2	Configuration Management Process
SUP.3	Quality Assurance Process
SUP.4	Verification Process
SUP.5	Validation Process
SUP.6	Joint Review Process
SUP.7	Audit Process
SUP.8	Problem Resolution Process
MAN.2	Project Management Process
MAN.3	Quality Management
MAN.4	Risk Management
ORG.2.1	Process establishment process
ORG.2.2	Process assessment process
ORG.4	Infrastructure process
ORG.5	Measurement Process
Process Attributes	PA1.1
	PA2.1
	PA2.2
	PA3.1
	PA3.2
	PA4.1
	PA4.2

Maturity Level 5	
CUS.1.2	Supplier Selection Process
CUS.1.3	Supplier Monitoring Process
CUS.1.4	Customer Acceptance Process
CUS.3	Requirements Elicitation Process
ENG.1.1	System requirements analysis and design process
ENG.1.2	Software requirements analysis process
ENG.1.3	Software design process
ENG.1.4	Software construction process
ENG.1.5	Software integration process
ENG.1.6	Software testing process
ENG.1.7	System integration and testing process
SUP.1	Documentation Process
SUP.2	Configuration Management Process
SUP.3	Quality Assurance Process
SUP.4	Verification Process
SUP.5	Validation Process
SUP.6	Joint Review Process
SUP.7	Audit Process
SUP.8	Problem Resolution Process
MAN.2	Project Management Process
MAN.3	Quality Management
MAN.4	Risk Management
ORG.2.1	Process establishment process
ORG.2.2	Process assessment process
ORG.2.3	Process improvement process
ORG.4	Infrastructure process
ORG.5	Measurement Process
Process Attributes	PA1.1
	PA2.1
	PA2.2
	PA3.1
	PA3.2
	PA4.1
	PA4.2
	PA5.1
	PA5.2

Table 27.   EQUIVALENT CMMI MATURITY LEVEL 3 - 5 PROCESSES

8.8.5   Validating the Model Mappings

The subsequent validation of the CMMI to ISO/IEC 15504 models was performed in South Africa by a workgroup of 11 technical experts, all familiar with the SC7 range of SE standards. This workgroup was established by Alastair Walker of the Software Process Improvement Laboratory (SPIL) organisation in order to provide an independent verification and comment against the Australian SQI-based model mapping. The author of this document was included in this workgroup.

For the validation exercise, the scope of the mapping activity was limited only to the sub practices (i.e. SUB) of CMMI. This also meant that comments would be raised against Special Practices (i.e. SP's) only when there occurred a special practice with no supporting sub-practices. The scope also excluded the Capability Dimension as this was a work in progress at that point in time. Therefore the CMMI Generic Practices and ISO/IEC 15504 Process Attributes processes were not yet incorporated into the mapping.

Three separate workshops were held by the workgroup in order to undertake comment generation, review and disposition where the following occurred:

1. A spreadsheet containing the CMMI Process Areas was assigned to individuals, who generated comments on a Comment Register.

2. These comments were assigned to a different member of the team for review and 'sanity check'.

3. Where differences of opinion emerged between the generator of the comment and the reviewer, the comment was reviewed in the full meeting, and a resolution obtained.

The spreadsheet that was sectioned and distributed for inspection by the South African workgroup contained the following process mapping data.

1. Mapping of CMMI to ISO/IEC 12207 – represented by a listing of the CMMI special practices in sequential order, mapped to Process Outcomes of the ISO/IEC 12207.

2. Mapping of ISO/IEC 12207 to CMMI – represented by listing sorted in the ISO/IEC 12207 process order, mapped to the special practices of the CMMI.

3. An equivalent staging to the CMMI processes to the ISO/IEC 12207 processes

4. A listing of the CMMI Process Areas, from CAR through to VER.

On the spreadsheet, different colours also demarcated the boundaries between the CMMI and ISO/IEC 12207 mapped processes. The following is an example of the spreadsheet mapping artefact that was assigned to Richard Him Lok:

WG Mem ID	ID	Category (TH, TL, E, G)	Clause, Sub-clause	Paragraph, Figure, Table	Comment and rationale
RHL	01		OPF.SP1.1-1/SUB6		Add F.3.3.1/4 - process information and data is maintained
RHL	02		OPF.SP1.2-1/SUB.1		Change to: F.3.1.6/1 - organisational commitment
RHL	03		OPF.SP2.1-1/SUB.2		Add F3.3.3/2 - changes made in a controlled way
RHL	04		OPF.SP2.1-1/SUB.3		Add F3.3.3/2 - changes made in a controlled way
RHL	05		OPF.SP2.2-1/SUB.6		Add F.3.3.3/4 - historical, technical and evaluation data is analysed
RHL	06		OPF.SP2.2-1/SUB.8		Add F.3.3.3/4 - historical, technical and evaluation data is analysed and used to improve processes
RHL	07		OPP.SP1.3-1/SUB.4		Add F3.1.6/1 - organisational commitment
RHL	08		OPP.SP1.4-1/SUB.1		Add F3.1.6/4 - perform activities
RHL	09		OPP.SP1.5-1/SUB.2		Add F.3.3.3/4 - historical data analysed
RHL	10		OPP.SP1.5-1/SUB.4		Add F3.4.2/1 - Training?

Table 28. **EXAMPLE OF THE SPREADSHEET MAPPING ARTEFACT**

The following process was used by the workgroup to determine the validity of the mapping and create comments:

1. The CMMI to ISO/IEC 12207 mapping links were first checked for consistency and correctness. The Special Practices (listed under the 'Reference' column) in each of the CMMI process areas were checked against the 'Maps To' column, which contained a reference to an ISO/IEC 12207 process - through the F.X.X.X reference and outcome number. A copy of the latest ISO/IEC 12207 Process Reference Model was provided for this exercise.

2. The links of the converse mapping from ISO/IEC 12207 to CMMI were then checked that each link was plausible and technically sound. Links that the workgroup

members felt should be associated with a different ISO/IEC 12207 were flagged and commented with the applicable reason.

3. Each member's assigned area was completed on the spreadsheet and consolidated. A workshop meeting would then be held to review the identified deviations to the mapping in a group discussion.

The validation comments and results of the workgroup were then submitted back to the SQI in Australia for incorporation into the mapping.

8.8.6   Assessment Data Translation

Given the current state of knowledge discussed, performing the translation of data between the models using the mapping would require additional judgement by the Assessment Team - results cannot be obtained from processed by an automated computer algorithm alone. This is due to the following factors:

1. The mappings are complex (one to many; many to one; many to many)

2. The ratings are assigned at a high level

3. The inherent nature of the rating process

Another factor affecting the approach of the translation is the CMMI Assessment Method used – of which there are three:

1. Class A: Rigorous and in-depth investigation of processes, with a basis for improvement plan. This method results in a thorough coverage of processes with each Process Attribute investigated for strengths and weaknesses. The robustness of the method should provide consistent, repeatable results with an objective view. This option will also allow for conformance to the ISO/IEC 15504 standard. However, it demands significant time and resource requirements of the organisation.

2. Class B: An Initial Assessment / Partial Incremental Assessment / Self-Assessment method. The Organisation gains a measure of insight into its own level of capability and provides a starting point or focuses on areas that need most attention – as well as providing buy-in from staff or clients. The trade-off against the benefits are

3. Class C: 'Quick-look' Assessment / Incremental Assessment.

Given that the validated model mapping is completed, the mapping should then be tested and verified in the field by assessors for producing a consistent set of results.

8.8.7   Analysis

Model mapping by inspection is a human resource-dependant process with a reliance on knowledge of the process model (working experience preferably) and thoroughness as a trait. The basic process requires that each element of one model is systematically compared against the other model at the matching structural level and then again in reverse direction between the two models.

The mapping has to inspected and linked in both directions in order to determine that the translation process can be performed from the direction of either process model. The two

mappings may not necessarily be exactly the same, but there should be a correlation for the most part.

The accuracy and validity of such a mapping is seen to have a strong dependency on the thoroughness and industry experience of the inspectors creating the mapping.

8.9   Summary

In this chapter and the preceding one, we have established the means to store assessment and mapping data, and we have provided the basis for creating a data translation method - given a reliable process model mapping set. The next two chapters will focus on analysing the structural commonalities between three process models and thereby create actual process model mappings for:

1.   The ISO/IEC 15504 and the ISO 9001

2.   The ISO/IEC 15504 and the SW-CMM

These two mappings would as a result give rise to the possibility that a third mapping could be derived between ISO 9001 and the SW-CMM using the ISO/IEC 15504 as an intermediate model. However, one has to establish the degree of validity for such a mapping if it is created. Due to the nature or underlying purpose of a process model, compatibility may not be a given.

Such a mapping should be analysed in terms of structural and practical compatibility in order to establish the degree of validity. The exercise of assessment results data translation between two given models is also likely to require input or judgement by an assessor that was involved in the original assessment.

Therefore the issues and differences between process models which may affect the translation must be identified in order for such a mapping to yield an accurate conversion of assessment data.

To gain insight into the issues that may arise in the creation of a process model mapping, we will look at two such case studies in the following chapters that illustrate:

- The creation of a process model mapping via an intermediate process model

- The creation of a process model mapping through inspection

9 Assessment Tool Database Selection

9.1 Introduction

An assessment tool's fundamental purpose is that of being capable of capturing, storing, processing, and analysing assessment data from one or more assessment standards.

This requires that the tool be integrated with a database that is designed for:

1. Representing the unique structures and data of the process reference model(s)

2. Storing the results data of an assessment conducted against the process reference model

In addition, a practical and efficient implementation of a data store requires that a suitable database engine be found to match the following profile:

1. Have a small file desktop footprint (i.e. file size total space taken on a computer) as to provide mobility and portability

2. Allow data to be stored in tables with indexing to provide optimum data retrieval

3. Allow complex data calculations to be performed at the database level for optimum processing speed (i.e. stored procedures)

9.1.1 Research Method

Due to the fact that the current majority of the notebooks and PC desktop operating systems are operating on the Microsoft Windows platform, the choice of an operating system platform on which to implement the assessment tool clearly has to be from the Windows family (Windows 95/98/Me/NT/2000/2003/XP) in order to achieve widespread distribution and compatibility. Similarly, a software application tool's supporting components – in particular the database engine – has to operate on such a platform.

The choice to implement a tool on an alternate operating system such as the Apple Mac operating system or even a Linux operating system would significantly limit the distribution reach of such an assessment tool and thus it's commercial viability.

Thus, the primary Windows-compatible databases on the market were investigated and profiled for functionality that would be suitable to the requirements profile described above.

9.2 Candidate Database Engines

9.2.1 Desktop-Level Databases

Desktop databases (i.e. database products targeted for the non-server Windows 95/98/ME/XP versions) typically have a small disk footprint and may be integrated with an assessment tool via the ODBC (Open Database Connectivity) standard drivers, which are widely available. These database engines are typically installed on the Microsoft Windows system along with their run-time libraries and configuration settings to allow applications to interface and query the database objects. Although these databases are for the most part limited to a single user, they are ideal for implementing small, portable application tools for mobile assessors performing on-site evaluations with notebooks.

The candidate databases examined here are designed for implementation on Windows-based GUI applications and are suitable for O/S platforms such as a Windows Professional (optimised for sign-user use) or Server (optimised for background processes such as enterprise databases, batch routines, file and print servers, etc.) versions.

An initial analysis for a suitable database was performed in 1995 (1995-45 SOQ project, Wits University, Richard Him Lok) for the design and implementation of the SPIL Assessment Tool (SPILAT). From the available desktop databases reviewed, the most suitable candidate for the tool at the time was found to be the Sybase SQL Anywhere database, which provides enterprise-level database features (stored procedures, customisable indexes, and triggers) in a functional-rich desktop package and footprint.

However, since the time of the initial SPILAT tool release, most of the other desktop databases have evolved and functionality has greatly increased with a number of new version releases; some products have since been taken over by other software companies. A recent comparative analysis was again performed for the current releases of all of the most popular desktop database software and the feature highlights are given in the following table:

Database	Description
Microsoft Access 2003	- Popular; widely implemented with the prevalence of the MS Office suite - Compatible with Microsoft Office and Visual Studio.NET development tools - Efficient; quick engine (based on FoxPro technologies) - Small desktop footprint in terms of space requirements; single database contained file - XML data formats; integrated table links to other Access databases, MS SQL Server and Excel spreadsheets - Cross tabs and Pivot Tables and Pivot Charts functionality - Export data via forms and reports to the web via Sharepoint Portal Services - Build forms and applications graphically within the application
dBase: Dbase Plus 2.5 (32-Bit Windows Applications, released by Databased Intelligence) Visual dBase 5.7 (16-Bit Windows Applications, released by Dbase Inc.)	- Each table is stored as a separate file - Single index for each table; added as a separate file - Direct flat-file access to data (i.e. non-relational data structures) - Used with Xbase programming language; Clipper and implemented with the Dbase Plus and Visual dBase applications - One of the oldest desktop database formats; legacy applications community exists. Development studios are backwards-compatible on data formats and can migrate earlier applications - Build forms and applications graphically within the studio

FileMaker Pro 5.5	- Popular on the Apple Macintosh; gaining popularity on the Windows platform; cross-platform support - Intuitive interface and hides many of the complexities inherent in database management - PDA database support; small desktop footprint in terms of space requirements - XML data formatting capabilities - Built-in web server for easy publishing of data on the Internet - Lacks built-in charting; limitations on data transfer between databases; limited write-to access to an SQL database
Corel Paradox 9.0	- Each table is stored as a separate file with an index file - Object-based programming with the proprietary ObjectPAL language - Create custom applications with the Paradox Application Framework - Publish forms and reports statically or dynamically to the web - Build and perform SQL queries with Query By Example interface - Allows for single user, client server, and n-tier applications - Runtime libraries; easy setup with Distribution Expert application
Sybase SQL Anywhere	- Small and efficient; quick engine based on Watcom SQL technologies - small desktop footprint in terms of space requirements; single database contained file; available for mobile PDA platforms - Industrial-strength Database Management System (DBMS) capabilities for desktop, mobile and workgroup environments - The only desktop DB that implements SQL queries; stored procedures; triggers; cascading updates and deletes; allows creation of multiple unique indexes on tables - Cost-based query optimization learns to dynamically improve performance - Data synchronization capabilities with back-end SQL Server database (Sybase, SQL Server, Oracle, or DB2) or mobile (PDA) ultralite clients - Supports Windows 3.x/95/NT;O/S2;DOS;NetWare Clients - Compatible with JavaScripting language - Conforms to ANSI SQL89 Level 2 and IBM SAA Standards - Robust recovery architecture; scalable from desktop to enterprise - A higher level of database programming knowledge, including SQL scripting with stored procedures, is required for implementation.

Microsoft MSDE 2000 (Microsoft Database Engine)	- The Microsoft SQL Server 2000 Desktop Engine (MSDE 2000) is a data engine built and based on the core SQL Server technology (see profile below). With support for single- and dual-processor desktop computers, MSDE 2000 is a reliable storage engine and query processor for desktop extensions of enterprise applications. The common technology base shared between SQL Server and MSDE 2000 enables developers to build applications that can scale seamlessly from portable computers to multiprocessor clusters. - Designed to run in the background, supporting transactional desktop applications, MSDE 2000 does not have its own user interface (UI) or tools. Users interact with MSDE 2000 through the application in which it is embedded. MSDE 2000 is packaged in a self-extracting archive for ease of distribution and embedding. - In addition, MSDE 2000 can be built into applications and redistributed royalty-free with Microsoft development tools, such as Microsoft Visual Studio® .NET and Microsoft Office XP Developer Edition. This allows developers to build enterprise-class reliability and advanced database features into their desktop applications.

Table 29. COMPARISON OF DESKTOP DATABASE FEATURES AND FUNCTIONALITY

Although the functionality of all the desktop databases have since grown substantially, the best choice of a suitable database still holds true to date for the Sybase SQL Anywhere Database - due to the following reasons that differentiate it from the other desktop databases:

1. Maintains a single database file containing all the tables for implementation

2. Provides scalability to enterprise level databases; self-optimisation on data queries

3. Provides database Management Tools to manage and optimize database as one would an enterprise-level database system

4. Is still the only desktop footprint database with SQL Queries, stored procedures, triggers and cascading updates and deletes – features only found in enterprise-level databases. It means that business rules can be optimised to run on the back-end database and query logic is abstracted from the tool application.

5. Database tables can have multiple indexes; database objects can be scripted for object management and easy recreation

6. Provides multiple platform support for extending an assessment tool to other operating systems

7. Its new data synchronization capabilities means that it is possible to build functionality that synchronises assessment data on notebooks back to a central enterprise-level database server with an assessment repository.

The next viable database candidate is the Microsoft Database Engine (MSDE) which is a scaled-down engine version of the SQL Server 2000 enterprise-level database. This allows a user to develop a database using the Microsoft SQL Server database tools, and then attach a copy of the database file to a software application such as the assessment tool. This engine requires that the

vendor license the Microsoft SQL Server database in terms of development licensing, but that clients would not need to pay for distribution licensing.

9.2.2 Enterprise-Level (SQL) Databases

The more functional, commercial-strength server databases may be used to create an enterprise-level ISO/IEC 15504 database. While not being portable, their strength is in offering data integrity, scaling, capacity handling, robustness and speed. Thus, they are ideal for the implementation of larger, permanent data storage systems which may consolidate data from numerous sources (e.g. for SPICE Trials assessments) and for running complex report queries over data of multiple assessments. These databases are also optimal for networking several clients together to provide simultaneous access to the data.

All of these databases use a form of the SQL (Structured Query Language) database programming language as a standard for creating, manipulating and querying the database objects. These databases also provide facilities for storing business and analysis logic on the database server itself (via stored procedures, triggers, etc.) as opposed to the client application.

Database	Comments
Microsoft SQL Server 2000	- Microsoft standard database; runs on Windows XP/NT/2000/2003 Servers versions and Professional versions - Large installed user base, extensive community support and knowledge bases from Microsoft website - Uses Transact-SQL scripting language with Stored procedures, triggers, cascading updates and deletes, indexed tables, etc. - Comparatively low maintenance cost in the industry - Business Intelligence tools such as the web-based SQL Reporting Services included - Integrates with Microsoft Office applications - Self-tuning and dynamic self-configuring features optimize database performance - Graphical tools and wizards to manage and maintain database performance monitoring and database design - Core support for XML - Multiple compatible versions from PDA, Desktop, Personal, Developer and Enterprise versions - Analysis (OLAP) Services and Data Mining capabilities - Data Transformation Services – scriptable packages that automate database routines and data transfers - High availability and performance through server clustering

	- Web access to data via web publishing support
Oracle Database 9i Database	- Runs on both Windows NT and Unix
	- Large installed user base, extensive community support and knowledge bases
	- Stored procedures, indexed tables, triggers, etc.
	- Rich set of database tools provided, with wizards
	- UsesPL-SQL as programming language for stored procedures and Java, to create model database objects inside the database
	- Supports Java web applications (Java Server Pages, Servlets, Enterprise Java Beans)
	- XML Support available
	- Oracle Performance Manager optimizes the database and SQL
Sybase Adaptive Server Enterprise Database 12.5.2	- Runs on Windows, Linux and Unix platforms
	- Java Support with J2EE applications server included
	- Large installed base; one of the earliest databases
	- SQL Stored procedures, indexed tables, triggers, etc.
	- Link to different types of data across the enterprise through Component Integration Services (CIS)
	- Multiple server nodes for high availability
IBM Informix Dynamic Server 9.4	- IBM Informix® Dynamic Server (IDS) 9.4 is a best-of-breed online transaction processing (OLTP) database for enterprise and workgroup computing.
	- Protects data assets in a highly-dependable database management system. High Availability Data Replication (HDR) provides complete turn-key disaster recovery. Enterprise Replication (ER) provides selective replication of data across multiple geographic locations.
	- Built on Dynamic Scalable Architecture (DSA) that uses hardware resources more efficiently and minimizes hardware requirements. IDS 9.4 increases the maximum size of an IDS instance from 4 terabytes to a theoretical 128 petabytes -- enabling use of today's large disk drives.
	- Simplifies and automates tasks traditionally associated with maintaining enterprise databases. Automated backup and restore functions eliminate many manual administration tasks.
	- Provides increased flexibility and compatibility for Business Partner applications, including enhanced support of industry

	standard SQL syntax.
IBM DB2 Universal Database Version 8.2	- Open/flexible: DB2 supports a wide variety of popular platforms (Linux, UNIX, Windows) and key standards as well as a wide variety of packaging options to match business needs.
	- Performance and Scale: A proven leader in the ability to handle millions of transactions or many terabytes of data, DB2 scales to handle any workload on a choice of architectures.
	- Easy to Use: Streamlining and simplifying database administration through self-managing technologies and management tools.
	- Cost Effective: Delivering outstanding TCO through aggressive pricing, industry leading support and numerous efficiencies that deliver more capability with minimum hardware requirements and leverage existing skills.
	- Foundation for information on demand: Reliability, availability, and security are more critical than ever with the dynamics of the global economy. DB2 never sacrifices these fundamentals when embracing new technologies, like web services, necessary for today's challenges.

Table 30. COMPARISON OF ENTERPRISE DATABASE FEATURES AND FUNCTIONALITY

9.3   Summary

All of the enterprise-level databases are functionally capable to perform the task of a central server for an assessment data repository. However, the organisation's IT standards, budgets, resource skills and back-end platforms will play a major part in the selection of a database, if it is not present already. To maintain the highest compatibility with the desktop database – if the Sybase SQL Anywhere database is chosen – then the Sybase Adaptive Server or the Microsoft SQL Server would be recommended, as the SQL stored procedure and object scripting syntax for these two enterprise database is 100% compatible with the Sybase SQL Anywhere database. The other databases (Oracle, Informix, etc.) have more proprietary SQL scripting (such as Oracle's PL-SQL used to code the stored procedures for the database) elements.

10 Designing a Universal Process Model Database

10.1 Introduction

As part of the goal to achieve mappings between the selected process reference models, an essential step is to find a single consolidated database structure that will allow a tool to capture the results of an assessment performed on any of the four models.

This 'universally compatible' data model would also allow a standard data interface and storage structure to be created for assessment data to be transferred between assessment tools built by different vendors. A chapter dedicated to exploring and establishing the validity of such a subject entitled 'Tool Data Interchange Specification' is presented later.

We have seen in the previous chapter 'Process Model Data Structures' how we can establish relationships between the process and capability dimensions by linking and mapping the appropriate entities (i.e. Processes and practices, Capability Rating Scales, etc.) and gone so far as to create database tables specifically for the mappings.

However, the same exercise we have also seen numerous other entities and structural levels that we have not yet catered for in terms of database design. The goal here is to create a set of data tables that will incorporate all these items across all process models and allow the assessment tool to store, retrieve and process data for aggregation of results.

10.1.1 Research Method

The key to establishing the design of a universal process data model that completely caters for all the elements across the process models is to create a representative structure that incorporates the links and entities of each level of a process model. To do this, we shall construct UML class diagrams for each process reference model to illustrate the internal relationships between their process and capability levels.

10.2 Creating UML Class Diagrams

An object is any person, place, thing, concept, event, screen, or report applicable to your system. Objects both know things (they have attributes) and they do things (they have methods). A class is a representation of an object and, it is simply a template from which objects are created. Classes form the main building blocks of an object-oriented application.

The UML Class Diagram describes the static structure of a system with a collection of static declarative model elements, such as classes, interfaces, and their relationships, connected as a graph to each other and to their contents.
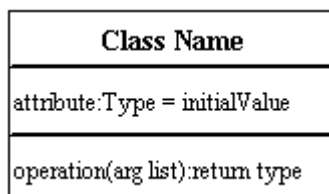
A **Class** is depicted rectangles stacked on top of each other. The rectangles contain the name of the class, the attributes and the operations. However, for this case of modelling the process models we shall ignore the attributes and operations, as they are not required.
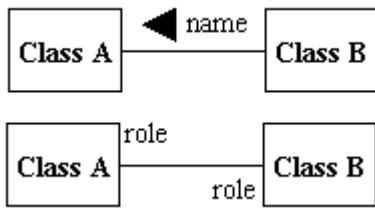
Associations represent static relationships between classes and use a filled arrow to indicate the direction of the relationship.

Roles are placed near the end of an association and represent the way the two classes see each other.

Associations are also known as "Binary Associations", because they together two classifiers.
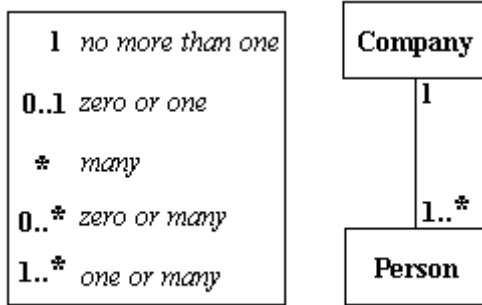
Multiplicity (or Cardinality) notations are placed near the ends of association links. These symbols indicate the number of instances of one class linked to one instance of the other class.

For example, one company will have one or more employees, but each employee works for one company only.
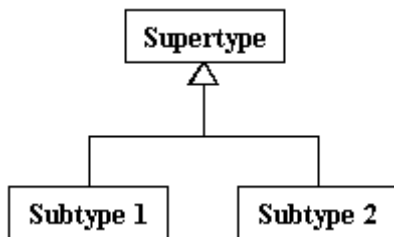
Generalization is another name for inheritance or an "is a" relationship. It refers to a relationship between two classes where one class is a specialized version of another. For example, Honda is a type of car. So the class Honda would have a generalization relationship with the class car.
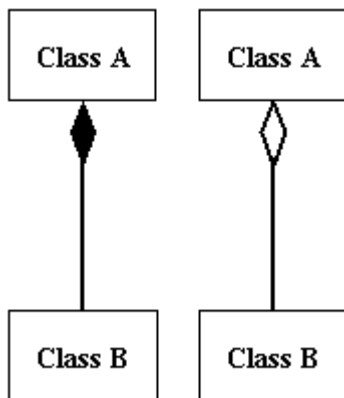
Composition and Aggregation

Composition is a special type of aggregation that denotes a strong ownership between Class A, the whole, and Class B, its part. Illustrate composition with a filled diamond.

Use a hollow diamond to represent a simple aggregation relationship, in which the "whole" class plays a more important role than the "part" class, but the two classes are not dependent on each other. The diamond ends in both a composition and aggregation relationship points toward the "whole" class or the aggregate.

Table 31.   UML CLASS DIAGRAM OBJECTS

In constructing classes for a process reference model, we will systematically take each explicit definition of the entity given in the model's reference documents. However, some definitions (as

in the case of the BOOTSTRAP model) would have to be interpreted as an implicit definition. The process model diagrams as illustrated in the first chapter, Primary Process Model Candidates are used as a basis for creating the class diagrams.

By representing process reference models with Class Diagrams, we have an overview of the model structure that allows for a better comprehension of concepts and layouts, and provides a Systems Analyst with the schematic information required for a software application implementation:

- The inconsistencies can be highlighted

- The areas of complexity can be highlighted

- Common entities (e.g. processes) between class diagrams of the models can be identified and associated to represent a single database field or table.

From the class diagrams, all the entities or objects of a process model can systematically be factored into a database design in order to provide for all items of assessment data in the table schema.

10.3 ISO/IEC 15504 Process Model Class Diagram
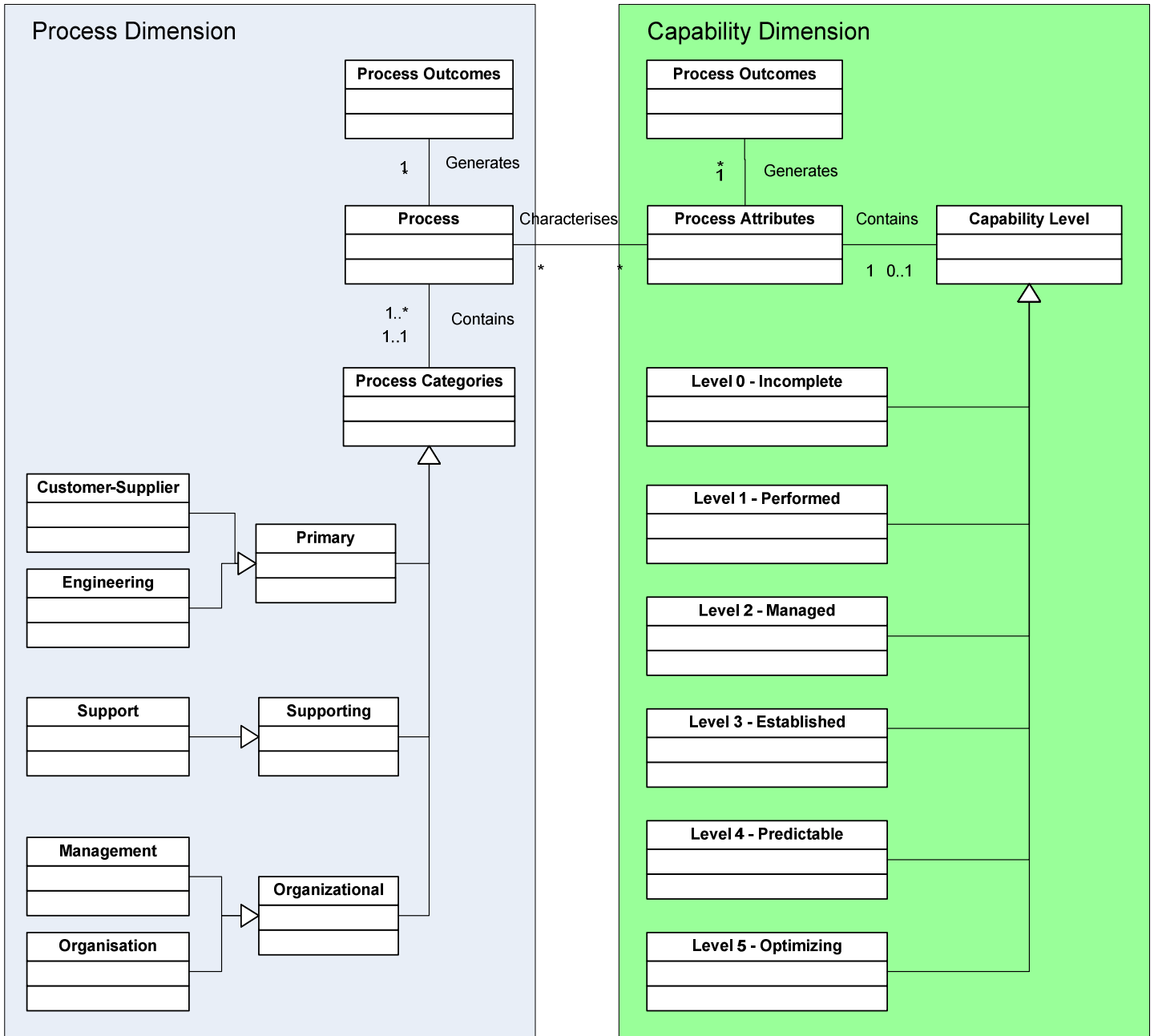
Figure 26. CLASS DIAGRAM FOR ISO/IEC 15504 PROCESS MODEL

The ISO/IEC 15504 process model class diagram allows us to deduce that it represents a complex structure of process and capability dimensional elements. However, this is due to the fact that the ISO/IEC 15504 framework was built on the proven structural design of other process models, and in the following class diagrams we shall see the structure of other models being contained as subsets within this model.

10.4 SW-CMM Process Model Class Diagram

The CMM class diagram allows us to observe the fact that both the Process and the Capability dimensions are provided for by fitting the CMM structure into the ISO/IEC 15504 structure.
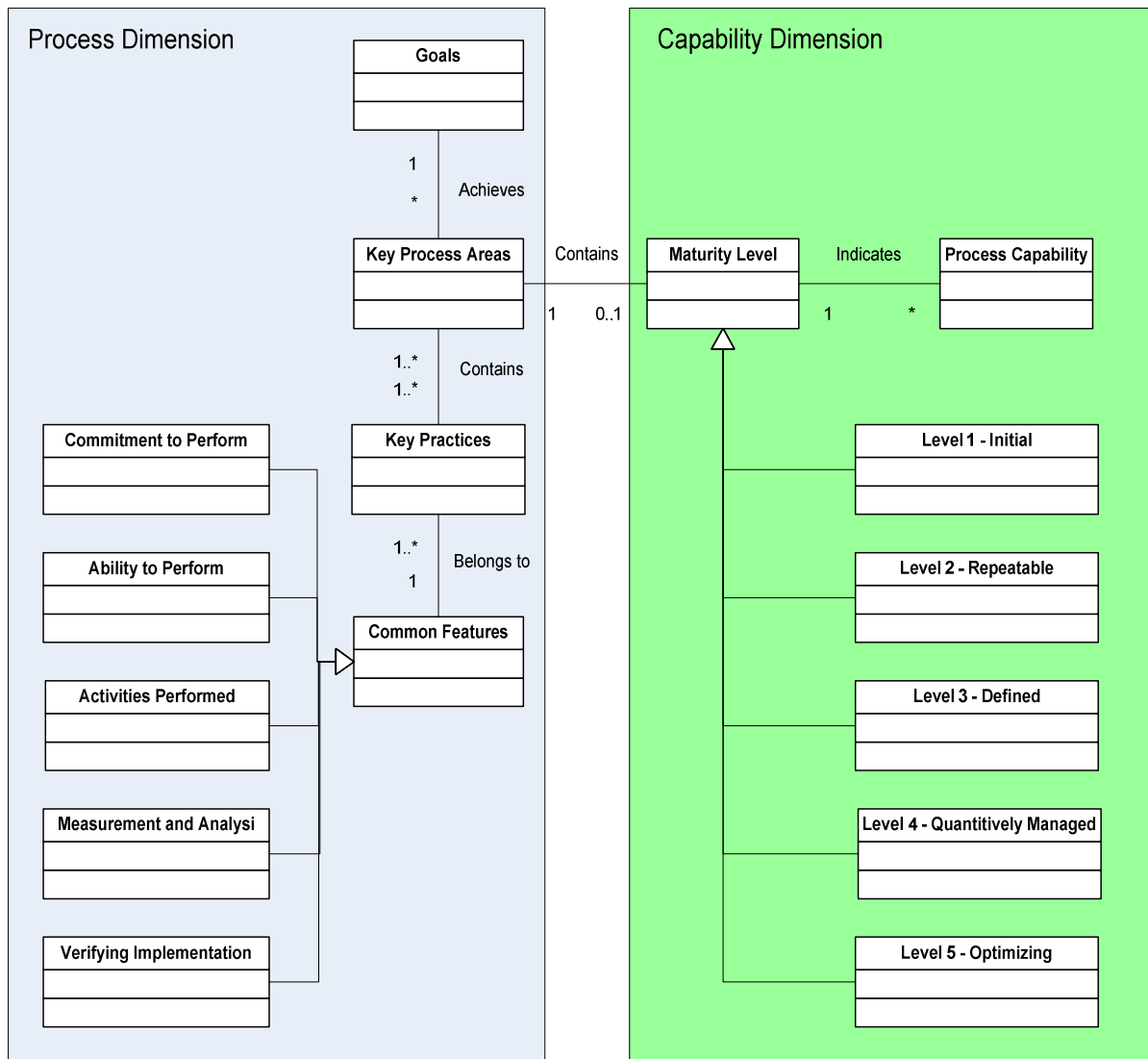
Figure 27. CLASS DIAGRAM FOR CMM PROCESS MODEL

The only single entity that is not catered for is the Goals – However, because it is a 1:1 mapping, in an implementation one can consider the solution of simply attaching the goals to the description of the Key Process Areas (which map to Processes).

10.5 ISO 9001 Process Model Class Diagram

The ISO 9001 class diagram is a simple structure which allows us to observe the fact that it primarily provides for the Process Dimension. If one maps the ISO 9001 Clauses to the Processes and the Sub-Clauses to the practices, then the Subsystem entities will map directly to the Process Categories and will allow us to contain the ISO 9001 data structures directly within the ISO/IEC 15504 data structure.
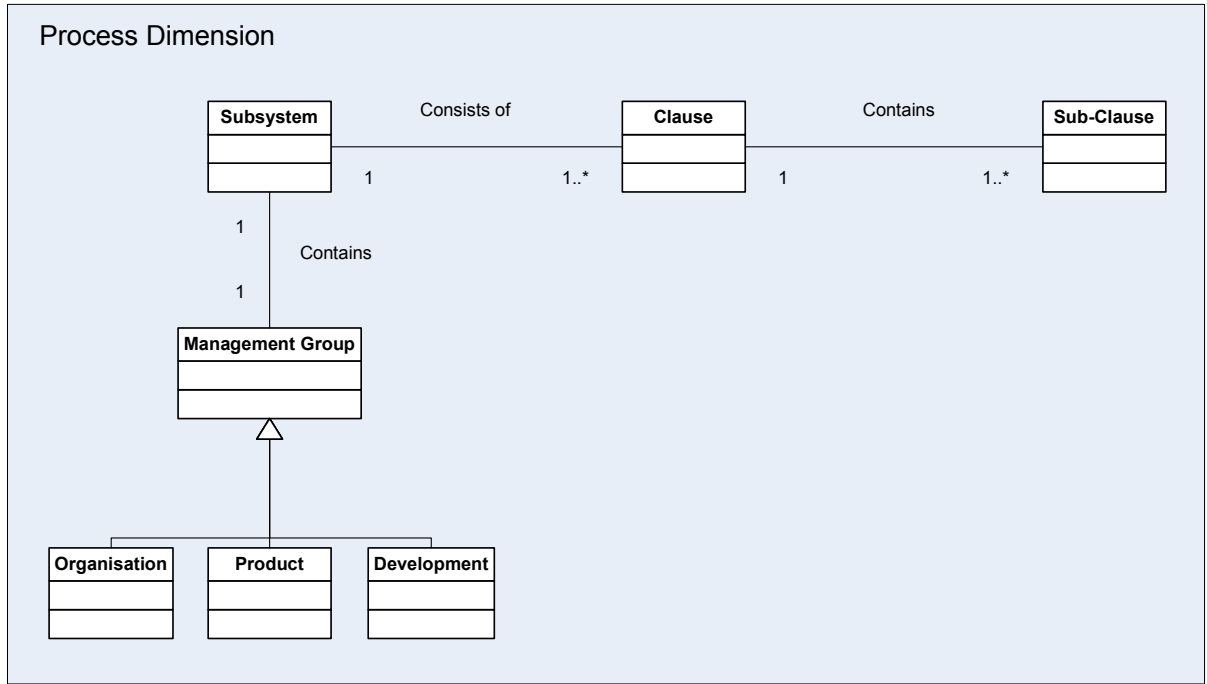
Figure 28.   CLASS DIAGRAM FOR ISO 9001 PROCESS MODEL

10.6   BOOTSTRAP Process Model Class Diagram
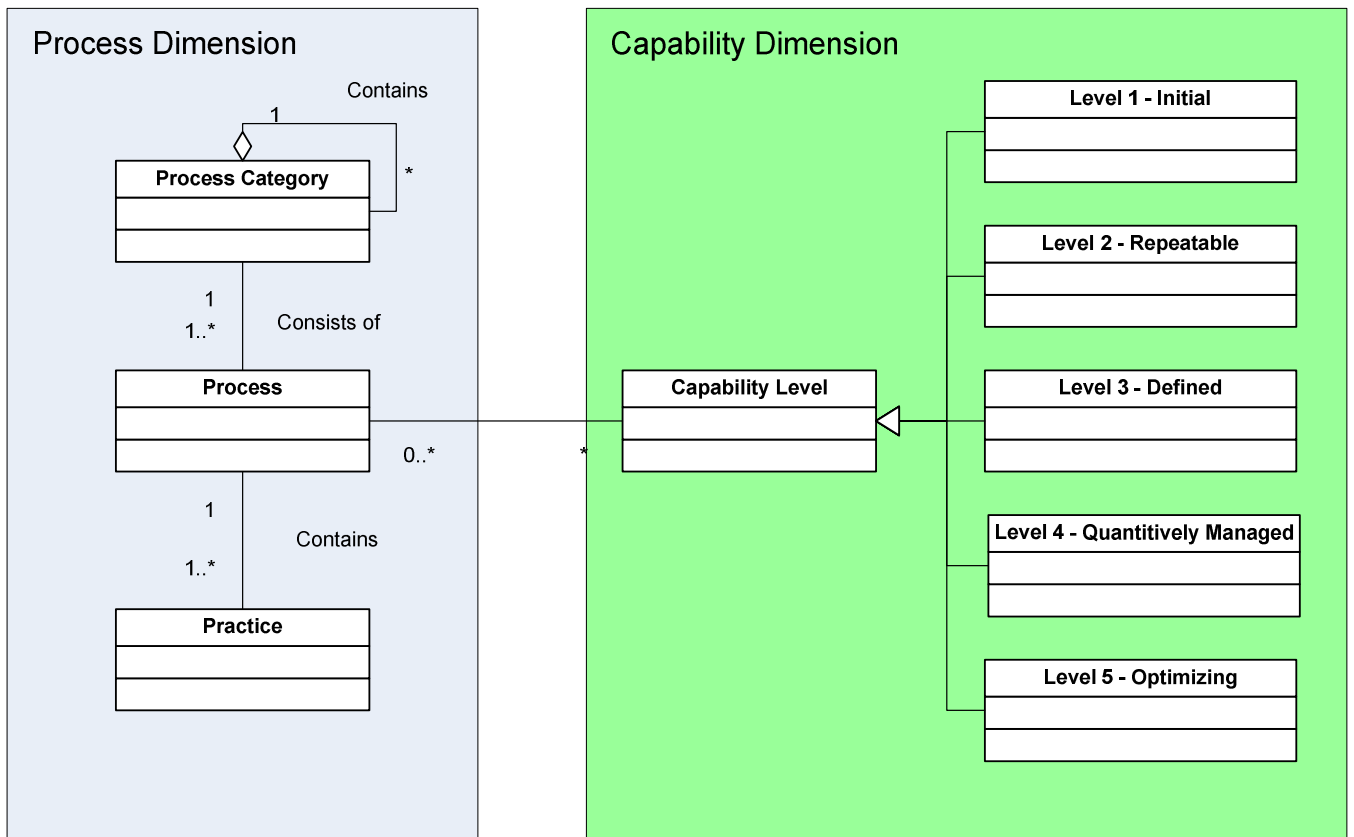
Figure 29. CLASS DIAGRAM FOR BOOTSTRAP PROCESS MODEL

The BOOTSTRAP class diagram depicts a relatively straightforward structure in that we can directly observe the fact that it represents a subset of the ISO/IEC 15504 class diagram. Therefore, the BOOTSTRAP model can be directly contained within data entities designed for the ISO/IEC 15504 reference model (i.e. ISO/IEC 12207).

10.7   Assessment Model Class Diagram (ISO/IEC 15504)
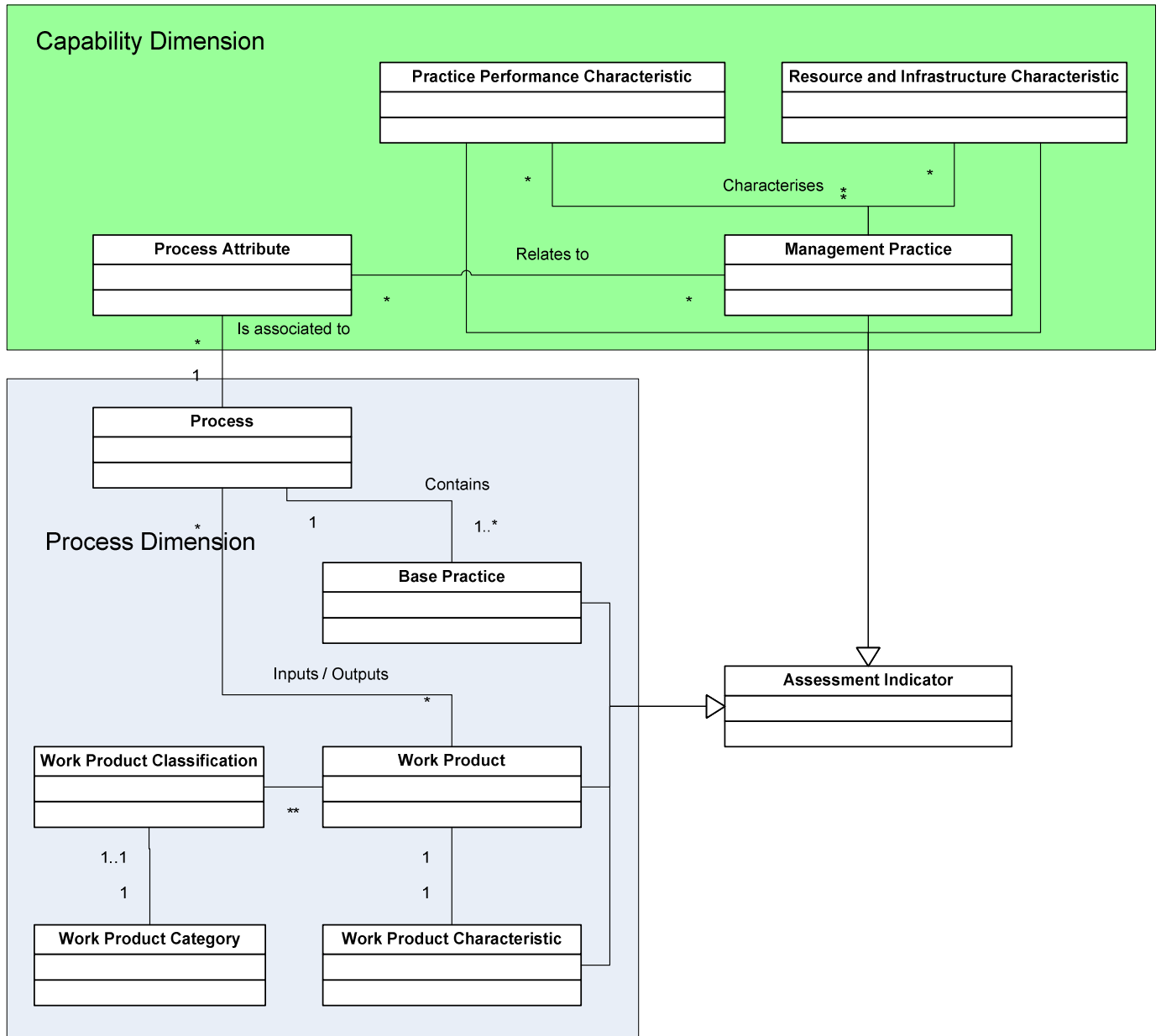
Figure 30. CLASS DIAGRAM FOR ASSESSMENT MODEL

The Assessment Model Class Diagram is representative of the ISO/IEC 15504 Assessment Model given in Part 5 of the standard. The ISO/IEC 15504 model will be used as the basis of an assessment structure to be implemented for all the process models, due to the following reasons:

1. The ISO/IEC is the most recent international assessment standard. In most cases, we will want to output results in this structure when converting assessment data from other models.

2. It is the most comprehensive and detailed assessment structure out of the primary process models. The ISO/IEC 15504 classes or entities tend to 'superset' the assessment requirements of the other process models.

3. The ISO/IEC 15504 standard has stated requirements for compatibility of the reference model.

10.8 Summary

The class diagrams indicate that if one creates a database structure designed for the storage of ISO/IEC 15504 process data models and assessment data models, the structure would also be able to store the data models of the ISO 9001, CMM and BOOTSTRAP as well.

This exercise is performed in the following chapter, Assessment Tool Data Interchange Specification. The goal in the chapter is to design the logical database schema for the universal process model and measurement framework, with implementation detail to the database field names and data types. By its very nature, the design of this multi-compatible database will serve as a blueprint for an assessment tool data interchange specification document.

11 Assessment Tool Data Interchange Specification

11.1 Introduction

In the previous chapter, the analysis of the class diagrams led one to surmise that by creating a data schema based on the ISO/IEC 15504 process model, it is possible to create a 'universal' database structure that would be able to store the process model and assessment model data of the other process models (i.e. CMM, ISO 9001 and BOOTSTRAP) as well.

It is important to observe that this data structure would also allow assessment tools to have the inherent capability (providing that the administration functionality is implemented) for letting organisations tailor and store their own compatible process reference models.

Such a universal process assessment data structure would form the foundation for the creation of mappings between any two selected process models. Given the four process models, a combination of six process model mappings should be established to enable the universal translation of assessment data across all of these models:

1. ISO/IEC 15504 to CMM (and vice versa)

2. ISO/IEC 15504 to ISO 9001 (and vice versa)

3. ISO/IEC 15504 to BOOTSTRAP (and vice versa)

4. CMM to ISO 9001 (and vice versa)

5. CMM to BOOTSTRAP (and vice versa)

6. ISO 9001 to BOOTSTRAP (and vice versa)

11.1.1 Research Method

In this exercise we will create the data structure described above, with the purpose of it serving as a data interchange specification that would allow one or more tools to exchange (i.e. import and export) data between themselves from any of the primary process models.

The benefits of the specification would potentially allow the following features to be implemented within an assessment tool:

1. A tool could save (export) an assessment project onto disk and transfer (import) it into the database of the same tool on another computer.

2. A tool could save (export) an assessment project onto disk and upload (import) it into another tool product (released by a different vendor) that complied to the data interchange specification.

3. A tool designed to process and manage data on one process model (say, a CMM assessment tool) could save (export) a CMM assessment project onto disk and migrate (import) it into another tool product designed to process and manage data on a different process model (say, and ISO/IEC 15504 assessment tool).

11.2 Process Model and Tool Database Design

The design of the universal process assessment database is organised into three data categories, which will allow us to perform the various functional operations on any of the four selected process models:

11.2.1 Project Management Data

This is descriptive data about the assessment project – the assessment input and output, process instance description and assessor data, etc. The tool is designed to manage multiple Projects, each with their own set of (customisable) Process Reference Models.

Within each project, one or more Process Instances may be stored, which are assessments that are measured and compared against the same set of Process Reference Models and assessment framework.

11.2.2 Process Model and Assessment Data

This is the data that makes up the process reference model. It should be stored in a flexible structure that will allow any of the selected process models to be captured.

By using the same data structures, we can derive the tables that will store the data captured from performing the assessment (i.e. the performance ratings of processes and practices)

11.2.3 System Data

This data is not pertinent to an assessment, but is required for the operation and maintenance of the assessment tool. This includes the storage of settings data to make tools more user-friendly, registration data, operating system data, etc.

11.3 Structural Process Model Design

11.3.1 Database Objects

These are the types of programmable objects that will be used for implementing the universal process assessment database model interface:

No	Object Type	Description	Implementation
	Table	Storage of project, model and assessment data	Mandatory
	Indexes	Table indexes are optimized to allow fast retrieval of data from tables, depending on the search fields used in queries	Required - according to query optimization
	Triggers	Used to enforce business rules and foreign-key relations on data entered into tables	Optional - according to requirements
	Stored Procedures	Similar to functions, used to implement business logic on the server for optimal processing	Optional - according to requirements

Table 32. PROGRAMMABLE DATABASE OBJECTS

11.3.2 Table Data Types

The following list describes the categories of tables to be implemented in a universal process assessment database. The name of each table will be prefixed by a three-letter code denoting the type of data stored:

No	Table Data Type	Description	Table Prefix Naming Convention
	Project / Assessment Data	These tables contain the user's project assesment data, including details on the process instances	prj_
	Assessment Model Data	These tables contain the framework data of the ISO / IEC assessment model, as well as other assessment compatible (e.g. ISO / IEC 12207; CMM; Trillium; ISO 9000; Bootstrap)	mdl_
	Mapping / Link Data	These tables provide record relationship mapping within the model, and the links to map between the records of different assessment models (e.g. ISO / IEC 12207; CMM; Trillium; ISO 9000; Bootstrap)	map_
	System tables	System tables may be required for implementation of the system - e.g. registration table; configuration settings table; etc.	sys_

Table 33. DATA TYPES FOR DATABASE TABLES

11.3.3 Database Tables List

These are the tables that are required to host assessment data in a GUI tool:

No	Table Name	Description	Table Data Type
	prj_project	Project details and information	Project Data
	prj_process_instance	Process Instance details and information	Project Data
	prj_process	Process Dimension assessment data	Project Data
	prj_capability	Capability Dimension assessment data	Project Data

prj_process_wp	Process work products assessment data	Project Data
mdl_process	ISO/IEC 15504 Process Dimension	Model Data
mdl_capability	ISO/IEC 15504 Capability Dimension	Model Data
mdl_work_products	ISO/IEC 15504 Process Work Products	Model Data
map_process_wp	Mapped links from processes to work products	Mapping Data

Table 34.   SET OF EXAMPLE DATABASE TABLES

11.4   Project Data Tables

11.4.1   Project Table (prj_project)

This table stores the details for a project record. The fundamental fields are a unique ID field, and the name of the project. Additional fields (e.g. organisation, project creation date, etc.) may be added at the tool developer's discretion onto a table joined to this one by the project_id field. A project typically is created for a company or organisation and is used to contain assessments performed on processes used by the same entity. Each project will also contain its own copy of the software process model framework, which can be tailorable to a unique but compliant version.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Name	Varchar(255)		N	

Table 35.   DATABASE TABLE LAYOUT FOR PROJECT RECORD

11.4.2   Process Instance Table (prj_process_instance)

This table stores the details of process instance assessments. There may be one or more process instances in a project, each representing a performed assessment. As with the project table, additional information (which may be unique to the developer's particular tool) can be added to another foreign key table joined to this one on the primary key fields.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key

	Project_ID	Integer		N	Y
	Process_Instance_ID	Integer		N	Y
	Name	Varchar(255)		N	

<p align="center">**Table 36.** DATABASE TABLE LAYOUT FOR PROCESS INSTANCE</p>

11.4.3 Process Model Reference Table (prj_process_model)

This table stores the unique reference details of the process models – which in the case of the primary process models include the ISO/IEC 15504, CMM, ISO 9001 and BOOTSTRAP. The assessment tool may potentially allow the user to add in additional compatible process models, or allow the user to create one from scratch.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_ID	Integer		N	Y
	Name	Varchar(255)		N	

<p align="center">**Table 37.** DATABASE TABLE LAYOUT FOR PROCESS MODEL REFERENCE RECORD</p>

11.5 Process Model Data Tables

As discussed in the previous chapter, the design model of the universal process assessment database will be structured based on the ISO/IEC 15504 process model as a 'superset' database. If structured correctly, the design should allow the assessment tool to store data for any of the other primary process models.

11.5.1 Process Model Process Dimension Table (mdl_process)

This table is designed to store all the records that make up the Process Dimension for any of the process reference models - with a separate copy per project to allow for modification and customization. Typically the project ID with a value of 0 is reserved to keep a template copy of the records of the baseline process reference model. All other projects are created with a copy of this model, and can be customised through modification.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	integer		N	Y

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Model_ID	integer		N	Y
	SubSystem_ID	integer		N	Y
	Category_ID	integer		N	Y
	Process_ID	integer		N	Y
	Practice_ID	integer		N	Y
	Reference	char(10)		N	
	Name	varchar(255)		N	
	Description	text			

Table 38. DATABASE TABLE LAYOUT FOR PROCESS DIMENSION RECORD

11.5.2 Process Model Capability Dimension Table (mdl_capability)

This table is designed to store all the records that make up the Capability Dimension for any of the process reference models - with a separate copy per project to allow for modification and customization. Typically the project ID with a value of 0 is reserved to keep a template copy of the records of the baseline process reference model. All other projects are created with a copy of this model, and can be customised through modification.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	integer		N	Y
	Model_ID	integer		N	Y
	System_ID	integer		N	Y
	SubSystem_ID	integer		N	Y
	Category_ID	integer		N	Y
	Process_ID	integer		N	Y
	Practice_ID	integer		N	Y
	Optimization_ID	integer		N	Y
	Reference	char(20)		N	
	Name	Varchar(255)		N	

				Y	
	Description	Text		Y	
	Indicators	Text		Y	

Table 39.   **DATABASE TABLE LAYOUT FOR CAPABILITY DIMENSION RECORD**

11.5.3   Process Model Work Products Table (mdl_work_products)

This table stores the list of work products – primarily catering for the ISO/IEC 15504 process reference model:

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_ID	Integer		N	Y
	System_ID	Integer		N	Y
	Work_Product_ID	Integer		N	Y
	Name	varchar(255)		N	
	Description	Text		Y	

Table 40.   **DATABASE TABLE LAYOUT FOR WORK PRODUCT RECORD**

11.5.4   Work Products Process Association Table (mdl_process_wp_link)

This table stores the mappings of input and output work products to processes, primarily catering for the ISO/IEC 15504 software process model. In the 'IO' flag field, an 'I' indicates that a record represents an input work product, and that 'O' is for an output work product.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_ID	Integer		N	Y
	System_ID	Integer		N	Y
	SubSystem_ID	Integer		N	Y
	Category_ID	Integer		N	Y
	Process_ID	Integer		N	Y

	Practice_ID	Integer		N	Y
	Work_Product_ID	Integer		N	Y
	Io	char(1)		N	Y

Database Table Layout for Work Products Process Association Record

11.6 Assessment Model Data Tables

11.6.1 Assessment Model Hierarchy

The following list categorises the types of ratings for each hierarchy level in the process model:

No	Hierarchy Level	Required Rating	Rating Type
	Processes	Mandatory	Capability Level (0 – 5 levels)
	Base Practices	Mandatory	Achievement (Fully, Largely, Partially , None)
	Work Products	Optional	Achievement (Fully, Largely, Partially , None)
	Capability Levels	Mandatory	0 - 5 Levels, based on the Process Attribute table of Achievement Ratings
	Process Attributes	Mandatory	Achievement (Fully, Largely, Partially , None)
	Management Practices	Mandatory	Achievement (Fully, Largely, Partially , None)

Table 41.   DATABASE TABLE LAYOUT FOR WORK PRODUCTS PROCESS ASSOCIATION RECORD

11.6.2 Achievement Ratings

The achievement ratings are stored in the following format in tables:

Achievement Rating	Stored Data	Notes
Unknown	-1	Not used for aggregation
None	0	0% Achievement
Partially	1	33% Achievement

Largely	2	66% Achievement
Fully	3	100% Achievement

Table 42.   DATABASE TABLE LAYOUT FOR ACHIEVEMENT RATINGS RECORD

11.6.3 Process Assessment Table (prj_process)

This tables stores assessment data for records in the Process dimension, and joins to the mdl_process table on the primary key. The 'achievement' field stores assessed ratings, and the 'warning' field serves as a marker on the record during assessment. The 'notes' field will carry a comment.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_ID	Integer		N	Y
	System_ID	Integer		N	Y
	SubSystem_ID	Integer		N	Y
	Category_ID	Integer		N	Y
	Process_ID	Integer		N	Y
	Practice_ID	integer		N	Y
	Process_Instance_ID	Integer		N	Y
	Rating	integer		N	
	Warning	char(1)		Y	
	Notes	Text		Y	

Table 43.   DATABASE TABLE LAYOUT FOR PROCESS ASSESSMENT RECORD

11.6.4 Capability Assessment Table (prj_capability)

This tables stores assessment data for records in the Capability Dimension, and joins to the mdl_capability table on the primary key. The 'achievement' field stores assessed ratings – for achievement and capability rating scales - and the 'warning' field serves as a marker on the record during assessment. The 'notes' field will carry a comment, and the 'evidence' field is for entering the source, location or description of proof of the record's assessment rating.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_ID	Integer		N	Y
	System_ID	Integer		N	Y
	SubSystem_ID	Integer		N	Y
	Category_ID	Integer		N	Y
	Process_ID	Integer		N	Y
	Practice_ID	Integer		N	Y
	Optimization_ID	Integer		N	Y
	Process_Instance_ID	Integer		N	Y
	Rating	Integer		N	
	Warning	Char(1)		N	
	Notes	Text		Y	
	Evidence	Text		Y	

Table 44. DATABASE TABLE LAYOUT FOR CAPABILITY DIMENSION RECORDS

11.6.5 Process Work Products Assessment Table (prj_process_wp)

This table stores the assessment records with the mappings to the work products that belong to the Process Dimension on the process level. A unique work product is defined for an input and an output work product using the IO field, and is assessed using the 'achievement' field. A field for entering in the source location of the evidence for the rating is provided.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_ID	Integer		N	Y
	System_ID	Integer		N	Y
	SubSystem_ID	Integer		N	Y

	Category_ID	Integer		N	Y
	Process_ID	Integer		N	Y
	Practice_ID	Integer		N	Y
	Process_Instance_ID	Integer		N	Y
	Work_Product_ID	integer		N	Y
	IO	char(1)		N	Y
	Achievement	integer		N	
	Evidence	Text		Y	
	Notes	Text		Y	

Table 45.   **DATABASE TABLE LAYOUT FOR WORK PRODUCTS ASSESSMENT RECORD**

11.7   Process Model Mapping Data Tables

In the beginning of the chapter, the permutation of six potential process model mappings was discussed as the basis for the creation of a universal process assessment tool, based on the design of the database being able to store each of the four selected process models.

Note that a mapping created between two process models would have to translate data in both directions (e.g. CMM to ISO/IEC 15504 direction and ISO/IEC 15504 to CMM direction) in order for the data conversions to occur from both sides. This means twelve data translation algorithms would have to be created for the universal mappings to be complete.

11.7.1   Process Dimension Mapping Table (mdl_map_process)

This table is designed to store the translation data between the Process Dimension of two process models. The records are simply made up of the unique identifiers from the record set of the two process models. The direction of the translation would be from Model A to Model B.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_A_ID	Integer		N	Y
	SubSystem_A _ID	Integer		N	Y
	Category_A _ID	Integer		N	Y

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Process_A _ID	Integer		N	Y
	Practice_A _ID	Integer		N	Y
	Model_B_ID	Integer		N	Y
	SubSystem_B _ID	Integer		N	Y
	Category_B _ID	Integer		N	Y
	Process_B _ID	Integer		N	Y
	Practice_B _ID	Integer		N	Y

Table 46. DATABASE TABLE LAYOUT FOR PROCESS DIMENSION MAPPING RECORD

11.7.2 Capability Dimension Mapping Table (mdl_map_capability)

This table is designed to store the translation data between the Capability Dimension of two process models. The records are simply made up of the unique identifiers from the record set of the two process models. The direction of the translation is from Model A to Model B.

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_A_ID	Integer		N	Y
	System_A _ID	Integer		N	Y
	SubSystem_A _ID	Integer		N	Y
	Category_A _ID	Integer		N	Y
	Process_A _ID	Integer		N	Y
	Practice_A _ID	Integer		N	Y
	Optimization_A _ID	Integer		N	Y
	Model_B_ID	Integer		N	Y
	System_B _ID	Integer		N	Y
	SubSystem_B _ID	Integer		N	Y
	Category_B _ID	integer		N	Y

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Process_B _ID	integer		N	Y
	Practice_B _ID	integer		N	Y
	Optimization_B _ID	Integer		N	Y

Table 47.   DATABASE TABLE LAYOUT FOR CAPABILITY DIMENSION MAPPING RECORD

11.7.3 Process Model Work Products Table (mdl_work_products)

This table stores the mapping of Work Products between models:

Col. No	Field Name	Field Type	Default Value	Nulls Allowed	Primary Key
	Project_ID	Integer		N	Y
	Model_A_ID	Integer		N	Y
	System_A_ID	Integer		N	Y
	Work_Product_A_ID	Integer		N	Y
	Model_B_ID	Integer		N	Y
	System_B_ID	Integer		N	Y
	Work_Product_B_ID	Integer		N	Y

Table 48.   DATABASE TABLE LAYOUT FOR PROCESS MODEL WORK PRODUCT RECORD

12   Methodology for Automated Data Mapping

12.1   Introduction

This chapter rationalises the work and insights of the preceding sections to develop a procedural methodology for the creation of mappings between process models, and the automation of the data translation process.

It also outlines the key factors for determining the viability of a mapping between two given process models. This is based on the analysis results of the previous two sections where process model mappings are created by inspection, and via an intermediate model.

12.2   Outline of the Methodology

The following high-level procedure outlines the procedural steps for creating and establishing an automated mapping between process models with an assessment tool:

1. Establish the basic model compatibility

2. Examine the supplementary compatibility issues

3. Determine the structural level of mapping

4. Create class diagrams for database table fitting

5. Fit the process models to the database system

6. Populate the database with the process models data

7. Perform systematic bidirectional mapping between the two models

8. Perform verification and validation of the mapping

9. Establish the level of automated translation for the assessment tool

12.3   Establish Basic Model Compatibility

The ISO/IEC 15504-2 document provides a Process Reference Model in the form of ISO/IEC 12207, for process assessment. The reference model identifies critical attributes that each process should have to be considered complete and effective, but without unduly constraining the implementation of the process.

Assessment models may be built so that they address the unique needs of an industry sector or organisation by addressing the requirements for compatibility contained in clause 7 of ISO/IEC 15504-2. Compatible models may be developed by organisations for their own internal use; by acquirers of software systems for use in specific acquisition situations; or by professional organisations defining requirements for specific application domains or use situations.

The requirements for constructing such compatible models are set out in ISO/IEC 15504-2:

1. There must be a clear and unambiguous mapping from the elements in a compatible model to the basic elements of the Reference model i.e. the Processes and Process Attributes.

2. The compatible model must contain a set of indicators of process performance and Capability.

3. Finally, there must be a mechanism for translating the results of assessments performed with the compatible process model to the form defined in ISO/IEC 15504-2.

In the case where one of the process models being mapped to or mapped from is the ISO/IEC 15504, it is obvious that compatibility is inherent. However, for the mapping of two process models (for example ISO 9001 to BOOTSTRAP) to occur, the user can utilise the strategy of using the ISO/IEC 15504 process model as an intermediate model, the technique being described in the previous chapter: Mapping Process Models via An Intermediate Model

12.4 Examine Supplementary Compatibility Issues

Once basic compatibility is established between the two process models, one has to consider and examine the alternate factors in each model that may adversely affect the overall compatibilities and viability of the mapping (i.e. "Showstoppers").

Amongst other factors, the unique characteristics and fundamental purpose of each process assessment standard has to be investigated and compared in an objective manner, as illustrated with the CMM and ISO 9001 mapping in the earlier case study.

The gap in detail between the process records of the two standards will determine the level of ambiguity in assigning assessment ratings - and therefore the viability of automating the translation process.

12.5 Determine the Structural Level of Mapping

In Chapter 7: Process Model Data Commonalities, we took a look at which structure level mappings could ideally occur between the 4 selected process models. This was done by creating structural correlation tables between the process and capability dimensions of the process models to determine the most significant level for consideration of mapping.

Intuitively, the 'Process' structure level would be the lowest common denominator between all the models, but if there exists a correlation at a lower level (for example the work product level or base practice level) between the two given process models, then the mapping at that level would be of higher accuracy and be less subjective.

12.6 Create Class Diagrams for Database Table Fitting

The class diagram, as described in Chapter 10: Designing a Universal Process Model Database allows us to obtain a working overview of all the entities belonging to a process model that need to be catered for in the mapping process. In the case of the four selected process models, the class diagrams have been created for this purpose in Chapter 10. Class diagrams would have to be created in the case of alternate process models like Trillium, for example.

12.7 Fit the Process Models to the Database System

By looking at the class diagram and visually mapping the entities to the class diagram of the ISO/IEC 15504, we can place each entity in the correct database table field and know if we have to create additional data tables or fields to make allowance for any additional (if not mapped) entities of the alternate process model.

The result would be a single database system that would allow data from both process models to be captured in the same set of data tables. This exercise was performed for the four selected process models in the preceding chapter 11: Assessment Tool Data Interchange Specification.

12.8 Populate the Database with the Process Model Data

This step simply requires that the record data from each process model be captured into the database system created for the mapping, in the appropriate structural levels. However, as straightforward as this task may be, it involves a considerable amount of capturing of data from the two models. Solutions to support this task would be the following:

1. Tailor an existing assessment tool (like the SPIL Assessment Tool) that currently supports the ISO/IEC 15504 data structures to adapt to the schema of the new process model so as to have a dedicated data model capturing and management tool

2. Capture the data on an organised spreadsheet layout on Microsoft Excel. Each worksheet could represent a different data table and the data can be cut and pasted from the appropriate process model documentation. Then it is possible to either link the Excel spreadsheet with database tables via ODBC for exporting, or else to export the data in an XML or .CSV format for import into the database system.

12.9 Perform Systematic Bidirectional Mapping

This exercise requires that the user populate the mapping table via a systematic process of checking each process model record (processes, practices, etc.) against the records of the alternate process Record to obtain a viable association link. Data capturing solutions may follow the same procedures as the above paragraph. An illustration of this exercise was illustrated in Chapter 8: Mapping Process Models by Inspection.

12.10 Perform Verification and Validation of the Mapping

An important and crucial step is to perform the exercises of verification and validation of the newly created mapping by inspection, as also illustrated in Chapter 8. This exercise should be performed as many times as possible with different groups of people that are knowledgeable in the two process models, to factor in experience and differing points of perspective.

12.11 Establish the Level of Automated Translation

The outcome of these verification and validation exercises would also provide indicators as to the level of accuracy of the mapping, and thereby the feasibility of performing an automated translation process.

The guiding principle would be the higher the structural level that the mapping occurs (e.g. process level) the more subjective the mapping and the less definitive the links would be. It follows that the less the feasibility of performing an automated mapping and assessment data translation process on a tool - as a subjective opinion of the assessor who performed the original assessment would be required for a level of accuracy.

However, the lower the structural level that the mapping is made at (for example, the work product level) the more tangible the artefacts or practices are and the more definitive the links become. Automated processes for translation is then a matter of an algorithm taking the assessment ratings from one model and converting it to the equivalent rating on the other model, and storing it. The resulting dataset is a converted process instance assessment.

13 Process Assessment Tool Design

13.1 Introduction

In this chapter we discuss the basic requirements for a high-level outline of a functional design for the implementation of a software application that will allow a user to perform software process assessments. The analysis and findings of the previous chapters in terms of the requirements for a universal process and assessment model data store will be consolidated into the design and planning of the automated process assessment tool.

13.1.1 Research Method

The software development experience of the author Richard Him Lok forms a foundation for these design concepts, in that he was responsible for the implementation of the SPIL Assessment Tool (SPILAT), an automated assessment tool that allows users to perform process assessments on both the ISO/IEC 15504 and the ISO 9001 process models.

Insights into some of the fundamental design decisions made on the development cycles of the tool are discussed in this chapter. Building on top of this design foundation, certain concepts for the enhancement of functionality are described herein can be considered as a requirements basis for the implementation of the next assessment tool release.

13.2 Choice of Rapid Design and Development Platform

The initial version of the SPILAT process assessment tool was developed in 1995 as part of a University Masters in Engineering project that was based on the formation of the new SPICE standard - that which would eventually be known as the ISO/IEC 15504 standard. From the first 0.10 release of the software product, the evolution of the tool has had to keep apace with the many revisions and structural changes of the ISO/IEC 15504 standard, right up to its current Technical Release edition.

In the early period of formation of the standard, not only would the processes and their details change, but major structural changes to the process model itself would occur in the annual releases - effecting the requirement for a database redesign on the tool in each instance.

To adapt and evolve with these constant foundational modifications, a flexible Rapid Application Development (RAD) tool for both the application and database had to be used in order to implement the latest changes efficiently. A new version of the tool was being released over the Internet and the local assessor community once every few months.

Such a development platform would have to be carefully selected to meet the challenge of this 'constant change' and 'moving goalposts' requirement, since statistically the initial choice of the implementation tool dictates the set platform for the rest of the product life in over 90% of cases. From the prevalent Microsoft Windows tools available at that time (Visual Basic 3.0; Visual C/C++ 1.0; Borland C/C++ 1.0; Delphi 1.0) the tool that was chosen (and still is used to date with the most recent release) was the Powerbuilder 3.0 Client-Server development platform. This was due to the following reasons that set it apart from the others:

1. The platform was designed as a client-server development tool, which meant that it abstracted the database business logic from the application and presentation logic.

2. The platform was also designed as a 4GL rapid application development (RAD) tool, allowing users to "drag and drop" windows to quickly create applications and configure the object properties to provide easy access to functionality.

3. The Powerscript programming language was simple and straightforward to use, on a par with Visual Basic. The applications windows and objects were also event-driven.

4. The tool supplied it's own powerful database (at that time Watcom database, now known as Sybase SQL Anywhere) that was fully relational with enterprise-level SQL object scripting, stored procedures, etc. It also had a small disk footprint with a single database file (as opposed to multiple files for each table on Dbase databases which were popular in the time) and was the fastest optimised desktop database at the time.

5. The entities of the tool (windows, menus, controls, etc.) was object-oriented and allowed for inheritance of objects. This was a concept feature that was ahead of its time at that point.

6. The Powerbuilder DataWindow was the most powerful and flexible – yet simple to use - data integration and display object at the time of development. To date there still is no single control available that matches the DataWindow for functionality in terms of rapid development for data query presentation capabilities. This component is used extensively throughout the application for reporting and screen data layouts.

The resulting effect of the Powerbuilder data management and presentation technology combined with the ease of use meant that the developer could focus more time in building the business logic of the application as opposed to having to spend time creating the framework and presentation interface. Changes could be planned for and propagated through the application with ease if a good object-oriented design was in place. Data processing routines were isolated to the area where it was the most optimal place to run the business data logic – at the database instead of the front-end client. This design has carried the application through to the latest version of Powerbuilder, currently on release 9.0.

13.3 Application Framework and Project Data Management

The base application framework from which to create a container for the assessment tool functionality was designed and implemented in an MDI (Multiple Document Interface) Window. This is essentially a Windows application that allows the developer to create and manage multiple sub-windows for assessment data capture and presentation. This Windows client interface has a standard bar menu system which allows the user to access the required functionality. The database server was installed and initialized as a separate sub-application on the desktop, and integrated with the tool for returning database queries and updates.

The application implements a "Project" concept as a container for grouping the following elements together:

1. The base Process Model(s) which are tailorable by the assessor as an ISO/IEC 15504 conformant model towards an organisation's unique software processes.

2. One or more Process Instances, which represent the assessments performed by the user.

3. The details of the project which include the client organisation's details as well as the description and scope of the assessments conducted

4. The details of the assessor(s) conducting the assessments as a requirement for the ISO/IEC 15504 standard.

Figure 31. SPIL ASSESSMENT TOOL: PROCESS INSTANCE ASSESSMENT DETAILS

The project grouping also allows the application to save (i.e. export) a project or a process instance as a CSV (Comma-Separated Values) file to load (import) onto another copy of the tool application, or another compatible application (see section on Data Interchange Specification).

A project corresponds to a single ISO/IEC 15504 process model instance or a conformant version of the model. A project is created or selected and opened during an assessment session. All process instances and assessment operations would be relative to the project.

The tool documentation includes a User Reference Manual and a Software Assessment Methodology (i.e. guidance on performing an ISO/IEC 15504 assessment specifically using the SPILAT assessment tool)

13.4 Process Model Management

The implementation of the Universal Process Model Database structure allowed the user to access the editing of the process and capability records of the ISO/IEC 15504 process model. This was an application feature which was not present in any of the other process assessment tools at the time of inception. The aim of providing the functionality was to allow an assessor or organisation to build their own process model which was tailored to the client's unique set of processes. Thus an ISO/IEC 15504 conformant process model could easily be created; this allowed an organisation's processes to be assessed and compared within its own context.
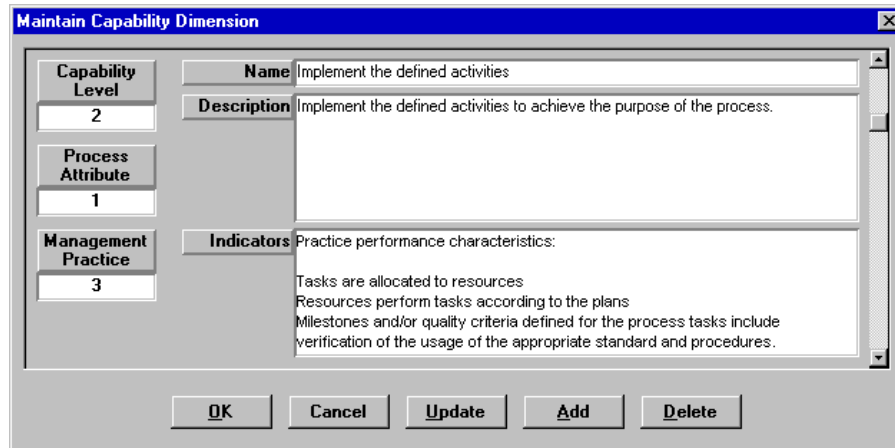
Figure 32. SPIL ASSESSMENT TOOL: MAINTAINING CAPABILITY DIMENSION RECORDS

A process model version can also be exported and imported on a project as a set of CSV files for distribution between assessors working on an organisation's processes.

In later releases of the SPILAT tool, additional process models were added onto the database structure in the form of:

1. The ISO 9001 process model

2. The SABS Audit Checklist (ACL) for ISO 9001

The ACL allowed the ISO/IEC 15504 process reference model to be mapped to the ISO 9001 model and thereby gave the assessment tool the ability to translate assessment data from the one model to the other.

Additional process models (e.g. CMM, BOOTSTRAP) with corresponding mappings could similarly be added to the tool in future releases.

13.5 Assessment Model Management

The window screens for capturing the assessment data were designed to allow the assessor to easily navigate through the process model records, reference the descriptive detail (reference numbers, descriptions, etc.) and associated artefacts (work products, etc.) of the process or practice - and capture the assessment results by selecting the appropriate Achievement Rating.
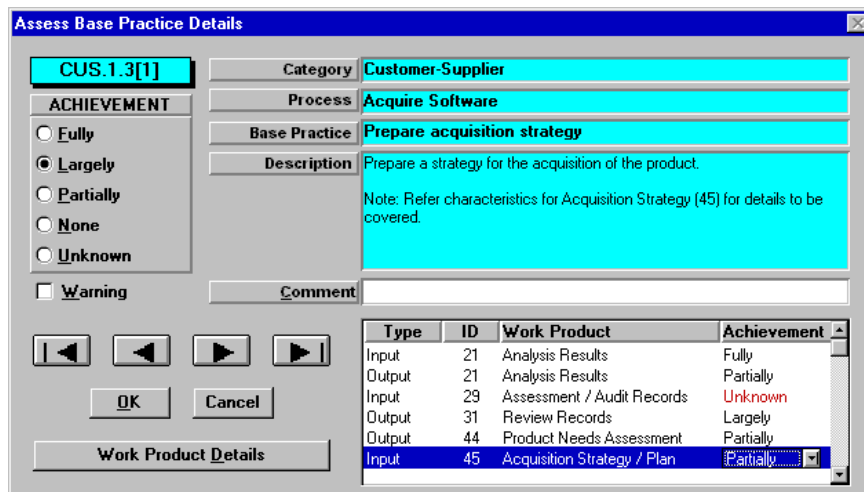
Figure 33. SPIL ASSESSMENT TOOL: ASSESSING PROCESSES

The procedure of capturing assessment data works in the manner that the assessor is to complete one Process Category at a time. The assessor could also choose to limit the scope of a project assessment to a selected number of Process Categories.

13.6 Assessment Data Presentation and Reporting

The aggregation of the assessment data to create the achievement result profiles is calculated during when a report is selected. When a report is selected, the user is allowed to choose the presentation format (bar chart; line charts; etc.) for the graphical reports. This enables the tool to responsively and efficiently generate reports 'on the fly'.

The MDI interface allows multiple report windows to be opened concurrently, and allows the user to perform visual comparisons between Process Instances. Extensive use of Powerbuilder's DataWindow control was used to present the assessment results in a variety of report formats and layouts. These could be printed out or directly displayed on an overhead projection unit for presentations.
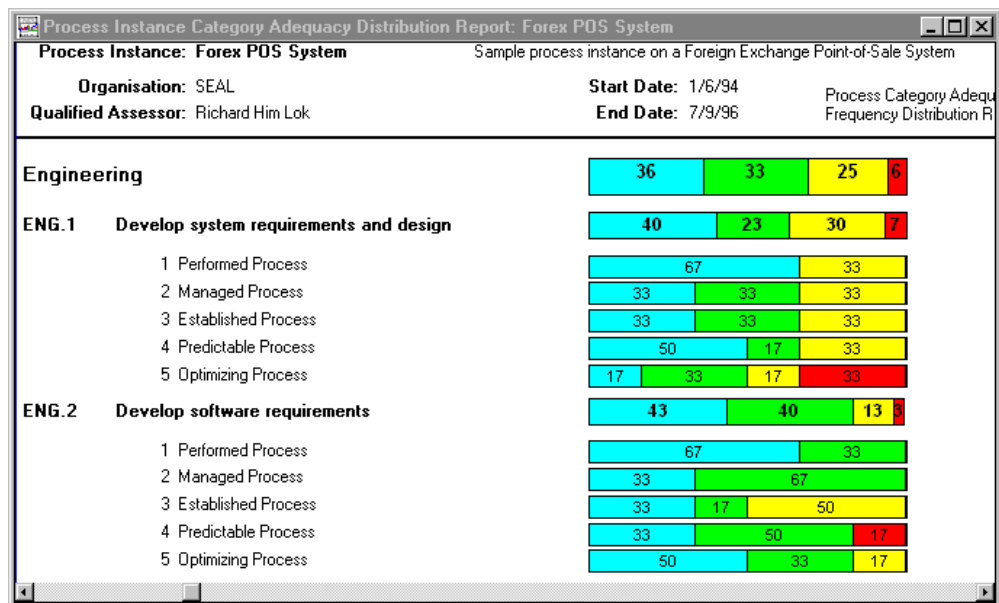
Figure 34. SPIL ASSESSMENT TOOL: ASSESSMENT REPORTS

13.7 Software Distribution

As with any software product, the effectiveness of the vendor's global distribution processes are crucial to the success of the assessment tool in terms of reach and accessibility. The initial strategy for the SEAL organisation was to distribute the assessment tool as a 'free' software application offering to gain initial acceptance in the global assessor community. For this, the solution was to implement the tool with a default Shareware mode, so that the tool could be freely distributed over the Internet via an interactive website.

The tool would initially be installed in a Shareware mode by the user with limited functionality until such time as the user obtained a key via an online registration process. This allowed the SEAL organisation to track and manage the user base, while allowing assessors to freely distribute the tool amongst themselves without any licensing restrictions.

Figure 35. SPIL ASSESSMENT TOOL: SHAREWARE DISTRIBUTION

The logistics of effectively distributing the tool with a Shareware registration process required the SEAL organisation to implement the following tool support structures:-

1. A setup and installation package consisting of 8 x 1.44MB stiffy disks which installed the assessment tool, the database, the database engine and the Powerbuilder application runtime libraries.

2. A SEAL website was implemented where the latest version of the assessment tools (8 file downloads, one for each 1.44MB setup disk) and supporting artefacts could be downloaded from.

3. The shareware-enabling functionality in the tool that would initially install the tool with the restriction of allowing an assessor to perform a limited number of assessment; limitations on printing reports, etc. The tool also had the ability to allow a user to enter in a unique registration key and 'unlock' the rest of the features in the tool. This required the implementation of a data encryption algorithm which would allow a registration key to be generated based on the registering user's name and organisation.

4. A web-based online registration form and database (along with database application management and reporting functionality) was implemented on the website to allow a user to register online and obtain a registration key.

5. A mailing list for the notification of updates and community news to the user base was maintained

6. A support tracking process for managing technical queries submitted by users was put in place.

The fact that the majority of the international software process assessor community (as well as the major clients that conduct their own internal software process assessments) have Internet access

as a facility, this resulted in the most cost-effective and reach-effective solution for the distribution of the SPILAT assessment tool.

13.8 Enhancing the Function Set

13.8.1 Motivation for Enhancement

The SPIL Assessment Tool has had numerous revisions and enhancements over the years. It was found that the motivating reasons for enhancements implemented between releases can be attributed to the following reasons:

1. New suggestions and ideas for improved functionality – the improvement cycle of the assessment tool includes constant review and feedback by the developer as well as the user community. New ideas generated by the developer or from requests and suggestions from current users for new features are usually motivated by the requirement to perform a necessary task (a new type of report required for a client, additional process model added to the existing tool database, etc) that is currently not available on the tool.

2. Enhancing existing functionality – the greatest number of self-affected suggestions originated from frequent internal reviews of the existing features for improvement. Such ideas stem from personal working experience, for functional requirements to perform operations quicker and smarter (display a report in a certain manner, calculate or aggregate results in a different way, etc.)

3. Changes to the assessment standard – whether it was process content (i.e. detail of processes and practices) or structural changes, a new release of the standard with modifications to the underlying standard's documentation set would necessitate an update of the assessment tool in each instance. The greatest impact of changes to an assessment tool would occur if the process model underwent structural changes (such as Management Practices being added or removed from the model, etc.)

4. New functionality in the development platform – a new release of the development environment with new features and functions would frequently create the potential for new enhancements (new visual screen components, improved objects for greater efficiency, etc.) in the tool. The developer would have to purchase an upgrade of the development tool in order to access the new functionality and perform basic testing.

13.8.2 Future Enhancements

The new features of the latest version 10.0 release of the Powerbuilder platform bring the following new enhancements potential to the SPILAT assessment tool. These features have been extracted from the Powerbuilder 10 Sales Datasheet and an analysis of the potential usage has been added as a comment for each:

1. *Unicode support – Business needs are global, and now PowerBuilder makes it simple to build applications for your globally dispersed user base. Unicode support means one row of data in a DataWindow can display characters from different multibyte charactersets! Now there's no need to maintain different language versions of applications for different character set based languages. Write one application that the whole world can see.*

This feature provides the potential to easily convert and present the assessment tool in a different language (French, Chinese), and could give the tool a significant extension in its global reach and distribution. The developer would have to consider the effort of language translation of the assessment tool – including all the manuals and any associated web-based functionality – for the increase in global acceptance and usage of the product.

2. **UDDI** – *Easy to use wizards provide UDDI browsing functionality to locate and consume Web services in traditional PowerBuilder applications as well as JSP pages. And, this UDDI search capability can easily be built into applications PowerBuilder developers build using the UDDI PBNI extension.*

Web services linked to a central assessment data repository for an assessor organisation can be made available on the Internet for assessors in the field to issue requests for an instant assessment results profile comparison or an instant statistical results comparison. For example, an assessment conducted at a client organisation can be compared in the global database with other 'like' assessments performed, based on selected criteria like process model similarity, size of the client organisation, maturity level of the client organisation,

3. **XML Web DataWindow** – *This component has been fine tuned for the Web, greatly enhancing the performance of your data driven Web applications. Using CSS , XSLT, and XML, style, layout and content are all generated separately. This means faster downloads of DataWindow pages and greater efficiency, scalability, extensibility, and accessibility of these standard W3C technologies.*

The XML Web DataWindow primarily affects the assessment tool as regards to performance if it is converted to a web-based application. However, the developer can also consider using XML as the format for the data communications layer of the assessment tool. With XML emerging as the standard for data integration and exchange, the data for an assessment project can be saved (i.e. output) in XML format and loaded into another tool that is compatible with the self-describing XML format.

This is a significant enhancement towards tool compatibility if the 'Universal' process and assessment model database implementation described in the preceding chapter used XML to physically implement its standard tool data interface specification.

4. **PowerDesigner Plug-in for Object Modelling** – *Allows for refactoring PowerBuilder applications for the Web, making it now an easy, drag-and-drop process! No need to worry that the application built with an old version of PowerBuilder needs to go to the Web, even though the developers who wrote have moved on long ago. This feature also enables users to do true Object Oriented programming, implementing best practices into development for more efficient and easier to maintain projects*

This new feature has potentially the biggest impact to the assessment tool. Since internet access is fairly ubiquitous nowadays, the idea of creating a web-based assessment tool that is always available over the Internet with the latest updates and features is an enticing prospect. Assessors can be constantly linked to a central assessment data repository for global assessment profiles comparisons and statistical assessment data comparisons.

5. ***ADO.NET*** *– The ADO.NET database interface enables PowerBuilder applications to use ADO.net just like they use OLE DB or ODBC to connect to various databases, and perform database and table operations.*

   The new ADO.NET functionality is the latest and most efficient means of implementing a database connection in the Microsoft.NET framework. The new connection type should be implemented throughout the application code as a matter of course in order for the assessment tool to operate optimally on the new Windows XP and Windows 2003 Professional and Server platforms.

6. ***MobiLink*** *– Built-in support of iAnywhere's MobiLink technology means that you can easily build PowerBuilder applications for mobile users. When you build data synchronization into your applications, laptop users will always have up-to-date data, whether they're online or occasionally connected.*

   The new data synchronization feature means that the developer can explore the potential of creating centralized assessment data repositories for software assessor organisations and clients. Assessors working 'offline' on mobile notebooks can upload assessment data for storage, statistics and 'global' profile comparisons with the new synchronization features. It also allows assessors to maintain a single set of process models centrally, and allow for easy and regular data distribution to assessors in the field.

13.9   SPIL Assessment Tool Development History

The automated assessment tool described in this chapter was originally designed and developed by Richard Him Lok (the author) for the Software Engineering Applications Laboratory (SEAL) during his Masters tenure (QMS project code: 1995-14 RHL) in 1995 at the University of the Witwatersrand, South Africa. The Masters dissertation entitled 'An investigation into South African software quality management practices' was supervised by Prof. Alastair Walker, and led to his the involvement of the SPICE process model framework - which was at its developmental infancy at that point in time – before it became the ISO/IEC 15504 standard.

The work with the SPICE standard initially involved manually intensive exercises performing process assessments using paper-based tools and Microsoft Word and Excel spreadsheets to capture large amounts of information, and tediously tracking and calculating the assessment results. These exercises led to the inspiration of implementing a software tool that could automate this assessment exercise. At this point in time, Richard Him Lok was a software programmer using the Powerbuilder client-server applications development platform, and the initial version of the application was originated with the purpose of creating a database of the process model with a software application that could computerize the capturing of assessment data to the database, and calculate the ratings against algorithms that automated the measurement framework.

The software went through a number of early releases, with functionality developed by Richard Him Lok to generate reports for presenting assessment data, and to allow a user to customise the process model and save separate projects with multiple process assessments. At its time it was the only tool available that allowed assessors to perform assessments with such functionality. The tool was originally named the SEAL of Quality, and was later named the SPIL (Software Process Improvement Laboratory - founded by Alastair Walker) Assessment Tool. A separate project

(QMS project code: 1996-36 SOQ) was created for the design, specification, planning and quality management of the software.

Richard Him Lok also designed and implemented the database, including the database table structures and stored procedures running on the Sybase SQL Anyware desktop database. The tool was embedded with a Shareware mechanism to limit functionality - which encouraged users to register the software for free and unlock the rest of the functionality - so that SEAL could track the number of users and usage of the tool. The tool also made use of the Internet, and distribution was made by means of e-mail, ftp and via website download.

The tool exists to date and has undergone over 10 years of process model standards updates, and continues to be enhanced and distributed by the SPIL organisation.

14 Conclusion

14.1 Introduction

The research and practical work performed on this thesis has led us to the point where we can ascertain the veracity of the main thesis hypothesis, which can be summarised to the following statements:

1. Data mappings can be created with a repeatable process between the ISO/IEC 15504 process model and process models belonging to other software process assessment standards - given that the other process models are compatible to the ISO/IEC 15504 with the required structural model elements.

2. These data mappings of process models can be automated to apply a translation process for legacy assessment data to the ISO/IEC 15504 Assessment Model

14.1.1 Research Method Summary

The procedural route of the research undertaken in this project can be traced with the following building blocks from the preceding chapters:

1. Three process assessment frameworks (SW-CMM, ISO 9001 and BOOTSTRAP) were selected for their relationship and compatibility to ISO/IEC 15504 (Chapter 6), and therefore to be candidates for tool support and process data mapping and translation.

2. The four process models were structurally profiled so as to provide a base level of understanding the concepts and elements that made up the assessment framework of each process model. (Chapter 2)

3. Building on an understanding of the software process assessment frameworks, we then reviewed all the current assessment tools that were based on the selected process models. This was to understand and compare the makeup of the software applications so as to establish common patterns of functionality within assessment tools. (Chapter 3)

4. From an understanding of the standard functional composition of the assessment tools, their role in the process assessment process was identified and validated by creating UML Use Case diagrams and Use Case Descriptions to 'walk' the assessment process and isolate the points where tool support would enhance the performance of a manual assessment. The common functional benefits of assessment tools that are specific to the assessor was also investigated (Chapters 4 and 5). The pressing requirement for an automated tool which allowed an organisation to translate and cross-assess between process model frameworks was also established.

5. Following on from the mapping case studies, the effects of supplementary factors to a viable mapping was analysed. Besides having the basic compatibility requirement to the ISO/IEC 15504 process having to be in place, additional factors that stem from the inherent nature and purpose of a process model could adversely affect the overall validity of a mapping. (Chapter 6)

6. We then started to build the structural basis for performing mappings between process models. The hierarchical structures of each process model was broken down, analysed

and compared with each other in order to establish the correlations and relationships between them. To assist in conceptualising the structures as data, database tables were drafted for the generic process model in terms of the process and capability dimensions as well as the assessment model (Chapter 7)

7. An analysis on the exercise of process model mapping was undertaken to recognise the types of results that would be forthcoming from the creation of mapping sets. Further, the coverage of data mapping between process models was investigated to understand the limits of effectiveness as regards to the resulting data translation. (Chapter 8)

8. With the contextual knowledge of process model mapping developed, an analysis of two such case studies was detailed as illustrations of the mapping exercise. Integral to the research was the fact that the author was involved in both cases and provided a perspective and insight on the issues regarding the actual creation of a mapping. The two mapping techniques covered were by inspection, and via an intermediate model. (Chapters 8)

9. To prepare the foundation for the realisation of mappings - and therefore process model data storage – an investigation into the physical data store was performed. This was to understand the boundaries of a programmed implementation of the mapping representation as data records and the assessment data translation process. (Chapter 9)

10. With the physical implementation context established, a discussion into the method of construction of 'universal' database that would generically store process model records from each of the primary assessment standards was covered. This led to the creation of UML Class Diagrams to depict the physical data structure and entity relationships of each process model. (Chapter 10)

11. From the rationalisation of the Class Diagrams, the design of the Universal Process and Assessment Model database was drafted. The additional resulting benefit of this generic data model was a specification for assessment data interchange between assessment instruments. (Chapter 11)

12. Using the research and concepts from the preceding chapters, as well as the experience gained in twice performing the mapping exercise, a methodology for the creation and automation of a data mapping between process models was developed. (Chapter 12)

14.2 Creating Process Model Mappings

It has been proven that a practical methodology for the creation and automation of a process model mapping is viable between not only the ISO/IEC 15504, but also other process models. This is possible when a certain level of compatibility with the data structures and the process elements of each structural level are established between a set of process models.

However, the effectiveness of such a mapping is different story. Factors such as differing fundamental purposes, gaps in detail, supplementary factors, differing sizes of process record sets, can all affect the limitations of applicability. Together, these factors may even cumulate in an invalid or unusable mapping despite the basic compatibility requirements being present.

14.3 Automating Assessment Data Translation

The creation of a data mapping in order to automate an assessment data translation mechanism is possible between each of the selected process models due to the methodology - but the accuracy of translated data is based on the accuracy of the structural level map between process model elements. The higher the mapping occurs in a process model's 'hierarchy structure', (e.g. the Process level) the more subjective the results would tend to be - requiring additional input from the original assessor in order to confirm the validity of the translated result set of assessment data.

14.4 Conclusion and Continuation

As with many other propositions in the software engineering industry, the success of the software process assessment data mapping and translation procedure is dependant on contextual and environmental variables applied to each case, rather than a firm equation for success.

However, we have gained sufficient insight and knowledge in this project to create the foundation for a detailed methodology guideline that should minimise the risk factors, or at the very least detect the viability of a data mapping from the outset of the exercise. Such a detailed methodology would be the logical extension and continuation of this project.

The additional value therein would be to perform the actual mappings between all the process models, there being 6 permutations of mapping being identified.

On a higher level, the investigative work here would form the basis for the next level of enhancements to assessment tools, in particular the SPIL Assessment Tool. The actual realisation of this effort would also contribute to the acceptance and take up of the ISO/IEC 15504 standard in the industry.

In the case of the ISO/IEC 15504 in particular, it is fitting that for an emerging international standard whose purpose is to assess and improve the processes of software development, be itself supported by software assessment tools of quality.

15   Appendix

15.1   Profiles of Software Process Assessment Tools

The following profiles of process assessment tools support the research analysis and findings made in Chapter 3.

15.1.1   Appraisal Wizard

15.1.1.1   Specifications

- Vendor: ProcessFocus

- Tool Type: Software

- Version: 5

- Website: http://www.processfocus.com

- Operating System: Microsoft Windows

- Process Models: CMM

15.1.1.2   Description

The Appraisal Wizard was created to support formal assessments (CBA-IPI, SCEs and SCAMPI) as well as an organisation's own informal appraisal. The tool supports the scenario where an organisation has more than one process maturity models under assessment at once.

The Appraisal Wizard automates the appraisal planning, set-up, scheduling, document and observation recording, findings report generation, profile generation and produces a wide variety of reports and graphical representations supporting data analysis. The Appraisal Wizard is designed to allow team members to focus on the appraisal instead of data collection.

15.1.1.3   Usage

During an appraisal, the moderator chairs a meeting with 1 to 30 engineers (typically 4-6 developers) from the organisation. The engineers fill in questionnaires for each of the Key Process Areas (KPAs) of the CMM, and moderator enters the results in the IME spreadsheet. The spreadsheet displays the results of the last 6 appraisals performed and allows for comparison between the data.

15.1.1.4   Features

1. A Client-Server architecture which is usable in a range of configurations such as corporate networking or standalone PC/laptop (New for Version 5)

2. Supports CBA-IPI, SCE and SCAMPI methods or informal appraisals.

3. Supports appraisals against one or multiple models. Appraisal observations may be related to key practices in any model used in the appraisal.

4. Database allows for an unlimited number of appraisals to be stored

5. The product includes the SW-CMM, SA-CMM, P-CMM, CMMi and EIA 731 (additional models to be incorporated in future releases).

6. Allows user definition and tailoring of appraisal parameters such as: Sessions, Sources, Team Member Roles, Observation Types, Accuracy Status, Corroboration and Rating Values.

7. The product may be operated standalone or as a multi-user network application for use by all appraisal team members concurrently. In lieu of an available network, Appraisal Wizard Lite may be used by team members to record data and feed back to Appraisal Wizard.

8. Application security prevents unauthorized access.

9. Appraisal level security can provide read/write access to specific appraisal data content types for each user. (New for V5)

10. Application windows retain size and position allowing a familiar operating environment to be maintained while using the product.

11. Create a new appraisal from an existing appraisal copying all or portions of existing appraisal information. Fast setup for new appraisals!

12. Import/Export single or multiple appraisals from the Wizard database. This feature provides the capability to build a central repository of appraisal information for appraisals conducted by multiple appraisers in different locations.

13. Appraisal scheduling allows pre-appraisal, onset, and post-appraisal activities to be planned and recorded.

14. Provides capability to record documents / appraisal artefacts.

15. Unlimited observations may be recorded.

16. Automatic spell checking of observation text before an observation is saved, or batch spell check all observations.

17. Observations may be mapped against multiple key practices in multiple process improvement models

18. Observations may be mapped to appraisal documents / artefacts

19. Full attributes which are available for each observation include; observation text, session, source, observation type, accuracy status, corroboration, global observation, non-CMM observation, finding indicator and supporting artefact list.

20. User defined colour coding provides quick visual identification of key observation information such as observation type, corroboration and accuracy.

21. Centralized observation allows filtering of observations meeting any criteria. The list of observations may be filtered using combinations of values for any of the following: key process area, observation type, coronation, accuracy status, session, source, non-CMM observation, finding report observation, and project.

22. Appraisal Wizard will directly generate a Microsoft PowerPoint presentation containing appraisal findings.

15.1.1.5   Screenshots
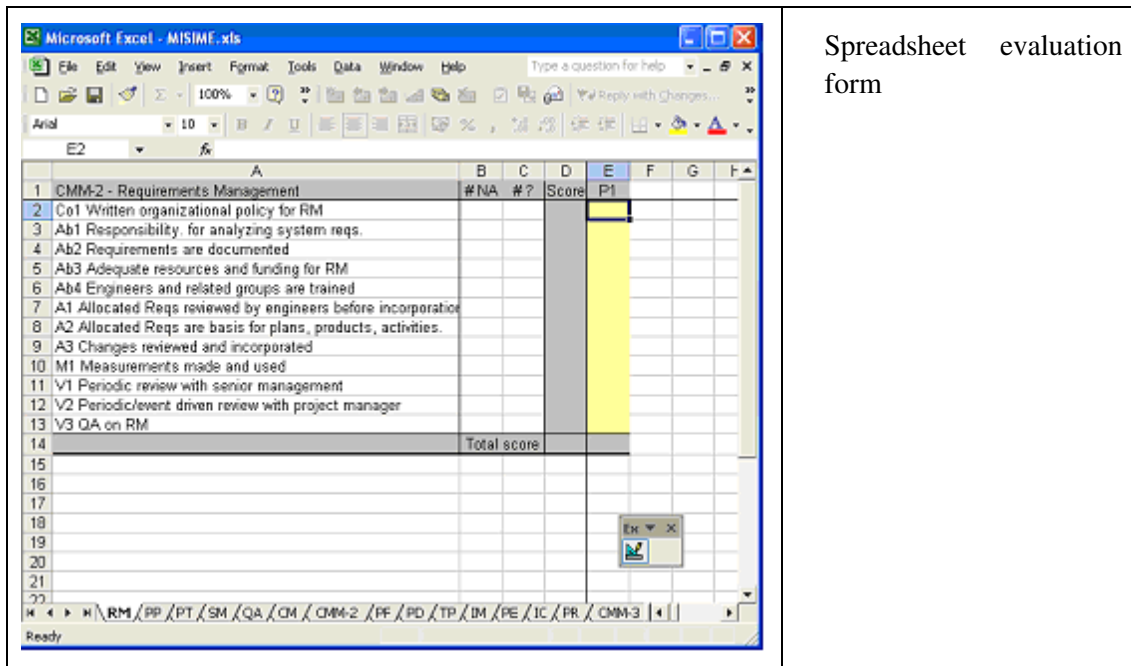
Spreadsheet evaluation form

Figure 36. SCREENSHOTS OF THE PROCESSFOCUS TOOL

15.1.2 Bootcheck

15.1.2.1   Specifications

- Vendor: Bootstrap Institute
- Tool Type: Software
- Version: 3.12
- Website: http://www.bootstrap.com
- Operating System: Microsoft Windows
- Process Models: BOOTSTRAP

15.1.2.2   Description

BootCheck is developed by co-operation with the BOOTSTRAP Institute and the ESI (European Software Institute). It is a PC tool for collecting data of the current level of software practices.

The BootCheck tool provides a self-assessment questionnaire to support the assessment by the company itself. The tool includes a comprehensive and structured questionnaire so it can be completed by the manager of the software producing unit of the organisation.

15.1.2.3   Usage

BootCheck assesses a process instance with the following steps:

- Background information about

  a. The organisation the assessment is performed

  b. The SPU - the software producing unit

  c. The project(s) - the project(s) that are assessed

- Evaluating

  a. To rate each process by scoring process base practices and process attributes with rating scale: Not adequate - Partially adequate - Largely Adequate - Fully Adequate - Not Applicable

- Profiles

  a. SPICE Profile

  b. Process Attribute Profile

  c. Capability Profile

Assessment report

- Self-Assessment Reports contains assessment results, background information, SPU and project(s) profiles

- Assessment Answer Report contains a process checklist with ratings

15.1.2.4   Features

The BootCheck assessment results can be used in various ways:

1. To baseline the current position

2. To support the SPI programme

3. To assist in an externally supported programme

4. To be the initial step in seeking ISO 9000 registration

5. To benchmark the performance against industry best practice

6. The results are presented according to three best practice models

7. Organisation Maturity Level Evaluation

8. A broad assessment of organisational maturity according to BOOTSTRAP approach.

9. A Process Capability Evaluation

10. A mapping against the SPICE model, which is the emerging ISO Standard for software process assessment

11. An ISO 9000 Gap Analysis Results

12. An assessment of likely state of ISO 9000 compliance

13. The collected data can be analysed and developed as an improvement plan specific for the organisation.

14. The assessment results can be returned to a processing address, where the data is handled with complete confidentiality.

15. BootCheck produces aggregated data at a European level to enable comparisons between maturity levels across industry. Contributing organisations are able to benchmark the performance against industry best practice.

15.1.2.5   Screenshots

	The main screen
	Evaluation screen

	Process model hierarchy
	Capability profile report
	Process attribute profile report

| | ISO/IEC 15504 (SPICE) profile report |

Figure 37. SCREENSHOTS OF THE BOOTCHECK TOOL

15.1.3 CMM-Quest

15.1.3.1   Profile

- Vendor: HM & S
- Tool Type: Software
- Version: 3.0
- Website: http:// www.processfocus.com
- Operating System: Microsoft Windows
- Process Models: CMMI

15.1.3.2   Description

CMM-Quest contains the new standard CMMI (Capability Maturity Model Integration), which is the direct successor of the well known CMM version 1.1 and it arrived instead of CMM 2.0.
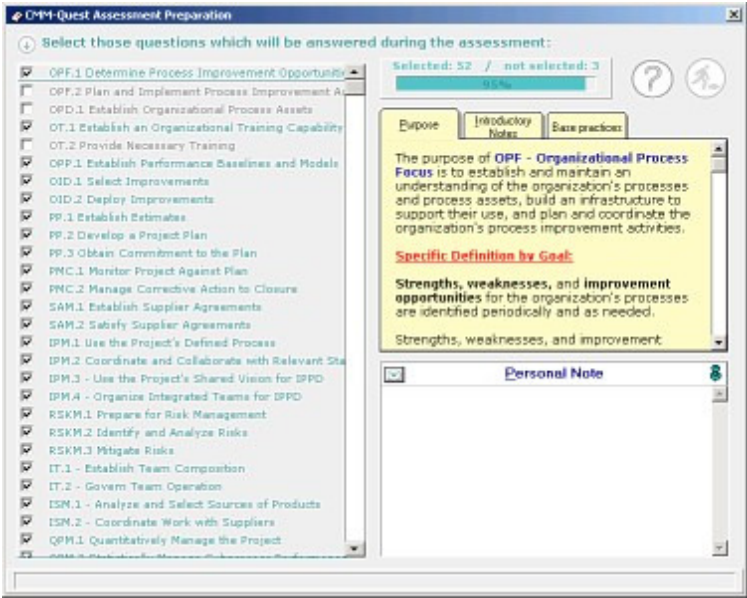
CMMI in the continuous representation claims to be SPICE (ISO/IEC 15504) "compatible and compliant". So now, in theory, a CMM-Quest assessment would be comparable to SPICE assessments. However, in practice the assignment of the CMMI Process Areas is not that easy, because there sometimes is a slightly different picture of the world behind.

There are two versions of the CMM-Quest application: the personal edition, and the Quest Company Version with its own space to define.

15.1.3.3   Usage

CMM-Quest requires the assessor to complete all questions regarding an organisation's level of process maturity

15.1.3.4   Screenshots

	Main menu
	Reviewing the processes
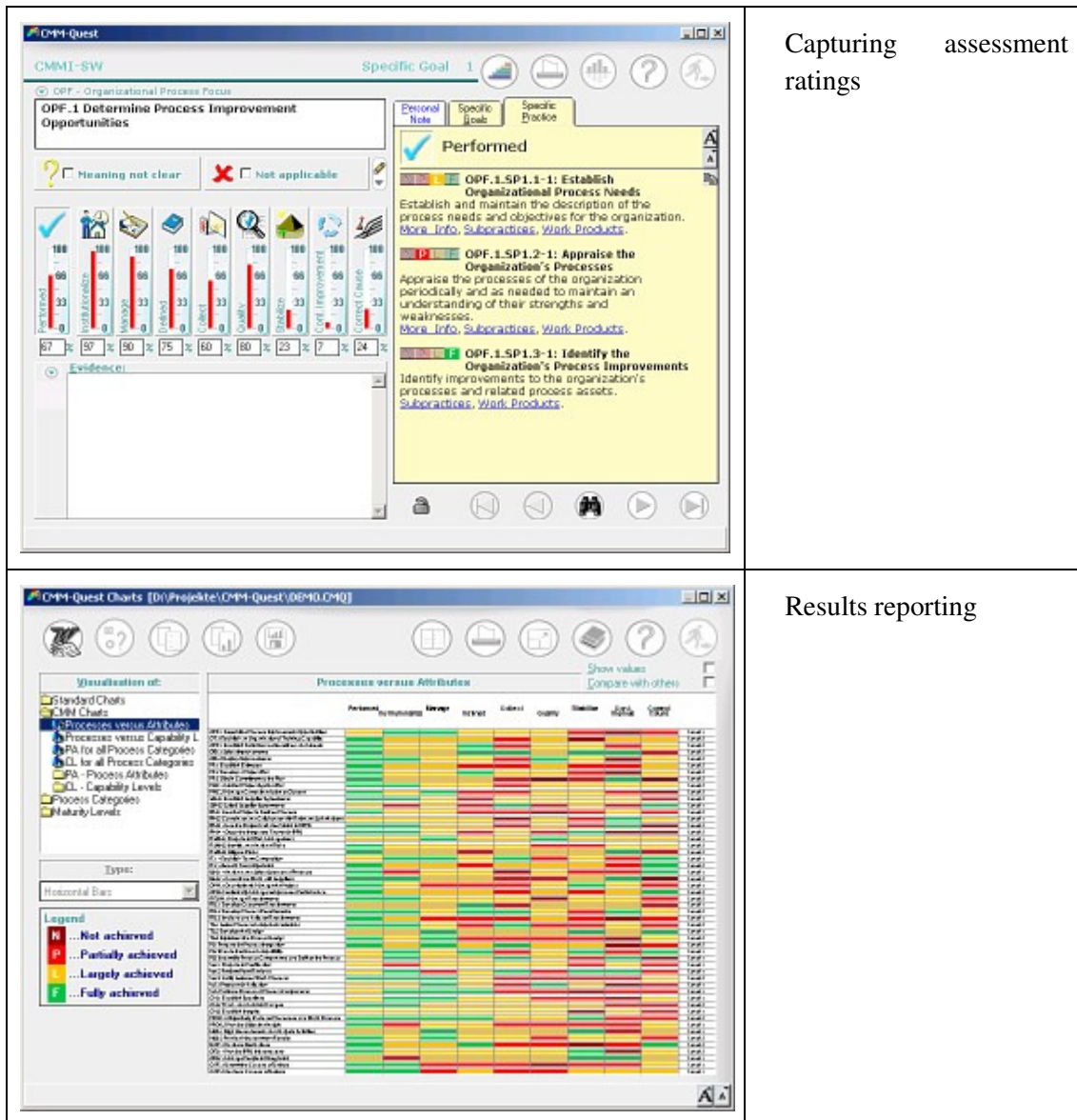
	Capturing assessment ratings
	Results reporting

Figure 38. SCREENSHOTS OF THE CMM-QUEST TOOL

15.1.4   IME Toolkit

15.1.4.1   Specifications

- Vendor: Management Information Systems
- Tool Type: MS Excel Spreadsheet Questionnaire
- Version: 1.0
- Website: http:// www.ma-info-systems.com
- Operating System: Microsoft Windows
- Process Models: CMM

15.1.4.2   Description

An Interim Maturity Evaluation (IME) is a tool to measure the maturity of an organisation and to track progress in process improvement. The IME uses the Capability Maturity Model (CMM)® as a frame of reference (see http://www.sei.cmu.edu/ for more information on CMM).

The IME is meant as a tool for self-evaluation. To allow for quick feedback loops it is recommended to conduct IME sessions every 3 or 4 months.

15.1.4.3   Usage
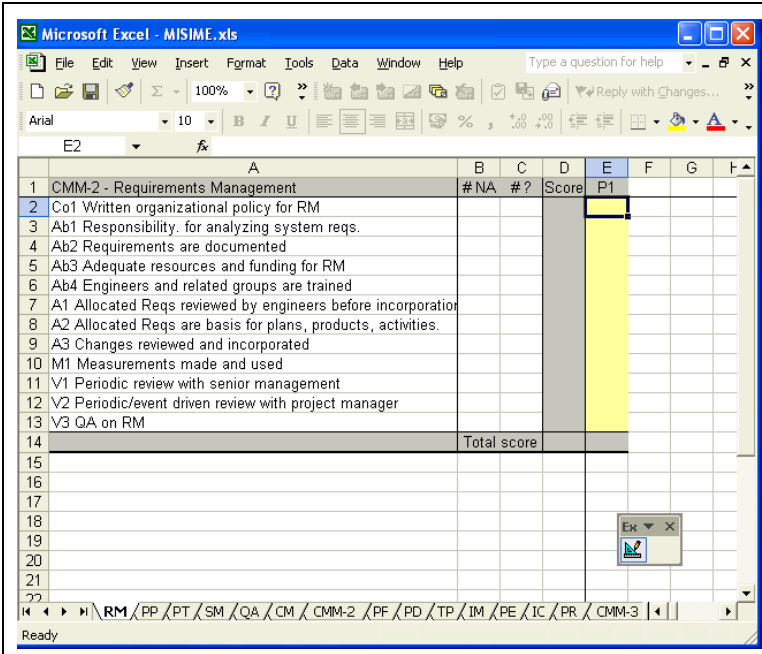
During an IME assessment the IME moderator chairs a meeting with 1 to 30 engineers (typically 4-6 developers). The engineers fill in questionnaires for each of the Key Process Areas (KPAs) of the CMM. The IME moderator enters the results in the IME spreadsheet. The spreadsheet shows the results of the last 6 IMEs and allows comparison between the data.

15.1.4.4   Features

The IME approach of Management Information Systems (MIS) is based on the Capability Maturity Model (CMM)® of the Software Engineering Institute. However, it does not use the original CMM texts literally. The original texts have been slightly modified to make them useable in non-software development departments. For that reason the word 'software' has been removed consistently.

The MIS IME approach allows different kind of scores to be filled in on the IME questionnaires and allows participants to score a number from 0 to 10, a "?" (for 'I don't know') or a "N/A" (for 'this is not applicable'), thus providing additional information

15.1.4.5   Screenshots

Spreadsheet evaluation form

	CMM Key Process Areas chart

Figure 39. SCREENSHOTS OF THE IME TOOLKIT TOOL

15.1.5 SPICE 1-2-1

15.1.5.1 Profile

Vendor:	HM & S
Tool Type:	Software
Version:	2.0
Website:	http://www.processfocus.com
Operating System:	Microsoft Windows
Process Models:	ISO/IEC 15504 (SPICE)

15.1.5.2 Description

There are three versions of the SPICE 1-2-1 application: the Personal Solution version, the Company Solution version and the Corporate Solution version, each version built on the previous with increasing levels of functionality.

SPICE 1-2-1 allows an assessor to evaluate the 40 processes defined by the ISO/IEC 15504 for software production. The tool contains more than 300 definitions and explanations covering software quality management and software engineering.

15.1.5.3 Usage

An assessor can capture the ratings of an evaluation on screens that detail the process model. The tool produces reports and charts, and assessors can compare assessments on a graphical basis (charts) to analyze the differences quickly and efficiently.

Assessments can be saved to a file. The active and passive help system guides the user through the questionnaire. A user can also make notes to assist in interpreting the results.

The tool has a Microsoft Word report document generator, which uses a standard or customisable template. Running a macro function allows a (compatible) tool to import of all the assessment data from SPICE 1-2-1.
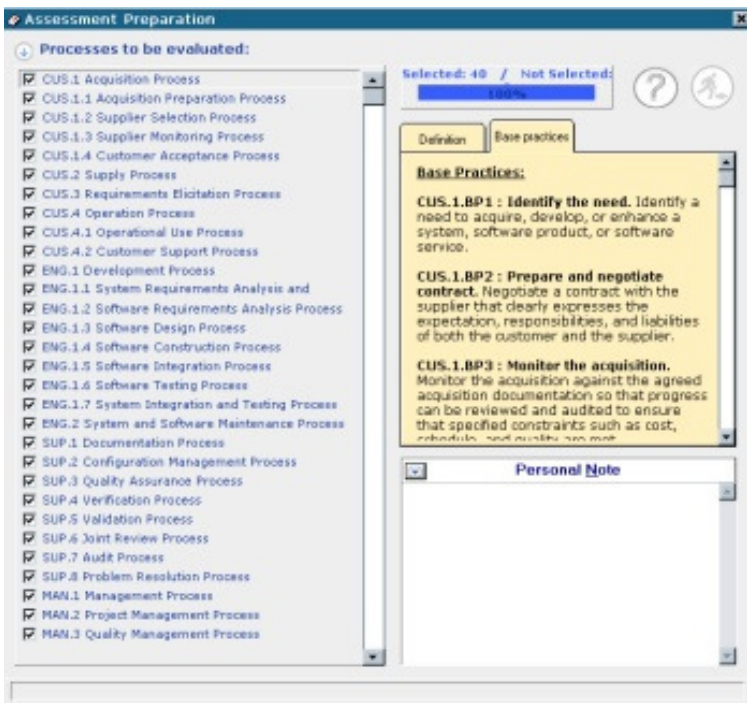
There are two additional utilities included with the software:

1. SynEval is the tool which is used by an assessor to analyse the results of several interviews and assessments.

2. SynEdit allows the SPICE 1-2-1 assessment tool to be customised for individual needs: The processes can be edited and enhanced; the rating explanations can be linked to an organisation's documents and all icons and captions can be modified.

15.1.5.4   Features

1. Create a new assessment or open an existing assessment

2. Select among the processes to evaluate

3. Enter assessment ratings

4. Read the process definitions and explanations

5. Evaluate your assessment ratings

6. Display and print charts and evaluations

7. Copy pictures (charts) to clipboard or save to disk to create your own assessment report

8. Copy data to the clipboard or save to disk in SPICE format to create your own charts, e.g. with Excel

9. Export function to send all data (including definitions, explanations etc.) to a text file or HTML format.

10. Comparison between two questionnaires in the charting window

11. Additional charts for details of all process areas and for all process attributes

12. Additional software SynEval enables you to calculate the correct ratings if you perform more than one assessment. The calculation is done on a per-process basis using frequency distribution. This is a must-have if you perform assessments for multiple projects

13. One day training & workshop for performing the assessment and operating the tools is included with the package.

15.1.5.5   Screenshots

	Main menu
	Reviewing the processes
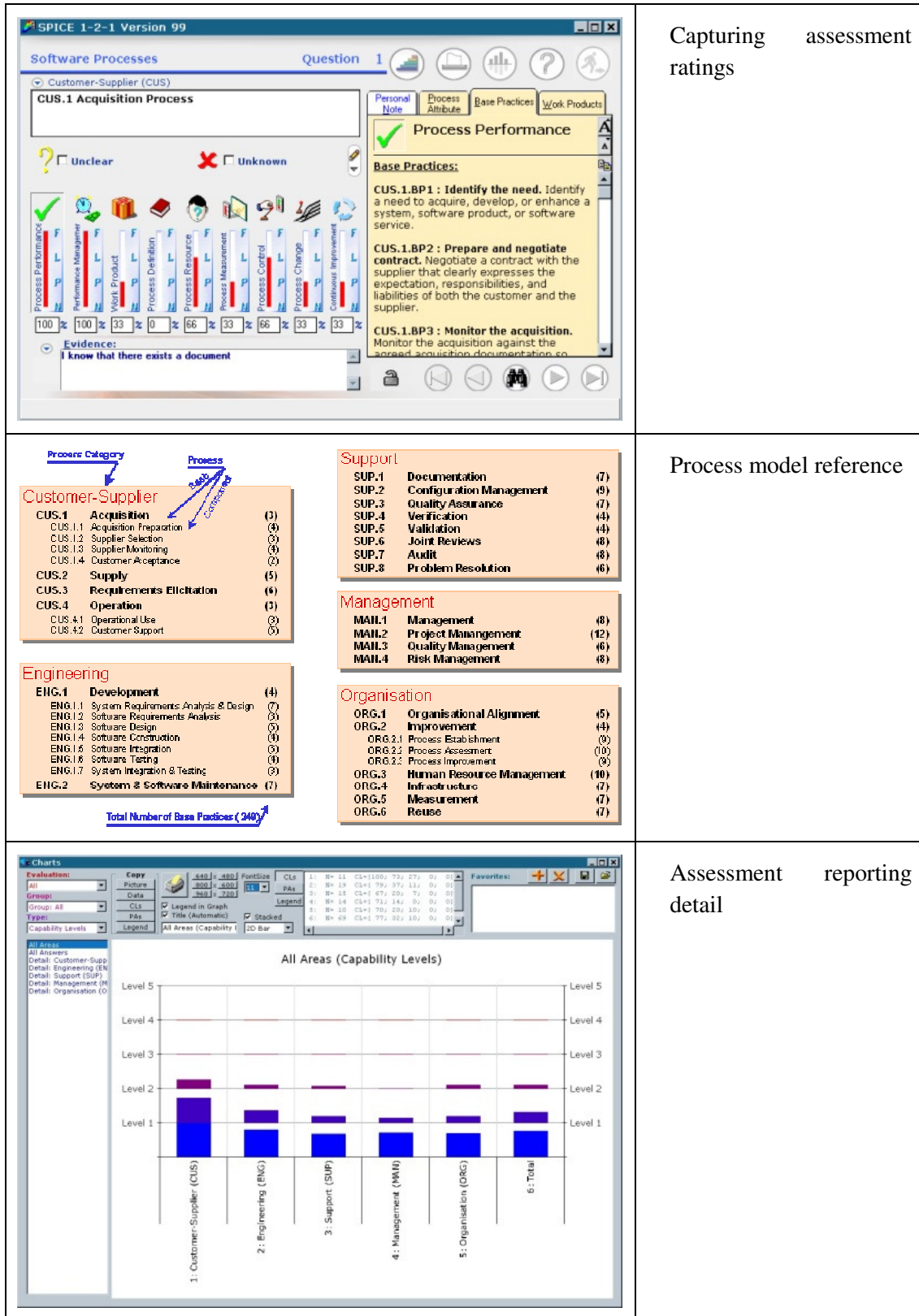
	Capturing assessment ratings
	Process model reference
	Assessment reporting detail

	Process model maintenance
	Various graphical reports
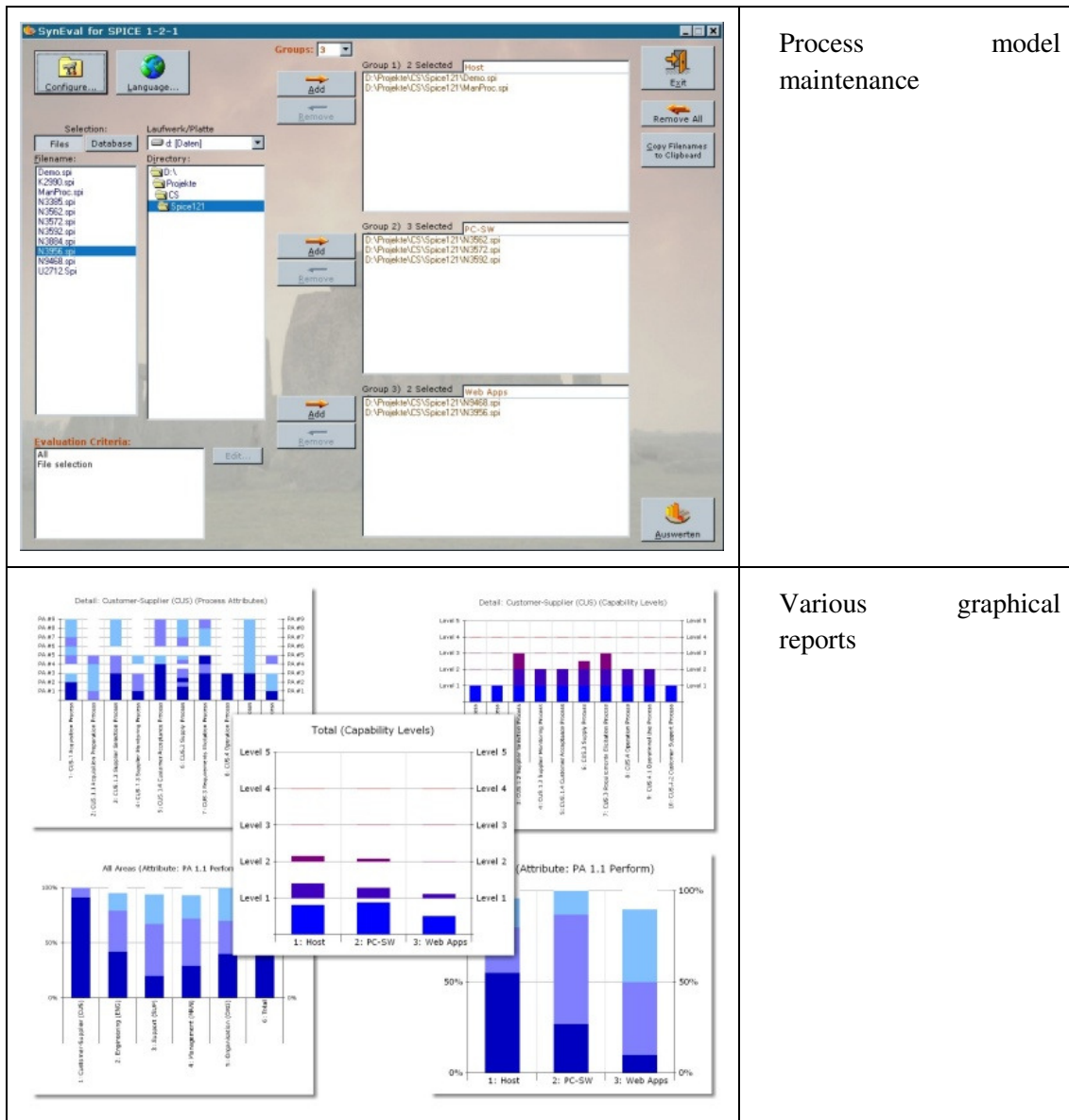
Figure 40. SCREENSHOTS OF THE SPICE TOOLKIT TOOL

15.1.6 SPICE-Lite

15.1.6.1 Specifications

- Vendor: HM & S
- Tool Type: Software
- Version: 5
- Website: http:// www.processfocus.com
- Operating System: Microsoft Windows
- Process Models: ISO/IEC 15504 (SPICE)

15.1.6.2   Description

There are three versions of the SPICE-Lite application: the standard version, the extended version and the professional version with increasing levels of functionality.

This tool is essentially a single-user version of SPICE 1-2-1 with reduced functionally. In particular, the SynEval and SynEdit utilities are excluded from SPICE-Lite.

15.1.6.3   Usage

SPiCE-Lite required the assessor to complete 37 questions regarding an organisation's software production processes. The tool includes more than 300 definitions and explanations cover software quality management and software engineering.

Additionally, SPiCE-Lite contains an automatic mapping to SPICE (ISO/IEC 15504) allowing an assessor to convert your assessment data into SPICE Capability Level profiles.

The operation of the tool is essentially the same as the SPICE 1-2-1 application with the evaluation of processes.

15.1.6.4   Screenshots

Main menu

	Reviewing the processes
	Capturing assessment ratings
	Results reporting

Figure 41. SCREENSHOTS OF THE SPICE LITE TOOL

15.1.7 SPICE Vision 1.5

15.1.7.1   Specifications

- Vendor: Novotis
- Tool Type: Software
- Version: 1.5
- Website: http:// www.spicevision.com
- Operating System: Microsoft Windows 2000 / XP incl MS.NET 2.0
- Process Models: ISO/IEC 15504

15.1.7.2   Description

The SPICE Vision tool derives its name from the original title of the ISO/IEC 15504 before it became a standard, and is focused on performing ISO/IEC 15504 conformant Process Assessments. It is one of the more recently updated tools, and was developed on the new Microsoft.NET 2.0 application framework, with tabbed and docked windows to present a large amount of information on a small screen.

15.1.7.3   Usage

- A Quick Start dialog box is presented on start-up, allowing the user to start a new assessment or continue with the last assessment. There is an option for using the default framework or a customised one.

- The documentation recommends planning for the assessment by way of capturing the assessment input (i.e. profile details on an assessment) and then deciding the scope. The tool allows the scope to be narrowed by removing processes from the ISO/IEC 15504 framework for the current assessment instance.

- An assessment is conducted against the ISO/IEC 15504 framework by navigating between the processes and attributes in the Navigator window. Assessment ratings for base practices are captured for each selected process in turn, and evidence or commentary can be captured for Processes, Base Practices, Attributes, Generic Practices, generic Resources, Work Products In and Out, and any applicable References.

- Each rateable item has a checkbox with four states to mark the progress of the assessment: Not yet rated, rated – achieved (green colour), rated – not achieved (red colour) and not applicable/will not be rated (grey colour).

- Assessment ratings for processes are automatically calculated for the selection of graphical reports available:

  - Assessment Report
  - Process Capability Chart
  - Process Attribute Chart

    o Process Risk Chart.

- A conformant framework can be customised to represent an organisation's set of unique processes, saved and use for new assessments in the future. This includes fine-tuning details such as being able to set the indicator weights.

- The merging of assessment results is also allowed, where the data from a secondary assessment save file is appended to the primary one (and not overwritten. In this manner more than one assessor can work on an assessment individually, and consolidate the data afterwards.

15.1.7.4 Features

1. General Features

   - Configurable windows environment. Using Latest windows technology

   - Windows configurations can be saved and restored

   - Configurable toolbars

   - Windows support for linking to files and http/ftp

   - Improved Language support (English, Spanish)

   - New Quick start dialogue

   - Text highlighting (bold, colours)

   - New Bullet lists

   - Improved Drag and drop text editing

   - New Configurable tooltips and other input aids

   - Licensed assessment frameworks (PRM / PAM)

2. Assessment Planning

   - Select assessment framework (PRM / PAM)

   - Select assessment file

   - Define assessment input

   - New User configurable structure for assessment input

   - Select multiple instances of processes in assessment scope

   - New Group processes using standard or user defined groups

   - Define target capability level for assessment (globally and/or individually by process)

   - Prepare checklists / assessor notes

   - Select practice indicator rating schema - Y/N or NPLF

   - Select indicator weighting scheme - none, according to supporting achievements, user defined

3. Assessment Performance

- Process and attribute Navigator

- Global assessment notes

- Four notes windows per process (notes, strengths, weaknesses and improvements)

- Improved Tabbed windows information - process definition, base practices, attribute definition, generic practices, generic resources, input and output work products, work product characteristics

- Rating of indicators

- Rating of process attributes

- Recommended Process Attribute rating based on selected weighting indicator scheme

- Merge assessment data from different assessors - process notes, strengths, weaknesses and improvement opportunities

- Display Process and Process Attribute expert guidance notes

- Display process reference material (best practices)

4. Assessment Reporting

- Selection of processes for chart generation

- Process Capability Level rating chart (automatic calculation based on process attribute rating)

- Process Attribute rating chart

- Process risk rating chart (automatic calculation based on target capability level and process gaps)

- Copy charts to clipboard

- Generation of Microsoft Word reports based on user definable word templates

- Generation of documented assessment records using generic work templates and selected data items

5. Assessment Framework

- Edit licensed assessment frameworks

- User definable assessment frameworks

- Edit process definitions and outcomes

- Edit Base Practices, Generic Practices, Work Products, Work Product Characteristics

- Assign Base Practices to process outcomes

- Assign Generic Practices to Process Attribute achievements

- Assign Work Products to Processes as input / output work products

- Edit Process expert guidance notes

- Edit Process Attribute expert guidance notes

- Edit process reference material (Best Practices)

- Establish weighting for Base Practices and Generic Practices

- Support for assigning Base Practices (special practices) to Process Attributes at all levels

15.1.7.5   Screenshots
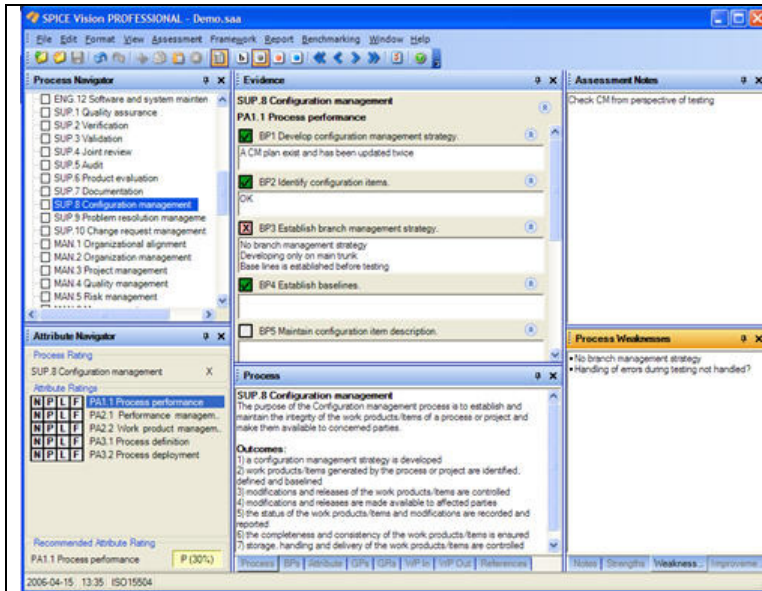
	This is the normal working screen in SPICE Vision. On the left of the screen you have windows for navigation of the processes and attributes. In the lower middle part of the screen you have access to the full content of your ISO/IEC 15504 standards framework through several tabbed windows. In the upper mid part of the screen is the window used to gather evidence during an assessment and to the right of the screen you have different windows for taking notes on a per assessment and per process level.
	Users are able to edit the standards framework for instance to create a company specific adaptation or to create your own process reference model and/or process assessment model
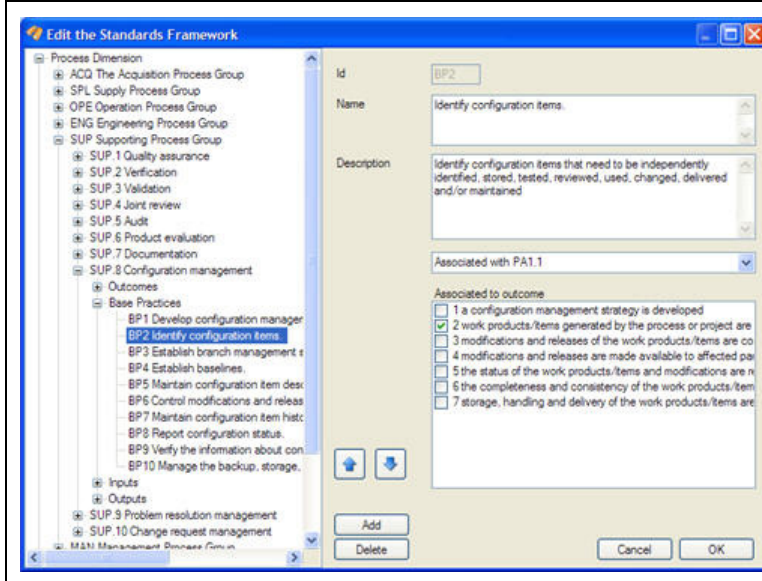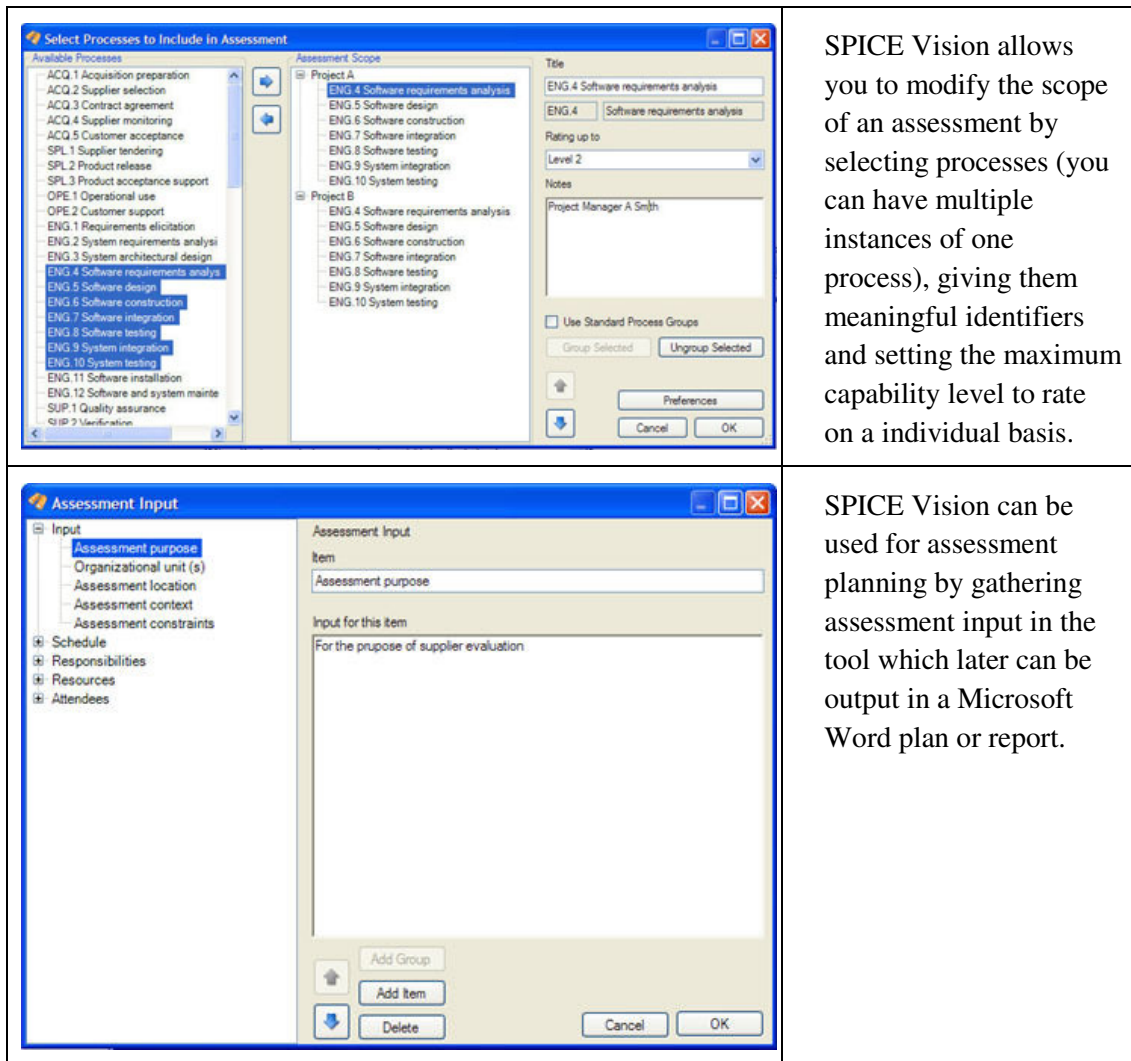
	SPICE Vision allows you to modify the scope of an assessment by selecting processes (you can have multiple instances of one process), giving them meaningful identifiers and setting the maximum capability level to rate on a individual basis.
	SPICE Vision can be used for assessment planning by gathering assessment input in the tool which later can be output in a Microsoft Word plan or report.

Figure 42. SCREENSHOTS OF THE SPICE VISION TOOL

15.1.8   STEP v2.0 – The SPIL Tool for Evaluation of Processes

15.1.8.1   Specifications

- Vendor: SPI Laboratory (Pty) Ltd
- Tool Type: Software
- Version: 2.0
- Website: http:// www.spilint.com
- Operating System: Microsoft Windows
- Process Models: ISO/IEC 15504, ISO 9001

15.1.8.2   Description

The SPIL Tool for Evaluation of Processes supports the assessment of processes and capabilities in organisations developing and implementing products or systems. This tool helps to determine the levels of process capability and areas for process improvement within one or more instances of the software development lifecycle. The ISO/IEC 15504 process model of the international standard for software process assessment and capability determination is used to evaluate these process instances of the software development lifecycle.

This tool was originally developed in association with the Software Engineering Applications Laboratory (SEAL) by the author of this Thesis (R Him Lok) and A Walker. The software was initially created in 1995, when the SPICE standard – as the ISO/IEC 15504 was known then - was in its infancy.

The software has since undergone numerous releases, as it evolved alongside the formation of the standard. Initially the tool was known as the SEAL of Quality ("SEALOQ"), and subsequently renamed to the SPIL Assessment Tool ("SPILAT"). It has now evolved into the SPIL Tool for Evaluation of Processes ("STEP")

The tool is compliant to the requirements of the ISO/IEC 15504:

- The tool meets all the normative requirements for the process and capability models defined in ISO/IEC 15504 Part 2.

- The tool supports all the normative requirements for capturing information associated with the planning, conduct and presentation of profiles as defined in the normative requirements in ISO/IEC 15504 Part 3.

- The tool supports all the informative requirements for the assessment model and indicator guidance as defined in ISO/IEC 15504 Part 5.

15.1.8.3   Usage

- A project is created for a collection of assessments within an organisation. Details are captured on the background of the organisation and the assessor(s).

- A process instance is created for conducting an evaluation using the ISO/IEC 15504 process model. Assessment ratings for work products and base practices are captured for each selected process category.

- Assessment ratings for processes are automatically calculated according to the formula of the standard. A selection of textual and graphical reports can be generated.

- An ISO 9001 assessment can be evaluated, with the ratings captured using the Audit Checklist (ACL) questionnaire.

- A project's process model can be tailored to and assessed against an organisation's own processes.

15.1.8.4   Features

6. An ISO/IEC 15504-compatible Assessment application running under Microsoft Windows operating systems with a graphical user interface and comprehensive help facilities.

7. Fast manipulation of data and speedy generation of colourful reports created via a local database built into the program.

8. Create multiple evaluations - one for each organisation or company. Single or multiple Process Instances can be created within each evaluation for examinations of different software systems or products, or of successive versions of a product.

9. Full assessment details are stored for each evaluation and process instance, with security ensured by password protection on evaluations. Assessor information and their background experience records are maintained within the system. Many system settings allow the operation of the tool to be customised to the user's preferences.

10. Processes are presented on full graphics user interface (GUI) - screens for assessing the achievements of work products, base practices, generic practices, and process management indicators. Interactive assessment screens allow the user to input achievement ratings and flag warnings via point-and-click, as well as entering notes and justifications on each practice or process attribute. Selectable manual/automatic aggregation of generic practices is performed for process attributes. Capability Levels of processes are automatically determined.

11. Conduct an evaluation with the complete ISO/IEC 15504 process model for instant referencing of descriptions of processes, practices, work products and indicators.

12. Each evaluation is created with a separate copy of the ISO/IEC 15504 model, and its processes can be edited and maintained in the system to provide a framework tailored to an organisation's specific needs.

13. All aspects of the ISO/IEC 15504 model, including process categories, generic practices, base practices and work products may be augmented or deleted. Work products and indicator evidence may be associated with processes and process attributes.

14. A rich suite of displayable and printable report views of assessment results - process capability rating profiles with automatic achievement rating aggregation, drilldown summary graphs, as well as process or capability rating distribution profiling.

15. Context sensitive pop-up menus are present on report views for capturing, printing and saving the data contained in the view.

16. Graphs allow for on-the-fly change of type (pie charts, bar graphs, line graphs, etc.) and re-orientation (zoom, rotate) of the graph on a 3D axis.

17. Transfer (import/export) the process instance data between evaluations or systems.

18. The tool supports team-based evaluations by allowing assessors of a process instances to work independently and to consolidate data at the end of the assessment.

19. Sample data files of a process instance examples are provided for the user to experiment and evaluate the tool quickly and easily.

20. The user can load up the sample data and to evaluate the full range of features and reports without having to enter large amounts of data by trial and error.

21. Comprehensive support is provided for ISO 9001 compliance evaluations based on the Recommended Practice of the South African Bureau of Standards ARP 042 (1997) 'ISO 9001 Audit Checklist for Software'.

22. The compliance indicators provides a uniquely rich support for ISO 9001-based quality system evaluation, with rating of compliance requirements and guidance against the ISO/IEC 15504 work products and process associations.

15.1.8.5   Screenshots

	Project details
	Assessment Ratings report
	Assessment of processes

	Assessing details
	Displaying reports
	Modifying the process model
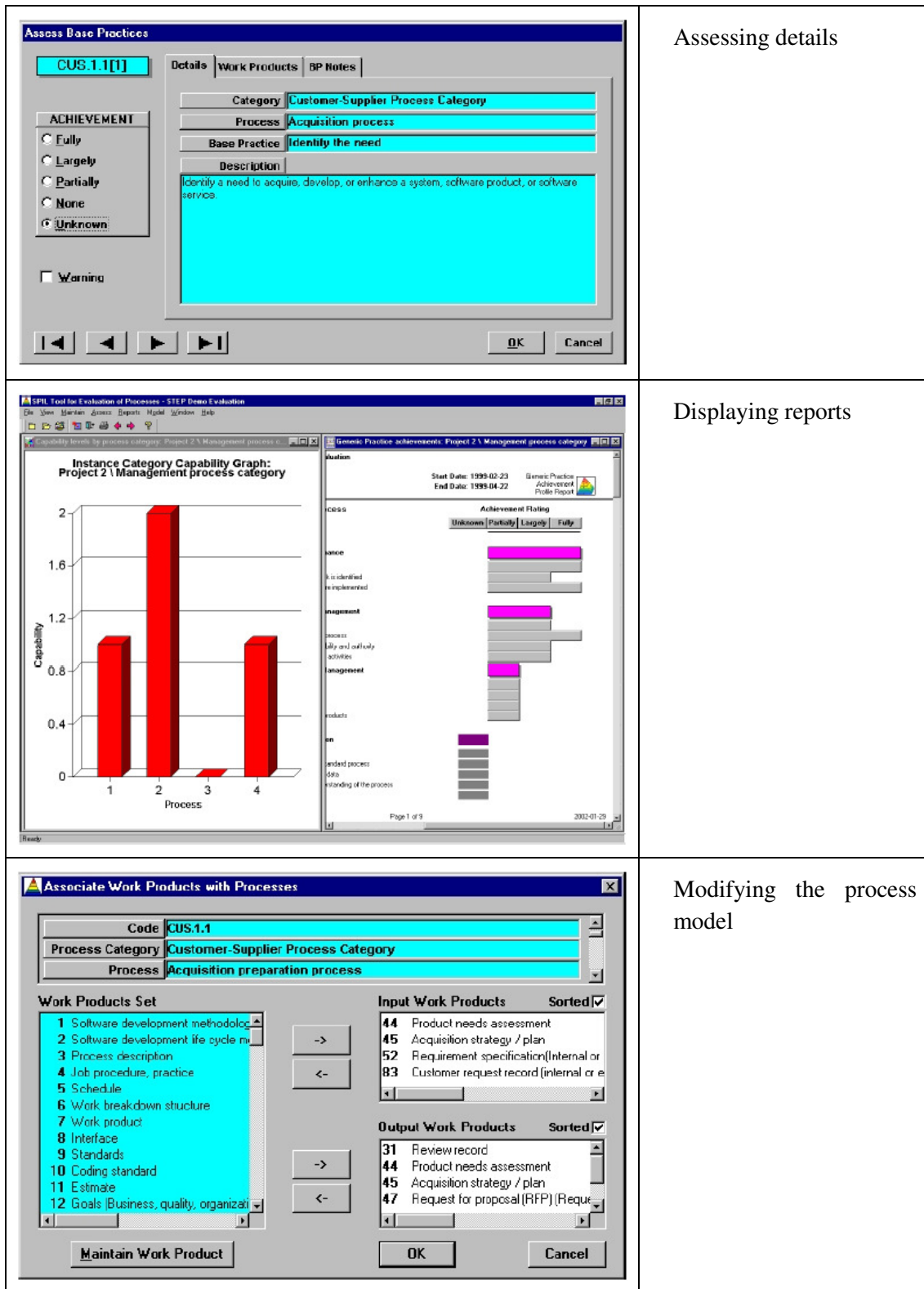
Figure 43. SCREENSHOTS OF THE STEP TOOL

15.2   Related Process Assessment Tools

The following assessment tools are associated with the evaluation of software development, although not directly to generic software process assessment. Screenshots have not been included with these profile descriptions.

15.2.1   PULSE

15.2.1.1   Specifications

- Vendor: Benchmarking In Europe

- Tool Type: Methodology + tools

- Website: http:// www.benchmarking-in-europe.com

- Process Models: Proprietary

15.2.1.2   Description

PULSE is an Assessment Methodology for Procurement Processes and Organisational Techniques for Improving IT Procurement

This project originated under the EC SPRITE-S2 Programme. It commenced in January 1998 with the following objectives: PULSE offered a methodology with associated tools to allow assessment of procurement capabilities and to determine those areas where improvements can be made to meet specific business objectives. PULSE also identified new organisational and communication techniques for better team working between the key functions of purchasing, technology development and strategic planning.

Key Conclusions and Recommendations: The outcome of the PULSE initiative was the development of the packaged kit for delivery of PULSE methodology and the *Team Working in IT Procurement Guide* - these are available in English and French. The packaged kit contains all tools and materials necessary for delivering the complete methodology. The *Team Working in IT Procurement Guide* gives an analysis of the results of the teamwork experiments. A licensing scheme is in place for the PULSE methodology.

The following documents are also available:

1. General Procurement Model of IT Procurement

2. The Assessment Model, with the definition and use of indicators of process performance and process capability, updated with the results of the PROBE project.

3. The Assessment Method, which establishes the assessment inputs to be defined, the responsibilities of all the parties in an assessment, the assessment process including planning, data collection, data validation, rating and reporting and the assessment outputs. This has been updated with the results of the PROBE project.

4. The Organisational Metrics Framework, which describes the metrics used to measure the performance of an IT procurement team. Presentational material is available to introduce staff to the assessment process, as well as a training syllabus and certification scheme for assessors.

The completion date for this project was March 1999.

15.2.2 S:PRIME

15.2.2.1   Specifications

- Vendor: SynSpace
- Tool Type: Software
- Website: http://www.synspace.com
- Process Models: SW-CMM + SEI / Software Risk Taxonomy

15.2.2.2   Description

S:PRIME is a risk evaluation methodology which provides an accurate picture of the areas where risks already perceived are handled effectively and those requiring immediate efforts to reduce the true risks faced by the organisation and the project.

The method involves completing two orthogonal questionnaires by different but complementary groups of respondents. Copies of these questionnaires are distributed to all participants.

The purpose of the first questionnaire is to identify the perception that managers have of the level of risk in the projects for which they are responsible. Questions are derived from the Software Risk Taxonomy established by SEI.

The following risk categories are covered by the risk questionnaire:

1. Contractual requirements,
2. Design and production,
3. Development environment,
4. Development process,
5. Management,
6. Personnel, and
7. External constraints.

The second questionnaire is addressed to practitioners within the organisation. Its purpose is to determine the status of the current practices against 15 key practice areas. Questions are mainly derived from level 2 and level 3 practices as required by CMM V1.1. Two more key areas were added to take into account situations typically found in small to medium enterprises.

The responses given to the risk questionnaire provides an indication of the perceived risks for each of the major categories. The compilation of the answers to the process questionnaire seeks to evaluate the current state of practice in each of the practice domains.

The required level of capability in each practice domain is supposed to be related to particular possible risks. Depending on the degree of risks perceived, a certain practice level is necessary to prevent the occurrence of a given risk or to reduce its impact.

The resulting degree of risk (exposure) is then presented in graphic form. Practices are singled out as those, which require immediate attention.

The ultimate goal of S:PRIME is to support organisations adopting the software engineering and management practices that are suited to their specific needs, and to help them make the right decisions to achieve this goal.

15.2.3 SPiCE for SPACE

15.2.3.1 Profile

- Vendor: SynSpace
- Tool Type: Software
- Website: http://www.synspace.com
- Process Models: Customised ISO/IEC 15504 model

15.2.3.2 Description

This tool is essentially a documented methodology for the assessment for software processes in space software projects.

As part of a programme for software process improvement sponsored by the European Space Agency (ESA), an ISO/IEC 15504 conformant method for software process assessment has been developed.

Called SPiCE for SPACE, or S4S, the method aims to encourage the production of the best possible software products and services within the European space industry.

S4S includes a reference model based on ISO/IEC 15504 - Part 5. The Process Dimension has been considerably refined to incorporate space software practices. An extended version of SPiCE 1-2-1 supports the performance of an S4S assessment.

Four processes, approximately 50 base practices, and an even larger number of notes have been added following ESA standard requirements for the production of space software. A documented process leads assessors step by step from Initiation to Reporting.

The new processes are:

1. Contract Maintenance (CUS.5)
2. Independent Software Verification & Validation (SUP.9)
3. Safety and Dependability Assurance (SUP.10)
4. Information Management (MAN.5)

Moreover CUS.2: Supply, is split into two component processes:

1. Supply Preparation (CUS.2.1)
2. Delivery (CUS.2.2)

In addition to the process definitions created for S4S, the work products of ISO/IEC 15504-5 have been restructured to reflect ESA specific deliverables. Two categories of work product types have been added. As no work product can exist without an activity, i.e. base practice, that produces it, on top of the 249 original base practices another 45 base practices are identified.

In S4S it is assumed that not all of the processes, base practices and associated work products are mandatory in any case. The process reference model is readily tailored to the needs of a specific project, as certain process indicators are listed as a function of criticality class.

S4S contains an assessment process, which includes a step-by-step breakdown of the assessment activities, the definition of key assessment roles and the description of assessment input and output work products. Following the process outlined in ISO/IEC 15504, an S4S assessment is divided into the following seven activities: Initiation, Planning, Briefing, Data Acquisition, Data Validation, Process Rating, and Reporting

S4S offers detailed guidance to assist assessors at each phase in the assessment, as experiences from the pilot assessments revealed that during the planning phase, assessors need to clearly understand the business context. This knowledge helps to identify the key processes of an organisation or project. Expert guidance of this type is incorporated in order to enable an efficient assessment performance.

Four pilot assessments of space software projects were performed in October 1999 and a further series of trial assessments began in February 2000. Another important enhancement to S4S that resulted from the pilot assessments was the addition of product and process metrics.

Experiences with S4S reveal that following the ECSS Standards helps to achieve the projects goals, especially concerning the quality of the delivered product. Furthermore, ECSS Standards are not only relevant for space projects, but also for other industrial sectors, especially for the development of embedded or safety-critical systems.

By promoting the best practice concepts of SPiCE and addressing the specific needs of space software, ESA expects S4S to emerge as the prevailing tool of process improvement within the European space software industry.

15.3 ISO/IEC 15504 Process Assessment Questionnaires

As examples of forms that can be implemented as data capture screens in an automated assessment tool, the questionnaires in this section have been extracted from Part 4 of the *ISO/IEC 15504 Part 7: Guide To the Competency of Assessors* document as model templates.

15.3.1 ISO/IEC 15504 Assessor Training Record Form

The following template may be used to record an assessor's training:

Training course	Description of training	Dates	Hours	Training provider

Table 49.   ASSESSOR TRAINING RECORD LAYOUT

15.3.2 ISO/IEC 15504 Assessor Record of Experience Form

The following table is captured to represent and assessor's record of experience in the software process:

Process Category	Description of experience	Dates	Level	Verification
CUS				
ENG				
MAN				
SUP				
ORG				
Other				

Table 50.   ASSESSOR EXPERIENCE RECORD LAYOUT

15.3.3 ISO/IEC 15504 Assessor Record of Participation Form

The following template may be used to record an assessor's participation as a provisional assessor or as an observer in assessments conducted according to the provisions of the ISO/IEC 15504.

Name of the person:

Date:

No. of days for the assessment:	
Scope of the assessment:	
Process categories/areas assessed by the person:	
Organisation/Organisational unit:	

Effective Communications:

Were the discussions with the customer reasonable?   Yes/no

Was a satisfactory understanding of this Technical Report shown?   Yes/no

Was the inter team relationship satisfactory?   Yes/no

Judgment and Leadership:

Were the assessment activities completed in a timely manner?   Yes/no

Were the interviews conducted satisfactorily?   Yes/no

Integrity:

Reasonable sample taken?   Yes/no

Range of activity satisfactory?   Yes/no

Depth of questioning satisfactory?   Yes/no

Review of results consistent?   Yes/no

Rapport :

Communication - telling the good and bad news: satisfactory/unsatisfactory

Review of the programme: satisfactory/unsatisfactory

Conduct: satisfactory/unsatisfactory

Team Management: satisfactory/unsatisfactory

Comments: (on Diplomacy, Discretion, Persistence and Resistance handling ability)

Performance: Acceptable/More Experience Required/Not acceptable

Name and signature of assessment sponsor/competent assessor/ team leader:

....

Table 51. **ASSESSOR PARTICIPATION RECORD LAYOUT**

15.3.4 ISO/IEC 15504 Assessment Log Form

The following template may be used as a model to record the details of assessments conducted according to the provisions of the ISO/IEC 15504 which an assessor has performed as a competent assessor.

Date	Assessment	No of days	Categories assessed	Verification

Table 52. **ASSESSMENT LOG RECORD LAYOUT**

15.3.5 ISO/IEC 15504 Assessor Professional Activities Log Form

The following template may be used by an assessor to record the professional activities of an assessor for maintenance of competence:

Date	Activity	Location	Hours

Table 53. **ASSESSOR PROFESSIONAL ACTIVITIES LAYOUT**

15.3.6 ISO/IEC 15504 Assessor Competence Matrix

The following table represents a matrix which may be set up to determine the competence of an assessor:

| Category of competence | Method of demonstration | | | |
	Career progression	Technology awareness	Breadth of performance	Other
CUS Process Category				
ENG Process Category				
MAN Process Category				
SUP Process Category				
ORG Process Category				
Assessment technology				
Personal attributes				

Table 54. **ASSESSOR COMPETENCE MATRIX**

15.3.7 ISO/IEC 15504 Assessor Demonstration of Competence Form

This form is constructed as a table for an assessor to identify the areas of competence which are relevant to his/her current assignment or any past assignments. This is typically to be discussed and validated with a supervisor or referee:

Areas of competence	Assignments	How demonstrated
Competence 1	Assignment 1	
	Assignment 2	
Competence 2	Assignment 1	
	Assignment 2	

Table 55. **ASSESSOR DEMONSTRATION OF COMPETENCE RECORD LAYOUT**

15.3.8 ISO/IEC 15504 Assessor Self Improvement List

A list for an assessor to track and manage the actions for self-improvement in the field of process assessment:

Item to improve	Improvement method	Method to measure progress

Table 56. **ASSESSOR SELF IMPROVEMENT RECORD LAYOUT**

16 Glossary

16.1 Abbreviations

The following abbreviated terms are used in this text:

- CMM – Capability Maturity Model, a software process assessment standard.

- SEAL – Software Engineering Applications Laboratory – a division of the Electrical Engineering department of the University of the Witwatersrand, Johannesburg, South Africa.

- SEAL Process Assessment Tool (SPAT) - A software application developed in conjunction with SEAL to assist with the assessment of software processes and is based on ISO/IEC 15504 software process model.

- SEI – Software Engineering Institute, the American organisation who created the CMM software process assessment standard

- SPICE - Software Process Improvement and Capability dEtermination; a new international standard for the evaluation of software development processes in organisations. The standard is also known by the International Standards Organisation code of ISO/IEC 15504.

- SPIL – Software Process Improvement Laboratory

- SSA – Support for Software Assessments. SEAL QMS Code reference number for this project.

16.2 Terminology

The following terms are used in this text:

- Capability Dimension – A measurement framework comprising of process capability levels and their associates process attributes

- Process Dimension – is provided by a Process Reference Model (see below)

- Process Reference Model – Defines a set of processes characterized by statements of process purpose and process outcomes

17 Bibliography

17.1 Technical Papers

- 'Models and Standards for Software Process Improvement', Systematic Software Engineering A/S, Jan 2005

- Alexandre S, Habra N, 'UML Modelling of Five Process Maturity Models', Version 1, CELTIC – FUNDP, 2003

- Halvorsen CP, Conradi R, 'A Taxonomy to Compare SPI Frameworks', Galaxy Republic AS / Norwegian University of Science and Technology, April 2002

- Rout TP, Dorling A, 'The Future for SPICE – the Evolution of ISO/IEC 15504', SPICE 2002 Conference, Venice

- Rout TP, Tuffley A, Cahill B, 'Capability Maturity Model Integration Mapping to ISO/IEC 15504-2:1998', Defence Materiel Organisation, 2001.

- Walker A J, 'Checklist support for ISO 9001 audits of software quality management systems', SEAL, University of Witwatersrand South Africa, 1999

- Paulk MC, 'Analyzing the Conceptual Relationship Between ISO/IEC 15504 (Software Process Assessment) and the Capability Maturity Model for Software', Software Engineering Institute, 1999 International Conference on Software Quality

- Walker A J, 'Meeting the ISO 9000 requirement for assessment of supplier capability', SEAL, University of Witwatersrand South Africa, 1998

- Rout TP, 'SPICE and the CMM: is the CMM compatible with ISO/IEC 15504?', Software Quality Institute, April 1998

- Minnich I, 'ISO 9001 and the SE-CMM', SECAT LLC, January 1998

- Garcia SM, 'Evolving Improvement Paradigms: Capability Maturity Models & ISO/IEC 15504 (PDTR)', Software Process Improvement and Practice, volume 3, issue 1, Wiley/Gaulthier-Villars, 1998

- Walker A J, 'Quality management applied to the development of a national checklist for ISO 9001 audits for software', SEAL, University of Witwatersrand South Africa, 1997

- Hunter R, Robinson G, Woodman I, 'Tool Support for Software Process Assessment and Improvement', Software Process: Improvement and Practice volume 3, pp213-223, 1997.

- Walker A J, 'Quality management applied to the development of a national checklist for ISO 9001 audits for software', SEAL, University of Witwatersrand South Africa, 1996

- Minnich I, 'ISO 9001 and the SW-CMM', SEAT LLC, 1996

- MP Ginsberg, LH Quinn (November 1995), Technical Report, CMU/SEI-94-TR-024, ESC-TR-94-024, 'Process Tailoring and the Software Capability Maturity Model', Software Engineering Institute, Carnegie Mellon University

- Paulk MC (July 1994), Technical Report, CMU/SEI-94-TR-12, ESC-TR-94-12, 'A Comparison of ISO 9001 and the Capability Maturity Model for Software', Software Engineering Institute, Carnegie Mellon University

17.2 Process Assessment Models and Frameworks

- ISO/IEC 12207:2002 FDAM 2 Information technology — Software life cycle processes, Amendment 2, 2004, International Organisation for Standardisation, Geneva.

- ISO/IEC 12207 Amendment 1: 2003, Information Technology – Software Lifecycle Processes, 2003, International Organisation for Standardisation, Geneva.

- ISO/IEC 15504-2, Information Technology — Process assessment — Part 2: Performing an assessment, 2003, International Organisation for Standardisation, Geneva.

- ISO/IEC 15504-3, Information technology — Process assessment — Part 3: Guidance on performing an assessment, 2003, International Organisation for Standardisation, Geneva.

- ISO/IEC 9003, Software and system engineering — Guidelines for the application of ISO 9001:2000 to computer software, 2003, International Organisation for Standardisation, Geneva.

- SCAMPI SM, Standard CMMI SM Assessment method for process improvement: Method description, Technical Report CMU/SEI-2000-TR-009, V1.0, Software Engineering Institute Carnegie Mellon University Pittsburgh, PA 15213. 86 pages, 2000

- ISO 9001: 2000, Quality Management Systems — Requirements, International Organisation for Standardisation, 2000, Geneva.

- Cooper J, Fisher M, Sherer SW (April 1999), Technical Report, Version 1.02, CMU/SEI-99-TR-002, ESC-TR-99-002, Software Acquisition Capability Maturity Model, Software Engineering Institute, Carnegie Mellon University

- CMMI Integration Project (September 1999) CMMI – SE/SW, CMMI: Capability Maturity Model Integrated – Systems/Software Engineering, Continuous Representation – Volume I & II Version 0.2b

- ISO/IEC JTC 1/SC 7/WG 10, ISO/IEC TR 15504, 1998, Technical Report Type 2, Part 1 – Part 9

- SABS ARP 042:1997 ISO 9001 Audit Checklist for Software, 1997, ACL 100-01 - ACL 100-25

- Messnarz R, A Comparison of BOOTSTRAP and SPICE, 1997, Software Process Newsletter, IEEE Computer Society TCSE

- ISO/IEC 12207, Information Technology – Software life cycle processes, 1995, International Organisation for Standardisation, Geneva.

- Bate R, Kuhn D, Wells C, Armitage J, Clark G, Cusick K, Garcia S, Hanna M, Jones R, Malpass P, Minnich I, Pierson H, Powell T, Reichner A, SE-CMM: Systems Engineering Capability Maturity Model Project (1995) A Systems Engineering Capability Maturity

Model SM , Version 1.1, Maturity Model SECMM-95-01 CMU/SEI-95-MM-003, Software Engineering Institute , Carnegie Mellon University

- Masters S, Bothwell C (February 1995), Technical Report, CMU/SEI-95-TR-001, ESC-TR-95-001, CMM Appraisal Framework, Version 1.0, Software Engineering Institute , Carnegie Mellon University

- Paul MC, Curtis B, Chrissis MB, Weber CV, Technical Report, CMU/SEI-93-TR-024, ESC-TR-93-177, February 1993, CMM: Capability Maturity Model for Software, Version 1.1, Software Engineering Institute , Carnegie Mellon University

- Paulk MC, Weber CV, Garcia SM, Chrissis MB, Bush M (February 1993) Technical Report, CMU/SEI-93-TR-025, ESC-TR-93-178, Key Practices of the Capability Maturity Model SM , Version 1.1, Software Engineering Institute, Carnegie Mellon University

- ISO 9001, International Organisation for Standardisation, 1994, Geneva.

17.3 Text Books

- Wang, Y and King, G. (2000) Software Engineering Processes: Principles and Applications. CRC Press LLC

- El Emam, K Drouin JN and Melo, W. (1998) SPICE: The Theory and Practice of Software Process and Improvement and Capability Determination, IEEE Computer Society

- Jenner, MG (1995) Software Quality Management and ISO 9001: How To Make Them Work For You, Wiley QED

- Kehoe R and Jarvis A (1995) ISO 9000-3: A Tool for Software Product and Process Improvement, Springer

- Sanders J and Curran E. (1995) Software Quality: A Framework for Success in Software Development and Support, Addison-Wesley

- Humphrey, WS. (1990) Managing the Software Process, SEI Series in Software Engineering

17.4 About the Author

Richard Him Lok is the Custom and Workflow Solutions Manager for the Solutions division of Datacentrix, an IT company that provides infrastructure, solutions and services. He holds an MSc in Software Engineering, a Microsoft Certified Solutions Engineer certification and a Powerbuilder Professional Developer certification. Richard also has an extensive software development background from Microsoft Windows client/server systems implementations to web-based custom workflow process applications implementations based on K2.net software.

Richard has also been involved with the ISO/IEC 15504 standard since 1995, when the initial version was released. Since then he has published various technical papers relating to ISO/IEC 15504 and automated process assessment tools, in association with the Software Engineering Applications Laboratory (SEAL) of the University of the Witwatersrand.

In affiliation with the Software Process Improvement Laboratories (SPIL International), he has developed a process assessment tool for the ISO/IEC 15504 standard, known as the SPIL

Assessment Tool (SPILAT). This tool (initially distributed as the SEAL process assessment tool) has undergone numerous version enhancements to date, and allows an organisation to tailor their own ISO/IEC 15504- compatible process models for assessment and report generation.

Additional related projects and research have been conducted in this area by various graduates from the University of the Witwatersrand in association with SEAL, resulting in a family of interrelated publications and MSC projects whose research this project has drawn from.

17.4.1 Related Projects

1. R Him Lok (1995), Thesis: An Investigation into South African Software Quality Management Practices, QMS Project 1995-14/RHL, University of the Witwatersrand, South Africa

2. R Him Lok (1995), Project: The SEAL Process Assessment Tool, QMS Project 1995-45/SOQ, University of the Witwatersrand, South Africa

17.4.2 Related Publications

1. Him Lok R, Walker A J, 'Automated tool support for an emerging international software process assessment standard', ISESS 97, IEEE Computer Society, Walnut Creek, pages 25–35, 1997.

2. Him Lok R, Walker A J, 'SPICE Assessments using the SEAL assessment tool', SPICE 96, Conference Proceedings, Brighton, pages 19-27, 1996.

3. Li L, Walker, AJ, 'Verification and Validation of the SEAL Software Assessment Tool', IEEE Computer Society Software Engineering Standards Conference 97, 1 - 6 June 1997, Walnut Creek, USA 1997

4. Walker AJ, Gee C, 'ISO 9001 model support for software process assessment', Proceedings of the 4th International conference in ISO 9000 and TQM (4th ICIT) 7 - 9 April 1999, Hong Kong Baptist University, Hong Kong, pp. 171 - 178 1999

5. Him Lok R, Walker AJ, Gee C, 'Quality considerations in the development of an automated tool supporting process and capability assessments complying to the requirements of ISO/IEC 15504 and ISO 9001', 2nd World Congress on Software Quality, Yokohama, Japan, 25 – 29 September 2000

6. Gee C, Walker A J, 'Early results of a comparative evaluation of ISO 9001 and ISO/IEC 15504 assessment methods applied to a software project', Institute of Computer Scientists and Information Technologists Conference, 14 - 15 November, (SAICSIT 97), 1997

7. Edited by Khaled El Emam, Jean-Normand Drouin and Walcelio Melo. 'SPICE: The Theory and Practice of Software Process Improvement and Capability Determination', AJ Walker, R Him Lok, L Li, J Knight, Appendix A: SEAL of Quality SPICE Assessment Tool, pages 437 - 442, IEEE Computer Society Order Number BP07798 Library of Congress Number 97-29226 ISBN 0-8186-7798-8, 1997

8. Braude B, Walker A J, 'The use of the Internet in an academic environment to commercially supply and support software products', SEAL, University of Witwatersrand South Africa, 1997